OFELI

An Object Oriented Finite Element Library

Reference Guide

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5.1 Conservation Law Equations

For solvers of conservation law equations.

Classes

- class ICPG1D
  Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 1-D.
- class ICPG2DT
  Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 2-D.
- class ICPG3DT
  Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 3-D.
- class LCL1D
  Class to solve the linear conservation law (Hyperbolic equation) in 1-D by a MUSCL Finite Volume scheme.
- class LCL2DT
  Class to solve the linear hyperbolic equation in 2-D by a MUSCL Finite Volume scheme on triangles.
- class LCL3DT
  Class to solve the linear conservation law equation in 3-D by a MUSCL Finite Volume scheme on tetrahedra.
- class Muscl
  Parent class for hyperbolic solvers with Muscl scheme.
- class Muscl1D
  Class for 1-D hyperbolic solvers with Muscl scheme.
- class Muscl2DT
  Class for 2-D hyperbolic solvers with Muscl scheme.
- class Muscl3DT
  Class for 3-D hyperbolic solvers with Muscl scheme using tetrahedra.

5.1.1 Detailed Description

For solvers of conservation law equations.

5.2 Electromagnetics

Gathers electromagnetic equation classes.

Classes

- class BiotSavart

  Class to compute the magnetic induction from the current density using the Biot-Savart formula.
- class EC2D1T3

  Eddy current problems in 2-D domains using solenoidal approximation.
- class Equa_Electromagnetics< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for Electromagnetics Equation classes.
- class HelmholtzBT3

  Builds finite element arrays for Helmholtz equations in a bounded media using 3-Node triangles.

5.2.1 Detailed Description

Gathers electromagnetic equation classes.

5.3 Finite Element Mesh

Gathers mesh related classes.

Classes

- class Domain

  To store and treat finite element geometric information.
- class Edge

  To describe an edge.
- class Element

  To store and treat finite element geometric information.
- class Figure

  To store and treat a figure (or shape) information.
- class Rectangle

  To store and treat a rectangular figure.
- class Brick

  To store and treat a brick (parallelepiped) figure.
- class Circle

  To store and treat a circular figure.
- class Sphere

  To store and treat a sphere.
- class Ellipse

  To store and treat an ellipsoidal figure.
- class Triangle

  To store and treat a triangle.
- class Polygon

  To store and treat a polygonal figure.
- class Grid

  To manipulate structured grids.
- class Mesh

  To store and manipulate finite element meshes.
- class NodeList

  Class to construct a list of nodes having some common properties.
- class ElementList

  Class to construct a list of elements having some common properties.
- class SideList

  Class to construct a list of sides having some common properties.
- class EdgeList

  Class to construct a list of edges having some common properties.
- class Node

  To describe a node.
- class Partition

  To partition a finite element mesh into balanced submeshes.
- class Side

  To store and treat finite element sides (edges in 2-D or faces in 3-D)

Macros

- #define GRAPH_MEMORY 1000000

  Memory necessary to store matrix graph.
- #define MAX_NB_ELEMENTS 10000

  Maximal Number of elements.
- #define MAX_NB_NODES 10000

  Maximal number of nodes.
- #define MAX_NB_SIDES 30000

  Maximal number of sides in.
- #define MAX_NB_EDGES 30000

  Maximal Number of edges.
- #define MAX_NBDOF_NODE 6

  Maximum number of DOF supported by each node.
- #define MAX_NBDOF_SIDE 6

  Maximum number of DOF supported by each side.
- #define MAX_NBDOF_EDGE 2

  Maximum number of DOF supported by each edge.
- #define MAX_NB_ELEMENT_NODES 20

  Maximum number of nodes by element.
- #define MAX_NB_ELEMENT_EDGES 10

  Maximum number of edges by element.
- #define MAX_NB_SIDE_NODES 9

  Maximum number of nodes by side.
- #define MAX_NB_ELEMENT_SIDES 8

  Maximum number of sides by element.
- #define MAX_NB_ELEMENT_DOF 27

  Maximum number of dof by element.
- #define MAX_NB_SIDE_DOF 4

  Maximum number of dof by side.
- #define MAX_NB_INT_PTS 20

  Maximum number of integration points in element.
- #define MAX_NB_MATERIALS 10

  Maximum number of materials.
- #define TheNode (*theNode)
- #define TheElement (*theElement)
- #define TheSide (*theSide)
- #define TheEdge (*theEdge)
- #define MeshElements(mesh) for ((mesh).topElement(); (theElement=(mesh).getElement());)
- #define MeshActiveElements(mesh) for ((mesh).topElement(); (theElement=(mesh).get↩ ActiveElement());)
- #define MeshNodeLoop(mesh, node) for ((mesh).topNode(); ((node)=(mesh).getNode());)
- #define MeshNodes(mesh) for ((mesh).topNode(); (theNode=(mesh).getNode());)
- #define MeshBoundaryNodes(mesh) for ((mesh).topBoundaryNode(); (theNode=(mesh).get↩ BoundaryNode());)
- #define MeshSides(mesh) for ((mesh).topSide(); (theSide=(mesh).getSide());)
- #define MeshSideSet(sl) for ((sl).top(); (theSide=(sl).get());)
- #define MeshBoundarySides(mesh) for ((mesh).topBoundarySide(); (theSide=(mesh).get↩ BoundarySide());)

- #define MeshEdges(mesh) for ((mesh).topEdge(); (theEdge=(mesh).getEdge());)
- #define theNodeLabel theNode->n()
- #define theSideLabel theSide->n()

    A macro that returns side label in a loop using macro `MeshSides`
- #define theSideNodeLabel(i) theSide->getNodeLabel(i)

    A macro that returns label of `i`*-th node of side using macro* `MeshSides`
- #define theElementLabel theElement->n()

    A macro that returns element label in a loop using macro `MeshElements`
- #define theElementNodeLabel(i) theElement->getNodeLabel(i)

    A macro that returns label of `i`*-th node of element using macro* `MeshElements`

Functions

- ostream & operator<< (ostream &s, const Edge &ed)

    Output edge data.
- ostream & operator<< (ostream &s, const Element &el)

    Output element data.
- Figure operator&& (const Figure &f1, const Figure &f2)

    Function to define a Figure instance as the intersection of two Figure instances.
- Figure operator- (const Figure &f1, const Figure &f2)

    Function to define a Figure instance as the set subtraction of two Figure instances.
- ostream & operator<< (ostream &s, const Material &m)

    Output material data.
- ostream & operator<< (ostream &s, const Mesh &ms)

    Output mesh data.
- ostream & operator<< (ostream &s, const NodeList &nl)

    Output NodeList instance.
- ostream & operator<< (ostream &s, const ElementList &el)

    Output ElementList instance.
- ostream & operator<< (ostream &s, const SideList &sl)

    Output SideList instance.
- ostream & operator<< (ostream &s, const EdgeList &el)

    Output EdgeList instance.
- size_t Label (const Node &nd)

    Return label of a given node.
- size_t Label (const Element &el)

    Return label of a given element.
- size_t Label (const Side &sd)

    Return label of a given side.
- size_t Label (const Edge &ed)

    Return label of a given edge.
- size_t NodeLabel (const Element &el, size_t n)

    Return global label of node local label in element.
- size_t NodeLabel (const Side &sd, size_t n)

    Return global label of node local label in side.
- Point< real_t > Coord (const Node &nd)

    Return coordinates of a given node.

- int Code (const Node &nd, size_t i=1)

  Return code of a given (degree of freedom of) node.
- int Code (const Element &el)

  Return code of a given element.
- int Code (const Side &sd, size_t i=1)

  Return code of a given (degree of freedom of) side.
- bool operator== (const Element &el1, const Element &el2)

  Check equality between 2 elements.
- bool operator== (const Side &sd1, const Side &sd2)

  Check equality between 2 sides.
- void DeformMesh (Mesh &mesh, const Vect< real_t > &u, real_t a=1)

  Calculate deformed mesh using a displacement field.
- void DeformMesh (Mesh &mesh, const PETScVect< real_t > &u, real_t a=1)

  Calculate deformed mesh using a displacement field as instance of PETScVect.
- void MeshToMesh (Mesh &m1, Mesh &m2, const Vect< real_t > &u1, Vect< real_t > &u2, size_t nx, size_t ny=0, size_t nz=0, size_t dof=1)

  Function to redefine a vector defined on a mesh to a new mesh.
- void MeshToMesh (Mesh &m1, Mesh &m2, const Vect< real_t > &u1, Vect< real_t > &u2, const Point< real_t > &xmin, const Point< real_t > &xmax, size_t nx, size_t ny, size_t nz, size_t dof=1)

  Function to redefine a vector defined on a mesh to a new mesh.
- real_t getMaxSize (const Mesh &m)

  Return maximal size of element edges for given mesh.
- real_t getMinSize (const Mesh &m)

  Return minimal size of element edges for given mesh.
- real_t getMinElementMeasure (const Mesh &m)

  Return minimal measure (length, area or volume) of elements of given mesh.
- real_t getMinSideMeasure (const Mesh &m)

  Return minimal measure (length or area) of sides of given mesh.
- real_t getMaxSideMeasure (const Mesh &m)

  Return maximal measure (length or area) of sides of given mesh.
- real_t getMeanElementMeasure (const Mesh &m)

  Return average measure (length, area or volume) of elements of given mesh.
- real_t getMeanSideMeasure (const Mesh &m)

  Return average measure (length or area) of sides of given mesh.
- void setNodeCodes (Mesh &m, const string &exp, int code, size_t dof=1)

  Assign a given code to all nodes satisfying a boolean expression using node coordinates.
- void setBoundaryNodeCodes (Mesh &m, const string &exp, int code, size_t dof=1)

  Assign a given code to all nodes on boundary that satisfy a boolean expression using node coordinates.
- void setSideCodes (Mesh &m, const string &exp, int code, size_t dof=1)

  Assign a given code to all sides satisfying a boolean expression using node coordinates.
- void setBoundarySideCodes (Mesh &m, const string &exp, int code, size_t dof=1)

  Assign a given code to all sides on boundary that satisfy a boolean expression using node coordinates.
- void setElementCodes (Mesh &m, const string &exp, int code)

  Assign a given code to all elements satisfying a boolean expression using node coordinates.
- int NodeInElement (const Node ∗nd, const Element ∗el)

  Say if a given node belongs to a given element.

- int NodeInSide (const Node *nd, const Side *sd)

  Say if a given node belongs to a given side.
- int SideInElement (const Side *sd, const Element *el)

  Say if a given side belongs to a given element.
- ostream & operator<< (ostream &s, const Node &nd)

  Output node data.
- ostream & operator<< (ostream &s, const Side &sd)

  Output side data.

5.3.1 Detailed Description

Gathers mesh related classes.

5.3.2 Macro Definition Documentation

#define GRAPH_MEMORY 1000000

Memory necessary to store matrix graph.
This value is necessary only if nodes are to be renumbered.

#define TheNode (*theNode)

A macro that gives the instance pointed by *theNode*

#define TheElement (*theElement)

A macro that gives the instance pointed by *theElement*

#define TheSide (*theSide)

A macro that gives the instance pointed by *theSide*

#define TheEdge (*theEdge)

A macro that gives the instance pointed by *theEdge*

#define MeshElements(*mesh*) for ((mesh).topElement(); (theElement=(mesh).getElement());)

A macro to loop on mesh elements `mesh`: Instance of Mesh

Note

: Each iteration updates the pointer `theElement` to current Element

#define MeshActiveElements(*mesh*) for ((mesh).topElement(); (theElement=(mesh).getActiveElement());)

A macro to loop on mesh active elements *mesh* : Instance of Mesh

Note

: Each iteration updates the pointer `theElement` to current Element
: This macro is necessary only if adaptive meshing is used

#define MeshNodeLoop(*mesh,* *node* **) for ((mesh).topNode(); ((node)=(mesh).getNode());)**

A macro to loop on mesh nodes `mesh`: Instance of Mesh `node`: Pointer to pointed node

#define MeshNodes(*mesh* **) for ((mesh).topNode(); (theNode=(mesh).getNode());)**

A macro to loop on mesh nodes *mesh* : Instance of Mesh

Note

: Each iteration updates the pointer *theNode* to current Node

#define MeshBoundaryNodes(*mesh* **) for ((mesh).topBoundaryNode(); (theNode=(mesh).getBoundaryNode());)**

A macro to loop on mesh nodes `mesh`: Instance of Mesh

Note

: Each iteration updates the pointer `theNode` to current Node

#define MeshSides(*mesh* **) for ((mesh).topSide(); (theSide=(mesh).getSide());)**

A macro to loop on mesh sides `mesh`: Instance of Mesh

Note

: Each iteration updates the pointer `theSide` to current Side

#define MeshSideSet(*sl* **) for ((sl).top(); (theSide=(sl).get());)**

A macro to loop on a subset of mesh sides `sl`: Instance of SideList class

Note

: Each iteration updates the pointer `theSide` to current Side

#define MeshBoundarySides(*mesh* **) for ((mesh).topBoundarySide(); (theSide=(mesh).getBoundarySide());)**

A macro to loop on mesh boundary sides `mesh`: Instance of Mesh
Notes:

- List of boundary sides must have been previously created by using class SideList
- Each iteration updates the pointer `theSide` to current Side

#define MeshEdges(*mesh* **) for ((mesh).topEdge(); (theEdge=(mesh).getEdge());)**

A macro to loop on mesh edges `mesh`: Instance of Mesh

Note

: Each iteration updates the pointer `theEdge` to current Edge

#define theNodeLabel theNode->n()

A macro that returns node label in a loop using macro *MeshNodes*

5.3.3 Function Documentation

Figure operator&& (const Figure & *f1*, const Figure & *f2*)

Function to define a Figure instance as the intersection of two Figure instances.
Function to define a Figure instance as the union of two Figure instances.

Parameters

in	*f1*	First Figure instance
in	*f2*	Second Figure instance

Returns

Updated resulting Figure instance

Figure operator- (const Figure & *f1*, const Figure & *f2*)

Function to define a Figure instance as the set subtraction of two Figure instances.

Parameters

in	*f1*	First Figure instance to subtract from
in	*f2*	Second Figure instance to subtract

Returns

Updated resulting Figure instance

size_t Label (const Node & *nd*)

Return label of a given node.

Parameters

in	*nd*	Reference to Node instance

Returns

Label of node

size_t Label (const Element & *el*)

Return label of a given element.

Parameters

in	*el*	Reference to Element instance

Returns

Label of element

size_t Label (const Side & *sd*)

Return label of a given side.

Parameters

in	*sd*	Reference to Side instance

Returns

Label of side

size_t Label (const Edge & *ed*)

Return label of a given edge.

Parameters

in	*ed*	Reference to Edge instance

Returns

Label of edge

size_t NodeLabel (const Element & *el*, size_t *n*)

Return global label of node local label in element.

Parameters

in	*el*	Reference to Element instance
in	*n*	Local label of node in element

Returns

Global label of node

size_t NodeLabel (const Side & *sd*, size_t *n*)

Return global label of node local label in side.

Parameters

in	*sd*	Reference to Side instance
in	*n*	Local label of node in side

Returns

Global label of node

Point< real_t > Coord (const Node & *nd*)

Return coordinates of a given node.

Parameters

in	*nd*	Reference to Node instance

Returns

Coordinates of node

int Code (const Node & *nd*, size_t *i* = *1*)

Return code of a given (degree of freedom of) node.

Parameters

in	*nd*	Reference to Node instance
in	*i*	Label of dof [Default: 1]

Returns

Code of dof of node

int Code (const Element & *el*)

Return code of a given element.

Parameters

in	*el*	Reference to Element instance

Returns

Code of element

int Code (const Side & *sd*, size_t *i* = *1*)

Return code of a given (degree of freedom of) side.

Parameters

in	*sd*	Reference to Side instance
in	*i*	Label of dof [Default: 1]

Returns

Code of dof of side

operator== (const Element & *el1*, const Element & *el2*)

Check equality between 2 elements.

Parameters

in	*el1*	Reference to first Side instance
in	*el2*	Reference to second Side instance

Returns

`true` is elements are equal, *i.e.* if they have the same nodes, `false` if not.

bool operator== (const Side & *sd1*, const Side & *sd2*)

Check equality between 2 sides.

Parameters

in	*sd1*	Reference to first Side instance
in	*sd2*	Reference to second Side instance

Returns

`true` is sides are equal, *i.e.* if they have the same nodes, `false` if not.

void DeformMesh (Mesh & *mesh*, const Vect< real_t > & *u*, real_t *a* = *1*)

Calculate deformed mesh using a displacement field.

Parameters

in,out	*mesh*	Mesh instance. On output, node coordinates are modified to take into account the displacement
in	*u*	Displacement field at nodes
in	*a*	Amplification factor [Default: 1]. The displacement is multiplied by a before to be added to node coordinates

void DeformMesh (Mesh & *mesh*, const PETScVect< real_t > & *u*, real_t *a* = *1*)

Calculate deformed mesh using a displacement field as instance of PETScVect.

Parameters

`in,out`	*mesh*	Mesh instance. On output, node coordinates are modified to take into account the displacement
`in`	*u*	Displacement field at nodes
`in`	*a*	Amplification factor [Default: `1`]. The displacement is multiplied by `a` before to be added to node coordinates

void MeshToMesh (Mesh & *m1*, Mesh & *m2*, const Vect< real_t > & *u1*, Vect< real_t > & *u2*, size_t *nx*, size_t *ny* = *0*, size_t *nz* = *0*, size_t *dof* = *1*)

Function to redefine a vector defined on a mesh to a new mesh.

The program interpolates (piecewise linear) first the vector on a finer structured grid. Then the values on the new mesh nodes are computed.

Remarks

> For efficiency the number of grid cells must be large enough so that interpolation provides efficient accuracy

Parameters

`in`	*m1*	Reference to the first mesh instance
`out`	*m2*	Reference to the second mesh instance
`in`	*u1*	Input vector of nodal values defined on first mesh
`out`	*u2*	Output vector of nodal values defined on second mesh
`in`	*nx*	Number of cells in the `x`-direction in the fine structured grid
`in`	*ny*	Number of cells in the `y`-direction in the fine structured grid The default value of `ny` is `0`, i.e. a 1-D grid
`in`	*nz*	Number of cells in the `z`-direction in the fine structured grid The default value of `nz` is `0`, i.e. a 1-D or 2-D grid
`in`	*dof*	Label of degree of freedom of vector `u`. Only this dof is considered. [Default: `1`]

Note

> The input vector `u1` is a one degree of freedom per node vector, i.e. its size must be equal (or greater than) the total number of nodes of mesh `m1`. The size of vector `u2` is deduced from the mesh `m2`

void MeshToMesh (Mesh & *m1*, Mesh & *m2*, const Vect< real_t > & *u1*, Vect< real_t > & *u2*, const Point< real_t > & *xmin*, const Point< real_t > & *xmax*, size_t *nx*, size_t *ny*, size_t *nz*, size_t *dof* = *1*)

Function to redefine a vector defined on a mesh to a new mesh.

The program interpolates (piecewise linear) first the vector on a finer structured grid. Then the values on the new mesh nodes are computed. In this function the grid rectangle is defined so that this one can cover only a submesh of `m1`.

Remarks

For efficiency the number of grid cells must be large enough so that interpolation provides efficient accuracy

Parameters

`in`	*m1*	Reference to the first mesh instance
`out`	*m2*	Reference to the second mesh instance
`in`	*u1*	Input vector of nodal values defined on first mesh
`out`	*u2*	Output vector of nodal values defined on second mesh
`in`	*xmin*	Point instance containing minimal coordinates of the rectangle that defines the grid
`in`	*xmax*	Point instance containing maximal coordinates of the rectangle that defines the grid
`in`	*nx*	Number of cells in the `x`-direction in the fine structured grid
`in`	*ny*	Number of cells in the `y`-direction in the fine structured grid The default value of `ny` is `0`, i.e. a 1-D grid
`in`	*nz*	Number of cells in the `z`-direction in the fine structured grid The default value of `nz` is `0`, i.e. a 1-D or 2-D grid
`in`	*dof*	Label of degree of freedom of vector `u`. Only this dof is considered. [Default: `1`]

Note

The input vector `u1` is a one degree of freedom per node vector, i.e. its size must be equal (or greater than) the total number of nodes of mesh `m1`. The size of vector `u2` is deduced from the mesh `m2`

real_t getMaxSize (const Mesh & *m*)

Return maximal size of element edges for given mesh.

Parameters

`in`	*m*	Reference to mesh instance

real_t getMinSize (const Mesh & *m*)

Return minimal size of element edges for given mesh.

Parameters

`in`	*m*	Reference to mesh instance

real_t getMinElementMeasure (const Mesh & *m*)

Return minimal measure (length, area or volume) of elements of given mesh.
Return maximal measure (length, area or volume) of elements of given mesh.

Parameters

in	*m*	Reference to mesh instance

real_t getMinSideMeasure (const Mesh & *m*)

Return minimal measure (length or area) of sides of given mesh.

Parameters

in	*m*	Reference to mesh instance

Note

Use this function only if sides are present in the mesh and for 2-D meshes

real_t getMaxSideMeasure (const Mesh & *m*)

Return maximal measure (length or area) of sides of given mesh.

Parameters

in	*m*	Reference to mesh instance

Note

Use this function only if sides are present in the mesh and for 2-D meshes

real_t getMeanElementMeasure (const Mesh & *m*)

Return average measure (length, area or volume) of elements of given mesh.

Parameters

in	*m*	Reference to mesh instance

real_t getMeanSideMeasure (const Mesh & *m*)

Return average measure (length or area) of sides of given mesh.

Parameters

in	*m*	Reference to mesh instance

Note

Use this function only if sides are present in the mesh and for 2-D meshes

void setNodeCodes (Mesh & *m*, const string & *exp*, int *code*, size_t *dof* = 1)

Assign a given code to all nodes satisfying a boolean expression using node coordinates.

Parameters

in	*m*	Reference to mesh instance
in	*exp*	Regular expression using x, y, and z coordinates of nodes, according to fparser parser
in	*code*	Code to assign
in	*dof*	Degree of freedom for which code is assigned [Default: 1]

void setBoundaryNodeCodes (Mesh & *m*, const string & *exp*, int *code*, size_t *dof* = 1)

Assign a given code to all nodes on boundary that satisfy a boolean expression using node coordinates.

Parameters

in	*m*	Reference to mesh instance
in	*exp*	Regular expression using x, y, and z coordinates of nodes, according to fparser parser
in	*code*	Code to assign
in	*dof*	Degree of freedom for which code is assigned [Default: 1]

void setSideCodes (Mesh & *m*, const string & *exp*, int *code*, size_t *dof* = 1)

Assign a given code to all sides satisfying a boolean expression using node coordinates.

Parameters

in	*m*	Reference to mesh instance
in	*exp*	Regular expression using x, y, and z coordinates of side nodes, according to fparser parser
in	*code*	Code to assign
in	*dof*	Degree of freedom for which code is assigned [Default: 1]

void setBoundarySideCodes (Mesh & *m*, const string & *exp*, int *code*, size_t *dof* = 1)

Assign a given code to all sides on boundary that satisfy a boolean expression using node coordinates.

Parameters

in	*m*	Reference to mesh instance
in	*exp*	Regular expression using `x`, `y`, and `z` coordinates of side nodes, according to `fparser` parser
in	*code*	Code to assign
in	*dof*	Degree of freedom for which code is assigned [Default: `1`]

void setElementCodes (Mesh & *m*, const string & *exp*, int *code*)

Assign a given code to all elements satisfying a boolean expression using node coordinates.

Parameters

in	*m*	Reference to mesh instance
in	*exp*	Regular expression using `x`, `y`, and `z` coordinates of element nodes, according to `fparser` parser
in	*code*	Code to assign

int NodeInElement (const Node ∗ *nd*, const Element ∗ *el*)

Say if a given node belongs to a given element.

Parameters

in	*nd*	Pointer to Node
in	*el*	Pointer to Element

Returns

Local label of the node if this one is found, `0` if not.

int NodeInSide (const Node ∗ *nd*, const Side ∗ *sd*)

Say if a given node belongs to a given side.

Parameters

in	*nd*	Pointer to Node
in	*sd*	Pointer to Side

Returns

Local label of the node if this one is found, `0` if not.

int SideInElement (const Side ∗ *sd*, const Element ∗ *el*)

Say if a given side belongs to a given element.

Parameters

in	*sd*	Pointer to Side
in	*el*	Pointer to Element

Returns

Local label of the side if this one is found, `0` if not.

5.4 Fluid Dynamics

Gathers Fluid Dynamics equation classes.

Classes

- class Equa_Fluid< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for Fluid Dynamics Equation classes.
- class NSP2DQ41

  Builds finite element arrays for incompressible Navier-Stokes equations in 2-D domains using Q_1/P_0 element and a penaly formulation for the incompressibility condition.
- class TINS2DT3B

  Builds finite element arrays for thermal diffusion and convection in 2-D domains using 3-Node triangles.

5.4.1 Detailed Description

Gathers Fluid Dynamics equation classes.

5.5 General Purpose Equations

Gathers equation related classes.

Classes

- class AbsEqua< T_ >

  Mother abstract class to describe equation.
- class Equation< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for all equation classes.
- class Estimator

  To calculate an a posteriori estimator of the solution.

Functions

- template<class T_ , size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalVect< T_, N_ > &be, Vect< T_ > &b)

  Assemble local vector into global vector.
- template<class T_ , size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalMatrix< T_, N_, N_ > &ae, Vect< T_ > &b)

  Assemble diagonal local vector into global vector.
- template<class T_ , size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalMatrix< T_, N_, N_ > &ae, Matrix< T_ > *A)

  Assemble local matrix into global matrix.
- template<class T_ , size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalMatrix< T_, N_, N_ > &ae, SkMatrix< T_ > &A)

  Assemble local matrix into global skyline matrix.
- template<class T_ , size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalMatrix< T_, N_, N_ > &ae, SkSMatrix< T_ > &A)

  Assemble local matrix into global symmetric skyline matrix.
- template<class T_ , size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalMatrix< T_, N_, N_ > &ae, SpMatrix< T_ > &A)

  Assemble local matrix into global sparse matrix.
- template<class T_ , size_t N_>
  void side_assembly (const Element &e, const LocalMatrix< T_, N_, N_ > &ae, SpMatrix< T_ > &A)

  Side assembly of local matrix into global matrix (as instance of class SpMatrix).
- template<class T_ , size_t N_>
  void side_assembly (const Element &e, const LocalMatrix< T_, N_, N_ > &ae, SkSMatrix< T_ > &A)

  Side assembly of local matrix into global matrix (as instance of class SkSMatrix).
- template<class T_ , size_t N_>
  void side_assembly (const Element &e, const LocalMatrix< T_, N_, N_ > &ae, SkMatrix< T_ > &A)

  Side assembly of local matrix into global matrix (as instance of class SkMatrix).

- template<class T_ , size_t N_>
  void side_assembly (const Element &e, const LocalVect< T_, N_ > &be, Vect< T_ > &b)

  Side assembly of local vector into global vector.
- ostream & operator<< (ostream &s, const Estimator &r)

  Output estimator vector in output stream.

5.5.1 Detailed Description

Gathers equation related classes.

5.5.2 Function Documentation

void element_assembly (const E_ & *e*, const LocalVect< T_, N_ > & *be*, Vect< T_ > & *b*)

Assemble local vector into global vector.

Parameters

in	*e*	Reference to local entity (Element or Side)
in	*be*	Local vector
in,out	*b*	Global vector

void element_assembly (const E_ & *e*, const LocalMatrix< T_, N_, N_ > & *ae*, Vect< T_ > & *b*)

Assemble diagonal local vector into global vector.

Parameters

in	*e*	Reference to local entity (Element or Side)
in	*ae*	Local matrix
in,out	*b*	Global vector

void element_assembly (const E_ & *e*, const LocalMatrix< T_, N_, N_ > & *ae*, Matrix< T_ > * *A*)

Assemble local matrix into global matrix.

This function is to be called with an abstract pointer to matrix (class Matrix)

Parameters

in	*e*	Reference to local entity (Element or Side)
in	*ae*	Local matrix
in,out	*A*	Pointer to global matrix

void element_assembly (const E_ & *e*, const LocalMatrix< T_, N_, N_ > & *ae*, SkMatrix< T_ > & *A*)

Assemble local matrix into global skyline matrix.

Parameters

in	*e*	Reference to local entity (Element or Side)
in	*ae*	Local matrix
in,out	*A*	Global matrix

void element_assembly (const E_ & *e*, const LocalMatrix< T_, N_, N_ > & *ae*, SkSMatrix< T_ > & *A*)

Assemble local matrix into global symmetric skyline matrix.

Parameters

in	*e*	Reference to local entity (Element or Side)
in	*ae*	Local matrix
in,out	*A*	Global matrix

void element_assembly (const E_ & *e*, const LocalMatrix< T_, N_, N_ > & *ae*, SpMatrix< T_ > & *A*)

Assemble local matrix into global sparse matrix.

Parameters

in	*e*	Reference to local entity (Element or Side)
in	*ae*	Local matrix
in,out	*A*	Global matrix

void side_assembly (const Element & *e*, const LocalMatrix< T_, N_, N_ > & *ae*, SpMatrix< T_ > & *A*)

Side assembly of local matrix into global matrix (as instance of class SpMatrix).

Parameters

in	*e*	Reference to local Element
in	*ae*	Local matrix
in,out	*A*	Global matrix

void side_assembly (const Element & *e*, const LocalMatrix< T_, N_, N_ > & *ae*, SkSMatrix< T_ > & *A*)

Side assembly of local matrix into global matrix (as instance of class SkSMatrix).

Parameters

`in`	*e*	Reference to local Element
`in`	*ae*	Local matrix
`in,out`	*A*	Global matrix

void side_assembly (const Element & *e*, const LocalMatrix< T_, N_, N_ > & *ae*, SkMatrix< T_ > & *A*)

Side assembly of local matrix into global matrix (as instance of class SkMatrix).

Parameters

`in`	*e*	Reference to local Element
`in`	*ae*	Local matrix
`in,out`	*A*	Global matrix

void side_assembly (const Element & *e*, const LocalVect< T_, N_ > & *be*, Vect< T_ > & *b*)

Side assembly of local vector into global vector.

Parameters

`in`	*e*	Reference to local Element
`in`	*be*	Local vector
`in,out`	*b*	Global vector

5.6 Global Variables

Gathers all global variables in the library.

Variables

- Node ∗ theNode

    A pointer to Node.
- Element ∗ theElement

    A pointer to Element.
- Side ∗ theSide

    A pointer to Side.
- Edge ∗ theEdge

    A pointer to Edge.
- int theStep

    Time step counter.
- int theIteration

    Iteration counter.
- int NbTimeSteps

    Number of time steps.
- int MaxNbIterations

    Maximal number of iterations.
- int Verbosity

    Parameter for verbosity of message outputting.
- real_t theTimeStep

    Time step label.
- real_t theTime

    Time value.
- real_t theFinalTime

    Final time value.
- real_t theTolerance

    Tolerance value for convergence.
- real_t theDiscrepancy

    Value of discrepancy for an iterative procedure Its default value is `1.0`.
- bool Converged

    Boolean variable to say if an iterative procedure has converged.
- bool InitPetsc

5.6.1 Detailed Description

Gathers all global variables in the library.

5.6.2 Variable Documentation

Node∗ theNode

A pointer to Node.
Useful for loops on nodes

Element* theElement

A pointer to Element.
Useful for loops on elements

Side* theSide

A pointer to Side.
Useful for loops on sides

Edge* theEdge

A pointer to Edge.
Useful for loops on edges

int theStep

Time step counter.
This counter must be initialized by the user if the macro timeLoop is not used

Remarks

May be used in conjunction with the macro TimeLoop. In this case, it has to be initialized before. Its default value is 1

int theIteration

Iteration counter.
This counter must be initialized by the user

Remarks

May be used in conjunction with the macro IterationLoop. Its default value is 1

int NbTimeSteps

Number of time steps.

Remarks

May be used in conjunction with the macro TimeLoop.

int MaxNbIterations

Maximal number of iterations.

Remarks

May be used in conjunction with the macro IterationLoop. Its default value is 1000

int Verbosity

Parameter for verbosity of message outputting.
Its default value is 1

real_t theTimeStep

Time step label.

Remarks

May be used in conjunction with the macro TimeLoop. In this case, it has to be initialized before

real_t theTime

Time value.

Remarks

May be used in conjunction with the macro TimeLoop. Its default value is `0.0`

real_t theFinalTime

Final time value.

Remarks

May be used in conjunction with the macro TimeLoop. In this case, it has to be initialized before

real_t theTolerance

Tolerance value for convergence.

Remarks

May be used within an iterative procedure. Its default value is `1.e-8`

bool Converged

Boolean variable to say if an iterative procedure has converged.
Its default value is `false`

bool InitPetsc

Boolean to say if PETSc use was initialized. Useful only if PETSc is used

5.7 Heat Transfer

Gathers Heat Transfer equation classes.

Classes

- class DC1DL2

  Builds finite element arrays for thermal diffusion and convection in 1-D using 2-Node elements.
- class DC2DT3

  Builds finite element arrays for thermal diffusion and convection in 2-D domains using 3-Node triangles.
- class DC2DT6

  Builds finite element arrays for thermal diffusion and convection in 2-D domains using 6-Node triangles.
- class DC3DAT3

  Builds finite element arrays for thermal diffusion and convection in 3-D domains with axisymmetry using 3-Node triangles.
- class DC3DT4

  Builds finite element arrays for thermal diffusion and convection in 3-D domains using 4-Node tetrahedra.
- class Equa_Therm< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for Heat transfer Finite Element classes.
- class PhaseChange

  This class enables defining phase change laws for a given material.

5.7.1 Detailed Description

Gathers Heat Transfer equation classes.

5.8 Input/Output

Gathers Input/Output utility classes.

Classes

- class IOField

  Enables working with files in the XML Format.
- class IPF

  To read project parameters from a file in IPF format.
- class Prescription

  To prescribe various types of data by an algebraic expression. Data may consist in boundary conditions, forces, tractions, fluxes, initial condition. All these data types can be defined through an enumerated variable.

Macros

- #define MAX_NB_PAR 50

  Maximum number of parameters.
- #define MAX_ARRAY_SIZE 100

  Maximum array size.
- #define MAX_INPUT_STRING_LENGTH 100

  Maximum string length.
- #define FILENAME_LENGTH 150

  Length of a string defining a file name.

5.8.1 Detailed Description

Gathers Input/Output utility classes.

5.8.2 Macro Definition Documentation

#define MAX_NB_PAR 50

Maximum number of parameters.
Used in class IPF

#define MAX_ARRAY_SIZE 100

Maximum array size.
Used in class IPF

#define MAX_INPUT_STRING_LENGTH 100

Maximum string length.
Used in class IPF

5.9 Interface Problems

Gathers classes and functions for general interface problems, including image processing.

Classes

- class FastMarching2D

  To run a Fast Marching Method on 2-D structured uniform grids.
- class FMMSolver

  The Fast Marching Method solver.

5.9.1 Detailed Description

Gathers classes and functions for general interface problems, including image processing.

5.10 Laplace equation

Gathers equation classes for the Laplace equation.

Classes

- class Equa_Laplace< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for classes about the Laplace equation.
- class Laplace1DL2

  To build element equation for a 1-D elliptic equation using the 2-Node line element (P_1).
- class Laplace1DL3

  To build element equation for the 1-D elliptic equation using the 3-Node line (P_2).
- class Laplace2DFVT

  To build and solve the Laplace equation using a standard Finite Volume method.
- class Laplace2DMHRT0

  To build element equation for the 2-D elliptic equation using the Mixed Hybrid finite element at lowest degree (Raviart-Thomas RT_0).
- class Laplace2DT3

  To build element equation for the Laplace equation using the 2-D triangle element (P_1).
- class SteklovPoincare2DBE

  Solver of the Steklov Poincare problem in 2-D geometries using piecewie constant boundary elemen.

5.10.1 Detailed Description

Gathers equation classes for the Laplace equation.

5.11 OFELI

Modules

- Conservation Law Equations
  For solvers of conservation law equations.
- Electromagnetics
  Gathers electromagnetic equation classes.
- Finite Element Mesh
  Gathers mesh related classes.
- Fluid Dynamics
  Gathers Fluid Dynamics equation classes.
- General Purpose Equations
  Gathers equation related classes.
- Global Variables
  Gathers all global variables in the library.
- Heat Transfer
  Gathers Heat Transfer equation classes.
- Input/Output
  Gathers Input/Output utility classes.
- Interface Problems
  Gathers classes and functions for general interface problems, including image processing.
- Laplace equation
  Gathers equation classes for the Laplace equation.
- Physical properties of media
  A module that contains classes for physical properties of materials and media.
- Shape Function
  Gathers shape function classes.
- Solid Mechanics
  Gathers Solid Mechanics finite element equations related classes.
- Solver
  Gathers Solver functions.
- Utilities
  Gathers utility functions and classes.
- Vector and Matrix
  Gathers vector and matrix related classes.

Files

- file AbsEqua.h
  Definition file for abstract class AbsEqua.
- file ICPG1D.h
  Definition file for class ICPG1D.
- file ICPG2DT.h
  Definition file for class ICPG2DT.
- file ICPG3DT.h
  Definition file for class ICPG3DT.
- file LCL1D.h

Definition file for class LCL1D.
- file LCL2DT.h
  Definition file for class LCL2DT.
- file LCL3DT.h
  Definition file for class LCL3DT.
- file Muscl.h
  Definition file for class Muscl.
- file Muscl1D.h
  Definition file for class Muscl1D.
- file Muscl2DT.h
  Definition file for class Muscl2DT.
- file Muscl3DT.h
  Definition file for class Muscl3DT.
- file BiotSavart.h
  Definition file for class BiotSavart.
- file EC2D1T3.h
  Definition file for class EC2D1T3.
- file Equa_Electromagnetics.h
  Definition file for class FE_Electromagnetics.
- file HelmholtzBT3.h
  Definition file for class HelmholtzBT3.
- file Equation.h
  Definition file for class Equation.
- file Equa_Fluid.h
  Definition file for class Equa_Fluid.
- file NSP2DQ41.h
  Definition file for class NSP2DQ41.
- file TINS2DT3B.h
  Definition file for class TINS2DT3B.
- file Equa_Laplace.h
  Definition file for class Equa_Laplace.
- file Laplace1DL2.h
  Definition file for class Laplace1DL2.
- file Laplace1DL3.h
  Definition file for class Laplace1DL3.
- file Laplace2DFVT.h
  Definition file for class Laplace.
- file Laplace2DMHRT0.h
  Definition file for class Laplace2DMHRT0.
- file Laplace2DT3.h
  Definition file for class Laplace.
- file SteklovPoincare2DBE.h
  Definition file for class SteklovPoincare2DBE.
- file Bar2DL2.h
  Definition file for class Bar2DL2.
- file Beam3DL2.h

Definition file for class Beam3DL2.

- file Elas2DQ4.h

  Definition file for class Elas2DQ4.
- file Elas2DT3.h

  Definition file for class Elas2DT3.
- file Elas3DH8.h

  Definition file for class Elas3DH8.
- file Elas3DT4.h

  Definition file for class Elas3DT4.
- file Equa_Solid.h

  Definition file for class Equa_Solid.
- file DC1DL2.h

  Definition file for class DC1DL2.
- file DC2DT3.h

  Definition file for class DC2DT3.
- file DC2DT6.h

  Definition file for class DC2DT6.
- file DC3DAT3.h

  Definition file for class DC3DAT3.
- file DC3DT4.h

  Definition file for class DC3DT4.
- file Equa_Therm.h

  Definition file for class Equa_Therm.
- file PhaseChange.h

  Definition file for class PhaseChange and its parent abstract class.
- file Funct.h

  Definition file for class Funct.
- file IOField.h

  Definition file for class IOField.
- file IPF.h

  Definition file for class IPF.
- file output.h

  File that contains some output utility functions.
- file Prescription.h

  Definition file for class Prescription.
- file saveField.h

  Prototypes for functions to save mesh in various file formats.
- file saveField.h

  Prototypes for functions to save mesh in various file formats.
- file Tabulation.h

  Definition file for class Tabulation.
- file UserData.h

  Definition file for abstract class UserData.
- file BMatrix.h

  Definition file for class BMatrix.
- file DMatrix.h

Definition file for class DMatrix.
- file DSMatrix.h

  Definition file for abstract class DSMatrix.
- file LocalMatrix.h

  Definition file for class LocalMatrix.
- file LocalVect.h

  Definition file for class LocalVect.
- file Matrix.h

  Definition file for abstract class Matrix.
- file PETScMatrix.h

  Definition file for class PETScMatrix.
- file Point.h

  Definition file and implementation for class Point.
- file Point2D.h

  Definition file for class Point2D.
- file SkMatrix.h

  Definition file for class SkMatrix.
- file SkSMatrix.h

  Definition file for class SkSMatrix.
- file SpMatrix.h

  Definition file for class SpMatrix.
- file TrMatrix.h

  Definition file for class TrMatrix.
- file Domain.h

  Definition file for class Domain.
- file Edge.h

  Definition file for class Edge.
- file Element.h

  Definition file for class Element.
- file Figure.h

  Definition file for figure classes.
- file getMesh.h

  Definition file for mesh conversion functions.
- file Grid.h

  Definition file for class Grid.
- file Material.h

  Definition file for class Material.
- file Mesh.h

  Definition file for class Mesh.
- file MeshExtract.h

  Definition file for classes for extracting submeshes.
- file MeshUtil.h

  Definitions of utility functions for meshes.
- file Node.h

  Definition file for class Node.
- file saveMesh.h

Prototypes for functions to save mesh in various file formats.

- file Side.h

  Definition file for class Side.
- file FEShape.h

  Definition file for class FEShape.
- file Hexa8.h

  Definition file for class Hexa8.
- file Line2.h

  Definition file for class Line2.
- file Line2H.h

  Definition file for class Line2H.
- file Line3.h

  Definition file for class Line3.
- file Penta6.h

  Definition file for class Penta6.
- file Quad4.h

  Definition file for class Quad4.
- file Tetra4.h

  Definition file for class Tetra4.
- file Triang3.h

  Definition file for class Triang3.
- file Triang6S.h

  Definition file for class Triang6S.
- file BiCG.h

  Solves an unsymmetric linear system of equations using the BiConjugate Gradient method.
- file BSpline.h

  Function to perform a B-spline interpolation.
- file CG.h

  Functions to solve a symmetric positive definite linear system of equations using the Conjugate Gradient method.
- file CGS.h

  Solves an unsymmetric linear system of equations using the Conjugate Gradient Squared method.
- file EigenProblemSolver.h

  Definition file for class EigenProblemSolver.
- file GMRes.h

  Function to solve a linear system of equations using the Generalized Minimum Residual method.
- file GS.h

  Function to solve a linear system of equations using the Gauss-Seidel method.
- file Jacobi.h

  Function to solve a linear system of equations using the Jacobi method.
- file ODESolver.h

  Definition file for class ODESolver.
- file OptimAux.h

  File that contains auxiliary functions for optimization.
- file OptimSA.h

  Function to solve an optimization problem using the Simulated Annealing method.
- file OptimTN.h

Function to solve an optimization problem using the Truncated Newton method.

- file Prec.h

  Definition file for preconditioning classes.

- file Richardson.h

  Function to solve a linear system of equations using the Richardson method.

- file SSOR.h

  Function to solve a linear system of equations using the Symmetric Successive Over Relaxation method.

- file TimeStepping.h

  Definition file for class TimeStepping.

- file constants.h

  File that contains some widely used constants.

- file Gauss.h

  Definition file for struct Gauss.

- file qksort.h

  File that contains template quick sorting function.

- file Timer.h

  Definition file for class Timer.

- file util.h

  File that contains various utility functions.

Classes

- class SkMatrix< T_ >

  To handle square matrices in skyline storage format.

- class SkSMatrix< T_ >

  To handle symmetric matrices in skyline storage format.

- class SpMatrix< T_ >

  To handle matrices in sparse storage format.

- class AbsEqua< T_ >

  Mother abstract class to describe equation.

- class LocalVect< T_, N_ >

  Handles small size vectors like element vectors.

- class ICPG1D

  Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 1-D.

- class ICPG2DT

  Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 2-D.

- class ICPG3DT

  Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 3-D.

- class LCL1D

  Class to solve the linear conservation law (Hyperbolic equation) in 1-D by a MUSCL Finite Volume scheme.

- class LCL2DT

  Class to solve the linear hyperbolic equation in 2-D by a MUSCL Finite Volume scheme on triangles.

- class LCL3DT

  Class to solve the linear conservation law equation in 3-D by a MUSCL Finite Volume scheme on tetrahedra.

- class Muscl

  Parent class for hyperbolic solvers with Muscl scheme.

- class Vect< T_ >

To handle general purpose vectors.

- class Muscl1D

  Class for 1-D hyperbolic solvers with Muscl scheme.
- class Muscl2DT

  Class for 2-D hyperbolic solvers with Muscl scheme.
- class Muscl3DT

  Class for 3-D hyperbolic solvers with Muscl scheme using tetrahedra.
- class BiotSavart

  Class to compute the magnetic induction from the current density using the Biot-Savart formula.
- class EC2D1T3

  Eddy current problems in 2-D domains using solenoidal approximation.
- class Equa_Electromagnetics< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for Electromagnetics Equation classes.
- class HelmholtzBT3

  Builds finite element arrays for Helmholtz equations in a bounded media using 3-Node triangles.
- class Equation< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for all equation classes.
- class Equa_Fluid< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for Fluid Dynamics Equation classes.
- class NSP2DQ41

  Builds finite element arrays for incompressible Navier-Stokes equations in 2-D domains using Q_1/P_0 element and a penaly formulation for the incompressibility condition.
- class TINS2DT3B

  Builds finite element arrays for thermal diffusion and convection in 2-D domains using 3-Node triangles.
- class FastMarching2D

  To run a Fast Marching Method on 2-D structured uniform grids.
- class FMM2D

  class for the fast marching 2-D algorithm
- class FMM3D

  class for the 3-D fast marching algorithm
- class FMMSolver

  The Fast Marching Method solver.
- class Equa_Laplace< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for classes about the Laplace equation.
- class Laplace1DL2

  To build element equation for a 1-D elliptic equation using the 2-Node line element (P_1).
- class Laplace1DL3

  To build element equation for the 1-D elliptic equation using the 3-Node line (P_2).
- class Laplace2DFVT

  To build and solve the Laplace equation using a standard Finite Volume method.
- class Laplace2DMHRT0

  To build element equation for the 2-D elliptic equation using the Mixed Hybrid finite element at lowest degree (Raviart-Thomas RT_0).
- class Laplace2DT3

  To build element equation for the Laplace equation using the 2-D triangle element (P_1).
- class SteklovPoincare2DBE

  Solver of the Steklov Poincare problem in 2-D geometries using piecewie constant boundary elemen.

- class Bar2DL2

  To build element equations for Planar Elastic Bar element with 2 DOF (Degrees of Freedom) per node.
- class Beam3DL2

  To build element equations for 3-D beam equations using 2-node lines.
- class Elas2DQ4

  To build element equations for 2-D linearized elasticity using 4-node quadrilaterals.
- class Elas2DT3

  To build element equations for 2-D linearized elasticity using 3-node triangles.
- class Elas3DH8

  To build element equations for 3-D linearized elasticity using 8-node hexahedra.
- class Elas3DT4

  To build element equations for 3-D linearized elasticity using 4-node tetrahedra.
- class Equa_Solid< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for Solid Mechanics Finite Element classes.
- class DC1DL2

  Builds finite element arrays for thermal diffusion and convection in 1-D using 2-Node elements.
- class DC2DT3

  Builds finite element arrays for thermal diffusion and convection in 2-D domains using 3-Node triangles.
- class DC2DT6

  Builds finite element arrays for thermal diffusion and convection in 2-D domains using 6-Node triangles.
- class DC3DAT3

  Builds finite element arrays for thermal diffusion and convection in 3-D domains with axisymmetry using 3-Node triangles.
- class DC3DT4

  Builds finite element arrays for thermal diffusion and convection in 3-D domains using 4-Node tetrahedra.
- class Equa_Therm< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for Heat transfer Finite Element classes.
- class PhaseChange

  This class enables defining phase change laws for a given material.
- class Funct

  A simple class to parse real valued functions.
- class IOField

  Enables working with files in the XML Format.
- class IPF

  To read project parameters from a file in IPF format.
- class Prescription

  To prescribe various types of data by an algebraic expression. Data may consist in boundary conditions, forces, tractions, fluxes, initial condition. All these data types can be defined through an enumerated variable.
- class Tabulation

  To read and manipulate tabulated functions.
- class UserData< T_ >

  Abstract class to define by user various problem data.
- class BMatrix< T_ >

  To handle band matrices.
- class DMatrix< T_ >

  To handle dense matrices.

- class DSMatrix< T_ >

  To handle symmetric dense matrices.
- class LocalMatrix< T_, NR_, NC_ >

  Handles small size matrices like element matrices, with a priori known size.
- class Matrix< T_ >

  Virtual class to handle matrices for all storage formats.
- class PETScVect< T_ >

  To handle general purpose vectors using Petsc.
- class PETScMatrix< T_ >

  To handle matrices in sparse storage format using the Petsc library.
- class PETScWrapper< T_ >

  This class is a wrapper to be used when the library Petsc is installed and used with OFELI.
- class Point< T_ >

  Defines a point with arbitrary type coordinates.
- class Point2D< T_ >

  Defines a 2-D point with arbitrary type coordinates.
- class Prec< T_ >

  To set a preconditioner.
- class TrMatrix< T_ >

  To handle tridiagonal matrices.
- class Domain

  To store and treat finite element geometric information.
- class Edge

  To describe an edge.
- class Element

  To store and treat finite element geometric information.
- class Figure

  To store and treat a figure (or shape) information.
- class Rectangle

  To store and treat a rectangular figure.
- class Brick

  To store and treat a brick (parallelepiped) figure.
- class Circle

  To store and treat a circular figure.
- class Sphere

  To store and treat a sphere.
- class Ellipse

  To store and treat an ellipsoidal figure.
- class Triangle

  To store and treat a triangle.
- class Polygon

  To store and treat a polygonal figure.
- class Grid

  To manipulate structured grids.
- class Material

  To treat material data. This class enables reading material data in material data files. It also returns these informations by means of its members.

- class Mesh

  To store and manipulate finite element meshes.
- class NodeList

  Class to construct a list of nodes having some common properties.
- class ElementList

  Class to construct a list of elements having some common properties.
- class SideList

  Class to construct a list of sides having some common properties.
- class EdgeList

  Class to construct a list of edges having some common properties.
- class Node

  To describe a node.
- class Partition

  To partition a finite element mesh into balanced submeshes.
- class Side

  To store and treat finite element sides (edges in 2-D or faces in 3-D)
- class FEShape

  Parent class from which inherit all finite element shape classes.
- class triangle

  Defines a triangle. The reference element is the rectangle triangle with two unit edges.
- class Hexa8

  Defines a three-dimensional 8-node hexahedral finite element using Q1-isoparametric interpolation.
- class Line2

  To describe a 2-Node planar line finite element.
- class Line2H

  To describe a 2-Node Hermite planar line finite element.
- class Line3

  To describe a 3-Node quadratic planar line finite element.
- class Penta6

  Defines a 6-node pentahedral finite element using P_1 interpolation in local coordinates (`s.x`,`s.y`) and Q_1 isoparametric interpolation in local coordinates (`s.x`,`s.z`) and (`s.y`,`s.z`).
- class Quad4

  Defines a 4-node quadrilateral finite element using Q_1 isoparametric interpolation.
- class Tetra4

  Defines a three-dimensional 4-node tetrahedral finite element using P_1 interpolation.
- class Triang3

  Defines a 3-Node (P_1) triangle.
- class Triang6S

  Defines a 6-Node straight triangular finite element using P_2 interpolation.
- class EigenProblemSolver

  Class to find eigenvalues and corresponding eigenvectors of a given matrix in a generalized eigenproblem, i.e. Find scalars l and non-null vectors v such that [K]{v} = l[M]{v} where [K] and [M] are symmetric matrices. The eigenproblem can be originated from a PDE. For this, we will refer to the matrices K and M as Stiffness and Mass matrices respectively.
- class Iter< T_ >

  Class to drive an iterative process.
- class LinearSolver< T_ >

Class to solve systems of linear equations by iterative methods.

- class ODESolver

  To solve a system of ordinary differential equations.

- class TimeStepping

  To solve time stepping problems, i.e. systems of linear ordinary differential equations of the form [A2]{y''} + [A1]{y'} + [A0]{y} = {b}.

- class Gauss

  Calculate data for Gauss integration.

- class Timer

  To handle elapsed time counting.

Enumerations

Functions

- T_ * A ()

  Return element matrix.

- T_ * b ()

  Return element right-hand side.

- T_ * Prev ()

  Return element previous vector.

- IOField ()

  Default constructor.

- IOField (const string &file, AccessType access, bool compact=true)

  Constructor using file name.

- IOField (const string &mesh_file, const string &file, Mesh &ms, AccessType access, bool compact=true)

  Constructor using file name, mesh file and mesh.

- IOField (const string &file, Mesh &ms, AccessType access, bool compact=true)

  Constructor using file name and mesh.

- IOField (const string &file, AccessType access, const string &name)

  Constructor using file name and field name.

- ~IOField ()

  Destructor.

- void setMeshFile (const string &file)

  Set mesh file.

- void open ()

  Open file.

- void open (const string &file, AccessType access)

  Open file.

- void close ()

  Close file.

- void put (Mesh &ms)

  Store mesh in file.

- void put (const Vect< real_t > &v)

  Store Vect instance v in file.

- void put (const PETScVect< real_t > &v)

  Store PETScVect instance v in file.

- real_t get (Vect< real_t > &v)

  Get Vect v instance from file.
- int get (Vect< real_t > &v, const string &name)

  Get Vect v instance from file if the field has the given name.
- int get (DMatrix< real_t > &A, const string &name)

  Get DMatrix A instance from file if the field has the given name.
- int get (DSMatrix< real_t > &A, const string &name)

  Get DSMatrix A instance from file if the field has the given name.
- int get (Vect< real_t > &v, real_t t)

  Get Vect v instance from file corresponding to a specific time value.
- void saveGMSH (string output_file, string mesh_file)

  *Save field vectors in a file using **GMSH** format.*
- Tabulation ()

  Default constructor.
- Tabulation (string file)

  Constructor using file name.
- ~Tabulation ()

  Destructor.
- void setFile (string file)

  Set file name.
- real_t getValue (string funct, real_t v)

  Return the calculated value of the function.
- real_t getDerivative (string funct, real_t v)

  Return the derivative of the function at a given point.
- real_t getValue (string funct, real_t v1, real_t v2)

  Return the calculated value of the function.
- real_t getValue (string funct, real_t v1, real_t v2, real_t v3)

  Return the calculated value of the function.
- Point< double > CrossProduct (const Point< double > &lp, const Point< double > &rp)

  Return Cross product of two vectors lp and rp
- Grid ()

  Construct a default grid with 10 intervals in each direction.
- Grid (real_t xm, real_t xM, size_t npx)

  Construct a 1-D structured grid given its extremal coordinates and number of intervals.
- Grid (real_t xm, real_t xM, real_t ym, real_t yM, size_t npx, size_t npy)

  Construct a 2-D structured grid given its extremal coordinates and number of intervals.
- Grid (Point< real_t > m, Point< real_t > M, size_t npx, size_t npy)

  Construct a 2-D structured grid given its extremal coordinates and number of intervals.
- Grid (real_t xm, real_t xM, real_t ym, real_t yM, real_t zm, real_t zM, size_t npx, size_t npy, size_t npz)

  Construct a 3-D structured grid given its extremal coordinates and number of intervals.
- Grid (Point< real_t > m, Point< real_t > M, size_t npx, size_t npy, size_t npz)

  Construct a 3-D structured grid given its extremal coordinates and number of intervals.
- void setXMin (const Point< real_t > &x)

  Set min. coordinates of the domain.
- void setXMax (const Point< real_t > &x)
- void setDomain (real_t xmin, real_t xmax)

Set Dimensions of the domain: 1-D case.
- void setDomain (real_t xmin, real_t xmax, real_t ymin, real_t ymax)

  Set Dimensions of the domain: 2-D case.
- void setDomain (real_t xmin, real_t xmax, real_t ymin, real_t ymax, real_t zmin, real_t zmax)

  Set Dimensions of the domain: 3-D case.
- void setDomain (Point< real_t > xmin, Point< real_t > xmax)

  Set Dimensions of the domain: 3-D case.
- const Point< real_t > & getXMin () const

  Return min. Coordinates of the domain.
- const Point< real_t > & getXMax () const

  Return max. Coordinates of the domain.
- void setN (size_t nx, size_t ny=0, size_t nz=0)

  Set number of grid intervals in the x, y and z-directions.
- size_t getNx () const

  Return number of grid intervals in the x-direction.
- size_t getNy () const

  Return number of grid intervals in the y-direction.
- size_t getNz () const

  Return number of grid intervals in the z-direction.
- real_t getHx () const

  Return grid size in the x-direction.
- real_t getHy () const

  Return grid size in the y-direction.
- real_t getHz () const

  Return grid size in the z-direction.
- Point< real_t > getCoord (size_t i) const

  Return coordinates a point with label `i` in a 1-D grid.
- Point< real_t > getCoord (size_t i, size_t j) const

  Return coordinates a point with label `(i,j)` in a 2-D grid.
- Point< real_t > getCoord (size_t i, size_t j, size_t k) const

  Return coordinates a point with label `(i,j,k)` in a 3-D grid.
- real_t getX (size_t i) const

  Return x-coordinate of point with index `i`
- real_t getY (size_t j) const

  Return y-coordinate of point with index `j`
- real_t getZ (size_t k) const

  Return z-coordinate of point with index `k`
- Point2D< real_t > getXY (size_t i, size_t j) const

  Return coordinates of point with indices `(i,j)`
- Point< real_t > getXYZ (size_t i, size_t j, size_t k) const

  Return coordinates of point with indices `(i,j,k)`
- real_t getCenter (size_t i) const

  Return coordinates of center of a 1-D cell with indices `i`, `i+1`
- Point< real_t > getCenter (size_t i, size_t j) const

  Return coordinates of center of a 2-D cell with indices `(i,j)`, `(i+1,j)`, `(i+1,j+1)`, `(i,j+1)`
- Point< real_t > getCenter (size_t i, size_t j, size_t k) const

Return coordinates of center of a 3-D cell with indices `(i,j,k)`, `(i+1,j,k)`, `(i+1,j+1,k)`, `(i,j+1,k)`, `(i,j,k+1)`, `(i+1,j,k+1)`, `(i+1,j+1,k+1)`, `(i,j+1,k+1)`

- void setCode (string exp, int code)

  Set a code for some grid points.
- void setCode (int side, int code)

  Set a code for grid points on sides.
- int getCode (int side) const

  Return code for a side number.
- int getCode (size_t i, size_t j) const

  Return code for a grid point.
- int getCode (size_t i, size_t j, size_t k) const

  Return code for a grid point.
- size_t getDim () const

  Return space dimension.
- void Deactivate (size_t i)

  Change state of a cell from active to inactive (1-D grid)
- void Deactivate (size_t i, size_t j)

  Change state of a cell from active to inactive (2-D grid)
- void Deactivate (size_t i, size_t j, size_t k)

  Change state of a cell from active to inactive (2-D grid)
- int isActive (size_t i) const

  Say if cell is active or not (1-D grid)
- int isActive (size_t i, size_t j) const

  Say if cell is active or not (2-D grid)
- int isActive (size_t i, size_t j, size_t k) const

  Say if cell is active or not (3-D grid)
- ostream & operator<< (ostream &s, const Grid &g)

  Output grid data.
- BMatrix ()

  Default constructor.
- BMatrix (size_t size, int ld, int ud)

  Constructor that for a band matrix with given size and bandwidth.
- BMatrix (const BMatrix &m)

  Copy Constructor.
- void setSize (size_t size, int ld, int ud)

  Set size (number of rows) and storage of matrix.
- void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `x` *and add result to* `y`
- void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `a*x` *and add result to* `y`
- void Mult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `x` *and save result in* `y`
- void TMult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector `x` *and save result in* `y`
- void Axpy (T_ a, const BMatrix< T_ > &x)

  Add to matrix the product of a matrix by a scalar.
- void Axpy (T_ a, const Matrix< T_ > *x)

Add to matrix the product of a matrix by a scalar.

- void set (size_t i, size_t j, const T_ &val)

  Add constant `val` to an entry `(i,j)` of the matrix.
- void add (size_t i, size_t j, const T_ &val)

  Add constant `val` value to an entry `(i,j)` of the matrix.
- T_ operator() (size_t i, size_t j) const

  Operator () (Constant version).
- T_ & operator() (size_t i, size_t j)

  Operator () (Non constant version).
- BMatrix< T_ > & operator= (const BMatrix< T_ > &m)

  Operator =.
- BMatrix< T_ > & operator= (const T_ &x)

  Operator = Assign matrix to identity times `x`.
- BMatrix< T_ > & operator*= (const T_ &x)

  *Operator *=.*
- BMatrix< T_ > & operator+= (const T_ &x)

  Operator +=.
- int setLU ()

  Factorize the matrix (LU factorization)
- int solve (Vect< T_ > &b)

  Solve linear system.
- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve linear system.
- T_ get (size_t i, size_t j) const

  Return entry `(i,j)` of matrix.
- DSMatrix ()

  Default constructor.
- DSMatrix (size_t dim)

  Constructor that for a symmetric matrix with given number of rqows.
- DSMatrix (const DSMatrix< T_ > &m)

  Copy Constructor.
- void setDiag ()

  Store diagonal entries in a separate internal vector.
- void setSize (size_t dim)

  Set size (number of rows) of matrix.
- void set (size_t i, size_t j, const T_ &val)

  Assign constant to entry `(i,j)` of the matrix.
- void setDiag (const T_ &a)

  Set matrix as diagonal and assign its diagonal entries as a constant.
- void setDiag (const vector< T_ > &d)

  Set matrix as diagonal and assign its diagonal entries.
- void add (size_t i, size_t j, const T_ &val)

  Add constant to an entry ofthe matrix.
- T_ operator() (size_t i, size_t j) const

  Operator `()` (Constant version).
- T_ & operator() (size_t i, size_t j)

Operator () (Non constant version).

- DSMatrix< T_ > & operator= (const DSMatrix< T_ > &m)

  Operator = Copy matrix m to current matrix instance.

- DSMatrix< T_ > & operator= (const T_ &x)

  Operator = Assign matrix to identity times x.

- int setLDLt ()

  Factorize matrix (LDL^T)

- void getColumn (size_t j, Vect< T_ > &v) const

  Get j-th column vector.

- Vect< T_ > getColumn (size_t j) const

  Get j-th column vector.

- void setColumn (size_t i, const Vect< T_ > &v)

  Copy a given vector to a prescribed column in the matrix.

- void getRow (size_t i, Vect< T_ > &v) const

  Get i-th row vector.

- Vect< T_ > getRow (size_t i) const

  Get i-th row vector.

- void setRow (size_t i, const Vect< T_ > &v)

  Copy a given vector to a prescribed row in the matrix.

- void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  *Multiply matrix by vector a*x and add result to y.*

- void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const

  *Multiply matrix by vector a*x and add to y.*

- void Mult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector x and save result in y.

- void TMult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector x and add result in y.

- int solve (Vect< T_ > &b)

  Solve linear system.

- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve linear system.

- T_ get (size_t i, size_t j) const

  Return entry (i,j) of matrix.

- void Axpy (T_ a, const DSMatrix< T_ > &m)

  Add to matrix the product of a matrix by a scalar.

- void Axpy (T_ a, const Matrix< T_ > *m)

  Add to matrix the product of a matrix by a scalar.

- LocalMatrix ()

  Default constructor.

- LocalMatrix (const LocalMatrix< T_, NR_, NC_ > &m)

  Copy constructor.

- LocalMatrix (Element *el, const SpMatrix< T_ > &a)

  Constructor of a local matrix associated to element from a SpMatrix.

- LocalMatrix (Element *el, const SkMatrix< T_ > &a)

  Constructor of a local matrix associated to element from a SkMatrix.

- LocalMatrix (Element *el, const SkSMatrix< T_ > &a)

Constructor of a local matrix associated to element from a SkSMatrix.

- void Localize (Element ∗el, const SpMatrix< T_ > &a)

  Initialize matrix as element matrix from global SpMatrix.
- void Localize (Element ∗el, const SkMatrix< T_ > &a)

  Initialize matrix as element matrix from global SkMatrix.
- void Localize (Element ∗el, const SkSMatrix< T_ > &a)

  Initialize matrix as element matrix from global SkSMatrix.
- LocalMatrix< T_, NR_, NC_ > & operator= (const LocalMatrix< T_, NR_, NC_ > &m)

  Operator =
- LocalMatrix< T_, NR_, NC_ > & operator= (const T_ &x)

  Operator =
- LocalMatrix< T_, NR_, NC_ > & operator+= (const LocalMatrix< T_, NR_, NC_ > &m)

  Operator +=
- LocalMatrix< T_, NR_, NC_ > & operator-= (const LocalMatrix< T_, NR_, NC_ > &m)

  Operator −=
- LocalVect< T_, NR_ > operator∗ (LocalVect< T_, NC_ > &x)

  Operator ∗
- LocalMatrix< T_, NR_, NC_ > & operator+= (const T_ &x)

  Operator +=
- LocalMatrix< T_, NR_, NC_ > & operator-= (const T_ &x)

  Operator −=
- LocalMatrix< T_, NR_, NC_ > & operator∗= (const T_ &x)

  Operator ∗=
- LocalMatrix< T_, NR_, NC_ > & operator/= (const T_ &x)

  Operator /=
- void MultAdd (const LocalVect< T_, NC_ > &x, LocalVect< T_, NR_ > &y)

  Multiply matrix by vector and add result to vector.
- void MultAddScal (const T_ &a, const LocalVect< T_, NC_ > &x, LocalVect< T_, NR_ > &y)

  Multiply matrix by scaled vector and add result to vector.
- void Mult (const LocalVect< T_, NC_ > &x, LocalVect< T_, NR_ > &y)

  Multiply matrix by vector.
- void Symmetrize ()

  Symmetrize matrix.
- int Factor ()

  Factorize matrix.
- int Solve (LocalVect< T_, NR_ > &b)

  Forward and backsubstitute to solve a linear system.
- int FactorAndSolve (LocalVect< T_, NR_ > &b)

  Factorize matrix and solve linear system.
- void Invert (LocalMatrix< T_, NR_, NC_ > &A)

  Calculate inverse of matrix.
- T_ getInnerProduct (const LocalVect< T_, NC_ > &x, const LocalVect< T_, NR_ > &y)

  Calculate inner product witrh respect to matrix.
- LocalVect ()

  Default constructor.
- LocalVect (const T_ ∗a)

Constructor using a C-array.

- LocalVect (const Element *el)

  Constructor using Element pointer.
- LocalVect (const Side *sd)

  Constructor using Side pointer.
- LocalVect (const LocalVect< T_, N_ > &v)

  Copy constructor.
- LocalVect (const Element *el, const Vect< T_ > &v, int opt=0)

  Constructor of an element vector from a global Vect instance.
- LocalVect (const Side *sd, const Vect< T_ > &v, int opt=0)

  Constructor of a side vector from a global Vect instance.
- void getLocal (const Element &el, const Vect< T_ > &v, int type)

  Localize an element vector from a global Vect instance.
- void Localize (const Element *el, const Vect< T_ > &v, size_t k=0)

  Localize an element vector from a global Vect instance.
- void Localize (const Side *sd, const Vect< T_ > &v, size_t k=0)

  Localize a side vector from a global Vect instance.
- LocalVect< T_, N_ > & operator= (const LocalVect< T_, N_ > &v)

  Operator =
- LocalVect< T_, N_ > & operator= (const T_ &x)

  Operator =
- LocalVect< T_, N_ > & operator+= (const LocalVect< T_, N_ > &v)

  Operator +=
- LocalVect< T_, N_ > & operator+= (const T_ &a)

  Operator +=
- LocalVect< T_, N_ > & operator-= (const LocalVect< T_, N_ > &v)

  Operator -=
- LocalVect< T_, N_ > & operator-= (const T_ &a)

  Operator -=
- LocalVect< T_, N_ > & operator*= (const T_ &a)

  *Operator *=*
- LocalVect< T_, N_ > & operator/= (const T_ &a)

  Operator /=
- T_ operator, (const LocalVect< T_, N_ > &v) const

  Return Dot (scalar) product of two vectors.
- SkSMatrix ()

  Default constructor.
- SkSMatrix (size_t size, int is_diagonal=false)

  Constructor that initializes a dense symmetric matrix.
- SkSMatrix (Mesh &mesh, size_t dof=0, int is_diagonal=false)

  Constructor using mesh to initialize skyline structure of matrix.
- SkSMatrix (const Vect< size_t > &ColHt)

  Constructor that initializes skyline structure of matrix using vector of column height.
- SkSMatrix (const Vect< size_t > &I, const Vect< size_t > &J, int opt=1)

  Constructor for a square matrix using non zero row and column indices.
- SkSMatrix (const Vect< size_t > &I, const Vect< size_t > &J, const Vect< T_ > &a, int opt=1)

Constructor for a square matrix using non zero row and column indices.

- SkSMatrix (const SkSMatrix< T_ > &m)

  Copy Constructor.
- void setMesh (Mesh &mesh, size_t dof=0)

  Determine mesh graph and initialize matrix.
- void setSkyline (Mesh &mesh)

  Determine matrix structure.
- void setDiag ()

  Store diagonal entries in a separate internal vector.
- void set (size_t i, size_t j, const T_ &val)

  Assign a value to an entry ofthe matrix.
- void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector x and add to y.
- void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector $a*x$ and add to y.
- void Mult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector x and save in y
- void TMult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector x and save in y.
- void add (size_t i, size_t j, const T_ &val)

  Add a constant to an entry of the matrix.
- size_t getColHeight (size_t i) const

  Return column height.
- Vect< T_ > getColumn (size_t j) const

  Get j-th column vector.
- Vect< T_ > getRow (size_t i) const

  Get i-th row vector.
- T_ & operator() (size_t i, size_t j)

  Operator () (Non constant version).
- T_ operator() (size_t i, size_t j) const

  Operator () (Constant version).
- SkSMatrix< T_ > & operator= (const SkSMatrix< T_ > &m)

  Operator =.
- SkSMatrix< T_ > & operator= (const T_ &x)

  Operator =.
- SkSMatrix< T_ > & operator+= (const SkSMatrix< T_ > &m)

  Operator +=.
- SkSMatrix< T_ > & operator*= (const T_ &x)

  *Operator *=.*
- int setLDLt ()

  Factorize matrix (LDLt (Crout) factorization).
- int solve (Vect< T_ > &b)

  Solve linear system.
- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve linear system.
- int solveLDLt (const Vect< T_ > &b, Vect< T_ > &x)

Solve a linear system using the LDLt (Crout) factorization.

- T_ get (size_t i, size_t j) const

  Return entry (i,j) of matrix if this one is stored, 0 else.
- void Axpy (T_ a, const SkSMatrix< T_ > &m)

  Add to matrix the product of a matrix by a scalar.
- void Axpy (T_ a, const Matrix< T_ > *m)

  Add to matrix the product of a matrix by a scalar.
- TrMatrix ()

  Default constructor.
- TrMatrix (size_t size)

  Constructor for a tridiagonal matrix with size rows.
- TrMatrix (const TrMatrix &m)

  Copy Constructor.
- void setSize (size_t size)

  Set size (number of rows) of matrix.
- void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector x and add result to y.
- void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const

  *Multiply matrix by vector a*x and add result to y.*
- void Mult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector x and save result in y.
- void TMult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector x and save result in y.
- void Axpy (T_ a, const TrMatrix< T_ > &m)

  Add to matrix the product of a matrix by a scalar.
- void Axpy (T_ a, const Matrix< T_ > *m)

  Add to matrix the product of a matrix by a scalar.
- void set (size_t i, size_t j, const T_ &val)

  Assign constant val to an entry (i,j) of the matrix.
- void add (size_t i, size_t j, const T_ &val)

  Add constant val value to an entry (i,j) of the matrix.
- T_ operator() (size_t i, size_t j) const

  Operator () (Constant version).
- T_ & operator() (size_t i, size_t j)

  Operator () (Non constant version).
- TrMatrix< T_ > & operator= (const TrMatrix< T_ > &m)

  Operator =.
- TrMatrix< T_ > & operator= (const T_ &x)

  Operator = Assign matrix to identity times x.
- TrMatrix< T_ > & operator*= (const T_ &x)

  *Operator *=.*
- int solve (Vect< T_ > &b)

  Solve a linear system with current matrix (forward and back substitution).
- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve a linear system with current matrix (forward and back substitution).
- T_ get (size_t i, size_t j) const

Return entry `(i,j)` *of matrix.*

- Iter ()

  Default Constructor.

- Iter (int max_it, real_t toler, int verbose=0)

  Constructor with iteration parameters.

- bool check (Vect< T_ > &u, const Vect< T_ > &v, int opt=2)

  Check convergence.

- int solve (Iteration s, Preconditioner p=DIAG_PREC)

  Solve equations using prescribed solver and preconditioner.

5.11.1 Detailed Description

5.11.2 Enumeration Type Documentation

enum PDE_Terms

Enumerate variable that selects various terms in partial differential equations

Enumerator

MASS Consistent mass term

CONSISTENT_MASS Consistent mass term

LUMPED_MASS Lumped mass term

CAPACITY Consistent capacity term

CONSISTENT_CAPACITY Consistent capacity term

LUMPED_CAPACITY Lumped capacity term

VISCOSITY Viscosity term

STIFFNESS Stiffness term

DIFFUSION Diffusion term

CONVECTION Convection term

DEVIATORIC Deviatoric term

DILATATION Dilatational term

ELECTRIC Electric term

MAGNETIC Magnetic term

LOAD Body load term

HEAT_SOURCE Body heat source term

BOUNDARY_TRACTION Boundary traction (pressure) term

HEAT_FLUX Boundary heat flux term

CONTACT Signorini contact

BUOYANCY Buoyancy force term

LORENTZ_FORCE Lorentz force term

enum EqDataType

Enumerate variable that selects equation data type

Enumerator

INITIAL_FIELD Initial condition
SOLUTION Solution vector (same as Initial)
INITIAL_AUX_1 Initial auxiliary field
INITIAL_AUX_2 Initial auxiliary field
INITIAL_AUX_3 Initial auxiliary field
INITIAL_AUX_4 Initial auxiliary field
BOUNDARY_CONDITION Boundary condition data
BODY_FORCE Body force data
SOURCE Source data (same as Body force)
POINT_FORCE Localized (at point) force
BOUNDARY_FORCE Boundary force data
FLUX Flux data (same as Boundary force)
TRACTION Traction data (same as Boundary force)
AUX_INPUT_FIELD_1 Auxiliary input field 1
AUX_INPUT_FIELD_2 Auxiliary input field 2
AUX_INPUT_FIELD_3 Auxiliary input field 3
AUX_INPUT_FIELD_4 Auxiliary input field 4
DISPLACEMENT_FIELD A displacement field
VELOCITY_FIELD A velocity field
TEMPERATURE_FIELD A temperature field

enum ArrayType

Selects local or global option for array as argument.

Enumerator

LOCAL_ARRAY For a local array labeled with local numbering
GLOBAL_ARRAY For a local array labeled with global numbering

enum TimeScheme

Selects time integration scheme

Enumerator

STATIONARY No time scheme: stationary
FORWARD_EULER Forward Euler scheme (Explicit)
BACKWARD_EULER Backward Euler scheme (Implicit)
CRANK_NICOLSON Crank-Nicolson scheme
HEUN Heun scheme
NEWMARK Newmark scheme

LEAP_FROG Leap Frog scheme

ADAMS_BASHFORTH Adams-Bashforth scheme (2nd Order)

AB2 Adams-Bashforth scheme (2nd Order)

RUNGE_KUTTA 4-th Order Runge-Kutta scheme (4th Order)

RK4 4-th Order Runge-Kutta scheme

RK3_TVD 3-rd Order Runge-Kutta TVD scheme

BDF2 Backward Difference Formula (2nd Order)

enum PDE

Choose partial differential equation to ‘

Enumerator

LAPLACE Laplace equation

DIFFUSION_CONVECTION Diffusion Convection equation

THERMAL_PHASE_CHANGE Thermal phase change problem (Stefan)

INCOMPRESSIBLE_NAVIER_STOKES Incompressible Navier-Stokes equations

LINEARIZED_ELASTICITY Linearized elasticity equations

PLANAR_TRUSS 2-D truss equation

SPATIAL_BEAM 3-D beam equations

enum FEType

Choose Finite Element Type

Enumerator

FE_2D_3N 2-D elements, 3-Nodes (P1)

FE_2D_6N 2-D elements, 6-Nodes (P2)

FE_2D_4N 2-D elements, 4-Nodes (Q1)

FE_3D_AXI_3N 3-D Axisymmetric elements, 3-Nodes (P1)

FE_3D_4N 3-D elements, 4-Nodes (P1)

FE_3D_8N 3-D elements, 8-Nodes (Q1)

enum AnalysisType

Choose analysis type

Enumerator

STEADY_STATE Steady state analysis

TRANSIENT Transient analysis

OPTIMIZATION Optimization analysis

enum MatrixType

Choose matrix storage and type

Enumerator

- ***SKYLINE*** Skyline storage
- ***SPARSE*** Sparse storage
- ***DIAGONAL*** Diagonal storage
- ***TRIDIAGONAL*** Tridiagonal storage
- ***SYMMETRIC*** Symmetric matrix
- ***UNSYMMETRIC*** Unsymmetric matrix
- ***IDENTITY*** Identity matrix

enum Iteration

Choose iterative solver for the linear system.

Enumerator

- ***DIRECT_SOLVER*** Direct solver
- ***CG_SOLVER*** CG Method
- ***CGS_SOLVER*** CGS Metod
- ***BICG_SOLVER*** BiCG Method
- ***BICG_STAB_SOLVER*** BiCGStab Method
- ***GMRES_SOLVER*** GMRes Method

enum Preconditioner

Choose preconditioner for the linear system.

Enumerator

- ***IDENT_PREC*** Identity (No preconditioning)
- ***DIAG_PREC*** Diagonal preconditioner
- ***DILU_PREC*** ILU (Incomplete factorization) preconditioner
- ***ILU_PREC*** DILU (Diagonal Incomplete factorization) preconditioner
- ***SSOR_PREC*** SSOR preconditioner

enum BCType

To select special boundary conditions.

Enumerator

- ***PERIODIC_A*** Periodic Boundary conditions (first side)
- ***PERIODIC_B*** Periodic Boundary conditions (second side)
- ***CONTACT_BC*** Contact Boundary conditions
- ***SLIP*** Slip Boundary conditions

5.11.3 Function Documentation

T_* OFELI::A ( )

Return element matrix.
Matrix is returned as a C-array

T_* OFELI::b ( )

Return element right-hand side.
Right-hand side is returned as a C-array

T_* OFELI::Prev ( )

Return element previous vector.
This is the vector given in time dependent constructor. It is returned as a C-array.

IOField (const string & *file*, AccessType *access*, bool *compact* = `true`)

Constructor using file name.

Parameters

`in`	*file*	File name.
`in`	*access*	Access code. This number is to be chosen among two enumerated values: • `IOField::IN` to read the file • `IOField::OUT` to write on it
`in`	*compact*	Flag to choose a compact storage or not [Default: `true`]

IOField (const string & *mesh_file*, const string & *file*, Mesh & *ms*, AccessType *access*, bool *compact* = `true`)

Constructor using file name, mesh file and mesh.

Parameters

`in`	*mesh_file*	File containing mesh
`in`	*file*	File that contains field stored or to store
`in`	*ms*	Mesh instance
`in`	*access*	Access code. This number is to be chosen among two enumerated values: • `IOField::IN` to read the file • `IOField::OUT` to write on it
`in`	*compact*	Flag to choose a compact storage or not [Default: `true`]

IOField (const string & *file*, Mesh & *ms*, AccessType *access*, bool *compact* = `true` **)**

Constructor using file name and mesh.

Parameters

`in`	*file*	File that contains field stored or to store
`in`	*ms*	Mesh instance
`in`	*access*	Access code. This number is to be chosen among two enumerated values: • `IOField::IN` to read the file • `IOField::OUT` to write on it
`in`	*compact*	Flag to choose a compact storage or not [Default: `true`]

IOField (const string & *file*, AccessType *access*, const string & *name*)

Constructor using file name and field name.

Parameters

`in`	*file*	File that contains field stored or to store
`in`	*access*	Access code. This number is to be chosen among two enumerated values: • `IOField::IN` to read the file • `IOField::OUT` to write on it
`in`	*name*	Seek a specific field with given *name*

void setMeshFile (const string & *file*)

Set mesh file.

Parameters

`in`	*file*	Mesh file

void open ( )

Open file.
Case where file name has been previously given (in the constructor).

void open (const string & *file*, AccessType *access*)

Open file.

Parameters

in	*file*	File name.
in	*access*	Access code. This number is to be chosen among two enumerated values: • `IOField::IN` to read the file • `IOField::OUT` to write on it

void put (const Vect< real_t > & *v*)

Store Vect instance `v` in file.

Parameters

in	*v*	Vect instance to store

void put (const PETScVect< real_t > & *v*)

Store PETScVect instance `v` in file.

Parameters

in	*v*	PETScVect instance to store

real_t get (Vect< real_t > & *v*)

Get Vect `v` instance from file.
First time step is read from the `XML` file.

int get (Vect< real_t > & *v*, const string & *name*)

Get Vect `v` instance from file if the field has the given name.
First time step is read from the `XML` file.

Parameters

in,out	*v*	Vect instance
in	*name*	Name to seek in the XML file

int get (DMatrix< real_t > & *A*, const string & *name*)

Get DMatrix `A` instance from file if the field has the given name.
First time step is read from the `XML` file.

Parameters

in,out	*A*	DMatrix instance

Parameters

in	*name*	Name to seek in the XML file

int get (DSMatrix< real_t > & *A*, const string & *name*)

Get DSMatrix `A` instance from file if the field has the given name.
First time step is read from the `XML` file.

Parameters

in,out	*A*	DSMatrix instance
in	*name*	Name to seek in the XML file

int get (Vect< real_t > & *v*, real_t *t*)

Get Vect `v` instance from file corresponding to a specific time value.
The sought vector corresponding to the time value is read from the `XML` file.

Parameters

in,out	*v*	Vector instance
in	*t*	Time value

void saveGMSH (string *output_file*, string *mesh_file*)

Save field vectors in a file using **GMSH** format.
This member function enables avoiding the use of `cfield`. It must be used once all field vectors have been stored in output file. It closes this file and copies its contents to a **GMSH** file.

Parameters

in	*output_file*	Output file name where to store using **GMSH** format
in	*mesh_file*	File containing mesh data

void setFile (string *file*)

Set file name.
This function is to be used when the default constructor is invoked.

real_t getValue (string *funct*, real_t *v*)

Return the calculated value of the function.
Case of a function of one variable

Parameters

in	*funct*	Name of the function to be evaluated, as read from input file

Parameters

in	*v*	Value of the variable

Returns

Computed value of the function

real_t getDerivative (string *funct*, real_t *v*)

Return the derivative of the function at a given point.
Case of a function of one variable

Parameters

in	*funct*	Name of the function to be evaluated, as read from input file
in	*v*	Value of the variable

Returns

Derivative value

real_t getValue (string *funct*, real_t *v1*, real_t *v2*)

Return the calculated value of the function.
Case of a function of two variables

Parameters

in	*funct*	Name of the function to be evaluated, as read from input file
in	*v1*	Value of the first variable
in	*v2*	Value of the second variable

Returns

Computed value of the function

real_t getValue (string *funct*, real_t *v1*, real_t *v2*, real_t *v3*)

Return the calculated value of the function.
Case of a function of three variables

Parameters

in	*funct*	Name of the funct to be evaluated, as read from input file
in	*v1*	Value of the first variable
in	*v2*	Value of the second variable
in	*v3*	Value of the third variable

Returns

Computed value of the function

Grid (real_t *xm*, real_t *xM*, size_t *npx*)

Construct a 1-D structured grid given its extremal coordinates and number of intervals.

Parameters

in	*xm*	Minimal value for x
in	*xM*	Maximal value for x
in	*npx*	Number of grid intervals in the x-direction

Grid (real_t *xm*, real_t *xM*, real_t *ym*, real_t *yM*, size_t *npx*, size_t *npy*)

Construct a 2-D structured grid given its extremal coordinates and number of intervals.

Parameters

in	*xm*	Minimal value for x
in	*xM*	Maximal value for x
in	*ym*	Minimal value for y
in	*yM*	Maximal value for y
in	*npx*	Number of grid intervals in the x-direction
in	*npy*	Number of grid intervals in the y-direction

Grid (Point$<$ real_t $>$ *m*, Point$<$ real_t $>$ *M*, size_t *npx*, size_t *npy*)

Construct a 2-D structured grid given its extremal coordinates and number of intervals.

Parameters

in	*m*	Minimal coordinate value
in	*M*	Maximal coordinate value
in	*npx*	Number of grid intervals in the x-direction
in	*npy*	Number of grid intervals in the y-direction

Grid (real_t *xm*, real_t *xM*, real_t *ym*, real_t *yM*, real_t *zm*, real_t *zM*, size_t *npx*, size_t *npy*, size_t *npz*)

Construct a 3-D structured grid given its extremal coordinates and number of intervals.

Parameters

in	*xm*	Minimal value for x
in	*xM*	Maximal value for x

Parameters

in	*ym*	Minimal value for y
in	*yM*	Maximal value for y
in	*zm*	Minimal value for z
in	*zM*	Maximal value for z
in	*npx*	Number of grid intervals in the x-direction
in	*npy*	Number of grid intervals in the y-direction
in	*npz*	Number of grid intervals in the z-direction

Grid (Point< real_t > *m*, Point< real_t > *M*, size_t *npx*, size_t *npy*, size_t *npz*)

Construct a 3-D structured grid given its extremal coordinates and number of intervals.

Parameters

in	*m*	Minimal coordinate value
in	*M*	Maximal coordinate value
in	*npx*	Number of grid intervals in the x-direction
in	*npy*	Number of grid intervals in the y-direction
in	*npz*	Number of grid intervals in the z-direction

void setXMin (const Point< real_t > & *x*)

Set min. coordinates of the domain.

Parameters

in	*x*	Minimal values of coordinates

void setXMax (const Point< real_t > & *x*)

Set max. coordinates of the domain.

Parameters

in	*x*	Maximal values of coordinates

void setDomain (real_t *xmin*, real_t *xmax*)

Set Dimensions of the domain: 1-D case.

Parameters

in	*xmin*	Minimal value of x-coordinate
in	*xmax*	Maximal value of x-coordinate

void setDomain (real_t *xmin*, real_t *xmax*, real_t *ymin*, real_t *ymax*)

Set Dimensions of the domain: 2-D case.

Parameters

in	*xmin*	Minimal value of x-coordinate
in	*xmax*	Maximal value of x-coordinate
in	*ymin*	Minimal value of y-coordinate
in	*ymax*	Maximal value of y-coordinate

void setDomain (real_t *xmin*, real_t *xmax*, real_t *ymin*, real_t *ymax*, real_t *zmin*, real_t *zmax*)

Set Dimensions of the domain: 3-D case.

Parameters

in	*xmin*	Minimal value of x-coordinate
in	*xmax*	Maximal value of x-coordinate
in	*ymin*	Minimal value of y-coordinate
in	*ymax*	Maximal value of y-coordinate
in	*zmin*	Minimal value of z-coordinate
in	*zmax*	Maximal value of z-coordinate

void setDomain (Point< real_t > *xmin*, Point< real_t > *xmax*)

Set Dimensions of the domain: 3-D case.

Parameters

in	*xmin*	Minimal coordinate value
in	*xmax*	Maximal coordinate value

void setN (size_t *nx*, size_t *ny* = *0*, size_t *nz* = *0*)

Set number of grid intervals in the x, y and z-directions.
Number of points is the number of intervals plus one in each direction

Parameters

in	*nx*	Number of grid intervals in the x-direction
in	*ny*	Number of grid intervals in the y-direction (Default=0: 1-D grid)
in	*nz*	Number of grid intervals in the z-direction (Default=0: 1-D or 2-D grid)

Remarks

: The size of the grid (`xmin` and `xmax`) must have been defined before.

size_t getNy ( ) const

Return number of grid intervals in the y-direction.
`ny=0` for 1-D domains (segments)

size_t getNz ( ) const

Return number of grid intervals in the z-direction.
`nz=0` for 1-D (segments) and 2-D domains (rectangles)

void setCode (string *exp*, int *code*)

Set a code for some grid points.

Parameters

in	*exp*	Regular expression that determines the set of grid points on which the code is applied.
in	*code*	Code to assign.

void setCode (int *side*, int *code*)

Set a code for grid points on sides.

Parameters

in	*side*	Side for which code is assigned. Possible values are: `MIN_X`, `MAX_X`, `MIN_Y`, `MAX_Y`, `MIN_Z`, `MAX_Z`
in	*code*	Code to assign.

int getCode (int *side*) const

Return code for a side number.

Parameters

in	*side*	Side for which code is returned. Possible values are: `MIN_X`, `MAX_X`, `MIN_Y`, `MAX_Y`, `MIN_Z`, `MAX_Z`

int getCode (size_t *i*, size_t *j*) const

Return code for a grid point.

Parameters

in	*i*	`i`-th index for node for which code is to be returned.

Parameters

in	*j*	j-th index for node for which code is to be returned.

int getCode (size_t *i*, size_t *j*, size_t *k*) const

Return code for a grid point.

Parameters

in	*i*	i-th index for node for which code is to be returned.
in	*j*	j-th index for node for which code is to be returned.
in	*k*	k-th index for node for which code is to be returned.

void Deactivate (size_t *i*)

Change state of a cell from active to inactive (1-D grid)

Parameters

in	*i*	grid cell to remove

void Deactivate (size_t *i*, size_t *j*)

Change state of a cell from active to inactive (2-D grid)

Parameters

in	*i*	i-th index for grid cell to remove. If this value is 0, all cells (*,j) are deactivated
in	*j*	j-th index for grid cell to remove If this value is 0, all cells (i,*) are deactivated

Remarks

if i and j have value 0 all grid cells are deactivated !!

void Deactivate (size_t *i*, size_t *j*, size_t *k*)

Change state of a cell from active to inactive (2-D grid)

Parameters

in	*i*	i-th index for grid cell to remove. If this value is 0, all cells (*,j,k) are deactivated
in	*j*	j-th index for grid cell to remove If this value is 0, all cells (i,*,k) are deactivated
in	*k*	k-th index for grid cell to remove If this value is 0, all cells (i,j,*) are deactivated

int isActive (size_t *i*) const

Say if cell is active or not (1-D grid)

Parameters

in	*i*	Index of cell

Returns

`1` if cell is active, `0` if not

int isActive (size_t *i*, size_t *j*) const

Say if cell is active or not (2-D grid)

Parameters

in	*i*	`i`-th index of cell
in	*j*	`j`-th index of cell

Returns

`1` if cell is active, `0` if not

int isActive (size_t *i*, size_t *j*, size_t *k*) const

Say if cell is active or not (3-D grid)

Parameters

in	*i*	`i`-th index of cell
in	*j*	`j`-th index of cell
in	*k*	`k`-th index of cell

Returns

`1` if cell is active, `0` if not

BMatrix ( )

Default constructor.
Initialize a zero dimension band matrix

BMatrix (size_t *size*, int *ld*, int *ud*)

Constructor that for a band matrix with given size and bandwidth.
Assign 0 to all matrix entries.

Parameters

in	*size*	Number of rows and columns
in	*ld*	Number of lower co-diagonals (must be > 0)
in	*ud*	Number of upper co-diagonals (must be > 0)

void setSize (size_t *size*, int *ld*, int *ud*)

Set size (number of rows) and storage of matrix.

Parameters

in	*size*	Number of rows and columns
in	*ld*	Number of lower co-diagonals (must be > 0)
in	*ud*	Number of upper co-diagonals (must be > 0)

void Axpy (T_ *a*, const BMatrix< T_ > & *x*)

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*x*	Matrix by which a is multiplied. The result is added to current instance

void Axpy (T_ *a*, const Matrix< T_ > * *x*) `[virtual]`

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*x*	Matrix by which a is multiplied. The result is added to current instance

Implements Matrix< T_ >.

T_ operator() (size_t *i*, size_t *j*) const `[virtual]`

Operator () (Constant version).

Parameters

in	*i*	Row index
in	*j*	Column index

Implements Matrix< T_ >.

T_ & operator() (size_t *i*, size_t *j*) `[virtual]`

Operator () (Non constant version).

Parameters

in	*i*	Row index
in	*j*	Column index

Implements Matrix< T_ >.

BMatrix< T_ > & operator= (const BMatrix< T_ > & *m*)

Operator =.
Copy matrix `m` to current matrix instance.

BMatrix< T_ > & operator*= (const T_ & *x*)

Operator *=.
Premultiply matrix entries by constant value `x`

BMatrix< T_ > & operator+= (const T_ & *x*)

Operator +=.
Add constant `x` to matrix entries.

int setLU ( )

Factorize the matrix (LU factorization)
LU factorization of the matrix is realized. Note that since this is an in place factorization, the contents of the matrix are modified.

Returns

- `0` if factorization was normally performed,
- `n` if the `n`-th pivot is null.

Remarks

A flag in this class indicates after factorization that this one has been realized, so that, if the member function solve is called after this no further factorization is done.

int solve (Vect< T_ > & *b*) `[virtual]`

Solve linear system.
The linear system having the current instance as a matrix is solved by using the LU decomposition. Solution is thus realized after a factorization step and a forward/backward substitution step. The factorization step is realized only if this was not already done.
Note that this function modifies the matrix contents is a factorization is performed. Naturally, if the the matrix has been modified after using this function, the user has to refactorize it using the function setLU. This is because the class has no non-expensive way to detect if the matrix has been modified. The function setLU realizes the factorization step only.

Parameters

in,out	*b*	Vect instance that contains right-hand side on input and solution on output.

Returns

- 0 if solution was normally performed,
- n if the n-th pivot is null.

Implements Matrix< T_ >.

int solve (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve linear system.

The linear system having the current instance as a matrix is solved by using the LU decomposition. Solution is thus realized after a factorization step and a forward/backward substitution step. The factorization step is realized only if this was not already done.
Note that this function modifies the matrix contents is a factorization is performed. Naturally, if the the matrix has been modified after using this function, the user has to refactorize it using the function setLU. This is because the class has no non-expensive way to detect if the matrix has been modified. The function setLU realizes the factorization step only.

Parameters

in	*b*	Vect instance that contains right-hand side.
out	*x*	Vect instance that contains solution

Returns

- 0 if solution was normally performed,
- n if the n-th pivot is null.

DSMatrix (size_t *dim*)

Constructor that for a symmetric matrix with given number of rqows.

Parameters

in	*dim*	Number of rows

DSMatrix (const DSMatrix< T_ > & *m*)

Copy Constructor.

Parameters

in	*m*	DSMatrix instance to copy

void setSize (size_t *dim*)

Set size (number of rows) of matrix.

Parameters

in	*dim*	Number of rows and columns.

void set (size_t *i*, size_t *j*, const T_ & *val*) `[virtual]`

Assign constant to entry `(i,j)` of the matrix.

Parameters

in	*i*	row index
in	*j*	column index
in	*val*	value to assign to `a(i,j)`

Implements Matrix< T_ >.

void setDiag (const T_ & *a*)

Set matrix as diagonal and assign its diagonal entries as a constant.

Parameters

in	*a*	Value to assign to all diagonal entries

void setDiag (const vector< T_ > & *d*)

Set matrix as diagonal and assign its diagonal entries.

Parameters

in	*d*	Vector entries to assign to matrix diagonal entries

void add (size_t *i*, size_t *j*, const T_ & *val*) `[virtual]`

Add constant to an entry ofthe matrix.

Parameters

in	*i*	row index
in	*j*	column index
in	*val*	value to add to `a(i,j)`

Implements Matrix< T_ >.

T_ operator() (size_t *i*, size_t *j*) const `[virtual]`

Operator `()` (Constant version).

Parameters

in	*i*	Row index
in	*j*	Column index

Implements Matrix< T_ >.

T_ & operator() (size_t *i*, size_t *j*) `[virtual]`

Operator `()` (Non constant version).

Parameters

in	*i*	Row index
in	*j*	Column index

Implements Matrix< T_ >.

int setLDLt ( )

Factorize matrix (`LDL`$^{\mathtt{T}}$)

Returns

- `0`, if factorization was normally performed,
- `n`, if the `n`-th pivot is null.

void getColumn (size_t *j*, Vect< T_ > & *v*) const

Get `j`-th column vector.

Parameters

in	*j*	Index of column to extract
out	*v*	Reference to Vect instance where the column is stored

Remarks

Vector v does not need to be sized before. It is resized in the function

Vect< T_ > getColumn (size_t *j*) const

Get `j`-th column vector.

Parameters

in	*j*	Index of column to extract

Returns

Vect instance where the column is stored

Remarks

Vector v does not need to be sized before. It is resized in the function

void setColumn (size_t *i*, const Vect< T_ > & *v*)

Copy a given vector to a prescribed column in the matrix.

Parameters

in	*i*	column index to be assigned
in	*v*	Vect instance to copy

void getRow (size_t *i*, Vect< T_ > & *v*) const

Get `i`-th row vector.

Parameters

in	*i*	Index of row to extract
out	*v*	Reference to Vect instance where the row is stored

Remarks

Vector v does not need to be sized before. It is resized in the function

Vect< T_ > getRow (size_t *i*) const

Get `i`-th row vector.

Parameters

in	*i*	Index of row to extract

Returns

Vect instance where the row is stored

Remarks

Vector v does not need to be sized before. It is resized in the function

void setRow (size_t *i*, const Vect< T_ > & *v*)

Copy a given vector to a prescribed row in the matrix.

Parameters

in	*i*	row index to be assigned
in	*v*	Vect instance to copy

void MultAdd (T_ *a*, const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by vector `a*x` and add to `y`.

Parameters

in	*a*	Constant to multiply by matrix
in	*x*	Vector to multiply by matrix
in,out	*y*	Vector to add to the result. `y` contains on output the result.

Implements Matrix< T_ >.

void TMult (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply transpose of matrix by vector `x` and add result in `y`.

Parameters

in	*x*	Vector to add to `y`
in,out	*y*	on input, vector to add to. On output, result.

Implements Matrix< T_ >.

int solve (Vect< T_ > & *b*) `[virtual]`

Solve linear system.

The matrix is factorized using the LDLt (Crout) decomposition. If this one is already factorized, no further factorization is performed. If the matrix has been modified the user has to refactorize it using the function setLDLt.

Parameters

in,out	*b*	Vect instance that contains right-hand side on input and solution on output.

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

Implements Matrix< T_ >.

int solve (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve linear system.

The matrix is factorized using the LDLt (Crout) decomposition. If this one is already factorized, no further factorization is performed. If the matrix has been modified the user has to refactorize it using the function setLDLt.

Parameters

in	*b*	Vect instance that contains right-hand side.
out	*x*	Vect instance that contains solution

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

void Axpy (T_ *a*, const DSMatrix< T_ > & *m*)

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*m*	Matrix by which `a` is multiplied. The result is added to current instance

void Axpy (T_ *a*, const Matrix< T_ > ∗ *m*) `[virtual]`

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*m*	Matrix by which `a` is multiplied. The result is added to current instance

Implements Matrix< T_ >.

LocalMatrix ( )

Default constructor.
Constructs a matrix with `0` rows and `0` columns

LocalMatrix (Element ∗ *el*, const SpMatrix< T_ > & *a*)

Constructor of a local matrix associated to element from a SpMatrix.

Parameters

in	*el*	Pointer to Element
in	*a*	Global matrix as instance of class SpMatrix.

LocalMatrix (Element $*$ *el*, const SkMatrix$<$ T_ $>$ & *a*)

Constructor of a local matrix associated to element from a SkMatrix.

Parameters

in	*el*	Pointer to Element
in	*a*	Global matrix as instance of class SkMatrix.

LocalMatrix (Element $*$ *el*, const SkSMatrix$<$ T_ $>$ & *a*)

Constructor of a local matrix associated to element from a SkSMatrix.

Parameters

in	*el*	Pointer to Element
in	*a*	Global matrix as instance of class SkSMatrix.

void Localize (Element $*$ *el*, const SpMatrix$<$ T_ $>$ & *a*)

Initialize matrix as element matrix from global SpMatrix.

Parameters

in	*el*	Pointer to Element
in	*a*	Global matrix as instance of class SpMatrix. This function is called by its corresponding constructor.

void Localize (Element $*$ *el*, const SkMatrix$<$ T_ $>$ & *a*)

Initialize matrix as element matrix from global SkMatrix.

Parameters

in	*el*	Pointer to Element
in	*a*	Global matrix as instance of class SkMatrix. This function is called by its corresponding constructor.

void Localize (Element $*$ *el*, const SkSMatrix$<$ T_ $>$ & *a*)

Initialize matrix as element matrix from global SkSMatrix.

Parameters

in	*el*	Pointer to Element
in	*a*	Global matrix as instance of class SkSMatrix. This function is called by its corresponding constructor.

LocalMatrix< T_, NR_, NC_ > & operator= (const LocalMatrix< T_, NR_, NC_ > & *m*)

Operator =
Copy instance `m` into current instance.

LocalMatrix< T_, NR_, NC_ > & operator= (const T_ & *x*)

Operator =
Assign matrix to identity times `x`

LocalMatrix< T_, NR_, NC_ > & operator+= (const LocalMatrix< T_, NR_, NC_ > & *m*)

Operator +=
Add `m` to current matrix.

LocalMatrix< T_, NR_, NC_ > & operator-= (const LocalMatrix< T_, NR_, NC_ > & *m*)

Operator -=
Subtract `m` from current matrix.

LocalVect< T_, NR_ > operator* (LocalVect< T_, NC_ > & *x*)

Operator *
Return a Vect instance as product of current matrix by vector `x`.

LocalMatrix< T_, NR_, NC_ > & operator+= (const T_ & *x*)

Operator +=
Add constant `x` to current matrix entries.

LocalMatrix< T_, NR_, NC_ > & operator-= (const T_ & *x*)

Operator -=
Subtract `x` from current matrix entries.

LocalMatrix< T_, NR_, NC_ > & operator*= (const T_ & *x*)

Operator *=
Multiply matrix entries by constant `x`.

LocalMatrix< T_, NR_, NC_ > & operator/= (const T_ & *x*)

Operator /=
Divide by `x` current matrix entries.

void MultAdd (const LocalVect< T_, NC_ > & *x*, LocalVect< T_, NR_ > & *y*)

Multiply matrix by vector and add result to vector.

Parameters

in	x	Vector to multiply matrix by.
out	y	Resulting vector (`y += a * x`)

void MultAddScal (const T_ & *a*, const LocalVect< T_, NC_ > & *x*, LocalVect< T_, NR_ > & *y*)

Multiply matrix by scaled vector and add result to vector.

Parameters

in	*a*	Constant to premultiply by vector `x`.
in	*x*	(Scaled) vector to multiply matrix by.
out	*y*	Resulting vector (`y += a * x`)

void Mult (const LocalVect< T_, NC_ > & *x*, LocalVect< T_, NR_ > & *y*)

Multiply matrix by vector.

Parameters

in	*x*	Vector to multiply matrix by.
out	*y*	Resulting vector.

void Symmetrize ( )

Symmetrize matrix.
Fill upper triangle to form a symmetric matrix.

int Factor ( )

Factorize matrix.
Performs a LU factorization.

Returns

- `0`: Factorization has ended normally,
- `n`: `n`-th pivot was zero.

int Solve (LocalVect< T_, NR_ > & *b*)

Forward and backsubstitute to solve a linear system.

Parameters

in	*b*	Right-hand side in input and solution vector in output.

Returns

- `0`: Solution was performed normally.
- `n`: `n`-th pivot is zero.

Note

Matrix must have been factorized at first.

int FactorAndSolve (LocalVect< T_, NR_ > & *b*)

Factorize matrix and solve linear system.

Parameters

in,out	*b*	Right-hand side in input and solution vector in output.

Returns

`0` if solution was performed normally. `n` if `n`-th pivot is zero. This function simply calls **Factor()** then **Solve(b)**.

void Invert (LocalMatrix< T_, NR_, NC_ > & *A*)

Calculate inverse of matrix.

Parameters

out	*A*	Inverse of matrix

T_ getInnerProduct (const LocalVect< T_, NC_ > & *x*, const LocalVect< T_, NR_ > & *y*)

Calculate inner product witrh respect to matrix.
Returns the product $x^T Ay$

Parameters

in	*x*	Left vector
in	*y*	Right vector

Returns

Resulting product

LocalVect (const Element ∗ *el*, const Vect< T_ > & *v*, int *opt* = *0*)

Constructor of an element vector from a global Vect instance.
The constructed vector has local numbering of nodes

Parameters

in	*el*	Pointer to Element to localize
in	*v*	Global vector to localize

Parameters

in	*opt*	Option for DOF treatment • = 0, Normal case [Default] • Any other value : only one DOF is handled (Local vector has as dimension number of degrees of freedom)

LocalVect (const Side ∗ *sd*, const Vect< T_ > & *v*, int *opt* = *0*)

Constructor of a side vector from a global Vect instance.
The constructed vector has local numbering of nodes

Parameters

in	*sd*	Pointer to Side to localize
in	*v*	Global vector to localize
in	*opt*	Option for DOF treatment • = 0, Normal case [Default] • Any other value : only one DOF is handled (Local vector has as dimension number of degrees of freedom)

void getLocal (const Element & *el*, const Vect< T_ > & *v*, int *type*)

Localize an element vector from a global Vect instance.
The constructed vector has local numbering of nodes This function is called by the constructor↩
: `LocalVect(const Element *el, const Vect<T_> &v)`

Parameters

in	*el*	Pointer to Element to localize
in	*v*	Global vector to localize
in	*type*	Type of element. This is to be chosen among enumerated values: `LINE2`, `TRIANG3`, `QUAD4`, `TETRA4`, `HEXA8`, `PENTA6`

void Localize (const Element ∗ *el*, const Vect< T_ > & *v*, size_t *k* = *0*)

Localize an element vector from a global Vect instance.
The constructed vector has local numbering of nodes This function is called by the constructor↩
: **LocalVect(const Element ∗el, const Vect<T_> &v)**

Parameters

in	*el*	Pointer to Side to localize
in	*v*	Global vector to localize
in	*k*	Degree of freedom to localize [Default: All degrees of freedom are stored]

void Localize (const Side ∗ *sd*, const Vect< T_ > & *v*, size_t *k* = *0*)

Localize a side vector from a global Vect instance.

The constructed vector has local numbering of nodes This function is called by the constructor↩ : **LocalVect(const Side ∗sd, const Vect<T_> &v)**

Parameters

in	*sd*	Pointer to Side to localize
in	*v*	Global vector to localize
in	*k*	Degree of freedom to localize [Default: All degrees of freedom are stored]

LocalVect< T_, N_ > & operator= (const LocalVect< T_, N_ > & *v*)

Operator =

Copy a LocalVect instance to the current one

LocalVect< T_, N_ > & operator= (const T_ & *x*)

Operator =

Assign value x to all vector entries

LocalVect< T_, N_ > & operator+= (const LocalVect< T_, N_ > & *v*)

Operator +=

Add vector v to this instance

LocalVect< T_, N_ > & operator+= (const T_ & *a*)

Operator +=

Add constant a to vector entries

LocalVect< T_, N_ > & operator-= (const LocalVect< T_, N_ > & *v*)

Operator -=

Subtract vector v from this instance

LocalVect< T_, N_ > & operator-= (const T_ & *a*)

Operator -=

Subtract constant a from vector entries

LocalVect< T_, N_ > & operator∗= (const T_ & *a*)

Operator ∗=

Multiply vector by constant a

LocalVect< T_, N_ > & operator/= (const T_ & *a*)

Operator /=

Divide vector by constant a

T_ operator, (const LocalVect< T_, N_ > & *v*) const

Return Dot (scalar) product of two vectors.

A typical use of this operator is `double a = (v,w)` where `v` and `w` are 2 instances of `Local↩ Vect<double,n>`

Parameters

in	*v*	LocalVect instance by which the current instance is multiplied

SkSMatrix ( )

Default constructor.

Initializes a zero-dimension matrix

SkSMatrix (size_t *size*, int *is_diagonal* = `false`)

Constructor that initializes a dense symmetric matrix.

Normally, for a dense matrix this is not the right class.

Parameters

in	*size*	Number of matrix rows (and columns).
in	*is_diagonal*	Boolean to select if the matrix is diagonal or not [Default: false]

SkSMatrix (Mesh & *mesh*, size_t *dof* = *0*, int *is_diagonal* = `false`)

Constructor using mesh to initialize skyline structure of matrix.

Parameters

in	*mesh*	Mesh instance for which matrix graph is determined.
in	*dof*	Option parameter, with default value `0`. `dof=1` means that only one degree of freedom for each node (or element or side) is taken to determine matrix structure. The value `dof=0` means that matrix structure is determined using all DOFs.
in	*is_diagonal*	Boolean argument to say is the matrix is actually a diagonal matrix or not.

SkSMatrix (const Vect< size_t > & *ColHt*)

Constructor that initializes skyline structure of matrix using vector of column height.

Parameters

in	*ColHt*	Vect instance that contains rows lengths of matrix.

SkSMatrix (const Vect< size_t > & *I*, const Vect< size_t > & *J*, int *opt* = *1*)

Constructor for a square matrix using non zero row and column indices.

Parameters

in	*I*	Vector containing row indices
in	*J*	Vector containing column indices
in	*opt*	Flag indicating if vectors I and J are cleaned and ordered (opt=1) or not (opt=0). In the latter case, these vectors can contain the same contents more than once and are not necessarily ordered.

SkSMatrix (const Vect< size_t > & *I*, const Vect< size_t > & *J*, const Vect< T_ > & *a*, int *opt* = *1*)

Constructor for a square matrix using non zero row and column indices.

Parameters

in	*I*	Vector containing row indices
in	*J*	Vector containing column indices
in	*a*	Vector containing matrix entries in the same order than the one given by `I` and `J`
in	*opt*	Flag indicating if vectors `I` and `J` are cleaned and ordered (`opt=1`) or not (`opt=0`). In the latter case, these vectors can contain the same contents more than once and are not necessarily ordered

void setMesh (Mesh & *mesh*, size_t *dof* = *0*)

Determine mesh graph and initialize matrix.
This member function is called by constructor with the same arguments

Parameters

in	*mesh*	Mesh instance for which matrix graph is determined.
in	*dof*	Option parameter, with default value `0`. `dof=1` means that only one degree of freedom for each node (or element or side) is taken to determine matrix structure. The value `dof=0` means that matrix structure is determined using all DOFs.

void setSkyline (Mesh & *mesh*)

Determine matrix structure.
This member function calculates matrix structure using Mesh instance `mesh`.

void set (size_t *i*, size_t *j*, const T_ & *val*) `[virtual]`

Assign a value to an entry ofthe matrix.

Parameters

in	*i*	Row index
in	*j*	Column index
in	*val*	Value to assign to `a(i,j)`

Implements Matrix< T_ >.

void MultAdd (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by vector `x` and add to `y`.

Parameters

in	*x*	Vector to multiply by matrix
in,out	*y*	Vector to add to the result. `y` contains on output the result.

Implements Matrix< T_ >.

void MultAdd (T_ *a*, const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by vector `a*x` and add to `y`.

Parameters

in	*a*	Constant to multiply by matrix
in	*x*	Vector to multiply by matrix
in,out	*y*	Vector to add to the result. `y` contains on output the result.

Implements Matrix< T_ >.

void Mult (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by vector `x` and save in `y`

Parameters

in	*x*	Vector to multiply by matrix
out	*y*	Vector that contains on output the result.

Implements Matrix< T_ >.

void TMult (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply transpose of matrix by vector x and save in y.

Parameters

in	*x*	Vector to multiply by matrix
out	*y*	Vector that contains on output the result.

Implements Matrix< T_ >.

void add (size_t *i*, size_t *j*, const T_ & *val*) `[virtual]`

Add a constant to an entry of the matrix.

Parameters

in	*i*	Row index
in	*j*	Column index
in	*val*	Constant value to add to `a(i,j)`

Implements Matrix< T_ >.

size_t getColHeight (size_t *i*) const

Return column height.
Column height at entry `i` is returned.

T_ & operator() (size_t *i*, size_t *j*) `[virtual]`

Operator () (Non constant version).

Parameters

in	*i*	Row index
in	*j*	Column index

Implements Matrix< T_ >.

T_ operator() (size_t *i*, size_t *j*) const `[virtual]`

Operator () (Constant version).

Parameters

in	*i*	Row index
in	*j*	Column index

Implements Matrix< T_ >.

SkSMatrix< T_ > & operator= (const SkSMatrix< T_ > & *m*)

Operator =.
Copy matrix `m` to current matrix instance.

SkSMatrix< T_ > & operator= (const T_ & *x*)

Operator =.
define the matrix as a diagonal one with all diagonal entries equal to `x`.

SkSMatrix< T_ > & operator+= (const SkSMatrix< T_ > & *m*)

Operator +=.

Add matrix `m` to current matrix instance.

SkSMatrix< T_ > & operator*= (const T_ & *x*)

Operator *=.

Premultiply matrix entries by constant value `x`.

int setLDLt ( )

Factorize matrix (LDLt (Crout) factorization).

Returns

- `0` if factorization was normally performed
- `n` if the `n`-th pivot is null

int solve (Vect< T_ > & *b*) `[virtual]`

Solve linear system.

The linear system having the current instance as a matrix is solved by using the LDLt decomposition. Solution is thus realized after a factorization step and a forward/backward substitution step. The factorization step is realized only if this was not already done.
Note that this function modifies the matrix contents is a factorization is performed. Naturally, if the the matrix has been modified after using this function, the user has to refactorize it using the function setLU. This is because the class has no non-expensive way to detect if the matrix has been modified. The function setLDLt realizes the factorization step only.

Parameters

`in,out`	*b*	Vect instance that contains right-hand side on input and solution on output.

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

Implements Matrix< T_ >.

int solve (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve linear system.

The linear system having the current instance as a matrix is solved by using the LDLt decomposition. Solution is thus realized after a factorization step and a forward/backward substitution step. The factorization step is realized only if this was not already done.
Note that this function modifies the matrix contents is a factorization is performed. Naturally, if the the matrix has been modified after using this function, the user has to refactorize it using the function setLDLt. This is because the class has no non-expensive way to detect if the matrix has been modified. The function setLDLt realizes the factorization step only.

Parameters

in	*b*	Vect instance that contains right-hand side.
out	*x*	Vect instance that contains solution

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

int solveLDLt (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve a linear system using the LDLt (Crout) factorization.

This function solves a linear system. The LDLt factorization is performed if this was not already done using the function setLU.

Parameters

in	*b*	Vect instance that contains right-hand side
out	*x*	Vect instance that contains solution

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null

Solution is performed only is factorization has previouly been invoked.

void Axpy (T_ *a*, const SkSMatrix< T_ > & *m*)

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*m*	Matrix by which `a` is multiplied. The result is added to current instance

void Axpy (T_ *a*, const Matrix< T_ > * *m*) `[virtual]`

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*m*	Pointer to Matrix by which `a` is multiplied. The result is added to current instance

Implements Matrix< T_ >.

TrMatrix ( )

Default constructor.
Initialize a zero dimension tridiagonal matrix

void setSize (size_t *size*)

Set size (number of rows) of matrix.

Parameters

in	*size*	Number of rows and columns.

void Axpy (T_ *a*, const TrMatrix< T_ > & *m*)

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*m*	Matrix by which a is multiplied. The result is added to current instance

void Axpy (T_ *a*, const Matrix< T_ > * *m*) [virtual]

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*m*	Matrix by which a is multiplied. The result is added to current instance

Implements Matrix< T_ >.

T_ operator() (size_t *i*, size_t *j*) const [virtual]

Operator () (Constant version).

Parameters

in	*i*	Row index
in	*j*	Column index

Implements Matrix< T_ >.

T_ & operator() (size_t *i*, size_t *j*) [virtual]

Operator () (Non constant version).

Parameters

in	*i*	Row index
in	*j*	Column index

Implements Matrix< T_ >.

TrMatrix< T_ > & operator= (const TrMatrix< T_ > & *m*)

Operator =.
Copy matrix `m` to current matrix instance.

TrMatrix< T_ > & operator*= (const T_ & *x*)

Operator *=.
Premultiply matrix entries by constant value `x`.

int solve (Vect< T_ > & *b*) `[virtual]`

Solve a linear system with current matrix (forward and back substitution).

Parameters

in,out	*b*	Vect instance that contains right-hand side on input and solution on output.

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

Warning: Matrix is modified after this function.
Implements Matrix< T_ >.

int solve (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve a linear system with current matrix (forward and back substitution).

Parameters

in	*b*	Vect instance that contains right-hand side.
out	*x*	Vect instance that contains solution.

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

Warning: Matrix is modified after this function.

Iter ( )

Default Constructor.

This constructor set default values: the maximal number of iterations is set to 100 and the tolerance to 1.e-8

Iter (int *max_it*, real_t *toler*, int *verbose* = 0)

Constructor with iteration parameters.

Parameters

in	*max_it*	Maximum number of iterations
in	*toler*	Tolerance value for convergence
in	*verbose*	Verbosity parameter [default: 0] 0: No message output, > 0: message output with increasing display.

bool check (Vect< T_ > & *u*, const Vect< T_ > & *v*, int *opt* = 2)

Check convergence.

Parameters

in,out	*u*	Solution vector at previous iteration
in	*v*	Solution vector at current iteration
in	*opt*	Vector norm for convergence checking 1: 1-norm, 2: 2-norm, 0: Max. norm [default: 2]

Returns

true if convergence criterion is satisfied, false if not

After checking, this function copied v into u.

int solve (Iteration *s*, Preconditioner *p* = DIAG_PREC)

Solve equations using prescribed solver and preconditioner.

Parameters

in	*s*	Solver identification parameter To be chosen in the enumeration variable Iteration: DIRECT_SOLVER, CG_SOLVER, CGS_SOLVER, BICG_SOLVER, BICG_STAB_SOLVER, GMRES_SOLVER, QMR_SOLVER [Default: CGS_SOLVER]
in	*p*	Preconditioner identification parameter. To be chosen in the enumeration variable Preconditioner: IDENT_PREC, DIAG_PREC, SSOR_PREC, DILU_PREC, ILU_PREC [Default: DIAG_PREC]

Note

The argument p has no effect if the solver is DIRECT_SOLVER

5.12 Physical properties of media

A module that contains classes for physical properties of materials and media.

Classes

- class Material

  To treat material data. This class enables reading material data in material data files. It also returns these informations by means of its members.

5.12.1 Detailed Description

A module that contains classes for physical properties of materials and media.

5.13 Shape Function

Gathers shape function classes.

Classes

- class FEShape

  Parent class from which inherit all finite element shape classes.
- class triangle

  Defines a triangle. The reference element is the rectangle triangle with two unit edges.
- class Hexa8

  Defines a three-dimensional 8-node hexahedral finite element using Q1-isoparametric interpolation.
- class Line2

  To describe a 2-Node planar line finite element.
- class Line2H

  To describe a 2-Node Hermite planar line finite element.
- class Line3

  To describe a 3-Node quadratic planar line finite element.
- class Penta6

  Defines a 6-node pentahedral finite element using P_1 interpolation in local coordinates `(s.x,s.y)` *and Q_1 isoparametric interpolation in local coordinates* `(s.x,s.z)` *and* `(s.y,s.z)`*.*
- class Quad4

  Defines a 4-node quadrilateral finite element using Q_1 isoparametric interpolation.
- class Tetra4

  Defines a three-dimensional 4-node tetrahedral finite element using P_1 interpolation.
- class Triang3

  Defines a 3-Node (P_1) triangle.
- class Triang6S

  Defines a 6-Node straight triangular finite element using P_2 interpolation.

5.13.1 Detailed Description

Gathers shape function classes.

5.14 Solid Mechanics

Gathers Solid Mechanics finite element equations related classes.

Classes

- class Bar2DL2

  To build element equations for Planar Elastic Bar element with 2 DOF (Degrees of Freedom) per node.
- class Beam3DL2

  To build element equations for 3-D beam equations using 2-node lines.
- class Elas2DQ4

  To build element equations for 2-D linearized elasticity using 4-node quadrilaterals.
- class Elas2DT3

  To build element equations for 2-D linearized elasticity using 3-node triangles.
- class Elas3DH8

  To build element equations for 3-D linearized elasticity using 8-node hexahedra.
- class Elas3DT4

  To build element equations for 3-D linearized elasticity using 4-node tetrahedra.
- class Equa_Solid< T_, NEN_, NEE_, NSN_, NSE_ >

  Abstract class for Solid Mechanics Finite Element classes.

5.14.1 Detailed Description

Gathers Solid Mechanics finite element equations related classes.

5.15 Solver

Gathers Solver functions.

Files

- file OptimAux.h

  File that contains auxiliary functions for optimization.
- file OptimSA.h

  Function to solve an optimization problem using the Simulated Annealing method.
- file OptimTN.h

  Function to solve an optimization problem using the Truncated Newton method.

Classes

- class Reconstruction

  To perform various reconstruction operations.
- class EigenProblemSolver

  Class to find eigenvalues and corresponding eigenvectors of a given matrix in a generalized eigenproblem, i.e. Find scalars l and non-null vectors v such that [K]{v} = l[M]{v} where [K] and [M] are symmetric matrices. The eigenproblem can be originated from a PDE. For this, we will refer to the matrices K and M as Stiffness and Mass matrices respectively.
- class Iter< T_ >

  Class to drive an iterative process.
- class LinearSolver< T_ >

  Class to solve systems of linear equations by iterative methods.
- class ODESolver

  To solve a system of ordinary differential equations.
- class Prec< T_ >

  To set a preconditioner.
- class TimeStepping

  To solve time stepping problems, i.e. systems of linear ordinary differential equations of the form [A2]{y"} + [A1]{y'} + [A0]{y} = {b}.

Macros

- #define MAX_NB_EQUATIONS 5

  Maximum number of equations.
- #define MAX_NB_INPUT_FIELDS 3

  Maximum number of fields for an equation.
- #define MAX_NB_MESHES 10

  Maximum number of meshes.
- #define TIME_LOOP(ts, t, ft, n)

  A macro to loop on time steps to integrate on time ts : Time step t : Initial time value updated at each time step ft : Final time value n : Time step index.
- #define TimeLoop

  A macro to loop on time steps to integrate on time.
- #define IterationLoop while (++theIteration<MaxNbIterations && Converged==false)

  A macro to loop on iterations for an iterative procedure.

Functions

- ostream & operator<< (ostream &s, const Muscl3DT &m)

  Output mesh data as calculated in class Muscl3DT.

- template<class T_ >
  int BiCG (const SpMatrix< T_ > &A, int prec, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)

  Biconjugate gradient solver function.

- template<class T_ >
  int BiCGStab (const SpMatrix< T_ > &A, const Prec< T_ > &P, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)

  Biconjugate gradient stabilized solver function.

- template<class T_ >
  int BiCGStab (const SpMatrix< T_ > &A, int prec, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)

  Biconjugate gradient stabilized solver function.

- template<class T_ >
  int CG (const SpMatrix< T_ > &A, const Prec< T_ > &P, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)

  Conjugate gradient solver function.

- template<class T_ >
  int CG (const SpMatrix< T_ > &A, int prec, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)

  Conjugate gradient solver function.

- template<class T_ >
  int CGS (const SpMatrix< T_ > &A, int prec, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)

  Conjugate Gradient Squared solver function.

- template<class T_ >
  int GMRes (const SpMatrix< T_ > &A, const Prec< T_ > &P, const Vect< T_ > &b, Vect< T_ > &x, size_t m, int max_it, real_t toler, int verbose)

  GMRes solver function.

- template<class T_ >
  int GMRes (const SpMatrix< T_ > &A, int prec, const Vect< T_ > &b, Vect< T_ > &x, size_t m, int max_it, real_t toler, int verbose)

  GMRes solver function.

- template<class T_ >
  int GS (const SpMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x, real_t omega, int max_it, real_t toler, int verbose)

  Gauss-Seidel solver function.

- template<class T_ >
  int Jacobi (const SpMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x, real_t omega, int max_it, real_t toler, int verbose)

  Jacobi solver function.

- void BCAsConstraint (const Mesh &m, const Vect< real_t > &bc, Vect< real_t > &up, Vect< real_t > &low)

  To impose Dirichlet boundary conditions in an optimization problem. If such conditions are to present, this function has to be invoked by giving on input `bc(i)` as the value to impose for the `i`-th optimization variable.

- template<class OPT_ >
int OptimSA (OPT_ &theOpt, Vect< real_t > &x, real_t &rt, real_t &eps, int &ns, int &nt, int &neps, int &maxevl, Vect< real_t > &lb, Vect< real_t > &ub, Vect< real_t > &c, int &msg↩_lvl, int &seed1, int &seed2, real_t &t, Vect< real_t > &vm, Vect< real_t > &xopt, real_t &fopt, int &nacc, int &nfcnev, int &nobds)

    Simulated annealing optimization solver.
- template<class OPT_ >
int OptimTN (OPT_ &theOpt, Vect< real_t > &x, Vect< real_t > &low, Vect< real_t > &up, Vect< int > &pivot, int max_it, real_t toler, int msg_lvl)

    Truncated Newton optimization solver.
- template<class T_ , class M_ >
int Richardson (const M_ &A, const Vect< T_ > &b, Vect< T_ > &x, real_t omega, int max_it, real_t toler, int verbose)

    Richardson solver function.
- template<class T_ >
void Schur (SkMatrix< T_ > &A, SpMatrix< T_ > &U, SpMatrix< T_ > &L, SpMatrix< T_ > &D, Vect< T_ > &b, Vect< T_ > &c)

    Solve a linear system of equations with a 2x2-block matrix.
- template<class T_ >
void Schur (PETScMatrix< T_ > &A, PETScMatrix< T_ > &U, PETScMatrix< T_ > &L, PETScMatrix< T_ > &D, PETScVect< T_ > &b, PETScVect< T_ > &c)

    Solve a linear system of equations with a 2x2-block matrix.
- template<class T_ , class M_ >
int SSOR (const M_ &A, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)

    SSOR solver function.
- ostream & operator<< (ostream &s, const TimeStepping &ts)

    Output differential system information.

5.15.1 Detailed Description

Gathers Solver functions.

5.15.2 Macro Definition Documentation

#define MAX_NB_EQUATIONS 5

Maximum number of equations.
Useful for coupled problems

#define MAX_NB_INPUT_FIELDS 3

Maximum number of fields for an equation.
Useful for coupled problems

#define MAX_NB_MESHES 10

Maximum number of meshes.
Useful for coupled problems

#define TimeLoop

Value:

```
NbTimeSteps = int(theFinalTime/theTimeStep); \
        for (theTime=theTimeStep, theStep=1; theTime<
     theFinalTime+0.001*theTimeStep; theTime+=
     theTimeStep, ++theStep)
```

A macro to loop on time steps to integrate on time.
It uses the following global variables defined in **OFELI**: `theStep`, `theTime`, `theTimeStep`, `theFinalTime`

#define IterationLoop while (++theIteration<MaxNbIterations && Converged==false)

A macro to loop on iterations for an iterative procedure.
It uses the following global variables defined in **OFELI**: `theIteration`, `MaxNbIterations`, `Converged`

5.15.3 Function Documentation

int BiCG (const SpMatrix< T_ > & *A*, int *prec*, const Vect< T_ > & *b*, Vect< T_ > & *x*, int *max_it*, real_t *toler*, int *verbose*)

Biconjugate gradient solver function.

Parameters

in	*A*	Problem matrix (Instance of class SpMatrix).
in	*prec*	Enum variable selecting a preconditioner, among the values `IDENT_PREC`, `DIAG_PREC`, `ILU_PREC` or `SSOR_PREC`
in	*b*	Right-hand side vector (class Vect)
in,out	*x*	Vect instance containing initial solution guess in input and solution of the linear system in output (If iterations have succeeded).
in	*max_it*	Maximum number of iterations.
	toler	[in] Tolerance for convergence (measured in relative weighted 2-Norm).
	verbose	[in] Information output parameter • 0: No output • 1: Output iteration information, • 2 and greater: Output iteration information and solution at each iteration.

Returns

Number of performed iterations,

Template Parameters

<T_>	Data type (double, float, complex<double>, ...)

int BiCGStab (const SpMatrix< T_ > & *A*, const Prec< T_ > & *P*, const Vect< T_ > & *b*, Vect< T_ > & *x*, int *max_it*, real_t *toler*, int *verbose*)

Biconjugate gradient stabilized solver function.

Parameters

in	*A*	Problem matrix (Instance of class SpMatrix).
in	*P*	Preconditioner (Instance of class Prec).
in	*b*	Right-hand side vector (class Vect)
in,out	*x*	Vect instance containing initial solution guess on input and solution of the linear system on output (If iterations have succeeded).
in	*max←_it*	Maximum number of iterations.
in	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm).
in	*verbose*	Information output parameter • 0: No output • 1: Output iteration information, • 2 and greater: Output iteration information and solution at each iteration.

Returns

Number of performed iterations,

Template Parameters

<T←_>	Data type (double, float, complex<double>, ...)

int BiCGStab (const SpMatrix< T_ > & *A*, int *prec*, const Vect< T_ > & *b*, Vect< T_ > & *x*, int *max_it*, real_t *toler*, int *verbose*)

Biconjugate gradient stabilized solver function.

Parameters

in	*A*	Problem matrix (Instance of class SpMatrix).
in	*prec*	Enum variable selecting a preconditioner, among the values `IDENT_PREC`, `DIAG_PREC`, `ILU_PREC` or `SSOR_PREC`
in	*b*	Right-hand side vector (class Vect)
in,out	*x*	Vect instance containing initial solution guess in input and solution of the linear system in output (If iterations have succeeded).
in	*max←_it*	Maximum number of iterations.
in	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm).

Parameters

in	*verbose*	Information output parameter • 0: No output • 1: Output iteration information, • 2 and greater: Output iteration information and solution at each iteration.

Returns

Number of performed iterations,

Template Parameters

<*T*_>	Data type (double, float, complex<double>, ...)

int CG (const SpMatrix< T_ > & *A*, const Prec< T_ > & *P*, const Vect< T_ > & *b*, Vect< T_ > & *x*, int *max_it*, real_t *toler*, int *verbose*)

Conjugate gradient solver function.

Parameters

in	*A*	Problem matrix (Instance of class SpMatrix).
in	*P*	Preconditioner (Instance of class Prec).
in	*b*	Right-hand side vector (class Vect)
in,out	*x*	Vect instance containing initial solution guess in input and solution of the linear system in output (If iterations have succeeded).
in	*max_it*	Maximum number of iterations.
in	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm).
in	*verbose*	Information output parameter • 0: No output • 1: Output iteration information, • 2 and greater: Output iteration information and solution at each iteration.

Returns

Number of performed iterations,

Template Parameters

<T←_>	Data type (double, float, complex<double>, ...)

int CG (const SpMatrix< T_ > & *A*, int *prec*, const Vect< T_ > & *b*, Vect< T_ > & *x*, int *max_it*, real_t *toler*, int *verbose*)

Conjugate gradient solver function.

Parameters

in	*A*	Problem matrix (Instance of abstract class SpMatrix).
in	*prec*	Enum variable selecting a preconditioner, among the values `IDENT_PREC`, `DIAG_PREC`, `ILU_PREC` or `SSOR_PREC`
in	*b*	Right-hand side vector (class Vect)
in,out	*x*	Vect instance containing initial solution guess in input and solution of the linear system in output (If iterations have succeeded).
in	*max←_it*	Maximum number of iterations.
in	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm).
in	*verbose*	Information output parameter • 0: No output • 1: Output iteration information, • 2 and greater: Output iteration information and solution at each iteration.

Returns

Number of performed iterations,

Template Parameters

<T←_>	Data type (double, float, complex<double>, ...)

int CGS (const SpMatrix< T_ > & *A*, int *prec*, const Vect< T_ > & *b*, Vect< T_ > & *x*, int *max_it*, real_t *toler*, int *verbose*)

Conjugate Gradient Squared solver function.

Parameters

in	*A*	Problem matrix (Instance of class SpMatrix).

Parameters

in	*prec*	Enum variable selecting a preconditioner, among the values `IDENT_PREC`, `DIAG_PREC`, `ILU_PREC` or `SSOR_PREC`
in	*b*	Right-hand side vector (class Vect)
in,out	*x*	Vect instance containing initial solution guess in input and solution of the linear system in output (If iterations have succeeded).
in	*max←_it*	Maximum number of iterations.
in	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm).
in	*verbose*	Information output parameter • `0`: No output • `1`: Output iteration information, • 2 and greater: Output iteration information and solution at each iteration.

Returns

Number of performed iterations

Template Parameters

<*T←_*>	Data type (real_t, float, complex<real_t>, ...)

int GMRes (const SpMatrix< T_ > & *A*, const Prec< T_ > & *P*, const Vect< T_ > & *b*, Vect< T_ > & *x*, size_t *m*, int *max_it*, real_t *toler*, int *verbose*)

GMRes solver function.

Parameters

in	*A*	Problem matrix (Instance of class SpMatrix).
in	*P*	Preconditioner (Instance of class Prec).
in	*b*	Right-hand side vector (class Vect)
in,out	*x*	Vect instance containing initial solution guess in input and solution of the linear system in output (If iterations have succeeded).
in	*m*	Number of subspaces to generate for iterations.
in	*max←_it*	Maximum number of iterations.
in	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm).
in	*verbose*	Information output parameter (0: No output, 1: Output iteration information, 2 and greater: Output iteration information and solution at each iteration.

Returns

Number of performed iterations,

Template Parameters

<T↩_>	Data type (double, float, complex<double>, ...)

int GMRes (const SpMatrix< T_ > & *A*, int *prec*, const Vect< T_ > & *b*, Vect< T_ > & *x*, size_t *m*, int *max_it*, real_t *toler*, int *verbose*)

GMRes solver function.

Parameters

in	*A*	Problem matrix (Instance of class SpMatrix).
in	*prec*	Enum variable selecting a preconditioner, among the values `IDENT_PREC`, `DIAG_PREC`, `ILU_PREC` or `SSOR_PREC`
in	*b*	Right-hand side vector (class Vect)
in,out	*x*	Vect instance containing initial solution guess in input and solution of the linear system in output (If iterations have succeeded).
in	*m*	Number of subspaces to generate for iterations.
in	*max↩_it*	Maximum number of iterations.
in	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm).
in	*verbose*	Information output parameter (0: No output, 1: Output iteration information, 2 and greater: Output iteration information and solution at each iteration.

Returns

Number of performed iterations,

Template Parameters

<T↩_>	Data type (double, float, complex<double>, ...)

int GS (const SpMatrix< T_ > & *A*, const Vect< T_ > & *b*, Vect< T_ > & *x*, real_t *omega*, int *max_it*, real_t *toler*, int *verbose*)

Gauss-Seidel solver function.

Parameters

in	*A*	Problem matrix (Instance of class SpMatrix).
in	*b*	Right-hand side vector (class Vect)

Parameters

`in,out`	*x*	Vect instance containing initial solution guess in input and solution of the linear system in output (If iterations have succeeded).
`in`	*omega*	Relaxation parameter.
`in`	*max←_it*	Maximum number of iterations.
`in`	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm).
`in`	*verbose*	Information output parameter • 0: No output • 1: Output iteration information • 2 and greater: Output iteration information and solution at each iteration.

Returns

Number of performed iterations

Template Parameters

<T←_>	Data type (real_t, float, complex<real_t>, ...)

int Jacobi (const SpMatrix< T_ > & *A*, const Vect< T_ > & *b*, Vect< T_ > & *x*, real_t *omega*, int *max_it*, real_t *toler*, int *verbose*)

Jacobi solver function.

Parameters

`in`	*A*	Problem matrix (Instance of class SpMatrix).
`in`	*b*	Right-hand side vector (class Vect)
`in,out`	*x*	Vect instance containing initial solution guess in input and solution of the linear system in output (If iterations have succeeded).
`in`	*omega*	Relaxation parameter.
`in`	*max←_it*	Maximum number of iterations.
`in,out`	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm).
`in`	*verbose*	Information output parameter (0: No output, 1: Output iteration information, 2 and greater: Output iteration information and solution at each iteration.

Returns

Number of performed iterations,

Template Parameters

<T_>	Data type (real_t, float, complex<real_t>, ...)
<M_>	Matrix storage class

int void BCAsConstraint (const Mesh & *m*, const Vect< real_t > & *bc*, Vect< real_t > & *up*, Vect< real_t > & *low*)

To impose Dirichlet boundary conditions in an optimization problem. If such conditions are to present, this function has to be invoked by giving on input `bc(i)` as the value to impose for the `i`-th optimization variable.

Parameters

in	*m*	Mesh instance
in	*bc*	Vect instance where `bc(i)` is the value to impose for dof `i`
out	*up*	Vect instance that contains on output upper bounds for DOFs
out	*low*	Vect instance that contains on output lower bounds for DOFs

int OptimSA (OPT_ & *theOpt*, Vect< real_t > & *x*, real_t & *rt*, real_t & *eps*, int & *ns*, int & *nt*, int & *neps*, int & *maxevl*, Vect< real_t > & *lb*, Vect< real_t > & *ub*, Vect< real_t > & *c*, int & *msg_lvl*, int & *seed1*, int & *seed2*, real_t & *t*, Vect< real_t > & *vm*, Vect< real_t > & *xopt*, real_t & *fopt*, int & *nacc*, int & *nfcnev*, int & *nobds*)

Simulated annealing optimization solver.

Simulated annealing is a global optimization method that distinguishes between different local optima. Starting from an initial point, the algorithm takes a step and the function is evaluated. When minimizing a function, any downhill step is accepted and the process repeats from this new point. An uphill step may be accepted. Thus, it can escape from local optima. This uphill decision is made by the Metropolis criteria. As the optimization process proceeds, the length of the stx decline and the algorithm closes in on the global optimum. Since the algorithm makes very few assumptions regarding the function to be optimized, it is quite robust with respect to non-quadratic surfaces. The degree of robustness can be adjusted by the user. In fact, simulated annealing can be used as a local optimizer for difficult functions.

This implementation of simulated annealing was used in "Global Optimization of Statistical Functions with Simulated Annealing," Goffe, Ferrier and Rogers, Journal of Econometrics, vol. 60, no. 1/2, Jan./Feb. 1994, pp. 65-100. Briefly, we found it competitive, if not superior, to multiple restarts of conventional optimization routines for difficult optimization problems.

For more information on this routine, contact its author: Bill Goffe, `bgoffe@whale.st.usm.edu`

Synopsis: This function implements the continuous simulated annealing global optimization algorithm described in Corana et al.'s article "Minimizing Multimodal Functions of Continuous Variables with the "Simulated Annealing" Algorithm" in the September 1987 (vol. 13, no. 3, pp. 262-280) issue of the ACM Transactions on Mathematical Software.

A very quick (perhaps too quick) overview of OptimSA:
OptimSA tries to find the global optimum of an N dimensional function. It moves both up and downhill and as the optimization process proceeds, it focuses on the most promising area.
To start, it randomly chooses a trial point within the step length vm of the user selected starting point. The function is evaluated at this trial point and its value is compared to its value at the initial point.
In a maximization problem, all uphill moves are accepted and the algorithm continues from that trial point. Downhill moves may be accepted; the decision is made by the Metropolis criteria. It uses T (temperature) and the size of the downhill move in a probabilistic manner. The smaller *t* and the size of the downhill move are, the more likely that move will be accepted. If the trial is accepted, the algorithm moves on from that point. If it is rejected, another point is chosen instead for a trial evaluation.
Each element of *vm* periodically adjusted so that half of all function evaluations in that direction are accepted.

A fall in *t* is imposed upon the system with the rt variable by *t*(i+1) = rt∗t(i) where *i* is the *i-th* iteration. Thus, as *t* declines, downhill moves are less likely to be accepted and the percentage of rejections rise. Given the scheme for the selection for *vm*, *vm* falls. Thus, as *t* declines, *vm* falls and OptimSA focuses upon the most promising area for optimization.

The importance of the parameter *t:*

The parameter *t* is crucial in using OptimSA successfully. It influences *vm*, the step length over which the algorithm searches for optima. For a small initial *t*, the step length may be too small; thus not enough of the function might be evaluated to find the global optima. The user should carefully examine vm in the intermediate output (set msg_lvl = 1) to make sure that vm is appropriate. The relationship between the initial temperature and the resulting step length is function dependent.
To determine the starting temperature that is consistent with optimizing a function, it is worthwhile to run a trial run first. Set rt = 1.5 and t = 1.0. With rt > 1.0, the temperature increases and vm rises as well. Then select the *T* that produces a large enough vm.

For modifications to the algorithm and many details on its use, (particularly for econometric applications) see Goffe, Ferrier and Rogers, "Global Optimization of Statistical Functions with Simulated Annealing," Journal of Econometrics, vol. 60, no. 1/2, Jan./Feb. 1994, pp. 65-100.
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As far as possible, the parameters here have the same name as in the description of the algorithm on pp. 266-8 of Corana et al.

Note: The suggested values generally come from Corana et al. To drastically reduce runtime, see Goffe et al., pp. 90-1 for suggestions on choosing the appropriate `rt` and `nt`.

Parameters

`in`	*theOpt*	Instance of class *OPT_* that is implemented by the user and that provides the objective function.
`in`	*x*	The starting values for the variables of the function to be optimized.
`in`	*rt*	The temperature reduction factor. The value suggested by Corana et al. is .85. See Goffe et al. for more advice.

Parameters

<table>
<tr><td><code>in</code></td><td>eps</td><td>Error tolerance for termination. If the final function values from the last neps temperatures differ from the corresponding value at the current temperature by less than eps and the final function value at the current temperature differs from the current optimal function value by less than eps, execution terminates and the value 0 is returned.</td></tr>
<tr><td><code>in</code></td><td>ns</td><td>Number of cycles. After ns*n function evaluations, each element of vm is adjusted so that approximately half of all function evaluations are accepted. The suggested value is 20.</td></tr>
<tr><td><code>in</code></td><td>nt</td><td>Number of iterations before temperature reduction. After nt*ns*n function evaluations, temperature (t) is changed by the factor rt. Value suggested by Corana et al. is max(100,5*n). See Goffe et al. for further advice.</td></tr>
<tr><td><code>in</code></td><td>neps</td><td>Number of final function values used to decide upon termination. See <code>eps</code>. Suggested value is 4</td></tr>
<tr><td></td><td>maxevl</td><td>[in] The maximum number of function evaluations. If it is exceeded, the return code=1.</td></tr>
<tr><td><code>in</code></td><td>lb</td><td>The lower bound for the allowable solution variables.</td></tr>
<tr><td><code>in</code></td><td>ub</td><td>The upper bound for the allowable solution variables. If the algorithm chooses x(i) < lb(i) or x(i) > ub(i) i=1,...,n, a point is from inside is randomly selected. This focuses the algorithm on the region inside ub and lb. Unless the user wishes to concentrate the search to a particular region, ub and lb should be set to very large positive and negative values, respectively. Note that the starting vector x should be inside this region. Also note that lb and ub are fixed in position, while vm is centered on the last accepted trial set of variables that optimizes the function.</td></tr>
<tr><td></td><td>c</td><td>[in] Vector that controls the step length adjustment. The suggested value for all elements is 2.</td></tr>
<tr><td><code>in</code></td><td>msg_lvl</td><td>controls printing inside OptimSA.
0 - Nothing printed.
1 - Function value for the starting value and summary results before each temperature reduction. This includes the optimal function value found so far, the total number of moves (broken up into uphill, downhill, accepted and rejected), the number of out of bounds trials, the number of new optima found at this temperature, the current optimal x and the step length vm. Note that there are n*ns*nt function evalutations before each temperature reduction. Finally, notice is is also given upon achieveing the termination criteria.
2 - Each new step length (vm), the current optimal x (xopt) and the current trial x (x). This gives the user some idea about how far x strays from xopt as well as how vm is adapting to the function.
3 - Each function evaluation, its acceptance or rejection and new optima. For many problems, this option will likely require a small tree if hard copy is used. This option is best used to learn about the algorithm. A small value for MAXEVL is thus recommended when using msg_lvl=3. Suggested value: 1
Note: For a given value of msg_lvl, the lower valued options (other than 0) are utilized.</td></tr>
</table>

Parameters

in	*seed1*	The first seed for the random number generator ranmar_. 0 <= seed1 <= 31328. (integer)
in	*seed2*	The second seed for the random number generator ranmar_. 0 <= seed <= 30081. Different values for *seed1* and *seed2* will lead to an entirely different sequence of trial points and decisions on downhill moves (when maximizing). See Goffe et al. on how this can be used to test the results of *OptimSA*.
in	*t*	On input, the initial temperature. See Goffe et al. for advice. On output, the final temperature.
in	*vm*	The step length vector. On input it should encompass the region of interest given the starting value *x*. For point x[i], the next trial point is selected is from *x*[i]-vm[i] to *x*[i]+vm[i]. Since *vm* is adjusted so that about half of all points are accepted, the input value is not very important (i.e. is the value is off, *OptimSA* adjusts *vm* to the correct value).
out	*xopt*	The variables that optimize the function.
out	*fopt*	The optimal value of the function.
out	*nacc*	The number of accepted function evaluations.
out	*nfcnev*	The total number of function evaluations. In a minor point, note that the first evaluation is not used in the core of the algorithm; it simply initializes the algorithm.
out	*nobds*	The total number of trial function evaluations that would have been out of bounds of *lb* and *ub*. Note that a trial point is randomly selected between *lb* and *ub*.

Returns

- 0 - Normal return; termination criteria achieved.
- 1 - Number of function evaluations (nfcnev) is greater than the maximum number (maxevl).
- 2 - The starting value (x) is not inside the bounds (*lb* and *ub*).
- 3 - The initial temperature is not positive.
  99 - Should not be seen; only used internally.

Template Parameters

<OPT↩ ->	Class that defined the objective function and its gradient

int OptimTN (OPT_ & *theOpt*, Vect< real_t > & *x*, Vect< real_t > & *low*, Vect< real_t > & *up*, Vect< int > & *pivot*, int *max_it* = *-1*, real_t *toler* = *100OFELI_EPSMCH, int *msg_lvl* = *5*)**

Truncated Newton optimization solver.

Solves a bounds-constrained optimization problem using the Nash's Truncated Newton Algorithm (See paper by S.G. Nash, Newton-type Minimization via the Lanczos method, SIAM J. Numer. Anal. 21 (1984) 770-778). All vector variables are instances of class Vect<real_t>.

Parameters

in	*theOpt*	Instance of class **OPT_** that is implemented by the user and that provides the objective function.
in,out	*x*	Vector that contains an initial guess of the solution and as output the final optimization variables if optimization has succeeded
in	*low*	Vector of the same size as `x` that contains for each variable the lower bound to impose. Note that Dirichlet boundary conditions are treated as equality conditions (i.e. lower and upper bounds) and that these ones can be imposed via an auxiliary optimization file (BCAsConstraint)
in	*up*	Vector of the same size as `x` that contains for each variable the upper bound to impose. Note that Dirichlet boundary conditions are treated as equality conditions (i.e. lower and upper bounds) and that these ones can be imposed via an auxiliary optimization function BCAsConstraint)
in	*pivot*	Vector of the same size as `x` that contains on return for each variable an integer value that says if the corresponding constraint was reached (different from `0`) or not (= `0`). Note that Dirichlet boundary conditions are treated as equality constraints
in	*max_it*	Maximum number of iterations for convergence
in	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm of projected gradient)
in	*msg_lvl*	Output message level. Must be between `0` and `10`

Returns

Number of performed iterations

Template Parameters

<OPT_>	Class that provides the objective function. This class is defined by the user.

The **OPT_** class:

This class is defined by the user. It must have the member function :

void Objective(Vect<real_t> &x, real_t &f, Vect<real_t> &g)

Here above, `x` is the optimization variable vector, `f` is the value of the objective to calculate for the given `x` and `g` is the gradient vector for `x`.

The function **BCAsConstraint:**

This function is defined by the user:

void BCAsConstraint(const Mesh &m, const Vect<real_t> &bc, Vect<real_t> &up, Vect<real_t> &low)

This function imposes Dirichlet boundary conditions in an optimization problem as optimization constraints. If such conditions are to be present, this function has to be invoked by giving on input `bc(i)` as the value to impose for the `i`-th optimization variable.

int Richardson (const M_ & *A*, const Vect< T_ > & *b*, Vect< T_ > & *x*, real_t *omega*, int *max_it*, real_t *toler*, int *verbose*)

Richardson solver function.

Parameters

in	*A*	Problem matrix problem (Instance of abstract class **M_**).
in	*b*	Right-hand side vector (class Vect)
	x	Vect instance containing initial solution guess in input and solution of the linear system in output (If iterations have succeeded).
in	*omega*	Relaxation parameter.
in	*max←_it*	Maximum number of iterations.
in	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm).
in	*verbose*	Information output parameter (`0`: No output, `1`: Output iteration information, `2` and greater: Output iteration information and solution at each iteration.

Returns

nb_it Number of performed iterations,

Template Parameters

<*T_*>	Data type (real_t, float, complex<real_t>, ...)
<*M←_*>	Matrix storage class

void Schur (SkMatrix< T_ > & *A*, SpMatrix< T_ > & *U*, SpMatrix< T_ > & *L*, SpMatrix< T_ > & *D*, Vect< T_ > & *b*, Vect< T_ > & *c*)

Solve a linear system of equations with a 2x2-block matrix.

The linear system is of the form

```
| A  U |  |x|   |b|
|      |  | | = | |
| L  D |  |y|   |c|
```

Parameters

in	*A*	Instance of class SkMatrix class for the first diagonal block. The matrix must be invertible and factorizable (Do not use SpMatrix class) where `A`, `U`, `L`, `D` are instances of matrix classes,
in	*U*	Instance of class SpMatrix for the upper triangle block. The matrix can be rectangular

Parameters

in	*L*	Instance of class SpMatrix for the lower triangle block. The matrix can be rectangular
in	*D*	Instance of class SpMatrix for the second diagonal block. The matrix must be factorizable (Do not use SpMatrix class)
in,out	*b*	Vector (Instance of class Vect) that contains the first block of right-hand side on input and the first block of the solution on output. `b` must have the same size as the dimension of `A`.
in,out	*c*	Vect instance that contains the second block of right-hand side on output and the first block of the solution on output. `c` must have the same size as the dimension of `D`.

Template Argument:

Template Parameters

<*T*↩ _>	data type (real_t, float, ...)

void Schur (PETScMatrix< T_ > & *A*, PETScMatrix< T_ > & *U*, PETScMatrix< T_ > & *L*, PETScMatrix< T_ > & *D*, PETScVect< T_ > & *b*, PETScVect< T_ > & *c*)

Solve a linear system of equations with a 2x2-block matrix.

The linear system is of the form

```
| A  U |  |x|    |b|
|      |  | |  = | |
| L  D |  |y|    |c|
```

Parameters

in	*A*	Instance of class SkMatrix class for the first diagonal block. The matrix must be invertible and factorizable (Do not use SpMatrix class) where `A`, `U`, `L`, `D` are instances of matrix classes,
in	*U*	Instance of class PETScMatrix for the upper triangle block. The matrix can be rectangular
in	*L*	Instance of class PETScMatrix for the lower triangle block. The matrix can be rectangular
in	*D*	Instance of class PETScMatrix for the second diagonal block. The matrix must be factorizable (Do not use SpMatrix class)
in,out	*b*	Vector (Instance of class PETScVect) that contains the first block of right-hand side on input and the first block of the solution on output. `b` must have the same size as the dimension of `A`.
in,out	*c*	PETScVect instance that contains the second block of right-hand side on output and the first block of the solution on output. `c` must have the same size as the dimension of `D`.

Template Argument:

Template Parameters

<T←_>	data type (real_t, float, ...)

int SSOR (const M_ & *A*, const Vect< T_ > & *b*, Vect< T_ > & *x*, int *max_it*, real_t *toler*, int *verbose*)

SSOR solver function.

Parameters

in	*A*	Problem matrix (Instance of abstract class **M_**).
in	*b*	Right-hand side vector (class Vect)
in,out	*x*	Vect instance containing initial solution guess in input and solution of the linear system in output (If iterations have succeeded).
in	*max←_it*	Maximum number of iterations.
in	*toler*	Tolerance for convergence (measured in relative weighted 2-Norm).
in	*verbose*	Information output parameter (0: No output, 1: Output iteration information, 2 and greater : Output iteration information and solution at each iteration.

Returns

Number of performed iterations,

Template Arguments:

- *T_* data type (double, float, ...)
- *M_* Matrix storage class

5.16 Utilities

Gathers utility functions and classes.

Files

- file OFELI.h

  Header file that includes all kernel classes of the library.
- file OFELI_Config.h

  File that contains some macros.
- file constants.h

  File that contains some widely used constants.

Classes

- class Funct

  A simple class to parse real valued functions.
- class Tabulation

  To read and manipulate tabulated functions.
- class UserData< T_ >

  Abstract class to define by user various problem data.
- class Point< T_ >

  Defines a point with arbitrary type coordinates.
- class Point2D< T_ >

  Defines a 2-D point with arbitrary type coordinates.
- class Gauss

  Calculate data for Gauss integration.
- class Timer

  To handle elapsed time counting.

Macros

- #define OFELI_E 2.71828182845904523536028747135
- #define OFELI_PI 3.14159265358979323846264338328
- #define OFELI_THIRD 0.333333333333333333333333333333
- #define OFELI_SIXTH 0.166666666666666666666666666667
- #define OFELI_TWELVETH 0.083333333333333333333333333333
- #define OFELI_SQRT2 1.41421356237309504880168872421
- #define OFELI_SQRT3 1.73205080756887729352744634151
- #define OFELI_ONEOVERPI 0.31830988618379067153776752675
- #define OFELI_GAUSS2 0.57735026918962576450914878050196
- #define OFELI_EPSMCH DBL_EPSILON
- #define OFELI_TOLERANCE OFELI_EPSMCH*10000
- #define OFELI_IMAG std::complex<double>(0.,1.);
- #define PARSE(exp, var) theParser.Parse(exp,var)
- #define EVAL(d) theParser.Eval(d)

Typedefs

- typedef unsigned long lsize_t

    This type stands for type `unsigned long`*.*
- typedef double real_t

    This type stands for `double`*.*
- typedef std::complex< double > complex_t

    This type stands for type `std::complex<double>`

Functions

- ostream & operator<< (ostream &s, const complex_t &x)

    Output a complex number.
- ostream & operator<< (ostream &s, const std::string &c)

    Output a string.
- template<class T_ >
  ostream & operator<< (ostream &s, const vector< T_ > &v)

    Output a vector instance.
- template<class T_ >
  ostream & operator<< (ostream &s, const std::pair< T_, T_ > &a)

    Output a pair instance.
- void saveField (Vect< real_t > &v, string output_file, int opt)

    Save a vector to an output file in a given file format.
- void saveField (PETScVect< real_t > &v, string output_file, int opt)

    Save a PETSc vector to an output file in a given file format.
- void saveField (PETScVect< real_t > &v, const Mesh &mesh, string output_file, int opt)

    Save a PETSc vector to an output file in a given file format.
- void saveField (Vect< real_t > &v, const Grid &g, string output_file, int opt)

    Save a vector to an output file in a given file format, for a structured grid data.
- void saveGnuplot (string input_file, string output_file, string mesh_file)

    Save a vector to an input `Gnuplot` *file.*
- void saveTecplot (string input_file, string output_file, string mesh_file)

    Save a vector to an output file to an input `Tecplot` *file.*
- void saveVTK (string input_file, string output_file, string mesh_file)

    Save a vector to an output `VTK` *file.*
- void saveGmsh (string input_file, string output_file, string mesh_file)

    Save a vector to an output `Gmsh` *file.*
- ostream & operator<< (ostream &s, const Tabulation &t)

    Output Tabulated function data.
- template<class T_ >
  bool operator== (const Point< T_ > &a, const Point< T_ > &b)

    Operator ==
- template<class T_ >
  Point< T_ > operator+ (const Point< T_ > &a, const Point< T_ > &b)

    Operator +
- template<class T_ >
  Point< T_ > operator+ (const Point< T_ > &a, const T_ &x)

    Operator +

- template< class T_ >
  Point< T_ > operator- (const Point< T_ > &a)

  Unary Operator -
- template< class T_ >
  Point< T_ > operator- (const Point< T_ > &a, const Point< T_ > &b)

  Operator -
- template< class T_ >
  Point< T_ > operator- (const Point< T_ > &a, const T_ &x)

  Operator -
- template< class T_ >
  Point< T_ > operator* (const T_ &a, const Point< T_ > &b)

  Operator *
- template< class T_ >
  Point< T_ > operator* (const int &a, const Point< T_ > &b)

  Operator *.
- template< class T_ >
  Point< T_ > operator* (const Point< T_ > &b, const T_ &a)

  Operator /
- template< class T_ >
  Point< T_ > operator* (const Point< T_ > &b, const int &a)

  Operator *
- template< class T_ >
  T_ operator* (const Point< T_ > &a, const Point< T_ > &b)

  Operator *
- template< class T_ >
  Point< T_ > operator/ (const Point< T_ > &b, const T_ &a)

  Operator /
- bool areClose (const Point< double > &a, const Point< double > &b, double toler=OFELI_TOLERANCE)

  Return `true` *if both instances of class Point<double> are distant with less then* `toler`
- double SqrDistance (const Point< double > &a, const Point< double > &b)

  Return squared euclidean distance between points `a` *and* `b`
- double Distance (const Point< double > &a, const Point< double > &b)

  Return euclidean distance between points `a` *and* `b`
- template< class T_ >
  std::ostream & operator<< (std::ostream &s, const Point< T_ > &a)

  Output point coordinates.
- template< class T_ >
  bool operator== (const Point2D< T_ > &a, const Point2D< T_ > &b)

  Operator ==.
- template< class T_ >
  Point2D< T_ > operator+ (const Point2D< T_ > &a, const Point2D< T_ > &b)

  Operator +.
- template< class T_ >
  Point2D< T_ > operator+ (const Point2D< T_ > &a, const T_ &x)

  Operator +.
- template< class T_ >
  Point2D< T_ > operator- (const Point2D< T_ > &a)

Unary Operator -

- template<class T_ >
  Point2D< T_ > operator- (const Point2D< T_ > &a, const Point2D< T_ > &b)

  Operator -

- template<class T_ >
  Point2D< T_ > operator- (const Point2D< T_ > &a, const T_ &x)

  Operator -

- template<class T_ >
  Point2D< T_ > operator* (const T_ &a, const Point2D< T_ > &b)

  *Operator *.*

- template<class T_ >
  Point2D< T_ > operator* (const int &a, const Point2D< T_ > &b)
- template<class T_ >
  Point2D< T_ > operator* (const Point2D< T_ > &b, const T_ &a)

  Operator /

- template<class T_ >
  Point2D< T_ > operator* (const Point2D< T_ > &b, const int &a)

  *Operator **

- template<class T_ >
  T_ operator* (const Point2D< T_ > &b, const Point2D< T_ > &a)

  *Operator *.*

- template<class T_ >
  Point2D< T_ > operator/ (const Point2D< T_ > &b, const T_ &a)

  Operator /

- bool areClose (const Point2D< real_t > &a, const Point2D< real_t > &b, real_t toler=OFELI_TOLERANCE)

  *Return `true` if both instances of class **Point2D<real_t>** are distant with less then toler [Default: `OFELI_EPSMCH`].*

- real_t SqrDistance (const Point2D< real_t > &a, const Point2D< real_t > &b)

  Return squared euclidean distance between points `a` and `b`

- real_t Distance (const Point2D< real_t > &a, const Point2D< real_t > &b)

  Return euclidean distance between points `a` and `b`

- template<class T_ >
  std::ostream & operator<< (std::ostream &s, const Point2D< T_ > &a)

  Output point coordinates.

- void getMesh (string file, ExternalFileFormat form, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in an external file format.

- void getBamg (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in `Bamg` format.

- void getEasymesh (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in `Easymesh` format.

- void getGambit (string file, Mesh &mesh, size_t nb_dof=1)

  *Construct an instance of class Mesh from a mesh file stored in **Gambit** neutral format.*

- void getGmsh (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in `Gmsh` format.

- void getMatlab (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a Matlab mesh data.

- void getNetgen (string file, Mesh &mesh, size_t nb_dof=1)

Construct an instance of class Mesh from a mesh file stored in `Netgen` format.

- void getTetgen (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in `Tetgen` format.
- void getTriangle (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in `Triangle` format.
- void saveMesh (const string &file, const Mesh &mesh, ExternalFileFormat form)

  This function saves mesh data a file for a given external format.
- void saveGmsh (const string &gp_file, const Mesh &mesh)

  This function outputs a Mesh instance in a file in `Gmsh` format.
- void saveGnuplot (const string &file, const Mesh &mesh)

  This function outputs a Mesh instance in a file in `Gmsh` format.
- void saveMatlab (const string &file, const Mesh &mesh)

  This function outputs a Mesh instance in a file in `Matlab` format.
- void saveTecplot (const string &file, const Mesh &mesh)

  This function outputs a Mesh instance in a file in `Tecplot` format.
- void saveVTK (const string &file, const Mesh &mesh)

  This function outputs a Mesh instance in a file in `VTK` format.
- void saveBamg (const string &file, Mesh &mesh)

  This function outputs a Mesh instance in a file in `Bamg` format.
- void BSpline (size_t n, size_t t, Vect< Point< real_t > > &control, Vect< Point< real_t > > &output, size_t num_output)

  Function to perform a B-spline interpolation.
- void banner (const string &prog=" ")

  Outputs a banner as header of any developed program.
- template<class T_ >
  void QuickSort (std::vector< T_ > &a, int begin, int end)

  Function to sort a vector.
- template<class T_ >
  void qksort (std::vector< T_ > &a, int begin, int end)

  Function to sort a vector.
- template<class T_ , class C_ >
  void qksort (std::vector< T_ > &a, int begin, int end, C_ compare)

  Function to sort a vector according to a key function.
- int Sgn (real_t a)

  Return sign of `a`: -1 or 1.
- real_t Abs2 (complex_t a)

  Return square of modulus of complex number `a`
- real_t Abs2 (real_t a)

  Return square of real number `a`
- real_t Abs (real_t a)

  Return absolute value of `a`
- real_t Abs (complex_t a)

  Return modulus of complex number `a`
- real_t Abs (const Point< real_t > &p)

  Return Norm of vector `a`
- real_t Conjg (real_t a)

  Return complex conjugate of real number `a`

- complex_t Conjg (complex_t a)

  Return complex conjugate of complex number a
- real_t Max (real_t a, real_t b, real_t c)

  Return maximum value of real numbers a, b *and* c
- int Max (int a, int b, int c)

  Return maximum value of integer numbers a, b *and* c
- real_t Min (real_t a, real_t b, real_t c)

  Return minimum value of real numbers a, b *and* c
- int Min (int a, int b, int c)

  Return minimum value of integer numbers a, b *and* c
- real_t Max (real_t a, real_t b, real_t c, real_t d)

  Return maximum value of integer numbers a, b, c *and* d
- int Max (int a, int b, int c, int d)

  Return maximum value of integer numbers a, b, c *and* d
- real_t Min (real_t a, real_t b, real_t c, real_t d)

  Return minimum value of real numbers a, b, c *and* d
- int Min (int a, int b, int c, int d)

  Return minimum value of integer numbers a, b, c *and* d
- real_t Arg (complex_t x)

  Return argument of complex number x
- complex_t Log (complex_t x)

  Return principal determination of logarithm of complex number x
- template<class T_ >
  T_ Sqr (T_ x)

  Return square of value x
- template<class T_ >
  void Scale (T_ a, const vector< T_ > &x, vector< T_ > &y)

  Mutiply vector x *by* a *and save result in vector* y
- template<class T_ >
  void Scale (T_ a, const Vect< T_ > &x, Vect< T_ > &y)

  Mutiply vector x *by* a *and save result in vector* y
- template<class T_ >
  void Scale (T_ a, vector< T_ > &x)

  Mutiply vector x *by* a
- template<class T_ >
  void Xpy (size_t n, T_ *x, T_ *y)

  Add array x *to* y
- template<class T_ >
  void Xpy (const vector< T_ > &x, vector< T_ > &y)

  Add vector x *to* y
- template<class T_ >
  void Axpy (size_t n, T_ a, T_ *x, T_ *y)

  Multiply array x *by* a *and add result to* y
- template<class T_ >
  void Axpy (T_ a, const vector< T_ > &x, vector< T_ > &y)

  Multiply vector x *by* a *and add result to* y
- template<class T_ >
  void Axpy (T_ a, const Vect< T_ > &x, Vect< T_ > &y)

Multiply vector x by a and add result to y

- template<class T_ >
  void Copy (size_t n, T_ *x, T_ *y)

  Copy array x to y n is the arrays size.
- real_t Error2 (const vector< real_t > &x, const vector< real_t > &y)

  Return absolute L2 error between vectors x and y
- real_t RError2 (const vector< real_t > &x, const vector< real_t > &y)

  Return absolute L^2 error between vectors x and y
- real_t ErrorMax (const vector< real_t > &x, const vector< real_t > &y)

  Return absolute Max. error between vectors x and y
- real_t RErrorMax (const vector< real_t > &x, const vector< real_t > &y)

  Return relative Max. error between vectors x and y
- template<class T_ >
  T_ Dot (size_t n, T_ *x, T_ *y)

  Return dot product of arrays x and y
- real_t Dot (const vector< real_t > &x, const vector< real_t > &y)

  Return dot product of vectors x and y.
- real_t Dot (const Vect< real_t > &x, const Vect< real_t > &y)

  Return dot product of vectors x and y
- template<class T_ >
  T_ Dot (const Point< T_ > &x, const Point< T_ > &y)

  Return dot product of x and y
- template<class T_ >
  void Assign (vector< T_ > &v, const T_ &a)

  Assign the value a to all entries of a vector v
- template<class T_ >
  void Clear (vector< T_ > &v)

  Assign `0` to all entries of a vector.
- template<class T_ >
  void Clear (Vect< T_ > &v)

  Assign `0` to all entries of a vector.
- real_t Nrm2 (size_t n, real_t *x)

  Return 2-norm of array x
- real_t Nrm2 (const vector< real_t > &x)

  Return 2-norm of vector x
- template<class T_ >
  real_t Nrm2 (const Point< T_ > &a)

  Return 2-norm of a
- bool Equal (real_t x, real_t y, real_t toler=OFELI_EPSMCH)

  Function to return true if numbers x and y are close up to a given tolerance `toler`
- char itoc (int i)

  Function to convert an integer to a character.
- string itos (int i)

  Function to convert an integer to a string.
- std::string itos (size_t i)

  Function to convert an integer to a string.
- string dtos (real_t d)

Function to convert a real to a string.

- template<class T_ >
  T_ stringTo (const std::string &s)

  Function to convert a string to a template type parameter.
- void RTrim (char *s)

  Function to remove blanks at the end of a string.
- void LTrim (char *s)

  Function to remove blanks at the beginning of a string.
- void Trim (char *s)

  Function to remove blanks at the beginning and end of a string.
- template<class T_ >
  void Swap (T_ &a, T_ &b)

  Swap elements a and b.

5.16.1 Detailed Description

Gathers utility functions and classes.

5.16.2 Macro Definition Documentation

#define OFELI_E 2.7182818284590452353602874713 5

Value of *e* or *exp* (with 28 digits)

#define OFELI_PI 3.141592653589793238462643383 28

Value of *Pi* (with 28 digits)

#define OFELI_THIRD 0.33333333333333333333333333333

Value of *1/3* (with 28 digits)

#define OFELI_SIXTH 0.16666666666666666666666666667

Value of *1/6* (with 28 digits)

#define OFELI_TWELVETH 0.083333333333333333333333333333

Value of *1/12* (with 28 digits)

#define OFELI_SQRT2 1.4142135623730950488016887242 1

Value of *sqrt(2)* (with 28 digits)

#define OFELI_SQRT3 1.7320508075688772935274463415 1

Value of *sqrt(3)* (with 28 digits)

#define OFELI_ONEOVERPI 0.31830988618379067153776752675

Value of *1/Pi* (with 28 digits)

#define OFELI_GAUSS2 0.57735026918962576450914878050196

Value of *1/sqrt*(3) (with 32 digits)

#define OFELI_EPSMCH DBL_EPSILON

Value of Machine Epsilon

#define OFELI_TOLERANCE OFELI_EPSMCH*10000

Default tolerance for an iterative process = OFELI_EPSMCH * 10000

#define OFELI_IMAG std::complex<double>(0.,1.);

= Unit imaginary number (`i`)

#define PARSE(***exp, var*** **) theParser.Parse(exp,var)**

A macro that parses a regular expression *exp* using the variables in the string *var*. For instance, to parse the function *sin*(x+y) one must declare *PARSE*("sin(x+y)","x,y")

#define EVAL(***d*** **) theParser.Eval(d)**

A macro that evaluates a parsed regular expression For instance, with a declaration *PARSE*("sin(x+y)","x,y") the data *x=1* and *y=2* using this function must be evaluated as follows: *EVAL(d)* with *d*[0]=1, *d*[1]=2

5.16.3 Function Documentation

void saveField (Vect< real_t > & ***v*****, string** ***output_file*****, int** ***opt*** **)**

Save a vector to an output file in a given file format.
Case where the vector contains mesh information

Parameters

`in`	*v*	Vect instance to save
`in`	*output_file*	Output file where to save the vector
`in`	*opt*	Option to choose file format to save. This is to be chosen among enumerated values: GMSH GNUPLOT MATLAB TECPLOT VTK

void saveField (PETScVect< real_t > & ***v*****, string** ***output_file*****, int** ***opt*** **)**

Save a PETSc vector to an output file in a given file format.
Case where the vector does not contain mesh information

Parameters

`in`	*v*	PETScVect instance to save
`in`	*output_file*	Output file where to save the vector
`in`	*opt*	Option to choose file format to save. This is to be chosen among enumerated values: `GMSH`, `GNUPLOT`, `MATLAB`, `TECPLOT`, `VTK`

void saveField (PETScVect< real_t > & *v*, const Mesh & *mesh*, string *output_file*, int *opt*)

Save a PETSc vector to an output file in a given file format.
Case where the vector does not contain mesh information

Parameters

in	*v*	PETScVect instance to save
in	*mesh*	Mesh instance
in	*output_file*	Output file where to save the vector
in	*opt*	Option to choose file format to save. This is to be chosen among enumerated values: `GMSH`, `GNUPLOT`, `MATLAB`, `TECPLOT`, `VTK`

void saveField (Vect< real_t > & *v*, const Grid & *g*, string *output_file*, int *opt* = `VTK`)

Save a vector to an output file in a given file format, for a structured grid data.

Parameters

in	*v*	Vect instance to save
in	*g*	Grid instance
in	*output_file*	Output file where to save the vector
in	*opt*	Option to choose file format to save. This is to be chosen among enumerated values: `VTK`

void saveGnuplot (string *input_file*, string *output_file*, string *mesh_file*)

Save a vector to an input `Gnuplot` file.
Gnuplot is a command-line driven program for producing 2D and 3D plots. It is under the GNU General Public License. Available information can be found in the site:
`http://www.gnuplot.info/`

Parameters

in	*input_file*	Input file (OFELI XML file containing a field).
in	*output_file*	Output file (gnuplot format file)
in	*mesh_file*	File containing mesh data

void saveTecplot (string *input_file*, string *output_file*, string *mesh_file*)

Save a vector to an output file to an input `Tecplot` file.
Tecplot is high quality post graphical commercial processing program developed by **Amtec**. Available information can be found in the site: `http://www.tecplot.com`

Parameters

in	*input_file*	Input file (OFELI XML file containing a field).
in	*output_file*	Output file (gnuplot format file)

Parameters

in	*mesh_file*	File containing mesh data

saveVTK (string *input_file*, string *output_file*, string *mesh_file*)

Save a vector to an output `VTK` file.
The Visualization ToolKit (VTK) is an open source, freely available software system for 3D computer graphics. Available information can be found in the site:
`http://public.kitware.com/VTK/`

Parameters

in	*input_file*	Input file (OFELI XML file containing a field).
in	*output_file*	Output file (VTK format file)
in	*mesh_file*	File containing mesh data

void saveGmsh (string *input_file*, string *output_file*, string *mesh_file*)

Save a vector to an output `Gmsh` file.
`Gmsh` is a free mesh generator and postprocessor that can be downloaded from the site:
`http://www.geuz.org/gmsh/`

Parameters

in	*input_file*	Input file (OFELI XML file containing a field).
in	*output_file*	Output file (Gmsh format file)
in	*mesh_file*	File containing mesh data

bool operator== (const Point< T_ > & *a*, const Point< T_ > & *b*)

Operator ==
Return `true` if `a=b`, `false` if not.

Point< T_ > operator+ (const Point< T_ > & *a*, const Point< T_ > & *b*)

Operator +
Return sum of two points `a` and `b`

Point< T_ > operator+ (const Point< T_ > & *a*, const T_ & *x*)

Operator +
Translate `a` by `x`

Point< T_ > operator- (const Point< T_ > & *a*)

Unary Operator -
Return minus `a`

Point< T_ > operator- (const Point< T_ > & *a*, const Point< T_ > & *b*)

Operator -
Return point `a` minus point `b`

Point< T_ > operator- (const Point< T_ > & *a*, const T_ & *x*)

Operator -
Translate `a` by `-x`

Point< T_ > operator* (const T_ & *a*, const Point< T_ > & *b*)

Operator *
Return point `b` premultiplied by constant `a`

Point< T_ > operator* (const int & *a*, const Point< T_ > & *b*)

Operator *.
Return point `b` divided by integer constant `a`

Point< T_ > operator* (const Point< T_ > & *b*, const T_ & *a*)

Operator /
Return point `b` multiplied by constant `a`

Point< T_ > operator* (const Point< T_ > & *b*, const int & *a*)

Operator *
Return point `b` postmultiplied by constant `a`

T_ operator* (const Point< T_ > & *b*, const Point< T_ > & *a*)

Operator *
Return inner (scalar) product of points `a` and `b`

Point< T_ > operator/ (const Point< T_ > & *b*, const T_ & *a*)

Operator /
Return point `b` divided by constant `a`

bool operator== (const Point2D< T_ > & *a*, const Point2D< T_ > & *b*)

Operator ==.
Return `true` if `a=b`, false if not.

Point2D< T_ > operator+ (const Point2D< T_ > & *a*, const Point2D< T_ > & *b*)

Operator +.
Return sum of two points `a` and `b`

Point2D< T_ > operator+ (const Point2D< T_ > & *a*, const T_ & *x*)

Operator +.
Translate `a` by `x`

Point2D< T_ > operator- (const Point2D< T_ > & *a*)

Unary Operator -
Return minus a

Point2D< T_ > operator- (const Point2D< T_ > & *a*, const Point2D< T_ > & *b*)

Operator -
Return point a minus point b

Point2D< T_ > operator- (const Point2D< T_ > & *a*, const T_ & *x*)

Operator -
Translate a by -x

Point2D< T_ > operator* (const T_ & *a*, const Point2D< T_ > & *b*)

Operator *.
Return point b premultiplied by constant a

Point2D< T_ > operator* (const int & *a*, const Point2D< T_ > & *b*)

Operator *.
Return point b divided by integer constant a

Point2D< T_ > operator* (const Point2D< T_ > & *b*, const T_ & *a*)

Operator /
Return point b postmultiplied by constant a

Point2D< T_ > operator* (const Point2D< T_ > & *b*, const int & *a*)

Operator *
Return point b postmultiplied by constant a

T_ operator* (const Point2D< T_ > & *b*, const Point2D< T_ > & *a*)

Operator *.
Return point *b* postmultiplied by integer constant *a*.

Point2D< T_ > operator/ (const Point2D< T_ > & *b*, const T_ & *a*)

Operator /
Return point b divided by constant a

void getMesh (string *file*, ExternalFileFormat *form*, Mesh & *mesh*, size_t *nb_dof* = *1*)

Construct an instance of class Mesh from a mesh file stored in an external file format.

Parameters

in	*file*	Input mesh file name.

Parameters

in	*form*	Format of the mesh file. This one can be chosen among the enumerated values: • `GMSH`: Mesh generator **Gmsh**, see site: `http://www.geuz.org/gmsh/` • `MATLAB`: Matlab file, see site: `http://www.mathworks.com/products/matlab/` • `EASYMESH`: **Easymesh** is a 2-D mesh generator, see site: `http://web.mit.edu/easymesh_v1.4/www/easymesh.html` • `GAMBIT`: **Gambit** is a mesh generator associated to **Fluent** `http://www.stanford.edu/class/me469b/gambit_download.html` • `BAMG`: Mesh generator `Bamg`, see site: `http://raweb.inria.fr/rapportsactivite/RA2002/gamma/uid25.html` • `NETGEN`: **Netgen** is a 3-D mesh generator, see site: `http://www.hpfem.jku.at/netgen/` • `TETGEN`: **Tetgen** is a 3-D mesh generator, see site: `http://tetgen.berlios.de/` • `TRIANGLE_FF`: **Triangle** is a 2-D mesh generator, see site: `http://www.cs.cmu.edu/~quake/triangle.html`
out	*mesh*	Mesh instance created by the function.
in	*nb_dof*	Number of degrees of freedom for each node. This information is not provided, in general, by mesh generators. Its default value here is 1.

void getBamg (string *file*, **Mesh &** *mesh*, **size_t** *nb_dof* = *1* **)**

Construct an instance of class Mesh from a mesh file stored in `Bamg` format.

Parameters

in	*file*	Name of a file written in the Bamg format.

Note

Bamg is a 2-D mesh generator. It allows to construct adapted meshes from a given metric. It was developed at INRIA, France. Available information can be found in the site: `http://raweb.inria.fr/rapportsactivite/RA2002/gamma/uid25.html`

Parameters

out	*mesh*	Mesh instance created by the function.
in	*nb_dof*	Number of degrees of freedom for each node. This information is not provided, in general, by mesh generators. Its default value here is 1.

void getEasymesh (string *file*, Mesh & *mesh*, size_t *nb_dof* = *1*)

Construct an instance of class Mesh from a mesh file stored in `Easymesh` format.

Parameters

`in`	*file*	Name of a file (without extension) written in **Easymesh** format. Actually, the function Easymesh2MDF attempts to read mesh data from files `file.e`, `file.n` and `file.s` produced by **Easymesh**.

Note

Easymesh is a free program that generates 2-D, unstructured, Delaunay and constrained Delaunay triangulations in general domains. It can be downloaded from the site:
`http://www-dinma.univ.trieste.it/nirftc/research/easymesh/Default.htm`

Parameters

`in`	*mesh*	Mesh instance created by the function.
`in`	*nb_dof*	Number of degrees of freedom for each node. This information is not provided, in general, by mesh generators. Its default value here is 1.

void getGambit (string *file*, Mesh & *mesh*, size_t *nb_dof* = *1*)

Construct an instance of class Mesh from a mesh file stored in **Gambit** neutral format.

Note

Gambit is a commercial mesh generator associated to the CFD code `Fluent`. Informations about **Gambit** can be found in the site:
`http://www.fluent.com/software/gambit/`

Parameters

`in`	*file*	Name of a file written in the **Gambit** neutral format.
`out`	*mesh*	Mesh instance created by the function.
`in`	*nb_dof*	Number of degrees of freedom for each node. This information is not provided, in general, by mesh generators. Its default value here is 1.

void getGmsh (string *file*, Mesh & *mesh*, size_t *nb_dof* = *1*)

Construct an instance of class Mesh from a mesh file stored in `Gmsh` format.

Note

Gmsh is a free mesh generator that can be downloaded from the site:
`http://www.geuz.org/gmsh/`

Parameters

`in`	*file*	Name of a file written in the **Gmsh** format.
`out`	*mesh*	Mesh instance created by the function.
`in`	*nb_dof*	Number of degrees of freedom for each node. This information is not provided, in general, by mesh generators. Its default value here is 1.

void getMatlab (string *file*, Mesh & *mesh*, size_t *nb_dof* = *1*)

Construct an instance of class Mesh from a Matlab mesh data.

Note

> **Matlab** is a language of scientific computing including visualization. It is developed by `MathWorks`. Available information can be found in the site:
> `http://www.mathworks.com/products/matlab/`

Parameters

`in`	*file*	Name of a file created by Matlab by executing the script file `Matlab2OFELI.m`
`out`	*mesh*	Mesh instance created by the function.
`in`	*nb_dof*	Number of degrees of freedom for each node. This information is not provided, in general, by mesh generators. Its default value here is 1.

void getNetgen (string *file*, Mesh & *mesh*, size_t *nb_dof* = *1*)

Construct an instance of class Mesh from a mesh file stored in `Netgen` format.

Note

> **Netgen** is a tetrahedral mesh generator that can be downloaded from the site:
> `http://www.hpfem.jku.at/netgen/`

Parameters

`in`	*file*	Name of a file written in the Netgen format.
`out`	*mesh*	Mesh instance created by the function.
`in`	*nb_dof*	Number of degrees of freedom for each node. This information is not provided, in general, by mesh generators. [default = 1]

void getTetgen (string *file*, Mesh & *mesh*, size_t *nb_dof* = *1*)

Construct an instance of class Mesh from a mesh file stored in `Tetgen` format.

Note

> **Tetgen** is a free three-dimensional mesh generator that can be downloaded in the site:
> `http://tetgen.berlios.de/`

Parameters

in	*file*	Name of a file written in the **Tetgen** format.
out	*mesh*	Mesh instance created by the function.
in	*nb_dof*	Number of degrees of freedom for each node. This information is not provided, in general, by mesh generators. Its default value here is 1.

void getTriangle (string *file*, Mesh & *mesh*, size_t *nb_dof* = *1* **)**

Construct an instance of class Mesh from a mesh file stored in `Triangle` format.

Note

> **TRIANGLE** is a C program that can generate meshes, Delaunay triangulations and Voronoi diagrams for 2D pointsets that can be downloaded in the site:
> `http://people.scs.fsu.edu/~burkardt/c_src/triangle/triangle.html/`

Parameters

in	*file*	Name of a file written in the **Tetgen** format.
out	*mesh*	Mesh instance created by the function.
in	*nb_dof*	Number of degrees of freedom for each node. This information is not provided, in general, by mesh generators. Its default value here is 1.

void saveMesh (const string & *file*, const Mesh & *mesh*, ExternalFileFormat *form*)

This function saves mesh data a file for a given external format.

Parameters

in	*file*	File where to store mesh
in	*mesh*	Mesh instance to save
in	*form*	Format of the mesh file. This one can be chosen among the enumerated values: • `GMSH`: Mesh generator and graphical postprocessor **Gmsh:** `http://www.geuz.org/gmsh/` • `GNUPLOT`: Well known graphics software: `http://www.gnuplot.info/` • `MATLAB`: Matlab file: `http://www.mathworks.com/products/matlab/` • `TECPLOT`: Commercial graphics software: `http://www.tecplot.com` • `VTK`: Graphics format for the free postprocessor **ParaView:** `http://public.kitware.com/VTK/`

void saveGmsh (const string & *file*, const Mesh & *mesh*)

This function outputs a Mesh instance in a file in `Gmsh` format.

Note

> **Gmsh** is a free mesh generator that can be downloaded from the site: http://www.geuz.org/gmsh/

Parameters

out	*file*	Output file in **Gmsh** format.
in	*mesh*	Mesh instance to save.

void saveGnuplot (const string & *file*, const Mesh & *mesh*)

This function outputs a Mesh instance in a file in Gmsh format.

Note

> **Gnuplot** is a command-line driven program for producing 2D and 3D plots. It is under the GNU General Public License. Available information can be found in the site:
> http://www.gnuplot.info/

Parameters

out	*file*	Output file in **Gnuplot** format.
in	*mesh*	Mesh instance to save.

void saveMatlab (const string & *file*, const Mesh & *mesh*)

This function outputs a Mesh instance in a file in Matlab format.

Note

> **Matlab** is a language of scientific computing including visualization. It is developed by MathWorks. Available information can be found in the site:
> http://www.mathworks.com/products/matlab/

Parameters

out	*file*	Output file in **Matlab** format.
in	*mesh*	Mesh instance to save.

void saveTecplot (const string & *file*, const Mesh & *mesh*)

This function outputs a Mesh instance in a file in Tecplot format.

Note

> **Tecplot** is high quality post graphical commercial processing program developed by Amtec. Available information can be found in the site:
> http://www.tecplot.com

Parameters

out	*file*	Output file in **Tecplot** format.
in	*mesh*	Mesh instance to save.

void saveVTK (const string & *file*, const Mesh & *mesh*)

This function outputs a Mesh instance in a file in `VTK` format.

Note

The Visualization ToolKit (VTK) is an open source, freely available software system for 3D computer graphics. Available information can be found in the site:
`http://public.kitware.com/VTK/`

Parameters

out	*file*	Output file in **VTK** format.
in	*mesh*	Mesh instance to save.

void saveBamg (const string & *file*, Mesh & *mesh*)

This function outputs a Mesh instance in a file in `Bamg` format.

Parameters

in	*file*	Name of a file written in the Bamg format.

Note

Bamg is a 2-D mesh generator. It allows to construct adapted meshes from a given metric. It was developed at INRIA, France. Available information can be found in the site:
`http://raweb.inria.fr/rapportsactivite/RA2002/gamma/uid25.html`

Parameters

in	*mesh*	Mesh instance.

BSpline (size_t *n*, size_t *t*, Vect< Point< real_t > > & *control*, Vect< Point< real_t > > & *output*, size_t *num_output*)

Function to perform a B-spline interpolation.

This program is adapted from a free program ditributed by Keith Vertanen (`vertankd@cda.mrs.umn.edu`) in 1994.

Parameters

Parameters

in	*n*	Number of control points minus 1.
in	*t*	Degree of the polynomial plus 1.
in	*control*	Control point array made up of Point stucture.
out	*output*	Vector in which the calculated spline points are to be put.
in	*num_output*	How many points on the spline are to be calculated.

Note

Condition: `n+2>t` (No curve results if `n+2<=t`) Control vector contains the number of points specified by `n` Output array is the proper size to hold `num_output` point structures

void banner (const string & *prog* = " ")

Outputs a banner as header of any developed program.

Parameters

in	*prog*	Calling program name. Enables writing a copyright notice accompanying the program.

void QuickSort (std::vector< T_ > & *a*, int *begin*, int *end*)

Function to sort a vector.
qksort uses the famous quick sorting algorithm.

Parameters

in,out	*a*	Vector to sort.
in	*begin*	index of starting iterator
in	*end*	index of ending iterator

The calling program must provide an overloading of the operator < for the type **T_**

void qksort (std::vector< T_ > & *a*, int *begin*, int *end*)

Function to sort a vector.
qksort uses the famous quick sorting algorithm.

Parameters

in,out	*a*	Vector to sort.
in	*begin*	index of starting index (default value is 0)
in	*end*	index of ending index (default value is the vector size - 1)

void qksort (std::vector< T_ > & *a*, int *begin*, int *end*, C_ *compare*)

Function to sort a vector according to a key function.
qksort uses the famous quick sorting algorithm.

Parameters

in,out	*a*	Vector to sort.
in	*begin*	index of starting index (0 for the beginning of the vector)
in	*end*	index of ending index
in	*compare*	A function object that implements the ordering. The user must provide this function that returns a boolean function that is true if the first argument is less than the second and false if not.

void Scale (T_ *a*, const vector< T_ > & *x*, vector< T_ > & *y*)

Mutiply vector `x` by `a` and save result in vector `y`
`x` and `y` are instances of class vector<T_>

void Scale (T_ *a*, const Vect< T_ > & *x*, Vect< T_ > & *y*)

Mutiply vector `x` by `a` and save result in vector `y`
`x` and `y` are instances of class Vect<T_>

void Scale (T_ *a*, vector< T_ > & *x*)

Mutiply vector `x` by `a`
`x` is an instance of class vector<T_>

void Xpy (const vector< T_ > & *x*, vector< T_ > & *y*)

Add vector `x` to `y`
`x` and `y` are instances of class vector<T_>

void Axpy (size_t *n*, T_ *a*, T_ * *x*, T_ * *y*)

Multiply array `x` by `a` and add result to `y`
`n` is the arrays size.

void Axpy (T_ *a*, const vector< T_ > & *x*, vector< T_ > & *y*)

Multiply vector `x` by `a` and add result to `y`
`x` and `y` are instances of class vector<T_>

void Axpy (T_ *a*, const Vect< T_ > & *x*, Vect< T_ > & *y*)

Multiply vector `x` by `a` and add result to `y`
`x` and `y` are instances of class Vect<T_>

T_ Dot (size_t *n*, T_ * *x*, T_ * *y*)

Return dot product of arrays `x` and `y`
`n` is the arrays size.

double Dot (const vector< real_t > & *x*, const vector< real_t > & *y*)

Return dot product of vectors `x` and `y`.
`x` and `y` are instances of class vector<double>

real_t Dot (const Vect< real_t > & *x*, const Vect< real_t > & *y*)

Return dot product of vectors `x` and `y`
`x` and `y` are instances of class Vect<T_>

void Clear (vector< T_ > & *v*)

Assign `0` to all entries of a vector.

Parameters

`in`	*v*	Vector to clear

void Clear (Vect< T_ > & *v*)

Assign `0` to all entries of a vector.

Parameters

`in`	*v*	Vector to clear

real_t Nrm2 (size_t *n*, real_t * *x*)

Return 2-norm of array `x`

Parameters

`in`	*n*	is Array length
`in`	*x*	Array to treat

bool Equal (real_t *x*, real_t *y*, real_t *toler* = OFELI_EPSMCH)

Function to return true if numbers `x` and `y` are close up to a given tolerance `toler`
Default value of tolerance is the constant `OFELI_EPSMCH`

5.17 Vector and Matrix

Gathers vector and matrix related classes.

Classes

- class BMatrix< T_ >

  To handle band matrices.
- class DMatrix< T_ >

  To handle dense matrices.
- class DSMatrix< T_ >

  To handle symmetric dense matrices.
- class LocalMatrix< T_, NR_, NC_ >

  Handles small size matrices like element matrices, with a priori known size.
- class LocalVect< T_, N_ >

  Handles small size vectors like element vectors.
- class PETScMatrix< T_ >

  To handle matrices in sparse storage format using the Petsc library.
- class PETScVect< T_ >

  To handle general purpose vectors using Petsc.
- class PETScWrapper< T_ >

  This class is a wrapper to be used when the library Petsc is installed and used with OFELI.
- class SkMatrix< T_ >

  To handle square matrices in skyline storage format.
- class SkSMatrix< T_ >

  To handle symmetric matrices in skyline storage format.
- class SpMatrix< T_ >

  To handle matrices in sparse storage format.
- class TrMatrix< T_ >

  To handle tridiagonal matrices.
- class Vect< T_ >

  To handle general purpose vectors.

Typedefs

- typedef Eigen::Matrix< T_, Eigen::Dynamic, 1 > VectorX

  This type is the vector type in the Eigen library.

Functions

- template<class T_ >
  Vect< T_ > operator* (const BMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*
- template<class T_ >
  BMatrix< T_ > operator* (T_ a, const BMatrix< T_ > &A)

  *Operator * (Premultiplication of matrix by constant)*
- template<class T_ >
  ostream & operator<< (ostream &s, const BMatrix< T_ > &a)

  Output matrix in output stream.

- template<class T_ >
  Vect< T_ > operator* (const DMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*
- template<class T_ >
  ostream & operator<< (ostream &s, const DMatrix< T_ > &a)

  Output matrix in output stream.
- template<class T_ >
  Vect< T_ > operator* (const DSMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*
- template<class T_ >
  ostream & operator<< (ostream &s, const DSMatrix< T_ > &a)

  Output matrix in output stream.
- template<class T_ , size_t NR_, size_t NC_>
  LocalMatrix< T_, NR_, NC_ > operator* (T_ a, const LocalMatrix< T_, NR_, NC_ > &x)

  *Operator * (Multiply matrix x by scalar a)*
- template<class T_ , size_t NR_, size_t NC_>
  LocalMatrix< T_, NR_, NC_ > operator/ (T_ a, const LocalMatrix< T_, NR_, NC_ > &x)

  Operator / (Divide matrix x by scalar a)
- template<class T_ , size_t NR_, size_t NC_>
  LocalMatrix< T_, NR_, NC_ > operator+ (const LocalMatrix< T_, NR_, NC_ > &x, const LocalMatrix< T_, NR_, NC_ > &y)

  Operator + (Add matrix x to y)
- template<class T_ , size_t NR_, size_t NC_>
  LocalMatrix< T_, NR_, NC_ > operator- (const LocalMatrix< T_, NR_, NC_ > &x, const LocalMatrix< T_, NR_, NC_ > &y)

  Operator − (Subtract matrix y from x)
- template<class T_ , size_t NR_, size_t NC_>
  ostream & operator<< (ostream &s, const LocalMatrix< T_, NR_, NC_ > &a)

  Output vector in output stream.
- template<class T_ , size_t N_>
  LocalVect< T_, N_ > operator+ (const LocalVect< T_, N_ > &x, const LocalVect< T_, N_ > &y)

  Operator + (Add two vectors)
- template<class T_ , size_t N_>
  LocalVect< T_, N_ > operator- (const LocalVect< T_, N_ > &x, const LocalVect< T_, N_ > &y)

  Operator - (Subtract two vectors)
- template<class T_ , size_t N_>
  LocalVect< T_, N_ > operator* (T_ a, const LocalVect< T_, N_ > &x)

  *Operator * (Premultiplication of vector by constant)*
- template<class T_ , size_t N_>
  LocalVect< T_, N_ > operator/ (T_ a, const LocalVect< T_, N_ > &x)

  Operator / (Division of vector by constant)
- template<class T_ , size_t N_>
  real_t Dot (const LocalVect< T_, N_ > &a, const LocalVect< T_, N_ > &b)

  Calculate dot product of 2 vectors (instances of class LocalVect)
- template<class T_ , size_t N_>
  void Scale (T_ a, const LocalVect< T_, N_ > &x, LocalVect< T_, N_ > &y)

  Multiply vector x by constant a and store result in y.

- template<class T_, size_t N_>
  void Scale (T_ a, LocalVect< T_, N_ > &x)

  Multiply vector x by constant a and store result in x.
- template<class T_, size_t N_>
  void Axpy (T_ a, const LocalVect< T_, N_ > &x, LocalVect< T_, N_ > &y)

  *Add a*x to vector y.*
- template<class T_, size_t N_>
  void Copy (const LocalVect< T_, N_ > &x, LocalVect< T_, N_ > &y)

  Copy vector x into vector y.
- template<class T_, size_t N_>
  ostream & operator<< (ostream &s, const LocalVect< T_, N_ > &v)

  Output vector in output stream.
- template<class T_ >
  PETScVect< T_ > operator* (const PETScMatrix< T_ > &A, const PETScVect< T_ > &x)
- template<class T_ >
  ostream & operator<< (ostream &s, PETScMatrix< T_ > &A)

  Output matrix in output stream.
- template<class T_ >
  ostream & operator<< (ostream &s, const PETScWrapper< T_ > &w)

  Output Petsc Wrapper data in output stream.
- template<class T_ >
  Vect< T_ > operator* (const SkMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*
- template<class T_ >
  ostream & operator<< (ostream &s, const SkMatrix< T_ > &a)

  Output matrix in output stream.
- template<class T_ >
  Vect< T_ > operator* (const SkSMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*
- template<class T_ >
  ostream & operator<< (ostream &s, const SkSMatrix< T_ > &a)

  Output matrix in output stream.
- template<class T_ >
  Vect< T_ > operator* (const SpMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*
- template<class T_ >
  ostream & operator<< (ostream &s, const SpMatrix< T_ > &A)
- template<class T_ >
  Vect< T_ > operator* (const TrMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*
- template<class T_ >
  TrMatrix< T_ > operator* (T_ a, const TrMatrix< T_ > &A)

  *Operator * (Premultiplication of matrix by constant)*
- template<class T_ >
  ostream & operator<< (ostream &s, const TrMatrix< T_ > &A)

  Output matrix in output stream.
- real_t operator* (const vector< real_t > &x, const vector< real_t > &y)

  *Operator * (Dot product of 2 vector instances)*

Friends

- template<class TT_ >
  ostream & operator<< (ostream &s, const SpMatrix< TT_ > &A)

5.17.1 Detailed Description

Gathers vector and matrix related classes.

5.17.2 Typedef Documentation

VectorX

This type is the vector type in the Eigen library.

Remarks

: This type is available only if the Eigen library was installed in conjunction with OFELI

5.17.3 Function Documentation

Vect< T_ > operator* (const BMatrix< T_ > & *A*, const Vect< T_ > & *b*)

Operator * (Multiply vector by matrix and return resulting vector.

Parameters

in	*A*	BMatrix instance to multiply by vector
in	*b*	Vect instance

Returns

Vect instance containing `A*b`

BMatrix< T_ > operator* (T_ *a*, const BMatrix< T_ > & *A*)

Operator * (Premultiplication of matrix by constant)

Returns

a*A

Vect< T_ > operator* (const DMatrix< T_ > & *A*, const Vect< T_ > & *b*)

Operator * (Multiply vector by matrix and return resulting vector.

Parameters

in	*A*	DMatrix instance to multiply by vector
in	*b*	Vect instance

Returns

Vect instance containing `A*b`

Vect< T_ > operator* (const DSMatrix< T_ > & *A*, const Vect< T_ > & *b*)

Operator * (Multiply vector by matrix and return resulting vector.

Parameters

in	*A*	DSMatrix instance to multiply by vector
in	*b*	Vect instance

Returns

Vect instance containing `A*b`

LocalMatrix< T_, NR_, NC_ > operator* (T_ *a*, const LocalMatrix< T_, NR_, NC_ > & *x*)

Operator * (Multiply matrix `x` by scalar `a`)

Returns

`a*x`

LocalMatrix< T_, NR_, NC_ > operator/ (T_ *a*, const LocalMatrix< T_, NR_, NC_ > & *x*)

Operator / (Divide matrix `x` by scalar `a`)

Returns

`x/a`

LocalMatrix< T_, NR_, NC_ > operator+ (const LocalMatrix< T_, NR_, NC_ > & *x*, const LocalMatrix< T_, NR_, NC_ > & *y*)

Operator + (Add matrix x to y)

Returns

`x+y`

LocalMatrix< T_, NR_, NC_ > operator- (const LocalMatrix< T_, NR_, NC_ > & *x*, const LocalMatrix< T_, NR_, NC_ > & *y*)

Operator - (Subtract matrix y from x)

Returns

`x-y`

LocalVect< T_, N_ > operator+ (const LocalVect< T_, N_ > & *x*, const LocalVect< T_, N_ > & *y*)

Operator + (Add two vectors)

Returns

x+y

LocalVect< T_, N_ > operator- (const LocalVect< T_, N_ > & *x*, const LocalVect< T_, N_ > & *y*)

Operator - (Subtract two vectors)

Returns

x-y

LocalVect< T_, N_ > operator* (T_ *a*, const LocalVect< T_, N_ > & *x*)

Operator * (Premultiplication of vector by constant)

Returns

a*x

LocalVect< T_, N_ > operator/ (T_ *a*, const LocalVect< T_, N_ > & *x*)

Operator / (Division of vector by constant)

Returns

x/a

double Dot (const LocalVect< T_, N_ > & *a*, const LocalVect< T_, N_ > & *b*)

Calculate dot product of 2 vectors (instances of class LocalVect)

Returns

Dot product

PETScVect< T_ > operator* (const PETScMatrix< T_ > & *A*, const PETScVect< T_ > & *x*)

Multiply a matrix by a vector

Parameters

in	*A*	Matrix to multiply by (Instance of class PETScMatrix)
in	*x*	Vector to multiply by (Instance of class PETScVect)

Returns

Vector product `y = Ax`

Vect< T_ > operator* (const SkMatrix< T_ > & *A*, const Vect< T_ > & *b*)

Operator * (Multiply vector by matrix and return resulting vector.

Parameters

in	*A*	SkMatrix instance to multiply by vector
in	*b*	Vect instance

Returns

Vect instance containing `A*b`

Vect< T_ > operator* (const SkSMatrix< T_ > & *A*, const Vect< T_ > & *b*)

Operator * (Multiply vector by matrix and return resulting vector.

Parameters

in	*A*	SkSMatrix instance to multiply by vector
in	*b*	Vect instance

Returns

Vect instance containing `A*b`

Vect< T_ > operator* (const SpMatrix< T_ > & *A*, const Vect< T_ > & *b*)

Operator * (Multiply vector by matrix and return resulting vector.

Parameters

in	*A*	SpMatrix instance to multiply by vector
in	*b*	Vect instance

Returns

Vect instance containing `A*b`

ostream & operator<< (ostream & *s*, const SpMatrix< T_ > & *A*)

Output matrix in output stream

Vect< T_ > operator* (const TrMatrix< T_ > & *A*, const Vect< T_ > & *b*)

Operator * (Multiply vector by matrix and return resulting vector.

Parameters

in	*A*	TrMatrix instance to multiply by vector
in	*b*	Vect instance

Returns

Vect instance containing `A*b`

TrMatrix< T_ > operator* (T_ *a*, const TrMatrix< T_ > & *A*)

Operator * (Premultiplication of matrix by constant)

Returns

a*A

real_t operator* (const vector< real_t > & *x*, const vector< real_t > & *y*)

Operator * (Dot product of 2 vector instances)

Returns

`x.y`

5.17.4 Friends

ostream & operator<< (ostream & *s*, const SpMatrix< TT_ > & *A*) `[friend]`

Output matrix in output stream

Chapter 6

Namespace Documentation

6.1 OFELI Namespace Reference

A namespace to group all library classes, functions, ...

Classes

- class AbsEqua

  Mother abstract class to describe equation.
- class Bar2DL2

  To build element equations for Planar Elastic Bar element with 2 DOF (Degrees of Freedom) per node.
- class Beam3DL2

  To build element equations for 3-D beam equations using 2-node lines.
- class BiotSavart

  Class to compute the magnetic induction from the current density using the Biot-Savart formula.
- class BMatrix

  To handle band matrices.
- class Brick

  To store and treat a brick (parallelepiped) figure.
- class Circle

  To store and treat a circular figure.
- class DC1DL2

  Builds finite element arrays for thermal diffusion and convection in 1-D using 2-Node elements.
- class DC2DT3

  Builds finite element arrays for thermal diffusion and convection in 2-D domains using 3-Node triangles.
- class DC2DT6

  Builds finite element arrays for thermal diffusion and convection in 2-D domains using 6-Node triangles.
- class DC3DAT3

  Builds finite element arrays for thermal diffusion and convection in 3-D domains with axisymmetry using 3-Node triangles.
- class DC3DT4

  Builds finite element arrays for thermal diffusion and convection in 3-D domains using 4-Node tetrahedra.
- class DMatrix

  To handle dense matrices.
- class Domain

To store and treat finite element geometric information.

- class DSMatrix

  To handle symmetric dense matrices.
- class EC2D1T3

  Eddy current problems in 2-D domains using solenoidal approximation.
- class Edge

  To describe an edge.
- class EdgeList

  Class to construct a list of edges having some common properties.
- class EigenProblemSolver

  Class to find eigenvalues and corresponding eigenvectors of a given matrix in a generalized eigenproblem, i.e. Find scalars l and non-null vectors v such that [K]{v} = l[M]{v} where [K] and [M] are symmetric matrices. The eigenproblem can be originated from a PDE. For this, we will refer to the matrices K and M as Stiffness and Mass matrices respectively.
- class Elas2DQ4

  To build element equations for 2-D linearized elasticity using 4-node quadrilaterals.
- class Elas2DT3

  To build element equations for 2-D linearized elasticity using 3-node triangles.
- class Elas3DH8

  To build element equations for 3-D linearized elasticity using 8-node hexahedra.
- class Elas3DT4

  To build element equations for 3-D linearized elasticity using 4-node tetrahedra.
- class Element

  To store and treat finite element geometric information.
- class ElementList

  Class to construct a list of elements having some common properties.
- class Ellipse

  To store and treat an ellipsoidal figure.
- class Equa_Electromagnetics

  Abstract class for Electromagnetics Equation classes.
- class Equa_Fluid

  Abstract class for Fluid Dynamics Equation classes.
- class Equa_Laplace

  Abstract class for classes about the Laplace equation.
- class Equa_Solid

  Abstract class for Solid Mechanics Finite Element classes.
- class Equa_Therm

  Abstract class for Heat transfer Finite Element classes.
- class Equation

  Abstract class for all equation classes.
- class Estimator

  To calculate an a posteriori estimator of the solution.
- class FastMarching2D

  To run a Fast Marching Method on 2-D structured uniform grids.
- class FEShape

  Parent class from which inherit all finite element shape classes.
- class Figure

To store and treat a figure (or shape) information.
- class FMM2D

  class for the fast marching 2-D algorithm
- class FMM3D

  class for the 3-D fast marching algorithm
- class FMMSolver

  The Fast Marching Method solver.
- class Funct

  A simple class to parse real valued functions.
- class Gauss

  Calculate data for Gauss integration.
- class Grid

  To manipulate structured grids.
- class HelmholtzBT3

  Builds finite element arrays for Helmholtz equations in a bounded media using 3-Node triangles.
- class Hexa8

  Defines a three-dimensional 8-node hexahedral finite element using Q1-isoparametric interpolation.
- class ICPG1D

  Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 1-D.
- class ICPG2DT

  Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 2-D.
- class ICPG3DT

  Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 3-D.
- class IOField

  Enables working with files in the XML Format.
- class IPF

  To read project parameters from a file in IPF format.
- class Iter

  Class to drive an iterative process.
- class Laplace1DL2

  To build element equation for a 1-D elliptic equation using the 2-Node line element (P_1).
- class Laplace1DL3

  To build element equation for the 1-D elliptic equation using the 3-Node line (P_2).
- class Laplace2DFVT

  To build and solve the Laplace equation using a standard Finite Volume method.
- class Laplace2DMHRT0

  To build element equation for the 2-D elliptic equation using the Mixed Hybrid finite element at lowest degree (Raviart-Thomas RT_0).
- class Laplace2DT3

  To build element equation for the Laplace equation using the 2-D triangle element (P_1).
- class LCL1D

  Class to solve the linear conservation law (Hyperbolic equation) in 1-D by a MUSCL Finite Volume scheme.
- class LCL2DT

  Class to solve the linear hyperbolic equation in 2-D by a MUSCL Finite Volume scheme on triangles.
- class LCL3DT

  Class to solve the linear conservation law equation in 3-D by a MUSCL Finite Volume scheme on tetrahedra.
- class Line2

To describe a 2-Node planar line finite element.

- class Line2H

  To describe a 2-Node Hermite planar line finite element.
- class Line3

  To describe a 3-Node quadratic planar line finite element.
- class LinearSolver

  Class to solve systems of linear equations by iterative methods.
- class LocalMatrix

  Handles small size matrices like element matrices, with a priori known size.
- class LocalVect

  Handles small size vectors like element vectors.
- class Material

  To treat material data. This class enables reading material data in material data files. It also returns these informations by means of its members.
- class Matrix

  Virtual class to handle matrices for all storage formats.
- class Mesh

  To store and manipulate finite element meshes.
- class Muscl

  Parent class for hyperbolic solvers with Muscl scheme.
- class Muscl1D

  Class for 1-D hyperbolic solvers with Muscl scheme.
- class Muscl2DT

  Class for 2-D hyperbolic solvers with Muscl scheme.
- class Muscl3DT

  Class for 3-D hyperbolic solvers with Muscl scheme using tetrahedra.
- class Node

  To describe a node.
- class NodeList

  Class to construct a list of nodes having some common properties.
- class NSP2DQ41

  Builds finite element arrays for incompressible Navier-Stokes equations in 2-D domains using Q_1/P_0 element and a penaly formulation for the incompressibility condition.
- class ODESolver

  To solve a system of ordinary differential equations.
- class Partition

  To partition a finite element mesh into balanced submeshes.
- class Penta6

  Defines a 6-node pentahedral finite element using P_1 interpolation in local coordinates `(s.x,s.y)` and Q_1 isoparametric interpolation in local coordinates `(s.x,s.z)` and `(s.y,s.z)`.
- class PETScMatrix

  To handle matrices in sparse storage format using the Petsc library.
- class PETScVect

  To handle general purpose vectors using Petsc.
- class PETScWrapper

  This class is a wrapper to be used when the library Petsc is installed and used with OFELI.
- class PhaseChange

This class enables defining phase change laws for a given material.

- class Point

  Defines a point with arbitrary type coordinates.
- class Point2D

  Defines a 2-D point with arbitrary type coordinates.
- class Polygon

  To store and treat a polygonal figure.
- class Prec

  To set a preconditioner.
- class Prescription

  To prescribe various types of data by an algebraic expression. Data may consist in boundary conditions, forces, tractions, fluxes, initial condition. All these data types can be defined through an enumerated variable.
- class Quad4

  Defines a 4-node quadrilateral finite element using Q_1 isoparametric interpolation.
- class Reconstruction

  To perform various reconstruction operations.
- class Rectangle

  To store and treat a rectangular figure.
- class Side

  To store and treat finite element sides (edges in 2-D or faces in 3-D)
- class SideList

  Class to construct a list of sides having some common properties.
- class SkMatrix

  To handle square matrices in skyline storage format.
- class SkSMatrix

  To handle symmetric matrices in skyline storage format.
- class Sphere

  To store and treat a sphere.
- class SpMatrix

  To handle matrices in sparse storage format.
- class SteklovPoincare2DBE

  Solver of the Steklov Poincare problem in 2-D geometries using piecewie constant boundary elemen.
- class Tabulation

  To read and manipulate tabulated functions.
- class Tetra4

  Defines a three-dimensional 4-node tetrahedral finite element using P_1 interpolation.
- class Timer

  To handle elapsed time counting.
- class TimeStepping

  To solve time stepping problems, i.e. systems of linear ordinary differential equations of the form $[A2]\{y''\} + [A1]\{y'\} + [A0]\{y\} = \{b\}$.
- class TINS2DT3B

  Builds finite element arrays for thermal diffusion and convection in 2-D domains using 3-Node triangles.
- class Triang3

  Defines a 3-Node (P_1) triangle.
- class Triang6S

Defines a 6-Node straight triangular finite element using P_2 interpolation.

- class triangle

  Defines a triangle. The reference element is the rectangle triangle with two unit edges.
- class Triangle

  To store and treat a triangle.
- class TrMatrix

  To handle tridiagonal matrices.
- class UserData

  Abstract class to define by user various problem data.
- class Vect

  To handle general purpose vectors.

Enumerations

Functions

- ostream & operator<< (ostream &s, const Muscl3DT &m)

  Output mesh data as calculated in class Muscl3DT.
- T_ * A ()

  Return element matrix.
- T_ * b ()

  Return element right-hand side.
- T_ * Prev ()

  Return element previous vector.
- ostream & operator<< (ostream &s, const complex_t &x)

  Output a complex number.
- ostream & operator<< (ostream &s, const std::string &c)

  Output a string.
- template<class T_ >
  ostream & operator<< (ostream &s, const vector< T_ > &v)

  Output a vector instance.
- template<class T_ >
  ostream & operator<< (ostream &s, const std::pair< T_, T_ > &a)

  Output a pair instance.
- void saveField (Vect< real_t > &v, string output_file, int opt)

  Save a vector to an output file in a given file format.
- void saveField (PETScVect< real_t > &v, string output_file, int opt)

  Save a PETSc vector to an output file in a given file format.
- void saveField (PETScVect< real_t > &v, const Mesh &mesh, string output_file, int opt)

  Save a PETSc vector to an output file in a given file format.
- void saveField (Vect< real_t > &v, const Grid &g, string output_file, int opt)

  Save a vector to an output file in a given file format, for a structured grid data.
- void saveGnuplot (string input_file, string output_file, string mesh_file)

  Save a vector to an input `Gnuplot` file.
- void saveTecplot (string input_file, string output_file, string mesh_file)

  Save a vector to an output file to an input `Tecplot` file.
- void saveVTK (string input_file, string output_file, string mesh_file)

  Save a vector to an output `VTK` file.

- void saveGmsh (string input_file, string output_file, string mesh_file)

  Save a vector to an output `Gmsh` file.
- ostream & operator<< (ostream &s, const Tabulation &t)

  Output Tabulated function data.
- template<class T_, size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalVect< T_, N_ > &be, Vect< T_ > &b)

  Assemble local vector into global vector.
- template<class T_, size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalMatrix< T_, N_, N_ > &ae, Vect< T_ > &b)

  Assemble diagonal local vector into global vector.
- template<class T_, size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalMatrix< T_, N_, N_ > &ae, Matrix< T_ > *A)

  Assemble local matrix into global matrix.
- template<class T_, size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalMatrix< T_, N_, N_ > &ae, SkMatrix< T_ > &A)

  Assemble local matrix into global skyline matrix.
- template<class T_, size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalMatrix< T_, N_, N_ > &ae, SkSMatrix< T_ > &A)

  Assemble local matrix into global symmetric skyline matrix.
- template<class T_, size_t N_, class E_ >
  void element_assembly (const E_ &e, const LocalMatrix< T_, N_, N_ > &ae, SpMatrix< T_ > &A)

  Assemble local matrix into global sparse matrix.
- template<class T_, size_t N_>
  void side_assembly (const Element &e, const LocalMatrix< T_, N_, N_ > &ae, SpMatrix< T_ > &A)

  Side assembly of local matrix into global matrix (as instance of class SpMatrix).
- template<class T_, size_t N_>
  void side_assembly (const Element &e, const LocalMatrix< T_, N_, N_ > &ae, SkSMatrix< T_ > &A)

  Side assembly of local matrix into global matrix (as instance of class SkSMatrix).
- template<class T_, size_t N_>
  void side_assembly (const Element &e, const LocalMatrix< T_, N_, N_ > &ae, SkMatrix< T_ > &A)

  Side assembly of local matrix into global matrix (as instance of class SkMatrix).
- template<class T_, size_t N_>
  void side_assembly (const Element &e, const LocalVect< T_, N_ > &be, Vect< T_ > &b)

  Side assembly of local vector into global vector.
- template<class T_ >
  Vect< T_ > operator* (const BMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*
- template<class T_ >
  BMatrix< T_ > operator* (T_ a, const BMatrix< T_ > &A)

  *Operator * (Premultiplication of matrix by constant)*
- template<class T_ >
  ostream & operator<< (ostream &s, const BMatrix< T_ > &a)

Output matrix in output stream.

- template<class T_ >
  Vect< T_ > operator* (const DMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*
- template<class T_ >
  ostream & operator<< (ostream &s, const DMatrix< T_ > &a)

  Output matrix in output stream.
- template<class T_ >
  Vect< T_ > operator* (const DSMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*
- template<class T_ >
  ostream & operator<< (ostream &s, const DSMatrix< T_ > &a)

  Output matrix in output stream.
- template<class T_ , size_t NR_, size_t NC_>
  LocalMatrix< T_, NR_, NC_ > operator* (T_ a, const LocalMatrix< T_, NR_, NC_ > &x)

  *Operator * (Multiply matrix x by scalar a)*
- template<class T_ , size_t NR_, size_t NC_>
  LocalMatrix< T_, NR_, NC_ > operator/ (T_ a, const LocalMatrix< T_, NR_, NC_ > &x)

  Operator / (Divide matrix x by scalar a)
- template<class T_ , size_t NR_, size_t NC_>
  LocalMatrix< T_, NR_, NC_ > operator+ (const LocalMatrix< T_, NR_, NC_ > &x, const LocalMatrix< T_, NR_, NC_ > &y)

  Operator + (Add matrix x to y)
- template<class T_ , size_t NR_, size_t NC_>
  LocalMatrix< T_, NR_, NC_ > operator- (const LocalMatrix< T_, NR_, NC_ > &x, const LocalMatrix< T_, NR_, NC_ > &y)

  Operator − (Subtract matrix y from x)
- template<class T_ , size_t NR_, size_t NC_>
  ostream & operator<< (ostream &s, const LocalMatrix< T_, NR_, NC_ > &a)

  Output vector in output stream.
- template<class T_ , size_t N_>
  LocalVect< T_, N_ > operator+ (const LocalVect< T_, N_ > &x, const LocalVect< T_, N_ > &y)

  Operator + (Add two vectors)
- template<class T_ , size_t N_>
  LocalVect< T_, N_ > operator- (const LocalVect< T_, N_ > &x, const LocalVect< T_, N_ > &y)

  Operator - (Subtract two vectors)
- template<class T_ , size_t N_>
  LocalVect< T_, N_ > operator* (T_ a, const LocalVect< T_, N_ > &x)

  *Operator * (Premultiplication of vector by constant)*
- template<class T_ , size_t N_>
  LocalVect< T_, N_ > operator/ (T_ a, const LocalVect< T_, N_ > &x)

  Operator / (Division of vector by constant)
- template<class T_ , size_t N_>
  real_t Dot (const LocalVect< T_, N_ > &a, const LocalVect< T_, N_ > &b)

  Calculate dot product of 2 vectors (instances of class LocalVect)
- template<class T_ , size_t N_>
  void Scale (T_ a, const LocalVect< T_, N_ > &x, LocalVect< T_, N_ > &y)

Multiply vector x by constant a and store result in y.

- template<class T_, size_t N_>
  void Scale (T_ a, LocalVect< T_, N_ > &x)

  Multiply vector x by constant a and store result in x.
- template<class T_, size_t N_>
  void Axpy (T_ a, const LocalVect< T_, N_ > &x, LocalVect< T_, N_ > &y)

  *Add a*x to vector y.*
- template<class T_, size_t N_>
  void Copy (const LocalVect< T_, N_ > &x, LocalVect< T_, N_ > &y)

  Copy vector x into vector y.
- template<class T_, size_t N_>
  ostream & operator<< (ostream &s, const LocalVect< T_, N_ > &v)

  Output vector in output stream.
- template<class T_ >
  PETScVect< T_ > operator* (const PETScMatrix< T_ > &A, const PETScVect< T_ > &x)
- template<class T_ >
  ostream & operator<< (ostream &s, PETScMatrix< T_ > &A)

  Output matrix in output stream.
- string itos (int i)

  Function to convert an integer to a string.
- string dtos (real_t d)

  Function to convert a real to a string.
- template<class T_ >
  ostream & operator<< (ostream &s, const PETScWrapper< T_ > &w)

  Output Petsc Wrapper data in output stream.
- template<class T_ >
  bool operator== (const Point< T_ > &a, const Point< T_ > &b)

  Operator ==
- template<class T_ >
  Point< T_ > operator+ (const Point< T_ > &a, const Point< T_ > &b)

  Operator +
- template<class T_ >
  Point< T_ > operator+ (const Point< T_ > &a, const T_ &x)

  Operator +
- template<class T_ >
  Point< T_ > operator- (const Point< T_ > &a)

  Unary Operator -
- template<class T_ >
  Point< T_ > operator- (const Point< T_ > &a, const Point< T_ > &b)

  Operator -
- template<class T_ >
  Point< T_ > operator- (const Point< T_ > &a, const T_ &x)

  Operator -
- template<class T_ >
  Point< T_ > operator* (const T_ &a, const Point< T_ > &b)

  *Operator **
- template<class T_ >
  Point< T_ > operator* (const int &a, const Point< T_ > &b)

  *Operator *.*

- template<class T_ >
  Point< T_ > operator* (const Point< T_ > &b, const T_ &a)

  Operator /
- template<class T_ >
  Point< T_ > operator* (const Point< T_ > &b, const int &a)

  *Operator **
- template<class T_ >
  T_ operator* (const Point< T_ > &a, const Point< T_ > &b)

  *Operator **
- template<class T_ >
  Point< T_ > operator/ (const Point< T_ > &b, const T_ &a)

  Operator /
- Point< double > CrossProduct (const Point< double > &lp, const Point< double > &rp)

  Return Cross product of two vectors `lp` and `rp`
- bool areClose (const Point< double > &a, const Point< double > &b, double toler=OFELI_TOLERANCE)

  Return `true` if both instances of class Point<double> are distant with less then `toler`
- double SqrDistance (const Point< double > &a, const Point< double > &b)

  Return squared euclidean distance between points `a` and `b`
- double Distance (const Point< double > &a, const Point< double > &b)

  Return euclidean distance between points `a` and `b`
- template<class T_ >
  std::ostream & operator<< (std::ostream &s, const Point< T_ > &a)

  Output point coordinates.
- template<class T_ >
  bool operator== (const Point2D< T_ > &a, const Point2D< T_ > &b)

  Operator ==.
- template<class T_ >
  Point2D< T_ > operator+ (const Point2D< T_ > &a, const Point2D< T_ > &b)

  Operator +.
- template<class T_ >
  Point2D< T_ > operator+ (const Point2D< T_ > &a, const T_ &x)

  Operator +.
- template<class T_ >
  Point2D< T_ > operator- (const Point2D< T_ > &a)

  Unary Operator -
- template<class T_ >
  Point2D< T_ > operator- (const Point2D< T_ > &a, const Point2D< T_ > &b)

  Operator -
- template<class T_ >
  Point2D< T_ > operator- (const Point2D< T_ > &a, const T_ &x)

  Operator -
- template<class T_ >
  Point2D< T_ > operator* (const T_ &a, const Point2D< T_ > &b)

  *Operator *.*
- template<class T_ >
  Point2D< T_ > operator* (const int &a, const Point2D< T_ > &b)
- template<class T_ >
  Point2D< T_ > operator* (const Point2D< T_ > &b, const T_ &a)

Operator /

- template<class T_ >
  Point2D< T_ > operator* (const Point2D< T_ > &b, const int &a)

  *Operator **

- template<class T_ >
  T_ operator* (const Point2D< T_ > &b, const Point2D< T_ > &a)

  *Operator *.*

- template<class T_ >
  Point2D< T_ > operator/ (const Point2D< T_ > &b, const T_ &a)

  Operator /

- bool areClose (const Point2D< real_t > &a, const Point2D< real_t > &b, real_t toler=OFELI_TOLERANCE)

  *Return `true` if both instances of class **Point2D<real_t>** are distant with less then toler [Default: `OFELI_EPSMCH`].*

- real_t SqrDistance (const Point2D< real_t > &a, const Point2D< real_t > &b)

  Return squared euclidean distance between points `a` and `b`

- real_t Distance (const Point2D< real_t > &a, const Point2D< real_t > &b)

  Return euclidean distance between points `a` and `b`

- template<class T_ >
  std::ostream & operator<< (std::ostream &s, const Point2D< T_ > &a)

  Output point coordinates.

- template<class T_ >
  Vect< T_ > operator* (const SkMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*

- template<class T_ >
  ostream & operator<< (ostream &s, const SkMatrix< T_ > &a)

  Output matrix in output stream.

- template<class T_ >
  Vect< T_ > operator* (const SkSMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*

- template<class T_ >
  ostream & operator<< (ostream &s, const SkSMatrix< T_ > &a)

  Output matrix in output stream.

- template<class T_ >
  Vect< T_ > operator* (const SpMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*

- template<class T_ >
  ostream & operator<< (ostream &s, const SpMatrix< T_ > &A)

- template<class T_ >
  Vect< T_ > operator* (const TrMatrix< T_ > &A, const Vect< T_ > &b)

  *Operator * (Multiply vector by matrix and return resulting vector.*

- template<class T_ >
  TrMatrix< T_ > operator* (T_ a, const TrMatrix< T_ > &A)

  *Operator * (Premultiplication of matrix by constant)*

- template<class T_ >
  ostream & operator<< (ostream &s, const TrMatrix< T_ > &A)

  Output matrix in output stream.

- ostream & operator<< (ostream &s, const Edge &ed)

  Output edge data.

- ostream & operator<< (ostream &s, const Element &el)

  Output element data.
- Figure operator&& (const Figure &f1, const Figure &f2)

  Function to define a Figure instance as the intersection of two Figure instances.
- Figure operator- (const Figure &f1, const Figure &f2)

  Function to define a Figure instance as the set subtraction of two Figure instances.
- void getMesh (string file, ExternalFileFormat form, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in an external file format.
- void getBamg (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in `Bamg` format.
- void getEasymesh (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in `Easymesh` format.
- void getGambit (string file, Mesh &mesh, size_t nb_dof=1)

  *Construct an instance of class Mesh from a mesh file stored in **Gambit** neutral format.*
- void getGmsh (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in `Gmsh` format.
- void getMatlab (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a Matlab mesh data.
- void getNetgen (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in `Netgen` format.
- void getTetgen (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in `Tetgen` format.
- void getTriangle (string file, Mesh &mesh, size_t nb_dof=1)

  Construct an instance of class Mesh from a mesh file stored in `Triangle` format.
- ostream & operator<< (ostream &s, const Grid &g)

  Output grid data.
- ostream & operator<< (ostream &s, const Material &m)

  Output material data.
- ostream & operator<< (ostream &s, const Mesh &ms)

  Output mesh data.
- ostream & operator<< (ostream &s, const NodeList &nl)

  Output NodeList instance.
- ostream & operator<< (ostream &s, const ElementList &el)

  Output ElementList instance.
- ostream & operator<< (ostream &s, const SideList &sl)

  Output SideList instance.
- ostream & operator<< (ostream &s, const EdgeList &el)

  Output EdgeList instance.
- size_t Label (const Node &nd)

  Return label of a given node.
- size_t Label (const Element &el)

  Return label of a given element.
- size_t Label (const Side &sd)

  Return label of a given side.
- size_t Label (const Edge &ed)

  Return label of a given edge.

- size_t NodeLabel (const Element &el, size_t n)

  Return global label of node local label in element.
- size_t NodeLabel (const Side &sd, size_t n)

  Return global label of node local label in side.
- Point< real_t > Coord (const Node &nd)

  Return coordinates of a given node.
- int Code (const Node &nd, size_t i=1)

  Return code of a given (degree of freedom of) node.
- int Code (const Element &el)

  Return code of a given element.
- int Code (const Side &sd, size_t i=1)

  Return code of a given (degree of freedom of) side.
- bool operator== (const Element &el1, const Element &el2)

  Check equality between 2 elements.
- bool operator== (const Side &sd1, const Side &sd2)

  Check equality between 2 sides.
- void DeformMesh (Mesh &mesh, const Vect< real_t > &u, real_t a=1)

  Calculate deformed mesh using a displacement field.
- void DeformMesh (Mesh &mesh, const PETScVect< real_t > &u, real_t a=1)

  Calculate deformed mesh using a displacement field as instance of PETScVect.
- void MeshToMesh (Mesh &m1, Mesh &m2, const Vect< real_t > &u1, Vect< real_t > &u2, size_t nx, size_t ny=0, size_t nz=0, size_t dof=1)

  Function to redefine a vector defined on a mesh to a new mesh.
- void MeshToMesh (Mesh &m1, Mesh &m2, const Vect< real_t > &u1, Vect< real_t > &u2, const Point< real_t > &xmin, const Point< real_t > &xmax, size_t nx, size_t ny, size_t nz, size_t dof=1)

  Function to redefine a vector defined on a mesh to a new mesh.
- real_t getMaxSize (const Mesh &m)

  Return maximal size of element edges for given mesh.
- real_t getMinSize (const Mesh &m)

  Return minimal size of element edges for given mesh.
- real_t getMinElementMeasure (const Mesh &m)

  Return minimal measure (length, area or volume) of elements of given mesh.
- real_t getMinSideMeasure (const Mesh &m)

  Return minimal measure (length or area) of sides of given mesh.
- real_t getMaxSideMeasure (const Mesh &m)

  Return maximal measure (length or area) of sides of given mesh.
- real_t getMeanElementMeasure (const Mesh &m)

  Return average measure (length, area or volume) of elements of given mesh.
- real_t getMeanSideMeasure (const Mesh &m)

  Return average measure (length or area) of sides of given mesh.
- void setNodeCodes (Mesh &m, const string &exp, int code, size_t dof=1)

  Assign a given code to all nodes satisfying a boolean expression using node coordinates.
- void setBoundaryNodeCodes (Mesh &m, const string &exp, int code, size_t dof=1)

  Assign a given code to all nodes on boundary that satisfy a boolean expression using node coordinates.
- void setSideCodes (Mesh &m, const string &exp, int code, size_t dof=1)

  Assign a given code to all sides satisfying a boolean expression using node coordinates.

- void setBoundarySideCodes (Mesh &m, const string &exp, int code, size_t dof=1)
  Assign a given code to all sides on boundary that satisfy a boolean expression using node coordinates.
- void setElementCodes (Mesh &m, const string &exp, int code)
  Assign a given code to all elements satisfying a boolean expression using node coordinates.
- int NodeInElement (const Node ∗nd, const Element ∗el)
  Say if a given node belongs to a given element.
- int NodeInSide (const Node ∗nd, const Side ∗sd)
  Say if a given node belongs to a given side.
- int SideInElement (const Side ∗sd, const Element ∗el)
  Say if a given side belongs to a given element.
- ostream & operator<< (ostream &s, const Node &nd)
  Output node data.
- void saveMesh (const string &file, const Mesh &mesh, ExternalFileFormat form)
  This function saves mesh data a file for a given external format.
- void saveGmsh (const string &gp_file, const Mesh &mesh)
  This function outputs a Mesh instance in a file in `Gmsh` format.
- void saveGnuplot (const string &file, const Mesh &mesh)
  This function outputs a Mesh instance in a file in `Gmsh` format.
- void saveMatlab (const string &file, const Mesh &mesh)
  This function outputs a Mesh instance in a file in `Matlab` format.
- void saveTecplot (const string &file, const Mesh &mesh)
  This function outputs a Mesh instance in a file in `Tecplot` format.
- void saveVTK (const string &file, const Mesh &mesh)
  This function outputs a Mesh instance in a file in `VTK` format.
- void saveBamg (const string &file, Mesh &mesh)
  This function outputs a Mesh instance in a file in `Bamg` format.
- ostream & operator<< (ostream &s, const Side &sd)
  Output side data.
- ostream & operator<< (ostream &s, const Estimator &r)
  Output estimator vector in output stream.
- template<class T_ >
  int BiCG (const SpMatrix< T_ > &A, int prec, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)
  Biconjugate gradient solver function.
- template<class T_ >
  int BiCGStab (const SpMatrix< T_ > &A, const Prec< T_ > &P, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)
  Biconjugate gradient stabilized solver function.
- template<class T_ >
  int BiCGStab (const SpMatrix< T_ > &A, int prec, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)
  Biconjugate gradient stabilized solver function.
- void BSpline (size_t n, size_t t, Vect< Point< real_t > > &control, Vect< Point< real_t > > &output, size_t num_output)
  Function to perform a B-spline interpolation.
- template<class T_ >
  int CG (const SpMatrix< T_ > &A, const Prec< T_ > &P, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)

Conjugate gradient solver function.

- template<class T_ >
  int CG (const SpMatrix< T_ > &A, int prec, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)

  Conjugate gradient solver function.
- template<class T_ >
  int CGS (const SpMatrix< T_ > &A, int prec, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)

  Conjugate Gradient Squared solver function.
- template<class T_ >
  int GMRes (const SpMatrix< T_ > &A, const Prec< T_ > &P, const Vect< T_ > &b, Vect< T_ > &x, size_t m, int max_it, real_t toler, int verbose)

  GMRes solver function.
- template<class T_ >
  int GMRes (const SpMatrix< T_ > &A, int prec, const Vect< T_ > &b, Vect< T_ > &x, size_t m, int max_it, real_t toler, int verbose)

  GMRes solver function.
- template<class T_ >
  int GS (const SpMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x, real_t omega, int max_it, real_t toler, int verbose)

  Gauss-Seidel solver function.
- template<class T_ >
  int Jacobi (const SpMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x, real_t omega, int max_it, real_t toler, int verbose)

  Jacobi solver function.
- void BCAsConstraint (const Mesh &m, const Vect< real_t > &bc, Vect< real_t > &up, Vect< real_t > &low)

  To impose Dirichlet boundary conditions in an optimization problem. If such conditions are to present, this function has to be invoked by giving on input `bc(i)` as the value to impose for the `i`-th optimization variable.
- template<class OPT_ >
  int OptimSA (OPT_ &theOpt, Vect< real_t > &x, real_t &rt, real_t &eps, int &ns, int &nt, int &neps, int &maxevl, Vect< real_t > &lb, Vect< real_t > &ub, Vect< real_t > &c, int &msg↩_lvl, int &seed1, int &seed2, real_t &t, Vect< real_t > &vm, Vect< real_t > &xopt, real_t &fopt, int &nacc, int &nfcnev, int &nobds)

  Simulated annealing optimization solver.
- template<class OPT_ >
  int OptimTN (OPT_ &theOpt, Vect< real_t > &x, Vect< real_t > &low, Vect< real_t > &up, Vect< int > &pivot, int max_it, real_t toler, int msg_lvl)

  Truncated Newton optimization solver.
- template<class T_ , class M_ >
  int Richardson (const M_ &A, const Vect< T_ > &b, Vect< T_ > &x, real_t omega, int max_it, real_t toler, int verbose)

  Richardson solver function.
- template<class T_ >
  void Schur (SkMatrix< T_ > &A, SpMatrix< T_ > &U, SpMatrix< T_ > &L, SpMatrix< T_ > &D, Vect< T_ > &b, Vect< T_ > &c)

  Solve a linear system of equations with a 2x2-block matrix.
- template<class T_ >
  void Schur (PETScMatrix< T_ > &A, PETScMatrix< T_ > &U, PETScMatrix< T_ > &L, PETScMatrix< T_ > &D, PETScVect< T_ > &b, PETScVect< T_ > &c)

Solve a linear system of equations with a 2x2-block matrix.

- template< class T_, class M_ >
  int SSOR (const M_ &A, const Vect< T_ > &b, Vect< T_ > &x, int max_it, real_t toler, int verbose)

  SSOR solver function.
- ostream & operator<< (ostream &s, const TimeStepping &ts)

  Output differential system information.
- void banner (const string &prog=" ")

  Outputs a banner as header of any developed program.
- template< class T_ >
  void QuickSort (std::vector< T_ > &a, int begin, int end)

  Function to sort a vector.
- template< class T_ >
  void qksort (std::vector< T_ > &a, int begin, int end)

  Function to sort a vector.
- template< class T_, class C_ >
  void qksort (std::vector< T_ > &a, int begin, int end, C_ compare)

  Function to sort a vector according to a key function.
- int Sgn (real_t a)

  Return sign of `a`*:* `-1` *or* `1`*.*
- real_t Abs2 (complex_t a)

  Return square of modulus of complex number `a`
- real_t Abs2 (real_t a)

  Return square of real number `a`
- real_t Abs (real_t a)

  Return absolute value of `a`
- real_t Abs (complex_t a)

  Return modulus of complex number `a`
- real_t Abs (const Point< real_t > &p)

  Return Norm of vector `a`
- real_t Conjg (real_t a)

  Return complex conjugate of real number `a`
- complex_t Conjg (complex_t a)

  Return complex conjugate of complex number `a`
- real_t Max (real_t a, real_t b, real_t c)

  Return maximum value of real numbers `a`*,* `b` *and* `c`
- int Max (int a, int b, int c)

  Return maximum value of integer numbers `a`*,* `b` *and* `c`
- real_t Min (real_t a, real_t b, real_t c)

  Return minimum value of real numbers `a`*,* `b` *and* `c`
- int Min (int a, int b, int c)

  Return minimum value of integer numbers `a`*,* `b` *and* `c`
- real_t Max (real_t a, real_t b, real_t c, real_t d)

  Return maximum value of integer numbers `a`*,* `b`*,* `c` *and* `d`
- int Max (int a, int b, int c, int d)

  Return maximum value of integer numbers `a`*,* `b`*,* `c` *and* `d`
- real_t Min (real_t a, real_t b, real_t c, real_t d)

Return minimum value of real numbers a*,* b*,* c *and* d

- int Min (int a, int b, int c, int d)

  Return minimum value of integer numbers a*,* b*,* c *and* d
- real_t Arg (complex_t x)

  Return argument of complex number x
- complex_t Log (complex_t x)

  Return principal determination of logarithm of complex number x
- template<class T_ >
  T_ Sqr (T_ x)

  Return square of value x
- template<class T_ >
  void Scale (T_ a, const vector< T_ > &x, vector< T_ > &y)

  Mutiply vector x *by* a *and save result in vector* y
- template<class T_ >
  void Scale (T_ a, const Vect< T_ > &x, Vect< T_ > &y)

  Mutiply vector x *by* a *and save result in vector* y
- template<class T_ >
  void Scale (T_ a, vector< T_ > &x)

  Mutiply vector x *by* a
- template<class T_ >
  void Xpy (size_t n, T_ *x, T_ *y)

  Add array x *to* y
- template<class T_ >
  void Xpy (const vector< T_ > &x, vector< T_ > &y)

  Add vector x *to* y
- template<class T_ >
  void Axpy (size_t n, T_ a, T_ *x, T_ *y)

  Multiply array x *by* a *and add result to* y
- template<class T_ >
  void Axpy (T_ a, const vector< T_ > &x, vector< T_ > &y)

  Multiply vector x *by* a *and add result to* y
- template<class T_ >
  void Axpy (T_ a, const Vect< T_ > &x, Vect< T_ > &y)

  Multiply vector x *by* a *and add result to* y
- template<class T_ >
  void Copy (size_t n, T_ *x, T_ *y)

  Copy array x *to* y n *is the arrays size.*
- real_t Error2 (const vector< real_t > &x, const vector< real_t > &y)

  Return absolute L2 error between vectors x *and* y
- real_t RError2 (const vector< real_t > &x, const vector< real_t > &y)

  Return absolute L^2 *error between vectors* x *and* y
- real_t ErrorMax (const vector< real_t > &x, const vector< real_t > &y)

  Return absolute Max. error between vectors x *and* y
- real_t RErrorMax (const vector< real_t > &x, const vector< real_t > &y)

  Return relative Max. error between vectors x *and* y
- template<class T_ >
  T_ Dot (size_t n, T_ *x, T_ *y)

  Return dot product of arrays x *and* y

- real_t operator* (const vector< real_t > &x, const vector< real_t > &y)

  *Operator * (Dot product of 2 vector instances)*
- real_t Dot (const vector< real_t > &x, const vector< real_t > &y)

  Return dot product of vectors `x` and `y`.
- real_t Dot (const Vect< real_t > &x, const Vect< real_t > &y)

  Return dot product of vectors `x` and `y`
- template<class T_ >
  T_ Dot (const Point< T_ > &x, const Point< T_ > &y)

  Return dot product of `x` and `y`
- template<class T_ >
  void Assign (vector< T_ > &v, const T_ &a)

  Assign the value `a` to all entries of a vector `v`
- template<class T_ >
  void Clear (vector< T_ > &v)

  Assign `0` to all entries of a vector.
- template<class T_ >
  void Clear (Vect< T_ > &v)

  Assign `0` to all entries of a vector.
- real_t Nrm2 (size_t n, real_t *x)

  Return 2-norm of array `x`
- real_t Nrm2 (const vector< real_t > &x)

  Return 2-norm of vector `x`
- template<class T_ >
  real_t Nrm2 (const Point< T_ > &a)

  Return 2-norm of `a`
- bool Equal (real_t x, real_t y, real_t toler=OFELI_EPSMCH)

  Function to return true if numbers `x` and `y` are close up to a given tolerance `toler`
- char itoc (int i)

  Function to convert an integer to a character.
- std::string itos (size_t i)

  Function to convert an integer to a string.
- template<class T_ >
  T_ stringTo (const std::string &s)

  Function to convert a string to a template type parameter.
- void RTrim (char *s)

  Function to remove blanks at the end of a string.
- void LTrim (char *s)

  Function to remove blanks at the beginning of a string.
- void Trim (char *s)

  Function to remove blanks at the beginning and end of a string.
- template<class T_ >
  void Swap (T_ &a, T_ &b)

  Swap elements a and b.

Variables

- Node ∗ theNode

  A pointer to Node.
- Element ∗ theElement

  A pointer to Element.
- Side ∗ theSide

  A pointer to Side.
- Edge ∗ theEdge

  A pointer to Edge.
- int theStep

  Time step counter.
- int theIteration

  Iteration counter.
- int NbTimeSteps

  Number of time steps.
- int MaxNbIterations

  Maximal number of iterations.
- int Verbosity

  Parameter for verbosity of message outputting.
- real_t theTimeStep

  Time step label.
- real_t theTime

  Time value.
- real_t theFinalTime

  Final time value.
- real_t theTolerance

  Tolerance value for convergence.
- real_t theDiscrepancy

  Value of discrepancy for an iterative procedure Its default value is `1.0`*.*
- bool Converged

  Boolean variable to say if an iterative procedure has converged.
- bool InitPetsc

6.1.1 Detailed Description

A namespace to group all library classes, functions, ...

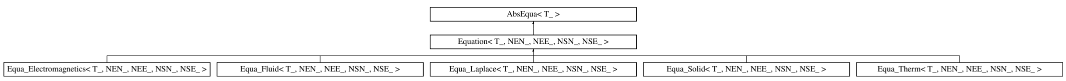
Namespace OFELI groups all OFELI library classes, functions and global variables.

Chapter 7

Class Documentation

7.1 AbsEqua< T_ > Class Template Reference

Mother abstract class to describe equation.
Inheritance diagram for AbsEqua< T_ >:



Public Member Functions

- AbsEqua ()
  Default constructor.
- AbsEqua (Mesh &mesh)
  Constructor with mesh instance.
- virtual ∼AbsEqua ()
  Destructor.
- void setMesh (Mesh &m)
  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const
  Return reference to Mesh instance.
- LinearSolver< T_ > & getLinearSolver ()
  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)
  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< T_ > ∗A, Vect< T_ > &b, Vect< T_ > &x)
  Solve the linear system.

7.1.1 Detailed Description

template<class T_>
class OFELI::AbsEqua< T_ >

Mother abstract class to describe equation.

Template Parameters

<T_>	Data type (real_t, float, complex<real_t>, ...)

7.1.2 Member Function Documentation

Mesh& getMesh ( ) const

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = IDENT_PREC)

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< T_ > * *A*, Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)

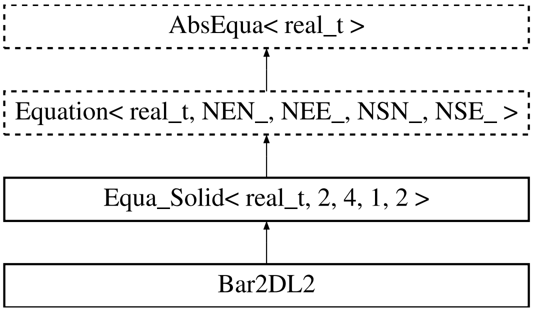
Parameters

`in`	b	Vector containing right-hand side
`in,out`	x	Vector containing initial guess of solution on input, actual solution on output

7.2 Bar2DL2 Class Reference

To build element equations for Planar Elastic Bar element with 2 DOF (Degrees of Freedom) per node.

Inheritance diagram for Bar2DL2:



Public Member Functions

- Bar2DL2 ()

  Default Constructor.
- Bar2DL2 (Element ∗el, real_t section)

  Constructor using element data.
- ∼Bar2DL2 ()

  Destructor.
- void Mass (real_t coef=1.)

  Add element consistent mass contribution to matrix and right-hand side after multiplication by `coef`
- void LMass (real_t coef=1.)

  Add element lumped mass contribution to matrix ans right-hand side after multiplication by `coef`
- void LMassToLHS (real_t coef=1)

  Add lumped mass matrix to left-hand side after multiplying it by coefficient `coef`
- void LMassToRHS (real_t coef=1)

  Add lumped mass contribution to right-hand side after multiplying it by coefficient `coef`
- void MassToLHS (real_t coef=1)

  Add consistent mass matrix to left-hand side after multiplying it by coefficient `coef`
- void MassToRHS (real_t coef=1)

  Add consistent mass contribution to right-hand side after multiplying it by coefficient `coef`
- void Stiffness (real_t coef=1.)

  Add element stiffness to left hand side.
- void BodyRHS (UserData< real_t > &ud)

  Add body right-hand side term to right hand side.
- real_t Stress () const

Return stresses in bar.

- void getStresses (const Vect< real_t > &u, Vect< real_t > &s)

  Return stresses in the truss structure (elementwise)
- int runOneTimeStep ()

  Run one time step.
- int run ()

  Solve the equation.
- void build ()

  Build the linear system of equations.
- void buildEigen (SkSMatrix< real_t > &K, SkSMatrix< real_t > &M)

  Build global stiffness and mass matrices for the eigen system.
- void buildEigen (SkSMatrix< real_t > &K, Vect< real_t > &M)

  Build global stiffness and mass matrices for the eigen system.
- void setLumpedMass ()

  Add lumped mass contribution to left and right-hand sides taking into account time integration scheme.
- void setMass ()

  Add consistent mass contribution to left and right-hand sides taking into account time integration scheme.
- virtual void Deviator (real_t coef=1)

  Add deviator matrix to left-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- virtual void Dilatation (real_t coef=1)

  Add dilatation matrix to left-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- virtual void DilatationToRHS (real_t coef=1)

  Add dilatation vector to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- virtual void DeviatorToRHS (real_t coef=1)

  Add deviator vector to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- virtual void StiffnessToRHS (real_t coef=1)

  Add stiffness matrix to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- void setDilatation ()

  Add dilatation matrix to left and/or right-hand side taking into account time.
- void setDeviator ()

  Add deviator matrix to left and/or right-hand side taking into account time integration scheme.
- void setStiffness ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.

- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > ∗A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > ∗A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)

  Assemble side (edge or face) vector into global one.

- void DGElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > *A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Young (const real_t &E)
  Set (constant) Young modulus.
- void Young (const string &exp)
  Set Young modulus given by an algebraic expression.
- void Poisson (const real_t &nu)
  Set (constant) Poisson ratio.
- void Poisson (const string &exp)
  Set Poisson ratio given by an algebraic expression.
- void Density (const real_t &rho)
  Set (constant) density.
- void Density (const string &exp)
  Set density given by an algebraic expression.
- void setMaterial ()
  Set material properties.
- void Init (const Element ∗el)
  Set element arrays to zero.
- void Init (const Side ∗sd)
  Set side arrays to zero.

7.2.1 Detailed Description

To build element equations for Planar Elastic Bar element with 2 DOF (Degrees of Freedom) per node.

This class implements a planar (two-dimensional) elastic bar using 2-node lines. Note that members calculating element arrays have as an argument a real `coef` that is multiplied by the contribution of the current element. This makes possible testing different algorithms.

7.2.2 Constructor & Destructor Documentation

Bar2DL2 ( )

Default Constructor.

Constructs an empty equation.

Bar2DL2 (Element ∗ *el*, real_t *section*)

Constructor using element data.

Parameters

in	*el*	Pointer to Element
in	*section*	Section of bar at present element

7.2.3 Member Function Documentation

void Mass (real_t *coef* = `1.`) `[virtual]`

Add element consistent mass contribution to matrix and right-hand side after multiplication by `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 2, 4, 1, 2 >.

void LMass (real_t *coef* = 1.) [virtual]

Add element lumped mass contribution to matrix ans right-hand side after multiplication by `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 2, 4, 1, 2 >.

void LMassToLHS (real_t *coef* = 1) [virtual]

Add lumped mass matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 2, 4, 1, 2 >.

void LMassToRHS (real_t *coef* = 1) [virtual]

Add lumped mass contribution to right-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 2, 4, 1, 2 >.

void MassToLHS (real_t *coef* = 1) [virtual]

Add consistent mass matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 2, 4, 1, 2 >.

void MassToRHS (real_t *coef* = 1) [virtual]

Add consistent mass contribution to right-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 2, 4, 1, 2 >.

void Stiffness (real_t *coef* = *1.*) [virtual]

Add element stiffness to left hand side.

Parameters

in	*coef*	Coefficient to multuply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 2, 4, 1, 2 >.

void BodyRHS (UserData< real_t > & *ud*)

Add body right-hand side term to right hand side.

Parameters

in	*ud*	instance containing user data with prescribes loads

void getStresses (const Vect< real_t > & *u*, Vect< real_t > & *s*)

Return stresses in the truss structure (elementwise)

Parameters

in	*u*	Vect instance containing displacements at nodes
in	*s*	Vect instance containing axial stresses in elements

int runOneTimeStep ( )

Run one time step.

This function performs one time step in equation solving. It is to be used only if a `TRANSIENT` analysis is required.

Returns

Return error from the linear system solver

int run ( )

Solve the equation.

If the analysis (see function **setAnalysis**) is `STEADY_STATE`, then the function solves the stationary equation.
If the analysis is `TRANSIENT`, then the function performs time stepping until the final time is reached.

void build ( )

Build the linear system of equations.
Before using this function, one must have properly selected appropriate options for:

- The choice of a steady state or transient analysis
- In the case of transient analysis, the choice of a time integration scheme and a lumped or consistent mass matrix
- The choice of desired linear system solver

void buildEigen (SkSMatrix< real_t > & *K*, SkSMatrix< real_t > & *M*)

Build global stiffness and mass matrices for the eigen system.
Case where the mass matrix is consistent

Parameters

in	*K*	Stiffness matrix
in	*M*	Consistent mass matrix

void buildEigen (SkSMatrix< real_t > & *K*, Vect< real_t > & *M*)

Build global stiffness and mass matrices for the eigen system.
Case where the mass matrix is lumped

Parameters

in	*K*	Stiffness matrix
in	*M*	Vector containing diagonal mass matrix

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.
`in`	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & v) `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & A) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & b) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *`IDENT_PREC`* **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > ∗ *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

`in`	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	*b*	Vector containing right-hand side
`in,out`	*x*	Vector containing initial guess of solution on input, actual solution on output

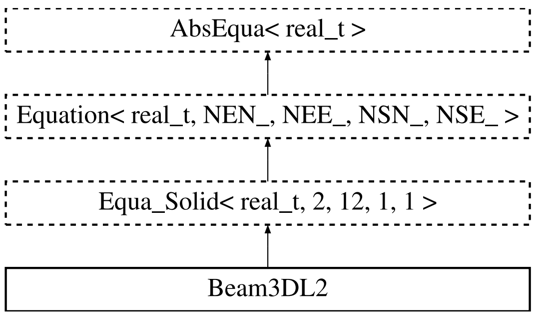
7.2.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

LocalVect instance containing local vector associated to current element.
This vector has been stored as the one at previous iteration or previous time step

7.3 Beam3DL2 Class Reference

To build element equations for 3-D beam equations using 2-node lines.
Inheritance diagram for Beam3DL2:



Public Member Functions

- Beam3DL2 ()

  Default Constructor.
- Beam3DL2 (Element ∗el, real_t A, real_t I1, real_t I2)

  Constructor using element data.
- Beam3DL2 (Element ∗el, real_t A, real_t I1, real_t I2, const Vect< real_t > &u, const real_t &time=0)

  Constructor for dynamic problems.
- Beam3DL2 (Mesh &ms, const Vect< real_t > &u, Vect< real_t > &d)

  Constructor to determine displacements.
- ∼Beam3DL2 ()

  Destructor.
- void LMassToLHS (real_t coef=1.)

  Add element lumped Mass contribution to matrix after multiplication by `coef`

- void LMassToRHS (real_t coef=1.)

  Add element lumped Mass contribution to RHS after multiplication by `coef`
- void MassToLHS (real_t coef=1.)

  Add element consistent Mass contribution to matrix after multiplication by `coef` *(not implemented)*
- void MassToRHS (real_t coef=1.)

  Add element consistent Mass contribution to RHS after multiplication by `coef` *(not implemented)*
- void Stiffness (real_t coef=1.)

  Add element stiffness to left hand side.
- void Load (const Vect< real_t > &f)

  Add contributions for loads.
- void setBending ()

  Set bending contribution to stiffness.
- void setAxial ()

  Set axial contribution to stiffness.
- void setShear ()

  Set shear contribution to stiffness.
- void setTorsion ()

  Set torsion contribution to stiffness.
- void setNoBending ()

  Set no bending contribution.
- void setNoAxial ()

  Set no axial contribution.
- void setNoShear ()

  Set no shear contribution.
- void setNoTorsion ()

  Set no torsion contribution.
- void setReducedIntegration ()

  Set reduced integration.
- real_t AxialForce () const

  Return axial force in element.
- Point< real_t > ShearForce () const

  Return shear force in element.
- Point< real_t > BendingMoment () const

  Return bending moment in element.
- real_t TwistingMoment () const

  Return twisting moment in element.
- void buildEigen (SkSMatrix< real_t > &K, Vect< real_t > &M)

  Build global stiffness and mass matrices for the eigen system.
- void setLumpedMass ()

  Add lumped mass contribution to left and right-hand sides taking into account time integration scheme.
- void setMass ()

  Add consistent mass contribution to left and right-hand sides taking into account time integration scheme.
- virtual void Mass (real_t coef=1)

  Add consistent mass matrix to left-hand side after multiplication by `coef` *[Default:* `1`*].*
- virtual void LMass (real_t coef=1)

  Add lumped mass matrix to left-hand side after multiplication by `coef` *[Default:* `1`*].*

- virtual void Deviator (real_t coef=1)

  Add deviator matrix to left-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- virtual void Dilatation (real_t coef=1)

  Add dilatation matrix to left-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- virtual void DilatationToRHS (real_t coef=1)

  Add dilatation vector to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- virtual void DeviatorToRHS (real_t coef=1)

  Add deviator vector to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- virtual void StiffnessToRHS (real_t coef=1)

  Add stiffness matrix to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- void setDilatation ()

  Add dilatation matrix to left and/or right-hand side taking into account time.
- void setDeviator ()

  Add deviator matrix to left and/or right-hand side taking into account time integration scheme.
- void setStiffness ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.

- void ElementAssembly (PETScMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)
  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)
  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)
  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)
  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > ∗A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)
  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > ∗A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const
  Return number of element nodes.

- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > ∗A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Young (const real_t &E)

  Set (constant) Young modulus.
- void Young (const string &exp)

  Set Young modulus given by an algebraic expression.
- void Poisson (const real_t &nu)

  Set (constant) Poisson ratio.
- void Poisson (const string &exp)

  Set Poisson ratio given by an algebraic expression.
- void Density (const real_t &rho)

  Set (constant) density.
- void Density (const string &exp)

  Set density given by an algebraic expression.
- void setMaterial ()

Set material properties.

- void Init (const Element *el)

  Set element arrays to zero.

- void Init (const Side *sd)

  Set side arrays to zero.

7.3.1 Detailed Description

To build element equations for 3-D beam equations using 2-node lines.

This class enables building finite element arrays for 3-D beam elements using 6 degrees of freedom per node and 2-Node line elements.

7.3.2 Constructor & Destructor Documentation

Beam3DL2 (Element * *el*, real_t *A*, real_t *I1*, real_t *I2*)

Constructor using element data.

Parameters

in	*el*	Pointer to Element
in	*A*	Section area of the beam
in	*I1*	first (x) momentum of inertia
in	*I2*	second (y) momentum of inertia

Beam3DL2 (Element * *el*, real_t *A*, real_t *I1*, real_t *I2*, const Vect< real_t > & *u*, const real_t & *time* = *0*)

Constructor for dynamic problems.

Parameters

in	*el*	Pointer to Element
in	*A*	Section area of the beam
in	*I1*	first (x) momentum of inertia
in	*I2*	second (y) momentum of inertia
in	*u*	Vector containing previous solution (at previous time step)
in	*time*	Current time value

Beam3DL2 (Mesh & *ms*, const Vect< real_t > & *u*, Vect< real_t > & *d*)

Constructor to determine displacements.

The unknowns consist in planar and rotational degrees of freedom. This member function construct a 3-D node vector that gives the displacement vector at each node.

Parameters

in	*ms*	Mesh instance
in	*u*	Vector containing the solution vector

Parameters

out	*d*	Vector containing three components for each node that are x, y and z displacements.

7.3.3 Member Function Documentation

void buildEigen (SkSMatrix< real_t > & *K*, Vect< real_t > & *M*)

Build global stiffness and mass matrices for the eigen system.
Case where the mass matrix is lumped

Parameters

in	*K*	Stiffness matrix
in	*M*	Vector containing diagonal mass matrix

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) [inherited]

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) [inherited]

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by _theElement

void DiagBC (int *dof_type* = NODE_DOF, int *dof* = 0) [inherited]

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

`in`	*b*	Global vector to be localized
`in`	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
`in`	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0]`, `_x[1]`, ... which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0]`, `_x[1]`, ... which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & *A*) [inherited]

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & *b*) [inherited]

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * *A*) [inherited]

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) [inherited]

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & v) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * A) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *IDENT_PREC*) [inherited]

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: DIRECT_SOLVER, CG_SOLVER, GMRES_SOLVER • DIRECT_SOLVER, Use a facorization solver [default] • CG_SOLVER, Conjugate Gradient iterative solver • CGS_SOLVER, Squared Conjugate Gradient iterative solver • BICG_SOLVER, BiConjugate Gradient iterative solver • BICG_STAB_SOLVER, BiConjugate Gradient Stabilized iterative solver • GMRES_SOLVER, GMRES iterative solver • QMR_SOLVER, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • IDENT_PREC, Identity preconditioner (no preconditioning [default]) • DIAG_PREC, Diagonal preconditioner • ILU_PREC, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > * *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) [inherited]

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

7.3.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev [inherited]

LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.4 BiotSavart Class Reference

Class to compute the magnetic induction from the current density using the Biot-Savart formula.

Public Member Functions

- BiotSavart ()

  Default constructor.
- BiotSavart (Mesh &ms)

  Constructor using mesh data.
- BiotSavart (Mesh &ms, const Vect< real_t > &J, Vect< real_t > &B, int code=0)

  Constructor using mesh and vector of real current density.
- BiotSavart (Mesh &ms, const Vect< complex_t > &J, Vect< complex_t > &B, int code=0)

  Constructor using mesh and vector of complex current density.
- ~BiotSavart ()

  Destructor.
- void setCurrentDensity (const Vect< real_t > &J)

  Set (real) current density given at elements.
- void setCurrentDensity (const Vect< complex_t > &J)

  Set (real) current density given at elements.
- void setMagneticInduction (Vect< real_t > &B)

  Transmit (real) magnetic induction vector given at nodes.
- void setMagneticInduction (Vect< complex_t > &B)

  Transmit (complex) magnetic induction vector given at nodes.
- void selectCode (int code)

  Choose code of faces or edges at which current density is given.
- void setPermeability (real_t mu)

  Set the magnetic permeability coefficient.
- void setBoundary ()

  Choose to compute the magnetic induction at boundary nodes only.
- Point< real_t > getB3 (Point< real_t > x)

  Compute the real magnetic induction at a given point using the volume Biot-Savart formula.
- Point< real_t > getB2 (Point< real_t > x)

  Compute the real magnetic induction at a given point using the surface Biot-Savart formula.
- Point< real_t > getB1 (Point< real_t > x)

  Compute the real magnetic induction at a given point using the line Biot-Savart formula.
- Point< complex_t > getBC3 (Point< real_t > x)

  Compute the complex magnetic induction at a given point using the volume Biot-Savart formula.
- Point< complex_t > getBC2 (Point< real_t > x)

  Compute the complex magnetic induction at a given point using the surface Biot-Savart formula.
- Point< complex_t > getBC1 (Point< real_t > x)

  Compute the complex magnetic induction at a given point using the line Biot-Savart formula.
- int run ()

  Run the calculation by the Biot-Savart formula.

7.4.1 Detailed Description

Class to compute the magnetic induction from the current density using the Biot-Savart formula.

Given a current density vector given at elements, a collection of sides of edges (piecewise constant), this class enables computing the magnetic induction vector (continuous and piecewise linear) using the Ampere equation. This magnetic induction is obtained by using the Biot-Savart formula which can be either a volume, surface or line formula depending on the nature of the current density vector.

7.4.2 Constructor & Destructor Documentation

BiotSavart (Mesh & *ms*)

Constructor using mesh data.

Parameters

in	*ms*	Mesh instance

BiotSavart (Mesh & *ms*, const Vect< real_t > & *J*, Vect< real_t > & *B*, int *code* = *0*)

Constructor using mesh and vector of real current density.

The current density is assumed piecewise constant

Parameters

in	*ms*	Mesh instance
in	*J*	Sidewise vector of current density (`J` is a real valued vector), in the case of a surface supported current
in	*B*	Nodewise vector that contains, once the member function run is used, the magnetic induction
in	*code*	Only sides with given *code* support current [Default: `0`]

BiotSavart (Mesh & *ms*, const Vect< complex_t > & *J*, Vect< complex_t > & *B*, int *code* = *0*)

Constructor using mesh and vector of complex current density.

The current density is assumed piecewise constant

Parameters

in	*ms*	Mesh instance
in	*J*	Sidewise vector of current density (`J` is a complex valued vector), in the case of a surface supported current
in	*B*	Nodewise vector that contains, once the member function run is used, the magnetic induction
in	*code*	Only sides with given `code` support current [Default: `0`]

7.4.3 Member Function Documentation

void setCurrentDensity (const Vect< real_t > & *J*)

Set (real) current density given at elements.

The current density is assumed piecewise constant and real valued. This function can be used in the case of the volume Biot-Savart formula.

Parameters

in	*J*	Current density vector (Vect instance) and real entries

void setCurrentDensity (const Vect< complex_t > & *J*)

Set (real) current density given at elements.

The current density is assumed piecewise constant and complex valued. This function can be used in the case of the volume Biot-Savart formula.

Parameters

in	*J*	Current density vector (Vect instance) of complex entries

void setMagneticInduction (Vect< real_t > & *B*)

Transmit (real) magnetic induction vector given at nodes.

Parameters

out	*B*	Magnetic induction vector (Vect instance) and real entries

void setMagneticInduction (Vect< complex_t > & *B*)

Transmit (complex) magnetic induction vector given at nodes.

Parameters

out	*B*	Magnetic induction vector (Vect instance) and complex entries

void setPermeability (real_t *mu*)

Set the magnetic permeability coefficient.

Parameters

in	*mu*	Magnetic permeability

void setBoundary ( )

Choose to compute the magnetic induction at boundary nodes only.

By default the magnetic induction is computed (using the function run) at all mesh nodes

Note

This function has no effect for surface of line Biot-Savart formula

Point<real_t> getB3 (Point< real_t > *x*)

Compute the real magnetic induction at a given point using the volume Biot-Savart formula.

This function computes a real valued magnetic induction for a real valued current density field

Parameters

in	x	Coordinates of point at which the magnetic induction is computed

Returns

Value of the magnetic induction at x

Point<real_t> getB2 (Point< real_t > *x*)

Compute the real magnetic induction at a given point using the surface Biot-Savart formula.

This function computes a real valued magnetic induction for a real valued current density field

Parameters

in	x	Coordinates of point at which the magnetic induction is computed

Returns

Value of the magnetic induction at x

Point<real_t> getB1 (Point< real_t > *x*)

Compute the real magnetic induction at a given point using the line Biot-Savart formula.

This function computes a real valued magnetic induction for a real valued current density field

Parameters

in	x	Coordinates of point at which the magnetic induction is computed

Returns

Value of the magnetic induction at x

Point<complex_t> getBC3 (Point< real_t > x)

Compute the complex magnetic induction at a given point using the volume Biot-Savart formula.

This function computes a complex valued magnetic induction for a complex valued current density field

Parameters

in	x	Coordinates of point at which the magnetic induction is computed

Returns

Value of the magnetic induction at `x`

Point<complex_t> getBC2 (Point< real_t > x)

Compute the complex magnetic induction at a given point using the surface Biot-Savart formula.

This function computes a complex valued magnetic induction for a complex valued current density field

Parameters

in	x	Coordinates of point at which the magnetic induction is computed

Returns

Value of the magnetic induction at `x`

Point<complex_t> getBC1 (Point< real_t > x)

Compute the complex magnetic induction at a given point using the line Biot-Savart formula.

This function computes a complex valued magnetic induction for a complex valued current density field

Parameters

in	x	Coordinates of point at which the magnetic induction is computed

Returns

Value of the magnetic induction at `x`

int run ( )

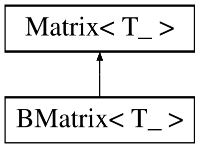
Run the calculation by the Biot-Savart formula.

This function computes the magnetic induction, which is stored in the vector `B` given in the constructor

7.5 BMatrix< T_ > Class Template Reference

To handle band matrices.

Inheritance diagram for BMatrix< T_ >:



Public Member Functions

- BMatrix ()

  Default constructor.
- BMatrix (size_t size, int ld, int ud)

  Constructor that for a band matrix with given size and bandwidth.
- BMatrix (const BMatrix &m)

  Copy Constructor.
- ∼BMatrix ()

  Destructor.
- void setSize (size_t size, int ld, int ud)

  Set size (number of rows) and storage of matrix.
- void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector x and add result to y
- void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector $a*x$ and add result to y
- void Mult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector x and save result in y
- void TMult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector x and save result in y
- void Axpy (T_ a, const BMatrix< T_ > &x)

  Add to matrix the product of a matrix by a scalar.
- void Axpy (T_ a, const Matrix< T_ > ∗x)

  Add to matrix the product of a matrix by a scalar.
- void set (size_t i, size_t j, const T_ &val)

  Add constant `val` to an entry `(i,j)` of the matrix.
- void add (size_t i, size_t j, const T_ &val)

  Add constant `val` value to an entry `(i,j)` of the matrix.
- T_ operator() (size_t i, size_t j) const

  Operator () (Constant version).
- T_ & operator() (size_t i, size_t j)

  Operator () (Non constant version).
- BMatrix< T_ > & operator= (const BMatrix< T_ > &m)

  Operator =.
- BMatrix< T_ > & operator= (const T_ &x)

  Operator = Assign matrix to identity times x.
- BMatrix< T_ > & operator∗= (const T_ &x)

Operator ∗=.

- BMatrix< T_ > & operator+= (const T_ &x)

  Operator +=.
- int setLU ()

  Factorize the matrix (LU factorization)
- int solve (Vect< T_ > &b)

  Solve linear system.
- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve linear system.
- T_ ∗ get () const

  Return C-Array.
- T_ get (size_t i, size_t j) const

  Return entry `(i,j)` of matrix.
- size_t getNbRows () const

  Return number of rows.
- size_t getNbColumns () const

  Return number of columns.
- void setPenal (real_t p)

  Set Penalty Parameter (For boundary condition prescription).
- void setDiagonal ()

  Set the matrix as diagonal.
- void setDiagonal (Mesh &mesh)

  Initialize matrix storage in the case where only diagonal terms are stored.
- T_ getDiag (size_t k) const

  Return `k`-th diagonal entry of matrix.
- size_t size () const

  Return matrix dimension (Number of rows and columns).
- void Assembly (const Element &el, T_ ∗a)

  Assembly of element matrix into global matrix.
- void Assembly (const Element &el, const DMatrix< T_ > &a)

  Assembly of element matrix into global matrix.
- void Assembly (const Side &sd, T_ ∗a)

  Assembly of side matrix into global matrix.
- void Assembly (const Side &sd, const DMatrix< T_ > &a)

  Assembly of side matrix into global matrix.
- void Prescribe (Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.
- void Prescribe (int dof, int code, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.
- void Prescribe (Vect< T_ > &b, int flag=0)

  Impose by a penalty method a homegeneous (=0) essential boundary condition.
- void Prescribe (size_t dof, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition when only one DOF is treated.
- void PrescribeSide ()

  Impose by a penalty method an essential boundary condition when DOFs are supported by sides.
- virtual int Factor ()=0

Factorize matrix. Available only if the storage class enables it.

- int FactorAndSolve (Vect< T_ > &b)

  Factorize matrix and solve the linear system.
- int FactorAndSolve (const Vect< T_ > &b, Vect< T_ > &x)

  Factorize matrix and solve the linear system.
- size_t getLength () const

  Return number of stored terms in matrix.
- int isDiagonal () const

  Say if matrix is diagonal or not.
- int isFactorized () const

  Say if matrix is factorized or not.
- virtual size_t getColInd (size_t i) const

  Return Column index for column `i` (See the description for class SpMatrix).
- virtual size_t getRowPtr (size_t i) const

  Return Row pointer for row `i` (See the description for class SpMatrix).
- T_ operator() (size_t i) const

  Operator () with one argument (Constant version).
- T_ & operator() (size_t i)

  Operator () with one argument (Non Constant version).
- T_ & operator[ ] (size_t k)

  Operator [] (Non constant version).
- T_ operator[ ] (size_t k) const

  Operator [] (Constant version).
- Matrix & operator+= (const Matrix< T_ > &m)

  Operator +=.
- Matrix & operator-= (const Matrix< T_ > &m)

  Operator -=.
- Matrix & operator-= (const T_ &x)

  Operator -=.

7.5.1 Detailed Description

template<class T_>
class OFELI::BMatrix< T_ >

To handle band matrices.

This class enables storing and manipulating band matrices. The matrix can have different numbers of lower and upper co-diagonals

Template Parameters

*T_*	Data type (double, float, complex<double>, ...)

7.5.2 Member Function Documentation

void setDiagonal (Mesh & *mesh*) `[inherited]`

Initialize matrix storage in the case where only diagonal terms are stored.
This member function is to be used for explicit time integration schemes

T_ getDiag (size_t *k*) const `[inherited]`

Return `k`-th diagonal entry of matrix.
First entry is given by **getDiag(1)**.

void Assembly (const Element & *el*, T_ ∗ *a*) `[inherited]`

Assembly of element matrix into global matrix.
Case where element matrix is given by a C-array.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a C-array

void Assembly (const Element & *el*, const DMatrix< T_ > & *a*) `[inherited]`

Assembly of element matrix into global matrix.
Case where element matrix is given by a DMatrix instance.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a DMatrix instance

void Assembly (const Side & *sd*, T_ ∗ *a*) `[inherited]`

Assembly of side matrix into global matrix.
Case where side matrix is given by a C-array.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a C-array instance

void Assembly (const Side & *sd*, const DMatrix< T_ > & *a*) `[inherited]`

Assembly of side matrix into global matrix.
Case where side matrix is given by a DMatrix instance.

Parameters

in	*sd*	Pointer to side instance

Parameters

in	*a*	Side matrix as a DMatrix instance

void Prescribe (Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) [inherited]

Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set**↩ **Penal**(..).

Parameters

in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (dof>0) or both matrix and right-hand side (dof=0, default value).

void Prescribe (int *dof*, int *code*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) [inherited]

Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set**↩ **Penal**(..).

Parameters

in	*dof*	Degree of freedom for which a boundary condition is to be enforced
in	*code*	Code for which a boundary condition is to be enforced
in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (dof>0) or both matrix and right-hand side (dof=0, default value).

void Prescribe (Vect< T_ > & *b*, int *flag* = *0*) [inherited]

Impose by a penalty method a homegeneous (=0) essential boundary condition.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty

parameter is defined by default equal to 1.e20. It can be modified by member function **set↩ Penal**(..).

Parameters

`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (size_t *dof*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition when only one DOF is treated.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. This gunction is to be used if only one DOF per node is treated in the linear system. The penalty parameter is by default equal to 1.e20. It can be modified by member function setPenal.

Parameters

`in`	*dof*	Label of the concerned degree of freedom (DOF).
`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void PrescribeSide ( ) `[inherited]`

Impose by a penalty method an essential boundary condition when DOFs are supported by sides.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set↩ Penal**(..).

int FactorAndSolve (Vect< T_ > & *b*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage cass enables it.

Parameters

`in,out`	*b*	Vect instance that contains right-hand side on input and solution on output

int FactorAndSolve (const Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage class enables it.

Parameters

in	b	Vect instance that contains right-hand side
out	x	Vect instance that contains solution

Returns

- `0` if solution was normally performed
- `n` if the n-th pivot is nul

int isFactorized ( ) const `[inherited]`

Say if matrix is factorized or not.
If the matrix was not factorized, the class does not allow solving by a direct solver.

T_ operator() (size_t *i*) const `[inherited]`

Operator () with one argument (Constant version).
Returns `i`-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	i	entry index

T_& operator() (size_t *i*) `[inherited]`

Operator () with one argument (Non Constant version).
Returns `i`-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	i	entry index

T_& operator[ ] (size_t *k*) `[inherited]`

Operator [] (Non constant version).
Returns `k`-th stored element in matrix Index `k` starts at `0`.

T_ operator[ ] (size_t *k*) const `[inherited]`

Operator [] (Constant version).
Returns `k`-th stored element in matrix Index `k` starts at `0`.

Matrix& operator+= (const Matrix< T_ > & *m*) `[inherited]`

Operator +=.

Add matrix `m` to current matrix instance.

Matrix& operator-= (const Matrix< T_ > & *m*) `[inherited]`

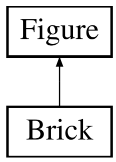
Operator -=.
Subtract matrix `m` from current matrix instance.

Matrix& operator-= (const T_ & *x*) `[inherited]`

Operator -=.
Subtract constant value `x` from all matrix entries.

7.6 Brick Class Reference

To store and treat a brick (parallelepiped) figure.
Inheritance diagram for Brick:



Public Member Functions

- Brick ()

  Default constructor.
- Brick (const Point< real_t > &bbm, const Point< real_t > &bbM, int code=1)

  Constructor.
- void setBoundingBox (const Point< real_t > &bbm, const Point< real_t > &bbM)

  Assign bounding box of the brick.
- Point< real_t > getBoundingBox1 () const

  Return first point of bounding box (xmin,ymin,zmin)
- Point< real_t > getBoundingBox2 () const

  Return second point of bounding box (xmax,ymax,zmax)
- real_t getSignedDistance (const Point< real_t > &p) const

  Return signed distance of a given point from the current brick.
- Brick & operator+= (Point< real_t > a)

  Operator +=.
- Brick & operator+= (real_t a)

  *Operator *=.*
- void setCode (int code)

  Choose a code for the domain defined by the figure.
- void getSignedDistance (const Grid &g, Vect< real_t > &d) const

  Calculate signed distance to current figure with respect to grid points.
- real_t dLine (const Point< real_t > &p, const Point< real_t > &a, const Point< real_t > &b) const

  Compute signed distance from a line.

7.6.1 Detailed Description

To store and treat a brick (parallelepiped) figure.

7.6.2 Constructor & Destructor Documentation

Brick (const Point< real_t > & *bbm*, const Point< real_t > & *bbM*, int *code* = *1*)

Constructor.

Parameters

in	*bbm*	first point (xmin,ymin,zmin)
in	*bbM*	second point (xmax,ymax,zmax)
in	*code*	Code to assign to rectangle

7.6.3 Member Function Documentation

void setBoundingBox (const Point< real_t > & *bbm*, const Point< real_t > & *bbM*)

Assign bounding box of the brick.

Parameters

in	*bbm*	first point (xmin,ymin,zmin)
in	*bbM*	second point (xmax,ymax,zmax)

real_t getSignedDistance (const Point< real_t > & *p*) const `[virtual]`

Return signed distance of a given point from the current brick.
The computed distance is negative if `p` lies in the brick, negative if it is outside, and 0 on its boundary

Parameters

in	*p*	Point<double> instance

Reimplemented from Figure.

Brick& operator+= (Point< real_t > *a*)

Operator +=.
Translate brick by a vector `a`

Brick& operator+= (real_t *a*)

Operator ∗=.
Scale brick by a factor `a`

void getSignedDistance (const Grid & *g*, Vect< real_t > & *d*) const `[inherited]`

Calculate signed distance to current figure with respect to grid points.

Parameters

in	*g*	Grid instance
in	*d*	Vect instance containing calculated distance from each grid index to Figure

Remarks

Vector `d` doesn't need to be sized before invoking this function

real_t dLine (const Point< real_t > & *p*, const Point< real_t > & *a*, const Point< real_t > & *b*) const `[inherited]`

Compute signed distance from a line.

Parameters

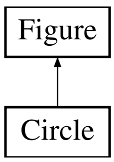
in	*p*	Point for which distance is computed
in	*a*	First vertex of line
in	*b*	Second vertex of line

Returns

Signed distance

7.7 Circle Class Reference

To store and treat a circular figure.
Inheritance diagram for Circle:



Public Member Functions

- Circle ()

  Default construcor.
- Circle (const Point< real_t > &c, real_t r, int code=1)

  Constructor.
- void setRadius (real_t r)

  Assign radius of circle.
- real_t getRadius () const

  Return radius of circle.

- void setCenter (const Point< real_t > &c)

  Assign coordinates of center of circle.
- Point< real_t > getCenter () const

  Return coordinates of center of circle.
- real_t getSignedDistance (const Point< real_t > &p) const

  Return signed distance of a given point from the current circle.
- Circle & operator+= (Point< real_t > a)

  Operator +=.
- Circle & operator+= (real_t a)

  Operator ∗=.
- void setCode (int code)

  Choose a code for the domain defined by the figure.
- void getSignedDistance (const Grid &g, Vect< real_t > &d) const

  Calculate signed distance to current figure with respect to grid points.
- real_t dLine (const Point< real_t > &p, const Point< real_t > &a, const Point< real_t > &b) const

  Compute signed distance from a line.

7.7.1 Detailed Description

To store and treat a circular figure.

7.7.2 Constructor & Destructor Documentation

Circle (const Point< real_t > & *c*, real_t *r*, int *code* = *1*)

Constructor.

Parameters

in	*c*	Coordinates of center of circle
in	*r*	Radius
in	*code*	Code to assign to the generated domain [Default: 1]

7.7.3 Member Function Documentation

real_t getSignedDistance (const Point< real_t > & *p*) const [virtual]

Return signed distance of a given point from the current circle.
The computed distance is negative if p lies in the disk, positive if it is outside, and 0 on the circle

Parameters

in	*p*	Point<double> instance

Reimplemented from Figure.

Circle& operator+= (Point< real_t > *a*)

Operator +=.
Translate circle by a vector `a`

Circle& operator+= (real_t *a*)

Operator ∗=.
Scale circle by a factor `a`

void getSignedDistance (const Grid & *g*, Vect< real_t > & *d*) const `[inherited]`

Calculate signed distance to current figure with respect to grid points.

Parameters

in	*g*	Grid instance
in	*d*	Vect instance containing calculated distance from each grid index to Figure

Remarks

Vector `d` doesn't need to be sized before invoking this function

real_t dLine (const Point< real_t > & *p*, const Point< real_t > & *a*, const Point< real_t > & *b*) const `[inherited]`

Compute signed distance from a line.

Parameters

in	*p*	Point for which distance is computed
in	*a*	First vertex of line
in	*b*	Second vertex of line

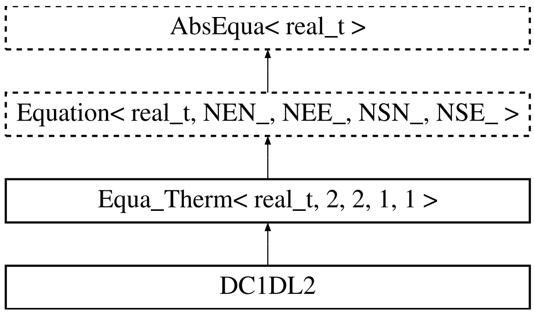
Returns

Signed distance

7.8 DC1DL2 Class Reference

Builds finite element arrays for thermal diffusion and convection in 1-D using 2-Node elements.

Inheritance diagram for DC1DL2:



Public Member Functions

- DC1DL2 ()

  Default Constructor.
- DC1DL2 (const Element ∗el)

  Constructor for an element.
- DC1DL2 (const Element ∗el, const Vect< real_t > &u, real_t time=0.)

  Constructor for an element (transient case).
- DC1DL2 (const Element ∗el, const Vect< real_t > &u, real_t time, real_t deltat, int scheme)

  Constructor for an element (transient case) with specification of time integration scheme.
- ∼DC1DL2 ()

  Destructor.
- void build ()

  Build the linear system without solving.
- void LCapacityToLHS (real_t coef=1)

  Add lumped capacity matrix to left-hand side after multiplying it by coefficient `coef`
- void LCapacityToRHS (real_t coef=1)

  Add lumped capacity contribution to right-hand side after multiplying it by coefficient `coef`
- void LCapacity (real_t coef)

  Add lumped capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`
- void CapacityToLHS (real_t coef=1)

  Add Consistent capacity matrix to left-hand side after multiplying it by coefficient `coef`*.*
- void CapacityToRHS (real_t coef=1)

  Add Consistent capacity contribution to right-hand side after multiplying it by coefficient `coef`
- void Capacity (real_t coef=1)

  Add Consistent capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`
- void Diffusion (real_t coef=1)

  Add diffusion matrix to left hand side after multiplying it by coefficient `coef`
- void DiffusionToRHS (real_t coef=1)

Add diffusion contribution to right hand side after multiplying it by coefficient `coef`

- void Convection (const real_t &v, real_t coef=1)

  Add convection matrix to left-hand side after multiplying it by coefficient `coef`
- void Convection (const Vect< real_t > &v, real_t coef=1)

  Add convection matrix to left-hand side after multiplying it by coefficient `coef`
- void Convection (real_t coef=1)

  Add convection matrix to left-hand side after multiplying it by coefficient `coef`
- void ConvectionToRHS (const real_t &v, real_t coef=1)

  Add convection contribution to right-hand side after multiplying it by coefficient `coef`
- void ConvectionToRHS (real_t coef=1)

  Add convection contribution to right-hand side after multiplying it by coefficient `coef`
- void BodyRHS (UserData< real_t > &ud, real_t coef=1)

  Add body right-hand side term to right hand side after multiplying it by coefficient `coef`
- void BodyRHS (const Vect< real_t > &b, int opt=GLOBAL_ARRAY)

  Add body right-hand side term to right hand side.
- void BoundaryRHS (UserData< real_t > &ud, real_t coef=1)

  Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`
- void BoundaryRHS (real_t flux)

  Add boundary right-hand side flux to right hand side.
- void BoundaryRHS (const Vect< real_t > &b, int opt=GLOBAL_ARRAY)

  Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`
- real_t Flux () const

  Return (constant) heat flux in element.
- void setInput (EqDataType opt, Vect< real_t > &u)

  Set equation input data.
- virtual void setStab ()

  Set stabilized formulation.
- void setLumpedCapacity ()

  Add lumped capacity contribution to left and right-hand sides taking into account time integration scheme.
- void setCapacity ()

  Add consistent capacity contribution to left and right-hand sides taking into account time integration scheme.
- void setDiffusion ()

  Add diffusion contribution to left and/or right-hand side taking into account time integration scheme.
- void setConvection ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void build (TimeStepping &s)

  Build the linear system of equations.
- void build (EigenProblemSolver &e)

  Build the linear system for an eigenvalue problem.
- int runTransient ()

  Run one time step.
- int runOneTimeStep ()

  Run one time step.
- int run ()

  Run the equation.
- void setRhoCp (const real_t &rhocp)

Set product of Density by Specific heat (constants)

- void setConductivity (const real_t &diff)

  Set (constant) thermal conductivity.
- void RhoCp (const string &exp)

  Set product of Density by Specific heat given by an algebraic expression.
- void Conduc (const string &exp)

  Set thermal conductivity given by an algebraic expression.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)

Assemble element matrix into global one.

- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > ∗A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > ∗A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > ∗A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void setMaterial ()

  Set material properties.
- void Init (const Element *el)

  Set element arrays to zero.
- void Init (const Side *sd)

  Set side arrays to zero.

7.8.1 Detailed Description

Builds finite element arrays for thermal diffusion and convection in 1-D using 2-Node elements.

Note that members calculating element arrays have as an argument a real `coef` that will be multiplied by the contribution of the current element. This makes possible testing different algorithms.

7.8.2 Constructor & Destructor Documentation

DC1DL2 ( )

Default Constructor.

Constructs an empty equation.

DC1DL2 (const Element * *el*, const Vect< real_t > & *u*, real_t *time* = `0.`)

Constructor for an element (transient case).

Parameters

el	[in] Pointer to element
u	[in] Vect instance that contains solution at previous time step
time	[in] Current time value (Default value is `0`)

DC1DL2 (const Element * *el*, const Vect< real_t > & *u*, real_t *time*, real_t *deltat*, int *scheme*)

Constructor for an element (transient case) with specification of time integration scheme.

Parameters

in	*el*	Pointer to element.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value (Default value is `0`).
in	*deltat*	Value of time step
in	*scheme*	Time Integration Scheme: • `FORWARD_EULER` for Forward Euler scheme • `BACKWARD_EULER` for Backward Euler scheme • `CRANK_NICOLSON` for Crank-Nicolson Euler scheme

7.8.3 Member Function Documentation

void LCapacityToLHS (real_t *coef* = *1*) `[virtual]`

Add lumped capacity matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [default: `1`]

Reimplemented from Equa_Therm< real_t, 2, 2, 1, 1 >.

void LCapacityToRHS (real_t *coef* = *1*) `[virtual]`

Add lumped capacity contribution to right-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [default: `1`]

Reimplemented from Equa_Therm< real_t, 2, 2, 1, 1 >.

void LCapacity (real_t *coef*)

Add lumped capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [default: `1`]

void CapacityToLHS (real_t *coef* = *1*) `[virtual]`

Add Consistent capacity matrix to left-hand side after multiplying it by coefficient `coef`.

Parameters

`in`	*coef*	Coefficient to multiply by added term [default: 1]

Reimplemented from Equa_Therm< real_t, 2, 2, 1, 1 >.

void CapacityToRHS (real_t *coef* = *1*) `[virtual]`

Add Consistent capacity contribution to right-hand side after multiplying it by coefficient `coef`

Parameters

`in`	*coef*	Coefficient to multiply by added term [default: 1]

Reimplemented from Equa_Therm< real_t, 2, 2, 1, 1 >.

void Capacity (real_t *coef* = *1*)

Add Consistent capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`

Parameters

`in`	*coef*	Coefficient to multiply by added term [default: 1]

void Diffusion (real_t *coef* = *1*) `[virtual]`

Add diffusion matrix to left hand side after multiplying it by coefficient `coef`

Parameters

`in`	*coef*	Coefficient to multiply by added term [default: 1]

Reimplemented from Equa_Therm< real_t, 2, 2, 1, 1 >.

void DiffusionToRHS (real_t *coef* = *1*) `[virtual]`

Add diffusion contribution to right hand side after multiplying it by coefficient `coef`
To be used for explicit diffusion term

Parameters

`in`	*coef*	Coefficient to multiply by added term [default: 1]

Reimplemented from Equa_Therm< real_t, 2, 2, 1, 1 >.

void Convection (const real_t & *v*, real_t *coef* = *1*)

Add convection matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

in	*v*	Constant velocity vector
in	*coef*	Coefficient to multiply by added term [default: 1]

void Convection (const Vect< real_t > & *v*, real_t *coef* = *1*)

Add convection matrix to left-hand side after multiplying it by coefficient `coef`
Case where velocity field is given by a vector `v`

Parameters

in	*v*	Velocity vector
in	*coef*	Coefficient to multiply by added term [default: 1]

void Convection (real_t *coef* = *1*) `[virtual]`

Add convection matrix to left-hand side after multiplying it by coefficient `coef`
Case where velocity field has been previouly defined

Parameters

in	*coef*	Coefficient to multiply by added term [default: 1]

Reimplemented from Equa_Therm< real_t, 2, 2, 1, 1 >.

void ConvectionToRHS (const real_t & *v*, real_t *coef* = *1*)

Add convection contribution to right-hand side after multiplying it by coefficient `coef`
To be used for explicit convection term.

Parameters

in	*v*	Velocity vector
in	*coef*	Coefficient to multiply by added term [default: 1]

void ConvectionToRHS (real_t *coef* = *1*) `[virtual]`

Add convection contribution to right-hand side after multiplying it by coefficient `coef`
Case where velocity field has been previouly defined

Parameters

in	*coef*	Coefficient to multiply by added term [default: 1]

Reimplemented from Equa_Therm< real_t, 2, 2, 1, 1 >.

void BodyRHS (UserData< real_t > & *ud*, real_t *coef* = *1* **)**

Add body right-hand side term to right hand side after multiplying it by coefficient `coef`

Parameters

in	*ud*	Instance of UserData or of a derived class. Contains a member function that provides body source.
in	*coef*	Coefficient to multiply by added term [default: 1]

void BodyRHS (const Vect< real_t > & *b*, int *opt* = GLOBAL_ARRAY) `[virtual]`

Add body right-hand side term to right hand side.

Parameters

in	*b*	Vector containing source at element nodes.
in	*opt*	Vector is local (`LOCAL_ARRAY`) with size 3 or global (`GLOBAL_ARRAY`) with size = Number of nodes [Default: `GLOBAL_ARRAY`].

Reimplemented from Equa_Therm< real_t, 2, 2, 1, 1 >.

void BoundaryRHS (UserData< real_t > & *ud*, real_t *coef* = *1* **)**

Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`

Parameters

in	*ud*	Instance of **UserData** or of an inherited class. Contains a member function that provides body source.
in	*coef*	Coefficient to multiply by added term [default: 1]

void BoundaryRHS (real_t *flux*)

Add boundary right-hand side flux to right hand side.

Parameters

in	*flux*	Vector containing source at side nodes.

void BoundaryRHS (const Vect< real_t > & *b*, int *opt* = GLOBAL_ARRAY) `[virtual]`

Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`

Parameters

Parameters

in	*b*	Vector containing source at side nodes.
in	*opt*	Vector is local (`LOCAL_ARRAY`) with size 3 or global (`GLOBAL_ARRAY`) with size = Number of nodes [Default: `GLOBAL_ARRAY`].

Reimplemented from Equa_Therm< real_t, 2, 2, 1, 1 >.

void setInput (EqDataType *opt*, Vect< real_t > & *u*)

Set equation input data.

Parameters

in	*opt*	Parameter that selects data type for input. This parameter is to be chosen in the enumerated variable EqDataType • `INITIAL_FIELD`: Initial temperature • `BOUNDARY_CONDITION_DATA`: Boundary condition (Dirichlet) • `SOURCE_DATA`: Heat source • `FLUX_DATA`: Heat flux (Neumann boundary condition) • `VELOCITY`: Velocity vector (for the convection term)
in	*u*	Vector containing input data

virtual void setStab ( ) `[virtual]`, `[inherited]`

Set stabilized formulation.
Stabilized variational formulations are to be used when the Pclet number is large. By default, no stabilization is used.

void build (TimeStepping & *s*) `[inherited]`

Build the linear system of equations.
Before using this function, one must have properly selected appropriate options for:

- The choice of a steady state or transient analysis. By default, the analysis is stationary
- In the case of transient analysis, the choice of a time integration scheme and a lumped or consistent capacity matrix. If transient analysis is chosen, the lumped capacity matrix option is chosen by default, and the implicit Euler scheme is used by default for time integration.

Parameters

in	*s*	Reference to used TimeStepping instance

void build (EigenProblemSolver & *e*) `[inherited]`

Build the linear system for an eigenvalue problem.

Parameters

`in`	*e*	Reference to used EigenProblemSolver instance

int runTransient ( ) `[inherited]`

Run one time step.

This function performs one time step in equation solving. It is to be used only if a *TRANSIENT* analysis is required.

Returns

Return error from the linear system solver

int runOneTimeStep ( ) `[inherited]`

Run one time step.

This function performs one time step in equation solving. It is identical to the function run↩ Transient.

Returns

Return error from the linear system solver

int run ( ) `[inherited]`

Run the equation.

If the analysis (see function setAnalysis) is `STEADY_STATE`, then the function solves the stationary equation.
If the analysis is `TRANSIENT`, then the function performs time stepping until the final time is reached.

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*el*	Reference to current element instance
`in`	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.
`in`	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & v) `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & A) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & b) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > ∗ A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *`IDENT_PREC`* **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > * *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

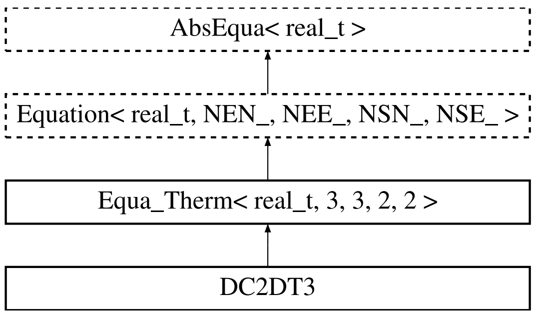
7.8.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

LocalVect instance containing local vector associated to current element.
This vector has been stored as the one at previous iteration or previous time step

7.9 DC2DT3 Class Reference

Builds finite element arrays for thermal diffusion and convection in 2-D domains using 3-Node triangles.
Inheritance diagram for DC2DT3:



Public Member Functions

- DC2DT3 ()
  Default Constructor. Constructs an empty equation.
- DC2DT3 (Mesh &ms)
  Constructor using Mesh data.
- DC2DT3 (Mesh &ms, Vect< real_t > &u)
  Constructor using Mesh and initial condition.
- DC2DT3 (const Element *el)
  Constructor for an element.
- DC2DT3 (const Side *sd)
  Constructor for a boundary side.
- DC2DT3 (const Element *el, const Vect< real_t > &u, real_t time=0.)
  Constructor for an element (transient case).

- DC2DT3 (const Element ∗el, const Vect< real_t > &u, real_t time, real_t deltat, int scheme)

  Constructor for an element (transient case) with specification of time integration scheme.
- DC2DT3 (const Side ∗sd, const Vect< real_t > &u, real_t time=0.)

  Constructor for a boundary side (transient case).
- DC2DT3 (const Side ∗sd, const Vect< real_t > &u, real_t time, real_t deltat, int scheme)

  Constructor for a side (transient case) with specification of time integration scheme.
- ∼DC2DT3 ()

  Destructor.
- void LCapacityToLHS (real_t coef=1)

  Add lumped capacity matrix to left-hand side after multiplying it by coefficient `coef`
- void LCapacityToRHS (real_t coef=1)

  Add lumped capacity contribution to right-hand side after multiplying it by coefficient `coef`
- void LCapacity (real_t coef)

  Add lumped capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`
- void CapacityToLHS (real_t coef=1)

  Add Consistent capacity matrix to left-hand side after multiplying it by coefficient `coef`
- void CapacityToRHS (real_t coef=1)

  Add Consistent capacity contribution to right-hand side after multiplying it by coefficient `coef`
- void Capacity (real_t coef=1)

  Add Consistent capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`
- void Diffusion (real_t coef=1)

  Add diffusion matrix to left-hand side after multiplying it by coefficient `coef`
- void Diffusion (const LocalMatrix< real_t, 2, 2 > &diff, real_t coef=1)

  Add diffusion matrix to left-hand side after multiplying it by coefficient `coef`
- void DiffusionToRHS (real_t coef=1)

  Add diffusion contribution to right-hand side after multiplying it by coefficient `coef` *To be used for explicit diffusion term.*
- void Convection (const Point< real_t > &v, real_t coef=1)

  Add convection matrix to left-hand side after multiplying it by coefficient `coef`
- void Convection (const Vect< real_t > &v, real_t coef=1)

  Add convection matrix to left-hand side after multiplying it by coefficient `coef`
- void Convection (real_t coef=1)

  Add convection matrix to left-hand side after multiplying it by coefficient `coef`
- void ConvectionToRHS (const Point< real_t > &v, real_t coef=1)

  Add convection contribution to right-hand side after multiplying it by coefficient `coef`
- void ConvectionToRHS (real_t coef=1)

  Add convection contribution to right-hand side after multiplying it by coefficient `coef`
- void LinearExchange (real_t coef, real_t T)

  Add an edge linear exchange term to left and right-hand sides.
- void BodyRHS (UserData< real_t > &ud, real_t coef=1)

  Add body right-hand side term to right hand side after multiplying it by coefficient `coef`
- void BodyRHS (const Vect< real_t > &bf, int opt=GLOBAL_ARRAY)

  Add body right-hand side term to right hand side.
- void BodyRHS (real_t bf)

  Add body right-hand side term to right hand side.
- void BoundaryRHS (UserData< real_t > &ud, real_t coef=1)

  Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`

- void BoundaryRHS (real_t flux)

  Add boundary right-hand side flux to right hand side.
- void BoundaryRHS (const Vect< real_t > &b, int opt=GLOBAL_ARRAY)

  Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`
- void Periodic (real_t coef=1.e20)

  Add contribution of periodic boundary condition (by a penalty technique).
- Point< real_t > & Flux () const

  Return (constant) heat flux in element.
- Point< real_t > & Grad (const LocalVect< real_t, 3 > &u) const

  Return gradient of a vector in element.
- Point< real_t > & Grad (const Vect< real_t > &u) const

  Return gradient of a vector in element.
- void setInput (EqDataType opt, Vect< real_t > &u)

  Set equation input data.
- void JouleHeating (const Vect< real_t > &sigma, const Vect< real_t > &psi)

  Set Joule heating term as source.
- void build ()

  Build the linear system of equations.
- virtual void setStab ()

  Set stabilized formulation.
- void setLumpedCapacity ()

  Add lumped capacity contribution to left and right-hand sides taking into account time integration scheme.
- void setCapacity ()

  Add consistent capacity contribution to left and right-hand sides taking into account time integration scheme.
- void setDiffusion ()

  Add diffusion contribution to left and/or right-hand side taking into account time integration scheme.
- void setConvection ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void build (EigenProblemSolver &e)

  Build the linear system for an eigenvalue problem.
- int runTransient ()

  Run one time step.
- int runOneTimeStep ()

  Run one time step.
- int run ()

  Run the equation.
- void setRhoCp (const real_t &rhocp)

  Set product of Density by Specific heat (constants)
- void setConductivity (const real_t &diff)

  Set (constant) thermal conductivity.
- void RhoCp (const string &exp)

  Set product of Density by Specific heat given by an algebraic expression.
- void Conduc (const string &exp)

  Set thermal conductivity given by an algebraic expression.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.

- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > *A)

  Assemble side (edge or face) matrix into global one.

- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > *A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void set (const Element ∗el)

  Run the equation.
- void setMaterial ()

  Set material properties.
- void Init (const Element ∗el)

  Set element arrays to zero.
- void Init (const Side ∗sd)

  Set side arrays to zero.

7.9.1 Detailed Description

Builds finite element arrays for thermal diffusion and convection in 2-D domains using 3-Node triangles.

Note that members calculating element arrays have as an argument a real `coef` that will be multiplied by the contribution of the current element. This makes possible testing different algorithms.

7.9.2 Constructor & Destructor Documentation

DC2DT3 (Mesh & *ms*)

Constructor using Mesh data.

Parameters

in	*ms*	Mesh instance

DC2DT3 (Mesh & *ms*, Vect< real_t > & *u*)

Constructor using Mesh and initial condition.

Parameters

in	*ms*	Mesh instance

Parameters

in	*u*	Vect instance containing initial solution

DC2DT3 (const Element ∗ *el*)

Constructor for an element.

Parameters

el	Pointer to Element instance

DC2DT3 (const Side ∗ *sd*)

Constructor for a boundary side.

Parameters

in	*sd*	Pointer to Side instance

DC2DT3 (const Element ∗ *el*, const Vect< real_t > & *u*, real_t *time* = `0.`)

Constructor for an element (transient case).

Parameters

in	*el*	Pointer to element
in	*u*	Vect instance that contains solution at previous time step
in	*time*	Current time value [Default: `0`]

DC2DT3 (const Element ∗ *el*, const Vect< real_t > & *u*, real_t *time*, real_t *deltat*, int *scheme*)

Constructor for an element (transient case) with specification of time integration scheme.

Parameters

in	*el*	Pointer to element.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value [Default: `0`].
in	*deltat*	Value of time step.
in	*scheme*	Time Integration Scheme: • `FORWARD_EULER` for Forward Euler scheme • `BACKWARD_EULER` for Backward Euler scheme • `CRANK_NICOLSON` for Crank-Nicolson Euler scheme

DC2DT3 (const Side * *sd*, const Vect< real_t > & *u*, real_t *time* = 0.)

Constructor for a boundary side (transient case).

Parameters

in	*sd*	Pointer to side.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value [Default: 0]

DC2DT3 (const Side * *sd*, const Vect< real_t > & *u*, real_t *time*, real_t *deltat*, int *scheme*)

Constructor for a side (transient case) with specification of time integration scheme.

Parameters

in	*sd*	Pointer to side.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value [Default: 0].
in	*deltat*	Value of time step.
in	*scheme*	Time Integration Scheme: • `FORWARD_EULER` for Forward Euler scheme • `BACKWARD_EULER` for Backward Euler scheme • `CRANK_NICOLSON` for Crank-Nicolson Euler scheme

7.9.3 Member Function Documentation

void LCapacityToLHS (real_t *coef* = 1) [virtual]

Add lumped capacity matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void LCapacityToRHS (real_t *coef* = 1) [virtual]

Add lumped capacity contribution to right-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void LCapacity (real_t *coef*)

Add lumped capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1]

void CapacityToLHS (real_t *coef* = *1*) [virtual]

Add Consistent capacity matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1]

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void CapacityToRHS (real_t *coef* = *1*) [virtual]

Add Consistent capacity contribution to right-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1]

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void Capacity (real_t *coef* = *1*)

Add Consistent capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

void Diffusion (real_t *coef* = *1*) [virtual]

Add diffusion matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1]

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void Diffusion (const LocalMatrix< real_t, 2, 2 > & *diff*, real_t *coef* = *1*)

Add diffusion matrix to left-hand side after multiplying it by coefficient `coef`
Case where the diffusivity matrix is given as an argument.

Parameters

in	*diff*	Diffusion matrix (class LocalMatrix).
in	*coef*	Coefficient to multiply by added term [Default: 1]

void DiffusionToRHS (real_t *coef* = *1*) `[virtual]`

Add diffusion contribution to right-hand side after multiplying it by coefficient `coef` To be used for explicit diffusion term.

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1]

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void Convection (const Point< real_t > & *v*, real_t *coef* = *1*)

Add convection matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

in	*v*	Constant velocity vector
in	*coef*	Coefficient to multiply by added term [Default: 1]

void Convection (const Vect< real_t > & *v*, real_t *coef* = *1*)

Add convection matrix to left-hand side after multiplying it by coefficient `coef`
Case where velocity field is given by a vector `v`

Parameters

in	*v*	Velocity vector
in	*coef*	Coefficient to multiply by added term (Default: 1]

void Convection (real_t *coef* = *1*) `[virtual]`

Add convection matrix to left-hand side after multiplying it by coefficient `coef`
Case where velocity field has been previously defined

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1]

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void ConvectionToRHS (const Point< real_t > & *v*, real_t *coef* = *1*)

Add convection contribution to right-hand side after multiplying it by coefficient `coef`
To be used for explicit convection term.

Parameters

in	*v*	Velocity vector
in	*coef*	Coefficient to multiply by added term [Default: 1]

void ConvectionToRHS (real_t *coef* = *1*) `[virtual]`

Add convection contribution to right-hand side after multiplying it by coefficient `coef`
Case where velocity field has been previouly defined

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1]

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void LinearExchange (real_t *coef*, real_t *T*)

Add an edge linear exchange term to left and right-hand sides.

Parameters

in	*coef*	Coefficient of exchange
in	*T*	External value for exchange

Remarks

This assumes a constant value of `T`

void BodyRHS (UserData< real_t > & *ud*, real_t *coef* = *1*)

Add body right-hand side term to right hand side after multiplying it by coefficient `coef`

Parameters

in	*ud*	Instance of UserData or of a derived class. Contains a member function that provides body source.
in	*coef*	Coefficient to multiply by added term [Default: 1]

void BodyRHS (const Vect< real_t > & *bf*, int *opt* = GLOBAL_ARRAY) `[virtual]`

Add body right-hand side term to right hand side.

Parameters

in	*bf*	Vector containing source at element nodes.
in	*opt*	Vector is local (`LOCAL_ARRAY`) with size 3 or global (`GLOBAL_ARRAY`) with size = Number of nodes [Default: `GLOBAL_ARRAY`].

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void BodyRHS (real_t *bf*)

Add body right-hand side term to right hand side.
Case where the body right-hand side is piecewise constant.

Parameters

in	*bf*	Value of thermal source (Constant in element).

void BoundaryRHS (UserData< real_t > & *ud*, real_t *coef* = *1*)

Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`

Parameters

in	*ud*	Instance of UserData or of an inherited class. Contains a member function that provides body source.
in	*coef*	Coefficient to multiply by added term [Default: 1]

void BoundaryRHS (real_t *flux*)

Add boundary right-hand side flux to right hand side.

Parameters

in	*flux*	Vector containing source at side nodes.

void BoundaryRHS (const Vect< real_t > & *b*, int *opt* = GLOBAL_ARRAY) `[virtual]`

Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`

Parameters

in	*b*	Vector containing source at side nodes
in	*opt*	Vector is local (`LOCAL_ARRAY`) with size 2 or global (`GLOBAL_ARRAY`) with size = Number of nodes [Default: `GLOBAL_ARRAY`].

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void Periodic (real_t *coef* = 1.e20)

Add contribution of periodic boundary condition (by a penalty technique).

Boundary nodes where periodic boundary conditions are to be imposed must have codes equal to `PERIODIC_A` on one side and `PERIODIC_B` on the opposite side.

Parameters

in	*coef*	Value of penalty parameter [Default: `1.e20`]

Point<real_t>& Grad (const LocalVect< real_t, 3 > & *u*) const

Return gradient of a vector in element.

Parameters

in	*u*	Vector for which gradient is computed.

Point<real_t>& Grad (const Vect< real_t > & *u*) const

Return gradient of a vector in element.

Parameters

in	*u*	Global vector for which gradient is computed. Vector `u` has as size the total number of nodes

void setInput (EqDataType *opt*, Vect< real_t > & *u*)

Set equation input data.

Parameters

in	*opt*	Parameter to select type of input (enumerated values) • `INITIAL_FIELD`: Initial temperature • `BOUNDARY_CONDITION_DATA`: Boundary condition (Dirichlet) • `SOURCE_DATA`: Heat source • `FLUX_DATA`: Heat flux (Neumann boundary condition) • `VELOCITY_FIELD`: Velocity vector (for the convection term)
in	*u*	Vector containing input data

void JouleHeating (const Vect< real_t > & *sigma*, const Vect< real_t > & *psi*)

Set Joule heating term as source.

Parameters

`in`	*sigma*	Vect instance containing electric conductivity (elementwise)
`in`	*psi*	Vect instance containing electric potential (elementwise)

void build ( )

Build the linear system of equations.
Before using this function, one must have properly selected appropriate options for:

- The choice of a steady state or transient analysis. By default, the analysis is stationary
- In the case of transient analysis, the choice of a time integration scheme and a lumped or consistent capacity matrix. If transient analysis is chosen, the lumped capacity matrix option is chosen by default, and the implicit Euler scheme is used by default for time integration.

void set (const Element ∗ *el*) `[protected]`

Run the equation.
If the analysis (see function setAnalysis) is `STEADY_STATE`, then the function solves the stationary equation.
If the analysis is `TRANSIENT`, then the function performs time stepping until the final time is reached.

virtual void setStab ( ) `[virtual]`, `[inherited]`

Set stabilized formulation.
Stabilized variational formulations are to be used when the Pclet number is large.
By default, no stabilization is used.

void build (EigenProblemSolver & *e*) `[inherited]`

Build the linear system for an eigenvalue problem.

Parameters

`in`	*e*	Reference to used EigenProblemSolver instance

int runTransient ( ) `[inherited]`

Run one time step.
This function performs one time step in equation solving. It is to be used only if a *TRANSIENT* analysis is required.

Returns

Return error from the linear system solver

int runOneTimeStep ( ) `[inherited]`

Run one time step.

This function performs one time step in equation solving. It is identical to the function run↩ Transient.

Returns

Return error from the linear system solver

int run ( ) `[inherited]`

Run the equation.

If the analysis (see function setAnalysis) is `STEADY_STATE`, then the function solves the stationary equation.
If the analysis is `TRANSIENT`, then the function performs time stepping until the final time is reached.

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = *NODE_FIELD*, int *flag* = *0*) [inherited]

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *IDENT_PREC* **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > ∗ *A*, Vect< real_t > & *b*, Vect< real_t > & *x*)
`[inherited]`

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

7.9.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

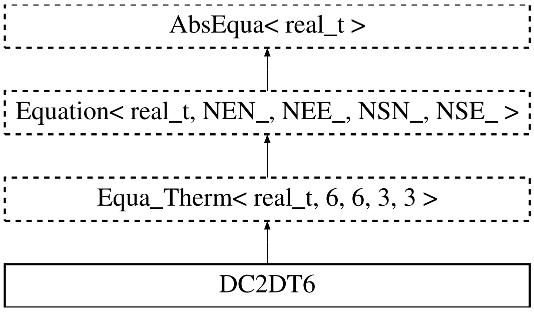
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.10 DC2DT6 Class Reference

Builds finite element arrays for thermal diffusion and convection in 2-D domains using 6-Node triangles.

Inheritance diagram for DC2DT6:



Public Member Functions

- DC2DT6 ()

  Default Constructor.
- DC2DT6 (const Element ∗el)

  Constructor for an element.
- DC2DT6 (const Side ∗sd)

  Constructor for a boundary side.
- DC2DT6 (const Element ∗el, const Vect< real_t > &u, real_t time=0.)

  Constructor for an element (Transient case).
- DC2DT6 (const Element ∗el, const Vect< real_t > &u, real_t time, real_t deltat, int scheme)

  Constructor for an element (transient case) with specification of time integration scheme.
- DC2DT6 (const Side ∗sd, const Vect< real_t > &u, real_t time=0.)

  Constructor for a boundary side (transient case).
- DC2DT6 (const Side ∗sd, const Vect< real_t > &u, real_t time, real_t deltat, int scheme)

  Constructor for a side (transient case) with specification of time integration scheme.
- ∼DC2DT6 ()

  Destructor.
- void Diffusion (real_t coef=1)

  Add diffusion matrix to left hand side after multiplying it by coefficient `coef`
- void Convection (real_t coef=1)

  Add convection matrix to left-hand side after multiplying it by coefficient `coef`
- void Convection (Point< real_t > &v, real_t coef=1)

  Add convection matrix to left hand side after multiplying it by coefficient `coef`
- void Convection (const Vect< real_t > &v, real_t coef=1)

  Add convection matrix to left-hand side after multiplying it by coefficient `coef`
- void BodyRHS (const Vect< real_t > &b, int opt=GLOBAL_ARRAY)

  Add body right-hand side term to right hand side.
- void BoundaryRHS (const Vect< real_t > &sf, int opt=GLOBAL_ARRAY)

  Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`
- virtual void setStab ()

Set stabilized formulation.
- virtual void LCapacityToLHS (real_t coef=1)

  Add lumped capacity contribution to left-hand side.
- virtual void LCapacityToRHS (real_t coef=1)

  Add lumped capacity contribution to right-hand side.
- virtual void CapacityToLHS (real_t coef=1)

  Add consistent capacity contribution to left-hand side.
- virtual void CapacityToRHS (real_t coef=1)

  Add consistent capacity contribution to right-hand side.
- void setLumpedCapacity ()

  Add lumped capacity contribution to left and right-hand sides taking into account time integration scheme.
- void setCapacity ()

  Add consistent capacity contribution to left and right-hand sides taking into account time integration scheme.
- virtual void DiffusionToRHS (real_t coef=1.)

  Add diffusion term to right-hand side.
- void setDiffusion ()

  Add diffusion contribution to left and/or right-hand side taking into account time integration scheme.
- virtual void ConvectionToRHS (real_t coef=1.)

  Add convection term to right-hand side.
- void setConvection ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void build ()

  Build the linear system of equations.
- void build (TimeStepping &s)

  Build the linear system of equations.
- void build (EigenProblemSolver &e)

  Build the linear system for an eigenvalue problem.
- int runTransient ()

  Run one time step.
- int runOneTimeStep ()

  Run one time step.
- int run ()

  Run the equation.
- void setRhoCp (const real_t &rhocp)

  Set product of Density by Specific heat (constants)
- void setConductivity (const real_t &diff)

  Set (constant) thermal conductivity.
- void RhoCp (const string &exp)

  Set product of Density by Specific heat given by an algebraic expression.
- void Conduc (const string &exp)

  Set thermal conductivity given by an algebraic expression.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

Update element matrix to impose bc by diagonalization technique.

- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.

- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.

- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.

- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.

- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.

- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.

- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.

- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.

- void SideNodeCoordinates ()

  Localize coordinates of side nodes.

- void ElementAssembly (Matrix< real_t > ∗A)

  Assemble element matrix into global one.

- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.

- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.

- void ElementAssembly (BMatrix< real_t > &A)

  Assemble element matrix into global one.

- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.

- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.

- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.

- void ElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one.

- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.

- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.

- void SideAssembly (PETScVect< real_t > &b)

  Assemble side right-hand side vector into global one.

- void SideAssembly (Matrix< real_t > ∗A)

  Assemble side (edge or face) matrix into global one.

- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.

- void SideAssembly (SkMatrix< real_t > &A)

Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > ∗A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > ∗A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

LocalVect instance containing local right-hand side vector associated to current element.

- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void setMaterial ()

  Set material properties.
- void Init (const Element ∗el)

  Set element arrays to zero.
- void Init (const Side ∗sd)

  Set side arrays to zero.

7.10.1 Detailed Description

Builds finite element arrays for thermal diffusion and convection in 2-D domains using 6-Node triangles.

Note that members calculating element arrays have as an argument a real `coef` that will be multiplied by the contribution of the current element. This makes possible testing different algorithms.

7.10.2 Constructor & Destructor Documentation

DC2DT6 ( )

Default Constructor.

Constructs an empty equation.

DC2DT6 (const Element ∗ *el*)

Constructor for an element.

Parameters

`in`	*el*	Pointer to element.

DC2DT6 (const Side ∗ *sd*)

Constructor for a boundary side.

Parameters

`in`	*sd*	Pointer to side.

DC2DT6 (const Element ∗ *el*, const Vect< real_t > & *u*, real_t *time* = `0.`)

Constructor for an element (Transient case).

Parameters

in	*el*	Pointer to element.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value [Default: 0].

DC2DT6 (const Element * *el*, const Vect< real_t > & *u*, real_t *time*, real_t *deltat*, int *scheme*)

Constructor for an element (transient case) with specification of time integration scheme.

Parameters

in	*el*	Pointer to element.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value [Default: 1]
in	*deltat*	Value of time step
in	*scheme*	Time Integration Scheme: • `FORWARD_EULER`: Forward Euler scheme • `BACKWARD_EULER`: Backward Euler scheme, • `CRANK_NICOLSON`: Crank-Nicolson Euler scheme.

DC2DT6 (const Side * *sd*, const Vect< real_t > & *u*, real_t *time* = 0.)

Constructor for a boundary side (transient case).

Parameters

in	*sd*	Pointer to side.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value [Default: 0].

DC2DT6 (const Side * *sd*, const Vect< real_t > & *u*, real_t *time*, real_t *deltat*, int *scheme*)

Constructor for a side (transient case) with specification of time integration scheme.

Parameters

in	*sd*	Pointer to side.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value
in	*deltat*	Value of time step

Parameters

in	*scheme*	Time Integration Scheme: To be chosen among the enumerated values: • `FORWARD_EULER`: Forward Euler scheme • `BACKWARD_EULER`: Backward Euler scheme, • `CRANK_NICOLSON`: Crank-Nicolson Euler scheme.

7.10.3 Member Function Documentation

void Diffusion (real_t *coef* = *1*) `[virtual]`

Add diffusion matrix to left hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Therm< real_t, 6, 6, 3, 3 >.

void Convection (real_t *coef* = *1*) `[virtual]`

Add convection matrix to left-hand side after multiplying it by coefficient `coef`
Case where velocity field has been previouly defined

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Therm< real_t, 6, 6, 3, 3 >.

void Convection (Point< real_t > & *v*, real_t *coef* = *1*)

Add convection matrix to left hand side after multiplying it by coefficient `coef`

Parameters

in	*v*	Constant velocity vector.
in	*coef*	Coefficient to multiply by added term [Default: 1].

void Convection (const Vect< real_t > & *v*, real_t *coef* = *1*)

Add convection matrix to left-hand side after multiplying it by coefficient `coef`
Case where velocity field is given by a vector `v`

Parameters

in	*v*	Velocity vector.

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

void BodyRHS (const Vect< real_t > & *b*, int *opt* = GLOBAL_ARRAY) [virtual]

Add body right-hand side term to right hand side.

Parameters

in	*b*	Local vector (of size 6) containing source at element nodes
in	*opt*	Vector is local (LOCAL_ARRAY) with size 6 or global (GLOBAL_ARRAY) with size = Number of nodes [Default: GLOBAL_ARRAY].

Reimplemented from Equa_Therm< real_t, 6, 6, 3, 3 >.

void BoundaryRHS (const Vect< real_t > & *sf*, int *opt* = GLOBAL_ARRAY) [virtual]

Add boundary right-hand side term to right hand side after multiplying it by coefficient coef

Parameters

in	*sf*	Vector containing source at side nodes
in	*opt*	Vector is local (LOCAL_ARRAY) with size 3 or global (GLOBAL_ARRAY) with size = Number of nodes [Default: GLOBAL_ARRAY].

Reimplemented from Equa_Therm< real_t, 6, 6, 3, 3 >.

virtual void setStab ( ) [virtual], [inherited]

Set stabilized formulation.

Stabilized variational formulations are to be used when the Pclet number is large. By default, no stabilization is used.

virtual void LCapacityToLHS (real_t *coef* = *1*) [virtual], [inherited]

Add lumped capacity contribution to left-hand side.

Parameters

in	*coef*	coefficient to multiply by the matrix before adding [Default: 1]

virtual void LCapacityToRHS (real_t *coef* = *1*) [virtual], [inherited]

Add lumped capacity contribution to right-hand side.

Parameters

in	*coef*	coefficient to multiply by the vector before adding [Default: 1]

virtual void CapacityToLHS (real_t *coef* = *1*) `[virtual], [inherited]`

Add consistent capacity contribution to left-hand side.

Parameters

`in`	*coef*	coefficient to multiply by the matrix before adding [Default: `1`]

virtual void CapacityToRHS (real_t *coef* = *1*) `[virtual], [inherited]`

Add consistent capacity contribution to right-hand side.

Parameters

`in`	*coef*	coefficient to multiply by the vector before adding [Default: `1`]

void build ( ) `[inherited]`

Build the linear system of equations.
Before using this function, one must have properly selected appropriate options for:

- The choice of a steady state or transient analysis. By default, the analysis is stationary
- In the case of transient analysis, the choice of a time integration scheme and a lumped or consistent capacity matrix. If transient analysis is chosen, the lumped capacity matrix option is chosen by default, and the implicit Euler scheme is used by default for time integration.

void build (TimeStepping & *s*) `[inherited]`

Build the linear system of equations.
Before using this function, one must have properly selected appropriate options for:

- The choice of a steady state or transient analysis. By default, the analysis is stationary
- In the case of transient analysis, the choice of a time integration scheme and a lumped or consistent capacity matrix. If transient analysis is chosen, the lumped capacity matrix option is chosen by default, and the implicit Euler scheme is used by default for time integration.

Parameters

`in`	*s*	Reference to used TimeStepping instance

void build (EigenProblemSolver & *e*) `[inherited]`

Build the linear system for an eigenvalue problem.

Parameters

in	*e*	Reference to used EigenProblemSolver instance

int runTransient ( ) `[inherited]`

Run one time step.

This function performs one time step in equation solving. It is to be used only if a *TRANSIENT* analysis is required.

Returns

Return error from the linear system solver

int runOneTimeStep ( ) `[inherited]`

Run one time step.

This function performs one time step in equation solving. It is identical to the function run↩ Transient.

Returns

Return error from the linear system solver

int run ( ) `[inherited]`

Run the equation.

If the analysis (see function setAnalysis) is `STEADY_STATE`, then the function solves the stationary equation.
If the analysis is `TRANSIENT`, then the function performs time stepping until the final time is reached.

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.
`in`	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > ∗ *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & v) `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & A) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & b) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *`IDENT_PREC`* **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > ∗ *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

`in`	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	*b*	Vector containing right-hand side
`in,out`	*x*	Vector containing initial guess of solution on input, actual solution on output

7.10.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

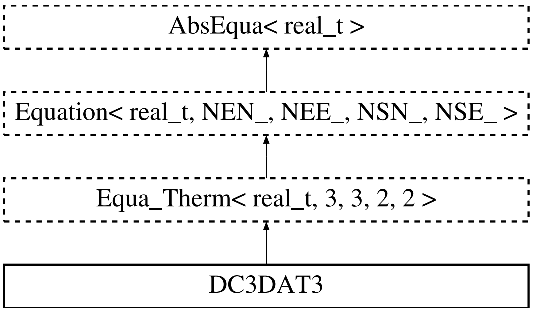
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.11 DC3DAT3 Class Reference

Builds finite element arrays for thermal diffusion and convection in 3-D domains with axisymmetry using 3-Node triangles.

Inheritance diagram for DC3DAT3:



Public Member Functions

- DC3DAT3 ()

  Default Constructor.
- DC3DAT3 (const Element ∗el)

  Constructor for an element.
- DC3DAT3 (const Side ∗sd)

  Constructor for a boundary side.
- DC3DAT3 (const Element ∗el, const Vect< real_t > &u, real_t time=0.)

  Constructor for an element (transient case).
- DC3DAT3 (const Element ∗el, const Vect< real_t > &u, real_t time, real_t deltat, int scheme)

  Constructor for an element (transient case) with specification of time integration scheme.
- DC3DAT3 (const Side ∗sd, const Vect< real_t > &u, real_t time=0.)

  Constructor for a boundary side (transient case).

- DC3DAT3 (const Side ∗sd, const Vect< real_t > &u, real_t time, real_t deltat, int scheme)

  Constructor for a side (transient case) with specification of time integration scheme.
- ∼DC3DAT3 ()

  Destructor.
- void LCapacityToLHS (real_t coef=1)

  Add lumped capacity matrix to left-hand side after multiplying it by coefficient `coef`.
- void LCapacityToRHS (real_t coef=1)

  Add lumped capacity contribution to right-hand side after multiplying it by coefficient `coef`.
- void LCapacity (real_t coef=1)

  Add lumped capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`
- void CapacityToLHS (real_t coef=1)

  Add Consistent capacity matrix to left-hand side after multiplying it by coefficient`coef`
- void CapacityToRHS (real_t coef=1)

  Add Consistent capacity contribution to right-hand side after multiplying it by coefficient `coef`.
- void Capacity (real_t coef=1)

  Add Consistent capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`.
- void Diffusion (real_t coef=1)

  Add diffusion matrix to left-hand side after multiplying it by coefficient `coef`
- void Diffusion (const LocalMatrix< real_t, 2, 2 > &diff, real_t coef=1)

  Add diffusion matrix to left-hand side after multiplying it by coefficient `coef`
- void DiffusionToRHS (real_t coef=1)

  Add diffusion contribution to right-hand side after multiplying it by coefficient `coef`
- void BodyRHS (UserData< real_t > &ud)

  Add body right-hand side term to right-hand side after multiplying it by coefficient `coef`
- void BodyRHS (const Vect< real_t > &b, int opt=GLOBAL_ARRAY)

  Add body right-hand side term to right hand side.
- void BoundaryRHS (real_t flux)

  Add boundary right-hand side term to right hand side.
- void BoundaryRHS (const Vect< real_t > &sf, int opt=GLOBAL_ARRAY)

  Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`
- Point< real_t > & Grad (const Vect< real_t > &u)

  Return gradient of a vector in element.
- void build ()

  Build the linear system without solving.
- virtual void setStab ()

  Set stabilized formulation.
- void setLumpedCapacity ()

  Add lumped capacity contribution to left and right-hand sides taking into account time integration scheme.
- void setCapacity ()

  Add consistent capacity contribution to left and right-hand sides taking into account time integration scheme.
- void setDiffusion ()

  Add diffusion contribution to left and/or right-hand side taking into account time integration scheme.
- virtual void Convection (real_t coef=1.)

  Add convection term to left-hand side.
- virtual void ConvectionToRHS (real_t coef=1.)

  Add convection term to right-hand side.

- void setConvection ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void build (TimeStepping &s)

  Build the linear system of equations.
- void build (EigenProblemSolver &e)

  Build the linear system for an eigenvalue problem.
- int runTransient ()

  Run one time step.
- int runOneTimeStep ()

  Run one time step.
- int run ()

  Run the equation.
- void setRhoCp (const real_t &rhocp)

  Set product of Density by Specific heat (constants)
- void setConductivity (const real_t &diff)

  Set (constant) thermal conductivity.
- void RhoCp (const string &exp)

  Set product of Density by Specific heat given by an algebraic expression.
- void Conduc (const string &exp)

  Set thermal conductivity given by an algebraic expression.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.

- void ElementAssembly (PETScMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)
  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)
  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)
  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)
  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > *A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)
  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > *A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const
  Return number of element nodes.

- size_t getNbEq () const
  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)
  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)
  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)
  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const
  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()
  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)
  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > ∗A, Vect< real_t > &b, Vect< real_t > &x)
  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat
  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat
  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev
  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS
  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes
  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS
  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void setMaterial ()
  Set material properties.
- void Init (const Element ∗el)
  Set element arrays to zero.
- void Init (const Side ∗sd)
  Set side arrays to zero.

7.11.1 Detailed Description

Builds finite element arrays for thermal diffusion and convection in 3-D domains with axisymmetry using 3-Node triangles.

Note that members calculating element arrays have as an argument a real `coef` that will be multiplied by the contribution of the current element. This makes possible testing different algorithms.

7.11.2 Constructor & Destructor Documentation

DC3DAT3 ( )

Default Constructor.
Constructs an empty equation.

DC3DAT3 (const Element * *el*)

Constructor for an element.

Parameters

in	*el*	Pointer to element.

DC3DAT3 (const Side * *sd*)

Constructor for a boundary side.

Parameters

in	*sd*	Pointer to side.

DC3DAT3 (const Element * *el*, const Vect< real_t > & *u*, real_t *time* = `0.`)

Constructor for an element (transient case).

Parameters

in	*el*	Pointer to element
in	*u*	Vect instance that contains solution at previous time step
in	*time*	Current time value [Default: `0`]

DC3DAT3 (const Element * *el*, const Vect< real_t > & *u*, real_t *time*, real_t *deltat*, int *scheme*)

Constructor for an element (transient case) with specification of time integration scheme.

Parameters

in	*el*	Pointer to element.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value.
in	*deltat*	Value of time step
in	*scheme*	Time Integration Scheme (): • `FORWARD_EULER` for Forward Euler scheme, `BACKWARD_EULER` for Backward Euler scheme, • `CRANK_NICOLSON` for Crank-Nicolson Euler scheme.

DC3DAT3 (const Side ∗ *sd*, **const Vect**< **real_t** > **&** *u*, **real_t** *time* = `0.` **)**

Constructor for a boundary side (transient case).

Parameters

`in`	*sd*	Pointer to side
`in`	*u*	Vect instance that contains solution at previous time step
`in`	*time*	Current time value [Default: `0`]

DC3DAT3 (const Side ∗ *sd*, **const Vect**< **real_t** > **&** *u*, **real_t** *time*, **real_t** *deltat*, **int** *scheme* **)**

Constructor for a side (transient case) with specification of time integration scheme.

Parameters

`in`	*sd*	Pointer to side
`in`	*u*	Vect instance that contains solution at previous time step.
`in`	*time*	Current time value.
`in`	*deltat*	Value of time step
`in`	*scheme*	Time Integration Scheme (enumerated values) : • `FORWARD_EULER`: Forward Euler scheme • `BACKWARD_EULER`: Backward Euler scheme • `CRANK_NICOLSON`: Crank-Nicolson Euler scheme

7.11.3 Member Function Documentation

void LCapacityToLHS (real_t *coef* = *1* **)** `[virtual]`

Add lumped capacity matrix to left-hand side after multiplying it by coefficient `coef`.

Parameters

`in`	*coef*	Coefficient to multiply by added term [Default: `1`].

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void LCapacityToRHS (real_t *coef* = *1* **)** `[virtual]`

Add lumped capacity contribution to right-hand side after multiplying it by coefficient `coef`.

Parameters

`in`	*coef*	Coefficient to multiply by added term [Default: `1`].

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void LCapacity (real_t *coef* = *1*)

Add lumped capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

void CapacityToLHS (real_t *coef* = *1*) `[virtual]`

Add Consistent capacity matrix to left-hand side after multiplying it by coefficient`coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void CapacityToRHS (real_t *coef* = *1*) `[virtual]`

Add Consistent capacity contribution to right-hand side after multiplying it by coefficient `coef`.

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void Capacity (real_t *coef* = *1*)

Add Consistent capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`.

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

void Diffusion (real_t *coef* = *1*) `[virtual]`

Add diffusion matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void Diffusion (const LocalMatrix< real_t, 2, 2 > & *diff*, real_t *coef* = 1)

Add diffusion matrix to left-hand side after multiplying it by coefficient `coef`
Case where the diffusivity matrix is given as an argument

Parameters

in	*diff*	Instance of class DMatrix containing diffusivity matrix
in	*coef*	Coefficient to multiply by added term [Default: 1]

void DiffusionToRHS (real_t *coef* = 1) `[virtual]`

Add diffusion contribution to right-hand side after multiplying it by coefficient `coef`
To be used for explicit diffusion term

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1]

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void BodyRHS (UserData< real_t > & *ud*)

Add body right-hand side term to right-hand side after multiplying it by coefficient `coef`

Parameters

in	*ud*	Instance of UserData or of an inherited class. Contains a member function that provides body source.

void BodyRHS (const Vect< real_t > & *b*, int *opt* = GLOBAL_ARRAY) `[virtual]`

Add body right-hand side term to right hand side.

Parameters

in	*b*	Local vector (of size 3) containing source at element nodes.
in	*opt*	Vector is local (`LOCAL_ARRAY`) with size 3 or global (`GLOBAL_ARRAY`) with size = Number of nodes [Default: `GLOBAL_ARRAY`].

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

void BoundaryRHS (real_t *flux*)

Add boundary right-hand side term to right hand side.

Parameters

in	*flux*	Value of flux to impose on the side

void BoundaryRHS (const Vect< real_t > & *sf*, int *opt* = GLOBAL_ARRAY) `[virtual]`

Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`

Parameters

in	*sf*	Vector containing source at side nodes
in	*opt*	Vector is local (`LOCAL_ARRAY`) with size 2 or global (`GLOBAL_ARRAY`) with size = Number of nodes [Default: `GLOBAL_ARRAY`].

Reimplemented from Equa_Therm< real_t, 3, 3, 2, 2 >.

Point<real_t>& Grad (const Vect< real_t > & *u*)

Return gradient of a vector in element.

Parameters

in	*u*	Vector for which gradient is computed.

virtual void setStab ( ) `[virtual]`, `[inherited]`

Set stabilized formulation.
Stabilized variational formulations are to be used when the Pclet number is large. By default, no stabilization is used.

void build (TimeStepping & *s*) `[inherited]`

Build the linear system of equations.
Before using this function, one must have properly selected appropriate options for:

- The choice of a steady state or transient analysis. By default, the analysis is stationary
- In the case of transient analysis, the choice of a time integration scheme and a lumped or consistent capacity matrix. If transient analysis is chosen, the lumped capacity matrix option is chosen by default, and the implicit Euler scheme is used by default for time integration.

Parameters

in	*s*	Reference to used TimeStepping instance

void build (EigenProblemSolver & *e*) `[inherited]`

Build the linear system for an eigenvalue problem.

Parameters

in	*e*	Reference to used EigenProblemSolver instance

int runTransient ( ) `[inherited]`

Run one time step.

This function performs one time step in equation solving. It is to be used only if a *TRANSIENT* analysis is required.

Returns

Return error from the linear system solver

int runOneTimeStep ( ) `[inherited]`

Run one time step.

This function performs one time step in equation solving. It is identical to the function run↩ Transient.

Returns

Return error from the linear system solver

int run ( ) `[inherited]`

Run the equation.

If the analysis (see function setAnalysis) is `STEADY_STATE`, then the function solves the stationary equation.
If the analysis is `TRANSIENT`, then the function performs time stepping until the final time is reached.

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = *NODE_FIELD*, int *flag* = *0*) [inherited]

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer _theElement

void SideVector (const Vect< real_t > & *b*) [inherited]

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • NODE_FIELD, DOFs are supported by nodes [default] • ELEMENT_FIELD, DOFs are supported by elements • SIDE_FIELD, DOFs are supported by sides The resulting local vector can be accessed by attribute ePrev.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer _theSide

void ElementNodeCoordinates ( ) [inherited]

Localize coordinates of element nodes.
Coordinates are stored in array _x[0], _x[1], ... which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer _theSide

void SideNodeCoordinates ( ) [inherited]

Localize coordinates of side nodes.
Coordinates are stored in array _x[0], _x[1], ... which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer _theElement

void ElementAssembly (Matrix< real_t > ∗ *A*) [inherited]

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & v) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > $*$ A) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

`in`	*el*	Reference to Element instance
`in`	*x*	Global vector to multiply by (Vect instance)
`out`	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

`in`	*sd*	Reference to Side instance
`in`	*x*	Global vector to multiply by (Vect instance)
`out`	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

`in`	*exp*	Algebraic expression
`in`	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *IDENT_PREC* **)** [inherited]

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: DIRECT_SOLVER, CG_SOLVER, GMRES_SOLVER • DIRECT_SOLVER, Use a facorization solver [default] • CG_SOLVER, Conjugate Gradient iterative solver • CGS_SOLVER, Squared Conjugate Gradient iterative solver • BICG_SOLVER, BiConjugate Gradient iterative solver • BICG_STAB_SOLVER, BiConjugate Gradient Stabilized iterative solver • GMRES_SOLVER, GMRES iterative solver • QMR_SOLVER, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • IDENT_PREC, Identity preconditioner (no preconditioning [default]) • DIAG_PREC, Diagonal preconditioner • ILU_PREC, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > ∗ *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) [inherited]

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

7.11.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev [inherited]

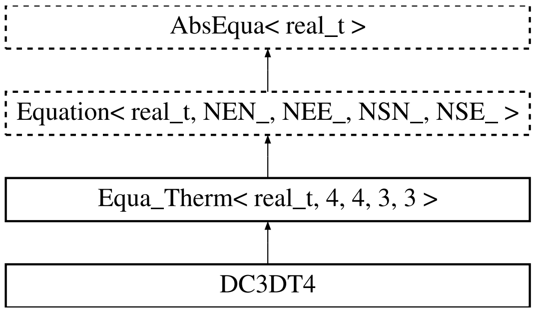
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.12 DC3DT4 Class Reference

Builds finite element arrays for thermal diffusion and convection in 3-D domains using 4-Node tetrahedra.

Inheritance diagram for DC3DT4:



Public Member Functions

- DC3DT4 ()

  Default Constructor.
- DC3DT4 (const Element ∗el)

  Constructor for an element.
- DC3DT4 (const Side ∗sd)

  Constructor for a boundary side.
- DC3DT4 (const Element ∗el, const Vect< real_t > &u, real_t time=0.)

  Constructor for an element (transient case).
- DC3DT4 (const Side ∗sd, const Vect< real_t > &u, real_t time=0.)

  Constructor for a boundary side (transient case).
- DC3DT4 (const Element ∗el, const Vect< real_t > &u, real_t time, real_t deltat, int scheme)

  Constructor for an element (transient case) with specification of time integration scheme.
- DC3DT4 (const Side ∗sd, const Vect< real_t > &u, real_t time, real_t deltat, int scheme)

  Constructor for a side (transient case) with specification of time integration scheme.
- ∼DC3DT4 ()

  Destructor.
- void build ()

  Build the linear system without solving.
- void LCapacity (real_t coef=1.)

  Add lumped capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`*.*
- void LCapacityToLHS (real_t coef=1)

  Add lumped capacity matrix to left-hand side after multiplying it by coefficient `coef`
- void LCapacityToRHS (real_t coef=1)

  Add lumped capacity contribution to right-hand side after multiplying it by coefficient `coef`
- void Capacity (real_t coef=1)

  Add Consistent capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`*.*
- void CapacityToLHS (real_t coef=1)

  Add consistent capacity matrix to left-hand side after multiplying it by coefficient `coef`
- void CapacityToRHS (real_t coef=1)

Add consistent capacity contribution to right-hand side after multiplying it by coefficient `coef`

- void Diffusion (real_t coef=1)

  Add diffusion matrix to left hand side after multiplying it by coefficient `coef`*.*
- void Diffusion (const DMatrix< real_t > &diff, real_t coef=1)

  Add diffusion matrix to left hand side after multiplying it by coefficient `coef`
- void DiffusionToRHS (real_t coef=1)

  Add diffusion contribution to right hand side after multiplying it by coefficient `coef`
- void Convection (real_t coef=1)

  Add convection matrix to left-hand side after multiplying it by coefficient `coef`
- void Convection (const Point< real_t > &v, real_t coef=1)

  Add convection matrix to left-hand side after multiplying it by coefficient `coef`
- void Convection (const Vect< Point< real_t > > &v, real_t coef=1)

  Add convection matrix to left-hand side after multiplying it by coefficient `coef`
- void RHS_Convection (const Point< real_t > &v, real_t coef=1.)

  Add convection contribution to right-hand side after multiplying it by coefficient `coef`
- void BodyRHS (UserData< real_t > &ud, real_t coef=1)

  Add body right-hand side term to right hand side after multiplying it by coefficient `coef`
- void BodyRHS (const Vect< real_t > &b, int opt=GLOBAL_ARRAY)

  Add body right-hand side term to right hand side.
- void BoundaryRHS (UserData< real_t > &ud, real_t coef=1)

  Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`
- void BoundaryRHS (const Vect< real_t > &b, int opt=GLOBAL_ARRAY)

  Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`
- void BoundaryRHS (real_t flux)

  Add boundary right-hand side flux to right hand side.
- Point< real_t > Flux () const

  Return (constant) heat flux in element.
- Point< real_t > Grad (const Vect< real_t > &u) const

  Return gradient of vector `u` *in element.* `u` *is a local vector.*
- void Periodic (real_t coef=1.e20)

  Add contribution of periodic boundary condition (by a penalty technique).
- virtual void setStab ()

  Set stabilized formulation.
- void setLumpedCapacity ()

  Add lumped capacity contribution to left and right-hand sides taking into account time integration scheme.
- void setCapacity ()

  Add consistent capacity contribution to left and right-hand sides taking into account time integration scheme.
- void setDiffusion ()

  Add diffusion contribution to left and/or right-hand side taking into account time integration scheme.
- virtual void ConvectionToRHS (real_t coef=1.)

  Add convection term to right-hand side.
- void setConvection ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void build (TimeStepping &s)

  Build the linear system of equations.
- void build (EigenProblemSolver &e)

Build the linear system for an eigenvalue problem.
- int runTransient ()

  Run one time step.
- int runOneTimeStep ()

  Run one time step.
- int run ()

  Run the equation.
- void setRhoCp (const real_t &rhocp)

  Set product of Density by Specific heat (constants)
- void setConductivity (const real_t &diff)

  Set (constant) thermal conductivity.
- void RhoCp (const string &exp)

  Set product of Density by Specific heat given by an algebraic expression.
- void Conduc (const string &exp)

  Set thermal conductivity given by an algebraic expression.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)

Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > *A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

Define a material property by an algebraic expression.

- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > ∗A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void setMaterial ()

  Set material properties.
- void Init (const Element ∗el)

  Set element arrays to zero.
- void Init (const Side ∗sd)

  Set side arrays to zero.

7.12.1 Detailed Description

Builds finite element arrays for thermal diffusion and convection in 3-D domains using 4-Node tetrahedra.

Note that members calculating element arrays have as an argument a real `coef` that will be multiplied by the contribution of the current element. This makes possible testing different algorithms.

7.12.2 Constructor & Destructor Documentation

DC3DT4 ( )

Default Constructor.

Constructs an empty equation.

DC3DT4 (const Element * *el*)

Constructor for an element.

Parameters

in	*el*	Pointer to element.

DC3DT4 (const Side * *sd*)

Constructor for a boundary side.

Parameters

sd	[in] Pointer to side.

DC3DT4 (const Element * *el*, const Vect< real_t > & *u*, real_t *time* = 0.)

Constructor for an element (transient case).

Parameters

in	*el*	Pointer to element.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value [Default: 0].

DC3DT4 (const Side * *sd*, const Vect< real_t > & *u*, real_t *time* = 0.)

Constructor for a boundary side (transient case).

Parameters

in	*sd*	Pointer to side.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value [Default: 0].

DC3DT4 (const Element * *el*, const Vect< real_t > & *u*, real_t *time*, real_t *deltat*, int *scheme*)

Constructor for an element (transient case) with specification of time integration scheme.

Parameters

in	*el*	Pointer to element.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value.
in	*deltat*	Value of time step

Parameters

in	*scheme*	Time Integration Scheme: • `FORWARD_EULER`: Forward Euler scheme • `BACKWARD_EULER`: Backward Euler scheme • `CRANK_NICOLSON`: Crank-Nicolson Euler scheme

DC3DT4 (const Side ∗ *sd*, const Vect< real_t > & *u*, real_t *time*, real_t *deltat*, int *scheme*)

Constructor for a side (transient case) with specification of time integration scheme.

Parameters

in	*sd*	Pointer to side.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value.
in	*deltat*	Value of time step
in	*scheme*	Time Integration Scheme (): • FORWARD_EULER: for Forward Euler scheme • BACKWARD_EULER: for Backward Euler scheme • CRANK_NICOLSON: for Crank-Nicolson Euler scheme

7.12.3 Member Function Documentation

void LCapacity (real_t *coef* = `1.`)

Add lumped capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`.

Parameters

in	*coef*	Coefficient to multiply by added term [Default: `1`].

void LCapacityToLHS (real_t *coef* = *1*) `[virtual]`

Add lumped capacity matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: `1`].

Reimplemented from Equa_Therm< real_t, 4, 4, 3, 3 >.

void LCapacityToRHS (real_t *coef* = *1*) `[virtual]`

Add lumped capacity contribution to right-hand side after multiplying it by coefficient `coef`

Parameters

`in`	*coef*	Coefficient to multiply by added term [Default: `1`].

Reimplemented from Equa_Therm< real_t, 4, 4, 3, 3 >.

void Capacity (real_t *coef* = *1*)

Add Consistent capacity contribution to left and right-hand sides after multiplying it by coefficient `coef`.

Parameters

`in`	*coef*	Coefficient to multiply by added term [Default: `1`].

void CapacityToLHS (real_t *coef* = *1*) `[virtual]`

Add consistent capacity matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

`in`	*coef*	Coefficient to multiply by added term [Default: `1`].

Reimplemented from Equa_Therm< real_t, 4, 4, 3, 3 >.

void CapacityToRHS (real_t *coef* = *1*) `[virtual]`

Add consistent capacity contribution to right-hand side after multiplying it by coefficient `coef`

Parameters

`in`	*coef*	Coefficient to multiply by added term [Default: `1`].

Reimplemented from Equa_Therm< real_t, 4, 4, 3, 3 >.

void Diffusion (real_t *coef* = *1*) `[virtual]`

Add diffusion matrix to left hand side after multiplying it by coefficient `coef`.

Parameters

`in`	*coef*	Coefficient to multiply by added term (default value = 1).

Reimplemented from Equa_Therm< real_t, 4, 4, 3, 3 >.

void Diffusion (const DMatrix< real_t > & *diff*, real_t *coef* = *1*)

Add diffusion matrix to left hand side after multiplying it by coefficient `coef`
Case where the diffusivity matrix is given as an argument.

Parameters

in	*diff*	Diffusion matrix (class DMatrix).
in	*coef*	Coefficient to multiply by added term [Default: 1].

void DiffusionToRHS (real_t *coef* = *1*) `[virtual]`

Add diffusion contribution to right hand side after multiplying it by coefficient `coef`
To be used for explicit diffusion term

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Therm< real_t, 4, 4, 3, 3 >.

void Convection (real_t *coef* = *1*) `[virtual]`

Add convection matrix to left-hand side after multiplying it by coefficient `coef`
Case where velocity field has been previouly defined

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Therm< real_t, 4, 4, 3, 3 >.

void Convection (const Point< real_t > & *v*, real_t *coef* = *1*)

Add convection matrix to left-hand side after multiplying it by coefficient `coef`

Parameters

in	*v*	Constant velocity vector
in	*coef*	Coefficient to multiply by added term [Default: 1].

void Convection (const Vect< Point< real_t > > & *v*, real_t *coef* = *1*)

Add convection matrix to left-hand side after multiplying it by coefficient `coef`
Case where velocity field is given by a vector `v`.

Parameters

in	*v*	Velocity vector.
in	*coef*	Coefficient to multiply by added term [Default: 1].

void RHS_Convection (const Point< real_t > & *v*, real_t *coef* = 1.)

Add convection contribution to right-hand side after multiplying it by coefficient `coef`
To be used for explicit convection term.

Parameters

`in`	*v*	Velocity vector.
`in`	*coef*	Coefficient to multiply by added term [Default: `1`].

void BodyRHS (UserData< real_t > & *ud*, real_t *coef* = 1)

Add body right-hand side term to right hand side after multiplying it by coefficient `coef`

Parameters

`in`	*ud*	Instance of UserData or of an inherited class. Contains a member function that provides body source.
`in`	*coef*	Coefficient to multiply by added term [Default: `1`].

void BodyRHS (const Vect< real_t > & *b*, int *opt* = GLOBAL_ARRAY) `[virtual]`

Add body right-hand side term to right hand side.

Parameters

`in`	*b*	Local vector containing source at element nodes.
`in`	*opt*	Vector is local (`LOCAL_ARRAY`) with size 4 or global (`GLOBAL_ARRAY`) with size = Number of nodes [Default: `GLOBAL_ARRAY`].

Reimplemented from Equa_Therm< real_t, 4, 4, 3, 3 >.

void BoundaryRHS (UserData< real_t > & *ud*, real_t *coef* = 1)

Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`

Parameters

`in`	*ud*	Instance of UserData or of an inherited class. Contains a member function that provides body source.
`in`	*coef*	Value by which the added term is multiplied [Default: `1`].

void BoundaryRHS (const Vect< real_t > & *b*, int *opt* = GLOBAL_ARRAY) `[virtual]`

Add boundary right-hand side term to right hand side after multiplying it by coefficient `coef`
Case where body source is given by a vector

Parameters

in	*b*	Vector containing source at side nodes.
in	*opt*	Vector is local (`LOCAL_ARRAY`) with size 3 or global (`GLOBAL_ARRAY`) with size = Number of nodes [Default: `GLOBAL_ARRAY`].

Reimplemented from Equa_Therm< real_t, 4, 4, 3, 3 >.

void BoundaryRHS (real_t *flux*)

Add boundary right-hand side flux to right hand side.

Parameters

in	*flux*	Vector containing source at side nodes.

void Periodic (real_t *coef* = `1.e20`)

Add contribution of periodic boundary condition (by a penalty technique).

Boundary nodes where periodic boundary conditions are to be imposed must have codes equal to `PERIODIC_A` on one side and `PERIODIC_B` on the opposite side.

Parameters

in	*coef*	Value of penalty parameter [Default: `1.e20`].

virtual void setStab ( ) `[virtual]`, `[inherited]`

Set stabilized formulation.

Stabilized variational formulations are to be used when the Pclet number is large. By default, no stabilization is used.

void build (TimeStepping & *s*) `[inherited]`

Build the linear system of equations.

Before using this function, one must have properly selected appropriate options for:

- The choice of a steady state or transient analysis. By default, the analysis is stationary
- In the case of transient analysis, the choice of a time integration scheme and a lumped or consistent capacity matrix. If transient analysis is chosen, the lumped capacity matrix option is chosen by default, and the implicit Euler scheme is used by default for time integration.

Parameters

in	*s*	Reference to used TimeStepping instance

void build (EigenProblemSolver & *e*) `[inherited]`

Build the linear system for an eigenvalue problem.

Parameters

in	*e*	Reference to used EigenProblemSolver instance

int runTransient ( ) `[inherited]`

Run one time step.

This function performs one time step in equation solving. It is to be used only if a *TRANSIENT* analysis is required.

Returns

Return error from the linear system solver

int runOneTimeStep ( ) `[inherited]`

Run one time step.

This function performs one time step in equation solving. It is identical to the function run↩ Transient.

Returns

Return error from the linear system solver

int run ( ) `[inherited]`

Run the equation.

If the analysis (see function setAnalysis) is `STEADY_STATE`, then the function solves the stationary equation.

If the analysis is `TRANSIENT`, then the function performs time stepping until the final time is reached.

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.
`in`	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & v) `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & A) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & b) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, **Preconditioner** *pc* **=** *IDENT_PREC* **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > * *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

`in`	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	*b*	Vector containing right-hand side
`in,out`	*x*	Vector containing initial guess of solution on input, actual solution on output

7.12.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

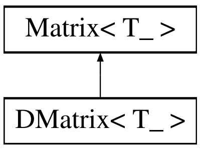
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.13 DMatrix< T_ > Class Template Reference

To handle dense matrices.

Inheritance diagram for DMatrix< T_ >:



Public Member Functions

- DMatrix ()

  Default constructor.
- DMatrix (size_t nr)

  Constructor for a matrix with `nr` *rows and* `nr` *columns.*
- DMatrix (size_t nr, size_t nc)

  Constructor for a matrix with `nr` *rows and* `nc` *columns.*
- DMatrix (Vect< T_ > &v)

  Constructor that uses a Vect instance. The class uses the memory space occupied by this vector.
- DMatrix (const DMatrix< T_ > &m)

  Copy Constructor.
- ~DMatrix ()

  Destructor.
- void setDiag ()

  Store diagonal entries in a separate internal vector.
- void setDiag (const T_ &a)

  Set matrix as diagonal and assign its diagonal entries as a constant.
- void setDiag (const vector< T_ > &d)

Set matrix as diagonal and assign its diagonal entries.

- void setSize (size_t size)

  Set size (number of rows) of matrix.
- void setSize (size_t nr, size_t nc)

  Set size (number of rows and columns) of matrix.
- void getColumn (size_t j, Vect< T_ > &v) const

  Get `j`*-th column vector.*
- Vect< T_ > getColumn (size_t j) const

  Get `j`*-th column vector.*
- void getRow (size_t i, Vect< T_ > &v) const

  Get `i`*-th row vector.*
- Vect< T_ > getRow (size_t i) const

  Get `i`*-th row vector.*
- void set (size_t i, size_t j, const T_ &val)

  Assign a constant value to an entry of the matrix.
- void setRow (size_t i, const Vect< T_ > &v)

  Copy a given vector to a prescribed row in the matrix.
- void setColumn (size_t i, const Vect< T_ > &v)

  Copy a given vector to a prescribed column in the matrix.
- void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `a*x` *and add result to* `y`*.*
- void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `x` *and add result to* `y`*.*
- void Mult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `x` *and save result in* `y`*.*
- void TMult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector `x` *and add result in* `y`*.*
- void add (size_t i, size_t j, const T_ &val)

  Add constant `val` *to entry* `(i,j)` *of the matrix.*
- void Axpy (T_ a, const DMatrix< T_ > &m)

  Add to matrix the product of a matrix by a scalar.
- void Axpy (T_ a, const Matrix< T_ > *m)

  Add to matrix the product of a matrix by a scalar.
- int setQR ()

  Construct a QR factorization of the matrix.
- int setTransQR ()

  Construct a QR factorization of the transpose of the matrix.
- int solveQR (const Vect< T_ > &b, Vect< T_ > &x)

  Solve a linear system by QR decomposition.
- int solveTransQR (const Vect< T_ > &b, Vect< T_ > &x)

  Solve a transpose linear system by QR decomposition.
- T_ operator() (size_t i, size_t j) const

  Operator () (Constant version). Return `a(i,j)`
- T_ & operator() (size_t i, size_t j)

  Operator () (Non constant version). Return `a(i,j)`
- int setLU ()

Factorize the matrix (LU factorization)

- int setTransLU ()

  Factorize the transpose of the matrix (LU factorization)

- int solve (Vect< T_ > &b)

  Solve linear system.

- int solveTrans (Vect< T_ > &b)

  Solve the transpose linear system.

- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve linear system.

- int solveTrans (const Vect< T_ > &b, Vect< T_ > &x)

  Solve the transpose linear system.

- DMatrix & operator= (DMatrix< T_ > &m)

  Operator =

- DMatrix & operator+= (const DMatrix< T_ > &m)

  Operator +=.

- DMatrix & operator-= (const DMatrix< T_ > &m)

  Operator -=.

- DMatrix & operator= (const T_ &x)

  Operator =

- DMatrix & operator*= (const T_ &x)

  *Operator *=*

- DMatrix & operator+= (const T_ &x)

  Operator +=

- DMatrix & operator-= (const T_ &x)

  Operator -=

- T_ * getArray () const

  Return matrix as C-Array.

- T_ get (size_t i, size_t j) const

  Return entry `(i,j)` *of matrix.*

- size_t getNbRows () const

  Return number of rows.

- size_t getNbColumns () const

  Return number of columns.

- void setPenal (real_t p)

  Set Penalty Parameter (For boundary condition prescription).

- void setDiagonal ()

  Set the matrix as diagonal.

- void setDiagonal (Mesh &mesh)

  Initialize matrix storage in the case where only diagonal terms are stored.

- T_ getDiag (size_t k) const

  Return k*-th diagonal entry of matrix.*

- size_t size () const

  Return matrix dimension (Number of rows and columns).

- void Assembly (const Element &el, T_ *a)

  Assembly of element matrix into global matrix.

- void Assembly (const Element &el, const DMatrix< T_ > &a)

Assembly of element matrix into global matrix.

- void Assembly (const Side &sd, T_ *a)

  Assembly of side matrix into global matrix.
- void Assembly (const Side &sd, const DMatrix< T_ > &a)

  Assembly of side matrix into global matrix.
- void Prescribe (Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.
- void Prescribe (int dof, int code, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.
- void Prescribe (Vect< T_ > &b, int flag=0)

  Impose by a penalty method a homegeneous (=0) essential boundary condition.
- void Prescribe (size_t dof, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition when only one DOF is treated.
- void PrescribeSide ()

  Impose by a penalty method an essential boundary condition when DOFs are supported by sides.
- virtual int Factor ()=0

  Factorize matrix. Available only if the storage class enables it.
- int FactorAndSolve (Vect< T_ > &b)

  Factorize matrix and solve the linear system.
- int FactorAndSolve (const Vect< T_ > &b, Vect< T_ > &x)

  Factorize matrix and solve the linear system.
- size_t getLength () const

  Return number of stored terms in matrix.
- int isDiagonal () const

  Say if matrix is diagonal or not.
- int isFactorized () const

  Say if matrix is factorized or not.
- virtual size_t getColInd (size_t i) const

  Return Column index for column `i` *(See the description for class SpMatrix).*
- virtual size_t getRowPtr (size_t i) const

  Return Row pointer for row `i` *(See the description for class SpMatrix).*
- T_ operator() (size_t i) const

  Operator () with one argument (Constant version).
- T_ & operator() (size_t i)

  Operator () with one argument (Non Constant version).
- T_ & operator[ ] (size_t k)

  Operator [] (Non constant version).
- T_ operator[ ] (size_t k) const

  Operator [] (Constant version).
- Matrix & operator+= (const Matrix< T_ > &m)

  Operator +=.
- Matrix & operator-= (const Matrix< T_ > &m)

  Operator -=.

7.13.1 Detailed Description

template<class T_>
class OFELI::DMatrix< T_ >

To handle dense matrices.

This class enables storing and manipulating general dense matrices. Matrices can be square or rectangle ones.

Template Parameters

*T_*	Data type (double, float, complex<double>, ...)

7.13.2 Constructor & Destructor Documentation

DMatrix ( )

Default constructor.

Initializes a zero-dimension matrix.

DMatrix (size_t *nr*)

Constructor for a matrix with `nr` rows and `nr` columns.

Matrix entries are set to `0`.

DMatrix (size_t *nr*, size_t *nc*)

Constructor for a matrix with `nr` rows and `nc` columns.

Matrix entries are set to 0.

DMatrix (Vect< T_ > & *v*)

Constructor that uses a Vect instance. The class uses the memory space occupied by this vector.

Parameters

in	*v*	Vector to copy

DMatrix (const DMatrix< T_ > & *m*)

Copy Constructor.

Parameters

in	*m*	Matrix to copy

7.13.3 Member Function Documentation

void setDiag (const T_ & *a*)

Set matrix as diagonal and assign its diagonal entries as a constant.

Parameters

in	*a*	Value to assign to all diagonal entries

void setDiag (const vector< T_ > & *d*)

Set matrix as diagonal and assign its diagonal entries.

Parameters

in	*d*	Vector entries to assign to matrix diagonal entries

void setSize (size_t *size*)

Set size (number of rows) of matrix.

Parameters

in	*size*	Number of rows and columns.

void setSize (size_t *nr*, size_t *nc*)

Set size (number of rows and columns) of matrix.

Parameters

in	*nr*	Number of rows.
in	*nc*	Number of columns.

void getColumn (size_t *j*, Vect< T_ > & *v*) const

Get `j`-th column vector.

Parameters

in	*j*	Index of column to extract
out	*v*	Reference to Vect instance where the column is stored

Remarks

Vector v does not need to be sized before. It is resized in the function

Vect<T_> getColumn (size_t *j*) const

Get j-th column vector.

Parameters

in	*j*	Index of column to extract

Returns

Vect instance where the column is stored

Remarks

Vector v does not need to be sized before. It is resized in the function

void getRow (size_t *i*, Vect< T_ > & *v*) const

Get i-th row vector.

Parameters

in	*i*	Index of row to extract
out	*v*	Reference to Vect instance where the row is stored

Remarks

Vector v does not need to be sized before. It is resized in the function

Vect<T_> getRow (size_t *i*) const

Get i-th row vector.

Parameters

in	*i*	Index of row to extract

Returns

Vect instance where the row is stored

Remarks

Vector v does not need to be sized before. It is resized in the function

void set (size_t *i*, size_t *j*, const T_ & *val*) [virtual]

Assign a constant value to an entry of the matrix.

Parameters

in	*i*	row index of matrix

Parameters

in	*j*	column index of matrix
in	*val*	Value to assign to `a(i,j)`.

Implements Matrix< T_ >.

void setRow (size_t *i*, const Vect< T_ > & *v*)

Copy a given vector to a prescribed row in the matrix.

Parameters

in	*i*	row index to be assigned
in	*v*	Vect instance to copy

void setColumn (size_t *i*, const Vect< T_ > & *v*)

Copy a given vector to a prescribed column in the matrix.

Parameters

in	*i*	column index to be assigned
in	*v*	Vect instance to copy

void MultAdd (T_ *a*, const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by vector `a*x` and add result to `y`.

Parameters

in	*a*	constant to multiply by
in	*x*	Vector to multiply by `a`
in,out	*y*	on input, vector to add to. On output, result.

Implements Matrix< T_ >.

void MultAdd (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by vector `x` and add result to `y`.

Parameters

in	*x*	Vector to add to `y`
in,out	*y*	on input, vector to add to. On output, result.

Implements Matrix< T_ >.

void Mult (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by vector `x` and save result in `y`.

Parameters

`in`	*x*	Vector to add to y
`out`	*y*	Result.

Implements Matrix< T_ >.

void TMult (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply transpose of matrix by vector `x` and add result in `y`.

Parameters

`in`	*x*	Vector to add to y
`in,out`	*y*	on input, vector to add to. On output, result.

Implements Matrix< T_ >.

void add (size_t *i*, size_t *j*, const T_ & *val*) `[virtual]`

Add constant `val` to entry `(i,j)` of the matrix.

Parameters

`in`	*i*	row index
`in`	*j*	column index
`in`	*val*	Constant to add

Implements Matrix< T_ >.

void Axpy (T_ *a*, const DMatrix< T_ > & *m*)

Add to matrix the product of a matrix by a scalar.

Parameters

`in`	*a*	Scalar to premultiply
`in`	*m*	Matrix by which a is multiplied. The result is added to current instance

void Axpy (T_ *a*, const Matrix< T_ > * *m*) `[virtual]`

Add to matrix the product of a matrix by a scalar.

Parameters

`in`	*a*	Scalar to premultiply

Parameters

in	*m*	Matrix by which `a` is multiplied. The result is added to current instance

Implements Matrix< T_ >.

int setQR ( )

Construct a QR factorization of the matrix.

This function constructs the QR decomposition using the Householder method. The upper triangular matrix R is returned in the upper triangle of the current matrix, except for the diagonal elements of R which are stored in an internal vector. The orthogonal matrix Q is represented as a product of n-1 Householder matrices Q1 . . . Qn-1, where Qj = 1 - uj.uj /cj . The i-th component of uj is zero for i = 1, ..., j-1 while the nonzero components are returned in a[i][j] for i = j, ..., n.

Returns

`0` if the decomposition was successful, `k` is the `k-th` row is singular

Remarks

The matrix can be square or rectangle

int setTransQR ( )

Construct a QR factorization of the transpose of the matrix.

This function constructs the QR decomposition using the Householder method. The upper triangular matrix R is returned in the upper triangle of the current matrix, except for the diagonal elements of R which are stored in an internal vector. The orthogonal matrix Q is represented as a product of n-1 Householder matrices Q1 . . . Qn-1, where Qj = 1 - uj.uj /cj . The i-th component of uj is zero for i = 1, ..., j-1 while the nonzero components are returned in a[i][j] for i = j, ..., n.

Returns

`0` if the decomposition was successful, `k` is the `k-th` row is singular

Remarks

The matrix can be square or rectangle

int solveQR (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve a linear system by QR decomposition.

This function constructs the QR decomposition, if this was not already done by using the member function QR and solves the linear system

Parameters

in	*b*	Right-hand side vector
out	*x*	Solution vector. Must have been sized before using this function.

Returns

The same value as returned by the function QR

int solveTransQR (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve a transpose linear system by QR decomposition.

This function constructs the QR decomposition, if this was not already done by using the member function QR and solves the linear system

Parameters

in	b	Right-hand side vector
out	x	Solution vector. Must have been sized before using this function.

Returns

The same value as returned by the function QR

T_ operator() (size_t *i*, size_t *j*) const [virtual]

Operator () (Constant version). Return `a(i,j)`

Parameters

in	i	row index
in	j	column index

Implements Matrix< T_ >.

T_& operator() (size_t *i*, size_t *j*) [virtual]

Operator () (Non constant version). Return `a(i,j)`

Parameters

in	i	row index
in	j	column index

Implements Matrix< T_ >.

int setLU ( )

Factorize the matrix (LU factorization)

LU factorization of the matrix is realized. Note that since this is an in place factorization, the contents of the matrix are modified.

Returns

- `0` if factorization was normally performed,
- `n` if the `n`-th pivot is null.

Remarks

A flag in this class indicates after factorization that this one has been realized, so that, if the member function solve is called after this no further factorization is done.

int setTransLU ( )

Factorize the transpose of the matrix (LU factorization)

LU factorization of the transpose of the matrix is realized. Note that since this is an in place factorization, the contents of the matrix are modified.

Returns

- `0` if factorization was normally performed,
- `n` if the `n`-th pivot is null.

Remarks

A flag in this class indicates after factorization that this one has been realized, so that, if the member function solve is called after this no further factorization is done.

int solve (Vect< T_ > & *b*) `[virtual]`

Solve linear system.

The linear system having the current instance as a matrix is solved by using the LU decomposition. Solution is thus realized after a factorization step and a forward/backward substitution step. The factorization step is realized only if this was not already done.
Note that this function modifies the matrix contents is a factorization is performed. Naturally, if the the matrix has been modified after using this function, the user has to refactorize it using the function setLU. This is because the class has no non-expensive way to detect if the matrix has been modified. The function setLU realizes the factorization step only.

Parameters

`in,out`	*b*	Vect instance that contains right-hand side on input and solution on output.

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

Implements Matrix< T_ >.

int solveTrans (Vect< T_ > & *b*)

Solve the transpose linear system.

The linear system having the current instance as a transpose matrix is solved by using the LU decomposition. Solution is thus realized after a factorization step and a forward/backward substitution step. The factorization step is realized only if this was not already done.
Note that this function modifies the matrix contents is a factorization is performed. Naturally, if the the matrix has been modified after using this function, the user has to refactorize it using the function setLU. This is because the class has no non-expensive way to detect if the matrix has been modified. The function setLU realizes the factorization step only.

Parameters

in,out	*b*	Vect instance that contains right-hand side on input and solution on output.

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

int solve (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve linear system.

The linear system having the current instance as a matrix is solved by using the LU decomposition. Solution is thus realized after a factorization step and a forward/backward substitution step. The factorization step is realized only if this was not already done.
Note that this function modifies the matrix contents is a factorization is performed. Naturally, if the the matrix has been modified after using this function, the user has to refactorize it using the function setLU. This is because the class has no non-expensive way to detect if the matrix has been modified. The function setLU realizes the factorization step only.

Parameters

in	*b*	Vect instance that contains right-hand side.
out	*x*	Vect instance that contains solution

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

int solveTrans (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve the transpose linear system.

The linear system having the current instance as a transpose matrix is solved by using the LU decomposition. Solution is thus realized after a factorization step and a forward/backward substitution step. The factorization step is realized only if this was not already done.
Note that this function modifies the matrix contents is a factorization is performed. Naturally, if the the matrix has been modified after using this function, the user has to refactorize it using the function setLU. This is because the class has no non-expensive way to detect if the matrix has been modified. The function setLU realizes the factorization step only.

Parameters

in	*b*	Vect instance that contains right-hand side.
out	*x*	Vect instance that contains solution

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

DMatrix& operator= (DMatrix< T_ > & *m*)

Operator =
Copy matrix `m` to current matrix instance.

DMatrix& operator+= (const DMatrix< T_ > & *m*)

Operator +=.
Add matrix `m` to current matrix instance.

DMatrix& operator-= (const DMatrix< T_ > & *m*)

Operator -=.
Subtract matrix `m` from current matrix instance.

DMatrix& operator= (const T_ & *x*)

Operator =
Assign matrix to identity times `x`

DMatrix& operator*= (const T_ & *x*)

Operator *=
Premultiply matrix entries by constant value `x`.

DMatrix& operator+= (const T_ & *x*)

Operator +=
Add constant value `x` to matrix entries

DMatrix& operator-= (const T_ & *x*)

Operator -=
Subtract constant value `x` from matrix entries.

T_* getArray ( ) const

Return matrix as C-Array.
Matrix is stored row by row.

void setDiagonal (Mesh & *mesh*) `[inherited]`

Initialize matrix storage in the case where only diagonal terms are stored.
This member function is to be used for explicit time integration schemes

T_ getDiag (size_t *k*) const `[inherited]`

Return `k`-th diagonal entry of matrix.
First entry is given by **getDiag(1)**.

void Assembly (const Element & *el*, T_ ∗ *a*) `[inherited]`

Assembly of element matrix into global matrix.
Case where element matrix is given by a C-array.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a C-array

void Assembly (const Element & *el*, const DMatrix< T_ > & *a*) `[inherited]`

Assembly of element matrix into global matrix.
Case where element matrix is given by a DMatrix instance.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a DMatrix instance

void Assembly (const Side & *sd*, T_ ∗ *a*) `[inherited]`

Assembly of side matrix into global matrix.
Case where side matrix is given by a C-array.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a C-array instance

void Assembly (const Side & *sd*, const DMatrix< T_ > & *a*) `[inherited]`

Assembly of side matrix into global matrix.
Case where side matrix is given by a DMatrix instance.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a DMatrix instance

void Prescribe (Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

Parameters

in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (int *dof*, int *code*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

Parameters

in	*dof*	Degree of freedom for which a boundary condition is to be enforced
in	*code*	Code for which a boundary condition is to be enforced
in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (Vect< T_ > & *b*, int *flag* = *0*) `[inherited]`

Impose by a penalty method a homegeneous (=0) essential boundary condition.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

Parameters

in,out	*b*	Vect instance that contains right-hand side.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (size_t *dof*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition when only one DOF is treated.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. This gunction is to be used if only one DOF per node is treated in the linear system. The penalty parameter is by default equal to 1.e20. It can be modified by member function setPenal.

Parameters

`in`	*dof*	Label of the concerned degree of freedom (DOF).
`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>`0`) or both matrix and right-hand side (`dof=0`, default value).

void PrescribeSide ( ) `[inherited]`

Impose by a penalty method an essential boundary condition when DOFs are supported by sides.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

int FactorAndSolve (Vect< T_ > & *b*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage cass enables it.

Parameters

`in,out`	*b*	Vect instance that contains right-hand side on input and solution on output

int FactorAndSolve (const Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage class enables it.

Parameters

`in`	*b*	Vect instance that contains right-hand side
`out`	*x*	Vect instance that contains solution

Returns

- `0` if solution was normally performed
- `n` if the n-th pivot is nul

int isFactorized ( ) const `[inherited]`

Say if matrix is factorized or not.

If the matrix was not factorized, the class does not allow solving by a direct solver.

T_ operator() (size_t *i*) const `[inherited]`

Operator () with one argument (Constant version).

Returns `i`-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	*i*	entry index

T_& operator() (size_t *i*) `[inherited]`

Operator () with one argument (Non Constant version).

Returns `i`-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	*i*	entry index

T_& operator[ ] (size_t *k*) `[inherited]`

Operator [] (Non constant version).

Returns `k`-th stored element in matrix Index `k` starts at `0`.

T_ operator[ ] (size_t *k*) const `[inherited]`

Operator [] (Constant version).

Returns `k`-th stored element in matrix Index `k` starts at `0`.

Matrix& operator+= (const Matrix< T_ > & *m*) `[inherited]`

Operator +=.

Add matrix `m` to current matrix instance.

Matrix& operator-= (const Matrix< T_ > & *m*) `[inherited]`

Operator -=.

Subtract matrix `m` from current matrix instance.

7.14 Domain Class Reference

To store and treat finite element geometric information.

Public Member Functions

- Domain ()

  Constructor of a null domain.
- Domain (const string &file)

  Constructor with an input file.
- ∼Domain ()

  Destructor.
- void setFile (string file)

  Set file containing Domain data.
- void setDim (size_t d)

  Set space dimension.
- size_t getDim () const

  Return space dimension.
- void setNbDOF (size_t n)

  Set number of degrees of freedom.
- size_t getNbDOF () const

  Return number of degrees of freedom.
- size_t getNbVertices () const

  Return number of vertices.
- size_t getNbLines () const

  Return number of lines.
- size_t getNbContours () const

  Return number of contours.
- size_t getNbHoles () const

  Return number of holes.
- size_t getNbSubDomains () const

  Return number of sub-domains.
- int get ()

  Read domain data interactively.
- void get (const string &file)

  Read domain data from a data file.
- Mesh & getMesh () const

  Return reference to generated Mesh instance.
- void genGeo (string file)

  Generate geometry file.
- void genMesh ()

  Generate 2-D mesh.
- void genMesh (const string &file)

  Generate 2-D mesh and save in file (OFELI format)
- void genMesh (string geo_file, string bamg_file, string mesh_file)

  Generate 2-D mesh and save geo, bamg and mesh file (OFELI format)
- void generateMesh ()

  Generate 2-D mesh using the BAMG mesh generator.
- Domain & operator*= (real_t a)

  *Operator *=*
- void insertVertex (real_t x, real_t y, real_t h, int code)

Insert a vertex.
- void insertLine (size_t n1, size_t n2, int dc, int nc)
  Insert a straight line.
- void insertCircle (size_t n1, size_t n2, size_t n3, int dc, int nc)
  Insert a circluar arc.
- void insertRequiredVertex (size_t v)
  Insert a required (imposed) vertex.
- void insertRequiredEdge (size_t e)
  Insert a required (imposed) edge (or line)
- void insertSubDomain (size_t n, int code)
  Insert subdomain.
- void insertSubDomain (size_t ln, int orient, int code)
  Insert subdomain.
- Point< real_t > getMinCoord () const
  Return minimum coordinates of vertices.
- Point< real_t > getMaxCoord () const
  Return maximum coordinates of vertices.
- real_t getMinh () const
  Return minimal value of mesh size.
- void setOutputFile (string file)
  Define output mesh file.

7.14.1 Detailed Description

To store and treat finite element geometric information.

This class is essentially useful to construct data for mesh generators.

7.14.2 Constructor & Destructor Documentation

Domain ( )

Constructor of a null domain.

This constructor assigns maximal values of parameters.

Domain (const string & *file*)

Constructor with an input file.

Parameters

in	*file*	Input file in the XML format defining the domain

7.14.3 Member Function Documentation

void get (const string & *file*)

Read domain data from a data file.

Parameters

in	*file*	Input file in Domain XML format

void genMesh (const string & *file*)

Generate 2-D mesh and save in file (OFELI format)

Parameters

in	*file*	File where the generated mesh is saved

void genMesh (string *geo_file*, string *bamg_file*, string *mesh_file*)

Generate 2-D mesh and save geo, bamg and mesh file (OFELI format)

Parameters

in	*geo_file*	Geo file
in	*bamg_file*	Bamg file
in	*mesh_file*	File where the generated mesh is saved

Domain& operator∗= (real_t *a*)

Operator ∗=
Rescale domain coordinates by myltiplying by a factor

Parameters

in	*a*	Value to multiply by

void insertVertex (real_t *x*, real_t *y*, real_t *h*, int *code*)

Insert a vertex.

Parameters

in	*x*	x-coordinate of vertex
in	*y*	y-coordinate of vertex
in	*h*	mesh size around vertex
in	*code*	code of coordinate

void insertLine (size_t *n1*, size_t *n2*, int *dc*, int *nc*)

Insert a straight line.

Parameters

in	*n1*	Label of the first vertex of line
in	*n2*	Label of the second vertex of line
in	*dc*	Code to associate to created nodes (Dirichlet)
in	*nc*	Code to associate to line (Neumann)

void insertCircle (size_t *n1*, size_t *n2*, size_t *n3*, int *dc*, int *nc*)

Insert a circluar arc.

Parameters

in	*n1*	Label of vertex defining the first end of the arc
in	*n2*	Label of vertex defining the second end of the arc
in	*n3*	Label of vertex defining the center of the arc
in	*dc*	Dirichlet code for nodes on the arc
in	*nc*	Neumann code for sides on the arc

void insertRequiredVertex (size_t *v*)

Insert a required (imposed) vertex.

Parameters

in	*v*	Label of vertex

void insertRequiredEdge (size_t *e*)

Insert a required (imposed) edge (or line)

Parameters

in	*e*	Label of line

void insertSubDomain (size_t *n*, int *code*)

Insert subdomain.

Parameters

in	*n*	
in	*code*	

void insertSubDomain (size_t *ln*, int *orient*, int *code*)

Insert subdomain.

Parameters

in	*ln*	Line label
in	*orient*	Orientation (1 or -1)
in	*code*	Subdomain code or reference

void setOutputFile (string *file*)

Define output mesh file.

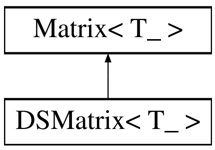
Parameters

in	*file*	String defining output mesh file

7.15 DSMatrix< T_ > Class Template Reference

To handle symmetric dense matrices.

Inheritance diagram for DSMatrix< T_ >:



Public Member Functions

- DSMatrix ()

  Default constructor.
- DSMatrix (size_t dim)

  Constructor that for a symmetric matrix with given number of rqows.
- DSMatrix (const DSMatrix< T_ > &m)

  Copy Constructor.
- ∼DSMatrix ()

  Destructor.
- void setDiag ()

  Store diagonal entries in a separate internal vector.
- void setSize (size_t dim)

  Set size (number of rows) of matrix.
- void set (size_t i, size_t j, const T_ &val)

  Assign constant to entry (i,j) of the matrix.
- void getColumn (size_t j, Vect< T_ > &v) const

  Get j-th column vector.

- Vect< T_ > getColumn (size_t j) const

  Get j-th column vector.
- void getRow (size_t i, Vect< T_ > &v) const

  Get i-th row vector.
- Vect< T_ > getRow (size_t i) const

  Get i-th row vector.
- void setRow (size_t i, const Vect< T_ > &v)

  Copy a given vector to a prescribed row in the matrix.
- void setColumn (size_t i, const Vect< T_ > &v)

  Copy a given vector to a prescribed column in the matrix.
- void setDiag (const T_ &a)

  Set matrix as diagonal and assign its diagonal entries as a constant.
- void setDiag (const vector< T_ > &d)

  Set matrix as diagonal and assign its diagonal entries.
- void add (size_t i, size_t j, const T_ &val)

  Add constant to an entry ofthe matrix.
- T_ operator() (size_t i, size_t j) const

  Operator () (Constant version).
- T_ & operator() (size_t i, size_t j)

  Operator () (Non constant version).
- DSMatrix< T_ > & operator= (const DSMatrix< T_ > &m)

  Operator = Copy matrix m to current matrix instance.
- DSMatrix< T_ > & operator= (const T_ &x)

  Operator = Assign matrix to identity times x.
- int setLDLt ()

  Factorize matrix (LDL^T)
- void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  *Multiply matrix by vector a*x and add result to y.*
- void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const

  *Multiply matrix by vector a*x and add to y.*
- void Mult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector x and save result in y.
- void TMult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector x and add result in y.
- void Axpy (T_ a, const DSMatrix< T_ > &m)

  Add to matrix the product of a matrix by a scalar.
- void Axpy (T_ a, const Matrix< T_ > *m)

  Add to matrix the product of a matrix by a scalar.
- int solve (Vect< T_ > &b)

  Solve linear system.
- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve linear system.
- int setLDLt (const Vect< T_ > &b, Vect< T_ > &x)

  Solve a linear system using the LDLt (Crout) factorization.
- T_ * getArray () const

  Return matrix as C-Array. Matrix is stored row by row. Only lower triangle is stored.

- T_ get (size_t i, size_t j) const

  Return entry (i,j) of matrix.
- size_t getNbRows () const

  Return number of rows.
- size_t getNbColumns () const

  Return number of columns.
- void setPenal (real_t p)

  Set Penalty Parameter (For boundary condition prescription).
- void setDiagonal ()

  Set the matrix as diagonal.
- void setDiagonal (Mesh &mesh)

  Initialize matrix storage in the case where only diagonal terms are stored.
- T_ getDiag (size_t k) const

  Return k-th diagonal entry of matrix.
- size_t size () const

  Return matrix dimension (Number of rows and columns).
- void Assembly (const Element &el, T_ ∗a)

  Assembly of element matrix into global matrix.
- void Assembly (const Element &el, const DMatrix< T_ > &a)

  Assembly of element matrix into global matrix.
- void Assembly (const Side &sd, T_ ∗a)

  Assembly of side matrix into global matrix.
- void Assembly (const Side &sd, const DMatrix< T_ > &a)

  Assembly of side matrix into global matrix.
- void Prescribe (Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.
- void Prescribe (int dof, int code, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.
- void Prescribe (Vect< T_ > &b, int flag=0)

  Impose by a penalty method a homegeneous (=0) essential boundary condition.
- void Prescribe (size_t dof, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition when only one DOF is treated.
- void PrescribeSide ()

  Impose by a penalty method an essential boundary condition when DOFs are supported by sides.
- virtual int Factor ()=0

  Factorize matrix. Available only if the storage class enables it.
- int FactorAndSolve (Vect< T_ > &b)

  Factorize matrix and solve the linear system.
- int FactorAndSolve (const Vect< T_ > &b, Vect< T_ > &x)

  Factorize matrix and solve the linear system.
- size_t getLength () const

  Return number of stored terms in matrix.
- int isDiagonal () const

  Say if matrix is diagonal or not.
- int isFactorized () const

  Say if matrix is factorized or not.

- virtual size_t getColInd (size_t i) const
  Return Column index for column i (See the description for class SpMatrix).
- virtual size_t getRowPtr (size_t i) const
  Return Row pointer for row i (See the description for class SpMatrix).
- T_ operator() (size_t i) const
  Operator () with one argument (Constant version).
- T_ & operator() (size_t i)
  Operator () with one argument (Non Constant version).
- T_ & operator[ ] (size_t k)
  Operator [] (Non constant version).
- T_ operator[ ] (size_t k) const
  Operator [] (Constant version).
- Matrix & operator+= (const Matrix< T_ > &m)
  Operator +=.
- Matrix & operator+= (const T_ &x)
  Operator +=.
- Matrix & operator-= (const Matrix< T_ > &m)
  Operator -=.
- Matrix & operator-= (const T_ &x)
  Operator -=.
- Matrix & operator*= (const T_ &x)
  *Operator *=.*

7.15.1 Detailed Description

template<class T_>
class OFELI::DSMatrix< T_ >

To handle symmetric dense matrices.
This class enables storing and manipulating symmetric dense matrices.

Template Parameters

*T_*	Data type (double, float, complex<double>, ...)

7.15.2 Member Function Documentation

int setLDLt (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve a linear system using the LDLt (Crout) factorization.
This function solves a linear system. The LDLt factorization is performed if this was not already done using the function setLU.

Parameters

in	*b*	Vect instance that contains right-hand side
out	*x*	Vect instance that contains solution

Returns

- `0` if solution was normally performed
- `n` if the `n`-th pivot is null

void setDiagonal (Mesh & *mesh*) `[inherited]`

Initialize matrix storage in the case where only diagonal terms are stored.
This member function is to be used for explicit time integration schemes

T_ getDiag (size_t *k*) const `[inherited]`

Return `k`-th diagonal entry of matrix.
First entry is given by **getDiag(1)**.

void Assembly (const Element & *el*, T_ * *a*) `[inherited]`

Assembly of element matrix into global matrix.
Case where element matrix is given by a C-array.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a C-array

void Assembly (const Element & *el*, const DMatrix< T_ > & *a*) `[inherited]`

Assembly of element matrix into global matrix.
Case where element matrix is given by a DMatrix instance.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a DMatrix instance

void Assembly (const Side & *sd*, T_ * *a*) `[inherited]`

Assembly of side matrix into global matrix.
Case where side matrix is given by a C-array.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a C-array instance

void Assembly (const Side & *sd*, const DMatrix< T_ > & *a*) `[inherited]`

Assembly of side matrix into global matrix.
Case where side matrix is given by a DMatrix instance.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a DMatrix instance

void Prescribe (Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0* **)** `[inherited]`

Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set↩ Penal**(..).

Parameters

`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (int *dof*, int *code*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0* **)** `[inherited]`

Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set↩ Penal**(..).

Parameters

`in`	*dof*	Degree of freedom for which a boundary condition is to be enforced
`in`	*code*	Code for which a boundary condition is to be enforced
`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (Vect< T_ > & *b*, int *flag* = *0* **)** `[inherited]`

Impose by a penalty method a homegeneous (=0) essential boundary condition.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty

parameter is defined by default equal to 1.e20. It can be modified by member function **set**←
Penal(..).

Parameters

`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (size_t *dof*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition when only one DOF is treated.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. This gunction is to be used if only one DOF per node is treated in the linear system. The penalty parameter is by default equal to 1.e20. It can be modified by member function setPenal.

Parameters

`in`	*dof*	Label of the concerned degree of freedom (DOF).
`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void PrescribeSide ( ) `[inherited]`

Impose by a penalty method an essential boundary condition when DOFs are supported by sides.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set**←
Penal(..).

int FactorAndSolve (Vect< T_ > & *b*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage cass enables it.

Parameters

`in,out`	*b*	Vect instance that contains right-hand side on input and solution on output

int FactorAndSolve (const Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage class enables it.

Parameters

in	*b*	Vect instance that contains right-hand side
out	*x*	Vect instance that contains solution

Returns

- `0` if solution was normally performed
- `n` if the n-th pivot is nul

int isFactorized ( ) const `[inherited]`

Say if matrix is factorized or not.
If the matrix was not factorized, the class does not allow solving by a direct solver.

T_ operator() (size_t *i*) const `[inherited]`

Operator () with one argument (Constant version).
Returns `i`-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	*i*	entry index

T_& operator() (size_t *i*) `[inherited]`

Operator () with one argument (Non Constant version).
Returns `i`-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	*i*	entry index

T_& operator[ ] (size_t *k*) `[inherited]`

Operator [] (Non constant version).
Returns `k`-th stored element in matrix Index `k` starts at `0`.

T_ operator[ ] (size_t *k*) const `[inherited]`

Operator [] (Constant version).
Returns `k`-th stored element in matrix Index `k` starts at `0`.

Matrix& operator+= (const Matrix< T_ > & *m*) `[inherited]`

Operator +=.

Add matrix `m` to current matrix instance.

Matrix& operator+= (const T_ & *x*) `[inherited]`

Operator +=.
Add constant value `x` to all matrix entries.

Matrix& operator-= (const Matrix< T_ > & *m*) `[inherited]`

Operator -=.
Subtract matrix `m` from current matrix instance.

Matrix& operator-= (const T_ & *x*) `[inherited]`

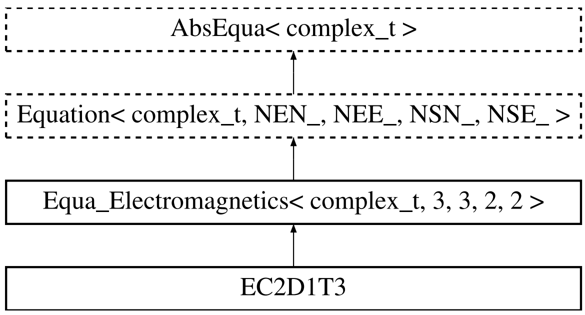
Operator -=.
Subtract constant value `x` from all matrix entries.

Matrix& operator*= (const T_ & *x*) `[inherited]`

Operator *=.
Premultiply matrix entries by constant value `x`

7.16 EC2D1T3 Class Reference

Eddy current problems in 2-D domains using solenoidal approximation.
Inheritance diagram for EC2D1T3:



Public Member Functions

- EC2D1T3 ()

  Default constructor.
- EC2D1T3 (const Element *el)

  Constructor using element data.
- EC2D1T3 (const Side *side)

  Constructor using side data.
- EC2D1T3 (const Element *el, const Vect< complex_t > &u, const real_t &time=0.)

  Constructor using element and previous time data.
- EC2D1T3 (const Side *sd, const Vect< complex_t > &u, const real_t &time=0.)

  Constructor using side and previous time data.
- ~EC2D1T3 ()

Destructor.

- void Magnetic (real_t omega, real_t coef=1.)

  Add magnetic contribution to matrix.
- void Electric (real_t coef=1.)

  Add electric contribution to matrix.
- real_t Joule ()

  Compute Joule density in element.
- complex_t IntegMF ()

  Add element integral contribution.
- complex_t IntegND (const Vect< complex_t > &h, int opt=GLOBAL_ARRAY)

  Compute integral of normal derivative on edge.
- real_t VacuumArea ()

  Add contribution to vacuum area calculation.
- void updateBC (const Element &el, const Vect< complex_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< complex_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< complex_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< complex_t > &b, LocalVect< complex_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< complex_t > &b, LocalVect< complex_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< complex_t > &b, LocalVect< complex_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< complex_t > &b, LocalVect< complex_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< complex_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< complex_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< complex_t > ∗A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< complex_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< complex_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< complex_t > &A)

Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< complex_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< complex_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< complex_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< complex_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< complex_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< complex_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< complex_t > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< complex_t > ∗A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< complex_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< complex_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< complex_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< complex_t > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< complex_t > ∗A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< complex_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< complex_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< complex_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< complex_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< complex_t > &x, Vect< complex_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< complex_t > &x, Vect< complex_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< complex_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< complex_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< complex_t > ∗A, Vect< complex_t > &b, Vect< complex_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< complex_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< complex_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< complex_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< complex_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< complex_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< complex_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void MagneticPermeability (const real_t &mu)

  Set (constant) magnetic permeability.
- void MagneticPermeability (const string &exp)

  Set magnetic permeability given by an algebraic expression.
- void ElectricConductivity (const real_t &sigma)

  Set (constant) electric conductivity.
- void ElectricConductivity (const string &exp)

  set electric conductivity given by an algebraic expression
- void ElectricResistivity (const real_t &rho)

  Set (constant) electric resistivity.
- void ElectricResistivity (const string &exp)

  Set electric resistivity given by an algebraic expression.
- void setMaterial ()

  Set material properties.
- void Init (const Element ∗el)

  Set element arrays to zero.
- void Init (const Side ∗sd)

  Set side arrays to zero.

7.16.1 Detailed Description

Eddy current problems in 2-D domains using solenoidal approximation.

Builds finite element arrays for time harmonic eddy current problems in 2-D domains with solenoidal configurations (Magnetic field has only one nonzero component). Magnetic field is constant in the vacuum, and then zero in the outer vacuum.

Uses 3-Node triangles.

The unknown is the time-harmonic magnetic induction (complex valued).

7.16.2 Constructor & Destructor Documentation

EC2D1T3 (const Element ∗ *el*)

Constructor using element data.

Parameters

in	*el*	Pointer to Element instance

EC2D1T3 (const Side ∗ *side*)

Constructor using side data.

Parameters

in	*side*	Pointer to Side instance

EC2D1T3 (const Element ∗ *el*, const Vect< complex_t > & *u*, const real_t & *time* = `0.`)

Constructor using element and previous time data.

Parameters

in	*el*	Pointer to Element instance
in	*u*	Solution at previous iteration
in	*time*	Time value [Default: 0]

EC2D1T3 (const Side ∗ *sd*, const Vect< complex_t > & *u*, const real_t & *time* = `0.`)

Constructor using side and previous time data.

Parameters

in	*sd*	Pointer to Side instance
in	*u*	Solution at previous iteration
in	*time*	Time value [Default: 0]

7.16.3 Member Function Documentation

void Magnetic (real_t *omega*, real_t *coef* = `1.`)

Add magnetic contribution to matrix.

Parameters

`in`	*omega*	Angular frequency
`in`	*coef*	Coefficient to multiply by [Default: `1`]

void Electric (real_t *coef* = `1.`)

Add electric contribution to matrix.

Parameters

`in`	*coef*	Coefficient to multiply by [Default: `1`]

complex_t IntegND (const Vect< complex_t > & *h*, int *opt* = GLOBAL_ARRAY)

Compute integral of normal derivative on edge.

Parameters

`in`	*h*	Vect instance containing magnetic field at element nodes
`in`	*opt*	Vector `h` is local (`LOCAL_ARRAY`) with size 3 or global (`GLOBAL_ARRAY`) with size = Number of nodes [Default: `GLOBAL_ARRAY`].

Note

This member function is to be called within each element, it detects boundary sides as the ones with nonzero code

void updateBC (const Element & *el*, const Vect< complex_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*el*	Reference to current element instance
`in`	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< complex_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< complex_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< complex_t > & *b*, LocalVect< complex_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< complex_t > & *b*, LocalVect< complex_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< complex_t > & *b*, LocalVect< complex_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< complex_t > & *b*, LocalVect< complex_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< complex_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< complex_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.

Coordinates are stored in array `_x[0]`, `_x[1]`, ... which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< complex_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< complex_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< complex_t > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< complex_t > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< complex_t > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< complex_t > ∗ *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< complex_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< complex_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< complex_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< complex_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< complex_t > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< complex_t > & *x*, Vect< complex_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< complex_t > & *x*, Vect< complex_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, **Preconditioner** *pc* **=** *`IDENT_PREC`* **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< complex_t > ∗ *A*, Vect< complex_t > & *b*, Vect< complex_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

`in`	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	*b*	Vector containing right-hand side
`in,out`	*x*	Vector containing initial guess of solution on input, actual solution on output

7.16.4 Member Data Documentation

LocalVect<complex_t ,NEE_> ePrev `[inherited]`

LocalVect instance containing local vector associated to current element.
This vector has been stored as the one at previous iteration or previous time step

7.17 Edge Class Reference

To describe an edge.

Public Member Functions

- Edge ()
  Default Constructor.
- Edge (size_t label)
  Constructor with label.
- Edge (const Edge &ed)
  Copy constructor.
- ~Edge ()
  Destructor.
- void Add (Node ∗node)
  Insert a node at end of list of nodes of edge.
- void setLabel (size_t i)
  Assign label of edge.
- void setFirstDOF (size_t n)
  Define First DOF.
- void setNbDOF (size_t nb_dof)
  Define number of DOF of edge.
- void DOF (size_t i, size_t dof)
  Define label of DOF.
- void setDOF (size_t &first_dof, size_t nb_dof)
  Define number of DOF.
- void setCode (size_t dof, int code)
  Assign code `code` *to DOF number* `dof`*.*
- void AddNeighbor (Side ∗sd)
  Add side pointed by `sd` *to list of edge sides.*

- size_t getLabel () const
  Return label of edge.
- size_t n () const
  Return label of edge.
- size_t getNbEq () const
  Return number of edge equations.
- size_t getNbDOF () const
  Return number of DOF.
- int getCode (size_t dof=1) const
  Return code for a given DOF of node.
- size_t getDOF (size_t i) const
  Return label of `i`-th DOF.
- size_t getFirstDOF () const
  Return number of first dof of node.
- Node ∗ getPtrNode (size_t i) const
  List of element nodes.
- Node ∗ operator() (size_t i) const
  Operator ().
- size_t getNodeLabel (size_t i) const
  Return node label.
- Side ∗ getNeighborSide (size_t i) const
  Return pointer to neighbor i-th side.
- int isOnBoundary () const
  Say if current edge is a boundary edge or not.
- void setOnBoundary ()
  Say that the edge is on the boundary.
- Node ∗ operator() (size_t i)
  Operator ().

7.17.1 Detailed Description

To describe an edge.

Defines an edge of a 3-D finite element mesh. The edges are given in particular by a list of nodes. Each node can be accessed by the member function getPtrNode.

7.17.2 Constructor & Destructor Documentation

Edge ( )

Default Constructor.

Initializes data to zero

Edge (size_t *label*)

Constructor with label.

Define an edge by giving its `label`

7.17.3 Member Function Documentation

void DOF (size_t *i*, size_t *dof*)

Define label of DOF.

Parameters

in	*i*	DOF index
in	*dof*	Its label

void setDOF (size_t & *first_dof*, size_t *nb_dof*)

Define number of DOF.

Parameters

in,out	*first_dof*	Label of the first DOF in input that is actualized
in	*nb_dof*	Number of DOF

void setCode (size_t *dof*, int *code*)

Assign code `code` to DOF number `dof`.

Parameters

in	*dof*	index of dof for assignment.
in	*code*	Value of code to assign.

int getCode (size_t *dof* = 1) const

Return code for a given DOF of node.
Default value is 1

Node∗ operator() (size_t *i*) const

Operator ().
Return pointer to node of local label `i`.

size_t getNodeLabel (size_t *i*) const

Return node label.

Parameters

in	*i*	Local label of node for which global label is returned

int isOnBoundary ( ) const

Say if current edge is a boundary edge or not.
Note this information is available only if boundary edges were determined. See class Mesh

Node* operator() (size_t *i*)

Operator ().

Returns pointer to node of local label `i`

7.18 EdgeList Class Reference

Class to construct a list of edges having some common properties.

Public Member Functions

- EdgeList (Mesh &ms)

  Constructor using a Mesh instance.
- ~EdgeList ()

  Destructor.
- void selectCode (int code, int dof=1)

  Select edges having a given code for a given degree of freedom.
- void unselectCode (int code, int dof=1)

  Unselect edges having a given code for a given degree of freedom.
- size_t getNbEdges () const

  Return number of selected edges.
- void top ()

  Reset list of edges at its top position (Non constant version)
- void top () const

  Reset list of edges at its top position (Constant version)
- Edge * get ()

  Return pointer to current edge and move to next one (Non constant version)
- Edge * get () const

  Return pointer to current edge and move to next one (Constant version)

7.18.1 Detailed Description

Class to construct a list of edges having some common properties.

This class enables choosing multiple selection criteria by using function `select...` However, the intersection of these properties must be empty.

7.18.2 Member Function Documentation

void selectCode (int *code*, int *dof* = *1*)

Select edges having a given code for a given degree of freedom.

Parameters

`in`	*code*	Code that edges share
`in`	*dof*	Degree of Freedom label [Default: 1]

void unselectCode (int *code*, int *dof* = 1)

Unselect edges having a given code for a given degree of freedom.

Parameters

in	*code*	Code of edges to exclude
in	*dof*	Degree of Freedom label [Default: 1]

7.19 EigenProblemSolver Class Reference

Class to find eigenvalues and corresponding eigenvectors of a given matrix in a generalized eigenproblem, *i.e.* Find scalars l and non-null vectors v such that [K]{v} = l[M]{v} where [K] and [M] are symmetric matrices. The eigenproblem can be originated from a PDE. For this, we will refer to the matrices K and M as *Stiffness* and *Mass* matrices respectively.

Public Member Functions

- EigenProblemSolver ()
  Default constructor.
- EigenProblemSolver (DSMatrix< real_t > &K, int n=0)
  Constructor for a dense symmetric matrix that computes the eigenvalues.
- EigenProblemSolver (SkSMatrix< real_t > &K, SkSMatrix< real_t > &M, int n=0)
  Constructor for Symmetric Skyline Matrices.
- EigenProblemSolver (SkSMatrix< real_t > &K, Vect< real_t > &M, int n=0)
  Constructor for Symmetric Skyline Matrices.
- EigenProblemSolver (DSMatrix< real_t > &A, Vect< real_t > &ev, int n=0)
  Constructor for a dense matrix that compute the eigenvalues.
- EigenProblemSolver (AbsEqua< real_t > &eq, bool lumped=true)
  Consrtuctor using partial differential equation.
- ∼EigenProblemSolver ()
  Destructor.
- void setMatrix (SkSMatrix< real_t > &K, SkSMatrix< real_t > &M)
  Set matrix instances (Symmetric matrices).
- void setMatrix (SkSMatrix< real_t > &K, Vect< real_t > &M)
  Set matrix instances (Symmetric matrices).
- void setMatrix (DSMatrix< real_t > &K)
  Set matrix instance (Symmetric matrix).
- void setPDE (AbsEqua< real_t > &eq, bool lumped=true)
  Define partial differential equation to solve.
- int run (int nb=0)
  Run the eigenproblem solver.
- void Assembly (const Element &el, real_t *eK, real_t *eM)
  Assemble element arrays into global matrices.
- void SAssembly (const Side &sd, real_t *sK)
  Assemble side arrays into global matrix and right-hand side.
- int runSubSpace (size_t nb_eigv, size_t ss_dim=0)

Run the subspace iteration solver.

- void setSubspaceDimension (int dim)

  Define the subspace dimension.
- void setMaxIter (int max_it)

  set maximal number of iterations.
- void setTolerance (real_t eps)

  set tolerance value
- int checkSturm (int &nb_found, int &nb_lost)

  Check how many eigenvalues have been found using Sturm sequence method.
- int getNbIter () const

  Return actual number of performed iterations.
- real_t getEigenValue (int n) const

  Return the n-th eigenvalue.
- void getEigenVector (int n, Vect< real_t > &v) const

  Return the n-th eigenvector.

7.19.1 Detailed Description

Class to find eigenvalues and corresponding eigenvectors of a given matrix in a generalized eigenproblem, *i.e.* Find scalars l and non-null vectors v such that [K]{v} = l[M]{v} where [K] and [M] are symmetric matrices. The eigenproblem can be originated from a PDE. For this, we will refer to the matrices K and M as *Stiffness* and *Mass* matrices respectively.

7.19.2 Constructor & Destructor Documentation

EigenProblemSolver (DSMatrix< real_t > & *K*, int *n* = 0)

Constructor for a dense symmetric matrix that computes the eigenvalues.

This constructor solves in place the eigenvalues problem and stores them in a vector (No need to use the function runSubSpace). The eigenvectors can be obtained by calling the member function getEigenVector.

Parameters

in	*K*	Matrix for which eigenmodes are sought.
in	*n*	Number of eigenvalues to extract. By default all eigenvalues are computed.

EigenProblemSolver (SkSMatrix< real_t > & *K*, SkSMatrix< real_t > & *M*, int *n* = 0)

Constructor for Symmetric Skyline Matrices.

Parameters

in	*K*	"Stiffness" matrix
in	*M*	Diagonal "Mass" matrix stored as a Vect instance
in	*n*	Number of eigenvalues to extract. By default all eigenvalues are computed.

Note

The generalized eigenvalue problem is defined by `Kx = aMx`, where `K` and `M` are referred to as stiffness and mass matrix.

EigenProblemSolver (SkSMatrix< real_t > & *K*, Vect< real_t > & *M*, int *n* = `0`)

Constructor for Symmetric Skyline Matrices.

Parameters

in	*K*	"Stiffness" matrix
in	*M*	Diagonal "Mass" matrix stored as a Vect instance
in	*n*	Number of eigenvalues to extract. By default all eigenvalues are computed.

Note

The generalized eigenvalue problem is defined by `Kx = aMx`, where `K` and `M` are referred to as stiffness and mass matrix.

EigenProblemSolver (DSMatrix< real_t > & *A*, Vect< real_t > & *ev*, int *n* = `0`)

Constructor for a dense matrix that compute the eigenvalues.

This constructor solves in place the eigenvalues problem and stores them in a vector (No need to use the function runSubSpace). The eigenvectors can be obtained by calling the member function getEigenVector.

Parameters

in	*A*	Matrix for which eigenmodes are sought.
in	*ev*	Vector containing all computed eigenvalues sorted increasingly.
in	*n*	Number of eigenvalues to extract. By default all eigenvalues are computed.

Remarks

The vector ev does not need to be sized before.

EigenProblemSolver (AbsEqua< real_t > & *eq*, bool *lumped* = `true`)

Consrtuctor using partial differential equation.

The used equation class must have been constructed using the Mesh instance

Parameters

in	*eq*	Reference to equation instance
in	*lumped*	Mass matrix is lumped (*true*) or not (*false*) [Default: `true`]

7.19.3 Member Function Documentation

void setMatrix (SkSMatrix< real_t > & *K*, SkSMatrix< real_t > & *M*)

Set matrix instances (Symmetric matrices).

This function is to be used when the default constructor is applied. Case where the mass matrix is consistent.

Parameters

in	*K*	Stiffness matrix instance
in	*M*	Mass matrix instance

void setMatrix (SkSMatrix< real_t > & *K*, Vect< real_t > & *M*)

Set matrix instances (Symmetric matrices).

This function is to be used when the default constructor is applied. Case where the mass matrix is (lumped) diagonal and stored in a vector.

Parameters

in	*K*	Stiffness matrix instance
in	*M*	Mass matrix instance where diagonal terms are stored as a vector.

void setMatrix (DSMatrix< real_t > & *K*)

Set matrix instance (Symmetric matrix).

This function is to be used when the default constructor is applied. Case of a standard (not generalized) eigen problem is to be solved

Parameters

in	*K*	Stiffness matrix instance

void setPDE (AbsEqua< real_t > & *eq*, bool *lumped* = `true`)

Define partial differential equation to solve.

The used equation class must have been constructed using the Mesh instance

Parameters

in	*eq*	Reference to equation instance
in	*lumped*	Mass matrix is lumped (*true*) or not (*false*) [Default: `true`]

int run (int *nb* = `0`)

Run the eigenproblem solver.

Parameters

in	*nb*	Number of eigenvalues to be computed. By default, all eigenvalues are computed.

void Assembly (const Element & *el*, real_t ∗ *eK*, real_t ∗ *eM*)

Assemble element arrays into global matrices.
This member function is to be called from finite element equation classes

Parameters

in	*el*	Reference to Element class
in	*eK*	Pointer to element stiffness (or assimilated) matrix
in	*eM*	Pointer to element mass (or assimilated) matrix

void SAssembly (const Side & *sd*, real_t ∗ *sK*)

Assemble side arrays into global matrix and right-hand side.
This member function is to be called from finite element equation classes

Parameters

in	*sd*	Reference to Side class
in	*sK*	Pointer to side stiffness

int runSubSpace (size_t *nb_eigv*, size_t *ss_dim* = *0*)

Run the subspace iteration solver.
This function rune the Bathe subspace iteration method.

Parameters

in	*nb_eigv*	Number of eigenvalues to be extracted
in	*ss_dim*	Subspace dimension. Must be at least equal to the number eigenvalues to seek. [Default: `nb_eigv`]

Returns

1: Normal execution. Convergence has been achieved. 2: Convergence for eigenvalues has not been attained.

void setSubspaceDimension (int *dim*)

Define the subspace dimension.

Parameters

in	*dim*	Subspace dimension. Must be larger or equal to the number of wanted eigenvalues. By default this value will be set to the number of wanted eigenvalues

void setTolerance (real_t *eps*)

set tolerance value

Parameters

in	*eps*	Convergence tolerance for eigenvalues [Default: 1.e-8]

int checkSturm (int & *nb_found*, int & *nb_lost*)

Check how many eigenvalues have been found using Sturm sequence method.

Parameters

out	*nb_found*	number of eigenvalues actually found
out	*nb_lost*	number of eigenvalues missing

Returns

- 0, Successful completion of subroutine.
  - 1, No convergent eigenvalues found.

void getEigenVector (int *n*, Vect< real_t > & *v*) const

Return the n-th eigenvector.

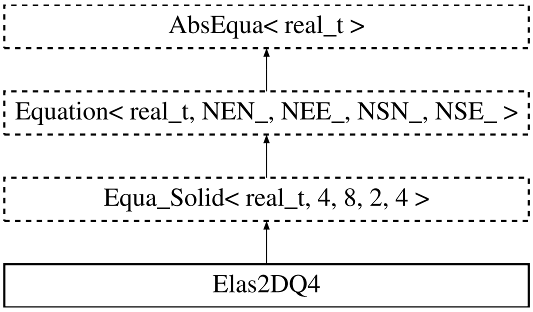
Parameters

in	*n*	Label of eigenvector (They are stored in ascending order of eigenvalues)
in,out	*v*	Vect instance where the eigenvector is stored.

7.20 Elas2DQ4 Class Reference

To build element equations for 2-D linearized elasticity using 4-node quadrilaterals.

Inheritance diagram for Elas2DQ4:



Public Member Functions

- Elas2DQ4 ()

  Default Constructor.
- Elas2DQ4 (const Element ∗el)

  Constructor using element data.
- Elas2DQ4 (const Side ∗sd)

  Constructor using side data.
- Elas2DQ4 (const Element ∗element, const Vect< real_t > &u, const real_t &time=0.)

  Constructor using element and previous time data.
- Elas2DQ4 (const Side ∗side, const Vect< real_t > &u, const real_t &time=0.)

  Constructor using side and previous time data.
- ∼Elas2DQ4 ()

  Destructor.
- void PlaneStrain ()

  Set plane strain hypothesis.
- void PlaneStrain (real_t E, real_t nu)

  Set plane strain hypothesis by giving values of Young's modulus and Poisson ratio.
- void PlaneStress ()

  Set plane stress hypothesis.
- void PlaneStress (real_t E, real_t nu)

  Set plane stress hypothesis by giving values of Young's modulus and Poisson ratio.
- void LMassToLHS (real_t coef=1.)

  Add element lumped mass contribution to matrix after multiplication by `coef` *[Default: 1].*
- void LMassToRHS (real_t coef=1.)

  Add element lumped mass contribution to right-hand side after multiplication by `coef` *[Default: 1].*
- void LMass (real_t coef=1.)

  Add element lumped mass contribution to matrix and right-hand side after multiplication by `coef` *[Default←→ : 1].*
- void Mass (real_t coef=1.)

  Add element consistent mass contribution to matrix and right-hand side after multiplication by `coef` *[Default: 1].*
- void Deviator (real_t coef=1.)

  Add element deviatoric matrix to left-hand side after multiplication by `coef` *[Default: 1].*
- void DeviatorToRHS (real_t coef=1.)

  Add element deviatoric contribution to right-hand side after multiplication by `coef` *[Default: 1].*
- void Dilatation (real_t coef=1.)

Add element dilatational contribution to left-hand side after multiplication by `coef` *[Default:* `1`*].*

- void DilatationToRHS (real_t coef=1.)

  Add element dilatational contribution to right hand side after multiplication by `coef` *[Default:* `1`*].*
- void BodyRHS (UserData< real_t > &ud)

  Add body right-hand side term to right hand side after multiplication by `coef`
- void BodyRHS (const Vect< real_t > &bf, int opt=GLOBAL_ARRAY)

  Add body right-hand side term to right hand side.
- void BoundaryRHS (UserData< real_t > &ud)

  Add boundary right-hand side term to right hand side after multiplication by `coef`
- void BoundaryRHS (const Vect< real_t > &sf)

  Add boundary right-hand side term to right hand side.
- int SignoriniContact (UserData< real_t > &ud, real_t coef=1.e07)

  Penalty Signorini contact side contribution to matrix and right-hand side.
- void Strain (LocalVect< real_t, 3 > &eps)

  Calculate strains at element barycenter.
- void Stress (LocalVect< real_t, 3 > &s, real_t &vm)

  Calculate principal stresses and Von-Mises stress at element barycenter.
- void Stress (LocalVect< real_t, 3 > &sigma, LocalVect< real_t, 3 > &s, real_t &vm)

  Calculate principal stresses and Von-Mises stress at element barycenter.
- virtual void MassToLHS (real_t coef=1)

  Add consistent mass contribution to left-hand side.
- virtual void MassToRHS (real_t coef=1)

  Add consistent mass contribution to right-hand side.
- void setLumpedMass ()

  Add lumped mass contribution to left and right-hand sides taking into account time integration scheme.
- void setMass ()

  Add consistent mass contribution to left and right-hand sides taking into account time integration scheme.
- virtual void Stiffness (real_t coef=1)

  Add stiffness matrix to left-hand side taking into account time integration scheme, after multiplication by `coef` *[Default:* `1`*].*
- virtual void StiffnessToRHS (real_t coef=1)

  Add stiffness matrix to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default:* `1`*].*
- void setDilatation ()

  Add dilatation matrix to left and/or right-hand side taking into account time.
- void setDeviator ()

  Add deviator matrix to left and/or right-hand side taking into account time integration scheme.
- void setStiffness ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.

- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > *A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.

- void SideAssembly (Vect< real_t > &v)
  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > ∗A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const
  Return number of element nodes.
- size_t getNbEq () const
  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)
  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)
  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)
  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const
  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()
  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)
  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > ∗A, Vect< real_t > &b, Vect< real_t > &x)
  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat
  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat
  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev
  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS
  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes
  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS
  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Young (const real_t &E)

  Set (constant) Young modulus.
- void Young (const string &exp)

  Set Young modulus given by an algebraic expression.
- void Poisson (const real_t &nu)

  Set (constant) Poisson ratio.
- void Poisson (const string &exp)

  Set Poisson ratio given by an algebraic expression.
- void Density (const real_t &rho)

  Set (constant) density.
- void Density (const string &exp)

  Set density given by an algebraic expression.
- void setMaterial ()

  Set material properties.
- void Init (const Element ∗el)

  Set element arrays to zero.
- void Init (const Side ∗sd)

  Set side arrays to zero.

7.20.1 Detailed Description

To build element equations for 2-D linearized elasticity using 4-node quadrilaterals.

This class enables building finite element arrays for linearized isotropic elasticity problem in 2-D domains using 4-Node quadrilaterals.
Unilateral contact is handled using a penalty function. Note that members calculating element arrays have as an argument a real `coef` that is multiplied by the contribution of the current element. This makes possible testing different algorithms.

7.20.2 Constructor & Destructor Documentation

Elas2DQ4 ( )

Default Constructor.

Constructs an empty equation.

Elas2DQ4 (const Element ∗ *element*, const Vect< real_t > & *u*, const real_t & *time* = `0.`)

Constructor using element and previous time data.

Parameters

in	*element*	Pointer to element
in	*u*	Vect instance containing solution at previous time step
in	*time*	Current time value [Default: 0]

Elas2DQ4 (const Side ∗ *side*, const Vect< real_t > & *u*, const real_t & *time* = `0.`)

Constructor using side and previous time data.

Parameters

in	*side*	Pointer to side
in	*u*	Vect instance containing solution at previous time step
in	*time*	Current time value [Default: `0`]

7.20.3 Member Function Documentation

void PlaneStrain (real_t *E*, real_t *nu*)

Set plane strain hypothesis by giving values of Young's modulus and Poisson ratio.

Parameters

in	*E*	Young's modulus
in	*nu*	Poisson ratio

void PlaneStress (real_t *E*, real_t *nu*)

Set plane stress hypothesis by giving values of Young's modulus and Poisson ratio.

Parameters

in	*E*	Young's modulus
in	*nu*	Poisson ratio

void DilatationToRHS (real_t *coef* = *1.*) `[virtual]`

Add element dilatational contribution to right hand side after multiplication by `coef` [Default: `1`].

To use for explicit formulations

Reimplemented from Equa_Solid< real_t, 4, 8, 2, 4 >.

void BodyRHS (UserData< real_t > & *ud*)

Add body right-hand side term to right hand side after multiplication by `coef`

Body forces are deduced from UserData instance `ud`

void BodyRHS (const Vect< real_t > & *bf*, int *opt* = GLOBAL_ARRAY)

Add body right-hand side term to right hand side.

Parameters

in	*bf*	Vector containing source at element nodes (DOF by DOF).
in	*opt*	Vector is local (`LOCAL_ARRAY`) with size 8 or global (`GLOBAL_ARRAY`) with size = Total number of DOF [Default: `GLOBAL_ARRAY`].

void BoundaryRHS (UserData< real_t > & *ud*)

Add boundary right-hand side term to right hand side after multiplication by `coef`
Boundary forces are deduced from UserData instance `ud`

void BoundaryRHS (const Vect< real_t > & *sf*)

Add boundary right-hand side term to right hand side.

Parameters

in	*sf*	Vector containing source at element nodes (DOF by DOF).

Warning

The vector `sf` is sidewise constant, *i.e.* its size is twice the number of sides.

int SignoriniContact (UserData< real_t > & *ud*, real_t *coef* = `1.e07`)

Penalty Signorini contact side contribution to matrix and right-hand side.

Parameters

in	*ud*	UserData instance defining contact data
in	*coef*	Penalty value by which the added term is multiplied [Default: `1.e07`]

Returns

`0` if no contact was realized on this side, `1` otherwise

void Strain (LocalVect< real_t, 3 > & *eps*)

Calculate strains at element barycenter.

Parameters

out	*eps*	Vector containing strains in element

void Stress (LocalVect< real_t, 3 > & *s*, real_t & *vm*)

Calculate principal stresses and Von-Mises stress at element barycenter.

Parameters

out	*s*	LocalVect containing principal stresses in element
out	*vm*	Value of Von-Mises stress in element

void Stress (LocalVect< real_t, 3 > & *sigma*, LocalVect< real_t, 3 > & *s*, real_t & *vm*)

Calculate principal stresses and Von-Mises stress at element barycenter.

Parameters

`out`	*sigma*	Vector containing principal stresses in element
`out`	*s*	Vector containing principal stresses in element
`out`	*vm*	Value of Von-Mises stress in element

virtual void MassToLHS (real_t *coef* = *1*) `[virtual]`, `[inherited]`

Add consistent mass contribution to left-hand side.

Parameters

`in`	*coef*	coefficient to multiply by the matrix before adding [Default: `1`]

virtual void MassToRHS (real_t *coef* = *1*) `[virtual]`, `[inherited]`

Add consistent mass contribution to right-hand side.

Parameters

`in`	*coef*	coefficient to multiply by the vector before adding [Default: `1`]

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*el*	Reference to current element instance
`in`	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

`in`	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
`in`	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides

Parameters

in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * A) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & v) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * A) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const [inherited]

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *IDENT_PREC* **)** [inherited]

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: DIRECT_SOLVER, CG_SOLVER, GMRES_SOLVER • DIRECT_SOLVER, Use a facorization solver [default] • CG_SOLVER, Conjugate Gradient iterative solver • CGS_SOLVER, Squared Conjugate Gradient iterative solver • BICG_SOLVER, BiConjugate Gradient iterative solver • BICG_STAB_SOLVER, BiConjugate Gradient Stabilized iterative solver • GMRES_SOLVER, GMRES iterative solver • QMR_SOLVER, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • IDENT_PREC, Identity preconditioner (no preconditioning [default]) • DIAG_PREC, Diagonal preconditioner • ILU_PREC, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > ∗ *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) [inherited]

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

7.20.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

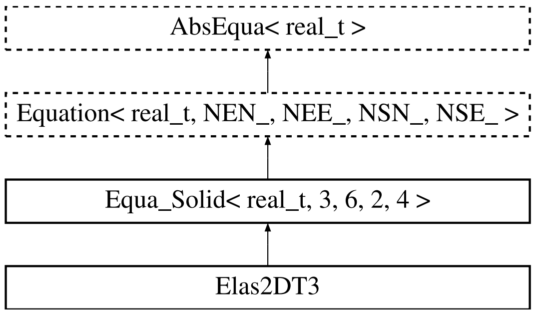
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.21 Elas2DT3 Class Reference

To build element equations for 2-D linearized elasticity using 3-node triangles.

Inheritance diagram for Elas2DT3:



Public Member Functions

- Elas2DT3 ()

  Default Constructor.
- Elas2DT3 (Mesh &ms)

  Constructor using Mesh data.
- Elas2DT3 (const Element *el)

  Constructor using element data.
- Elas2DT3 (const Side *sd)

  Constructor using side data.
- Elas2DT3 (const Element *el, const Vect< real_t > &u, real_t time=0.)

  Constructor using element, previous time solution `u` *and time value.*
- Elas2DT3 (const Element *el, const Vect< real_t > &u, real_t time, real_t deltat, int scheme)

  Constructor for an element (transient case) with specification of time integration scheme.
- Elas2DT3 (const Side *sd, const Vect< real_t > &u, real_t time=0.)

  Constructor using side, previous time solution `u` *and time value.*
- Elas2DT3 (const Side *sd, const Vect< real_t > &u, real_t time, real_t deltat, int scheme)

  Constructor for a side (transient case) with specification of time integration scheme.
- ~Elas2DT3 ()

  Destructor.
- void Media (real_t E, real_t nu, real_t rho)

  Set media properties.
- void PlaneStrain ()

  Set plane strain hypothesis.
- void PlaneStrain (real_t E, real_t nu)

  Set plane strain hypothesis by giving values of Young's modulus `E` *and Poisson ratio* `nu`

- void PlaneStress ()

  Set plane stress hypothesis.
- void PlaneStress (real_t E, real_t nu)

  Set plane stress hypothesis by giving values of Young's modulus `E` *and Poisson ratio* `nu`
- void LMassToLHS (real_t coef=1.)

  Add element lumped mass contribution to matrix after multiplication by `coef`
- void LMassToRHS (real_t coef=1.)

  Add element lumped mass contribution to right-hand side after multiplication by `coef`
- void LMass (real_t coef=1.)

  Add element lumped mass contribution to matrix and right-hand side after multiplication by `coef`
- void MassToLHS (real_t coef=1.)

  Add element consistent mass contribution to matrix after multiplication by `coef`
- void MassToRHS (real_t coef=1.)

  Add element consistent mass contribution to right-hand side after multiplication by `coef`
- void Mass (real_t coef=1.)

  Add element consistent mass contribution to matrix and right-hand side after multiplication by `coef`
- void Deviator (real_t coef=1.)

  Add element deviatoric matrix to left-hand side after multiplication by `coef`
- void DeviatorToRHS (real_t coef=1.)

  Add element deviatoric contribution to right-hand side after multiplication by `coef`
- void Dilatation (real_t coef=1.)

  Add element dilatational contribution to left-hand side after multiplication by `coef`
- void DilatationToRHS (real_t coef=1.)

  Add element dilatational contribution to right-hand side after multiplication by `coef`
- void BodyRHS (UserData< real_t > &ud)

  Add body right-hand side term to right-hand side after multiplication by `coef`
- void BodyRHS (const Vect< real_t > &f, int opt=GLOBAL_ARRAY)

  Add body right-hand side term to right hand side.
- void BoundaryRHS (UserData< real_t > &ud)

  Add boundary right-hand side term to right hand side after multiplication by `coef`
- void BoundaryRHS (const Vect< real_t > &f)

  Add boundary right-hand side term to right hand side.
- int SignoriniContact (UserData< real_t > &ud, real_t coef=1.e07)

  Penalty Signorini contact side contribution to matrix and right-hand side.
- int SignoriniContact (Vect< real_t > &f, real_t coef=1.e07)

  Penalty Signorini contact side contribution to matrix and right-hand side.
- void Reaction (Vect< real_t > &r)

  Calculate reactions.
- void ContactPressure (const Vect< real_t > &f, real_t penal, Point< real_t > &p)

  Calculate contact pressure.
- void Strain (Vect< real_t > &eps)

  Calculate strains in element.
- void Stress (Vect< real_t > &s, real_t &vm)

  Calculate principal stresses and Von-Mises stress in element.
- void Periodic (real_t coef=1.e20)

  Add contribution of periodic boundary condition (by a penalty technique).

- void setLumpedMass ()

  Add lumped mass contribution to left and right-hand sides taking into account time integration scheme.
- void setMass ()

  Add consistent mass contribution to left and right-hand sides taking into account time integration scheme.
- virtual void Stiffness (real_t coef=1)

  Add stiffness matrix to left-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- virtual void StiffnessToRHS (real_t coef=1)

  Add stiffness matrix to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- void setDilatation ()

  Add dilatation matrix to left and/or right-hand side taking into account time.
- void setDeviator ()

  Add deviator matrix to left and/or right-hand side taking into account time integration scheme.
- void setStiffness ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.

- void ElementAssembly (BMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)
  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)
  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)
  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > *A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)
  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > *A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const
  Return number of element nodes.
- size_t getNbEq () const
  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)
  Set initial solution (previous time step)

- real_t setMaterialProperty (const string &exp, const string &prop)
  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)
  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const
  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()
  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)
  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > ∗A, Vect< real_t > &b, Vect< real_t > &x)
  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat
  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat
  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev
  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS
  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes
  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS
  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Young (const real_t &E)
  Set (constant) Young modulus.
- void Young (const string &exp)
  Set Young modulus given by an algebraic expression.
- void Poisson (const real_t &nu)
  Set (constant) Poisson ratio.
- void Poisson (const string &exp)
  Set Poisson ratio given by an algebraic expression.
- void Density (const real_t &rho)
  Set (constant) density.
- void Density (const string &exp)
  Set density given by an algebraic expression.
- void setMaterial ()
  Set material properties.
- void Init (const Element ∗el)
  Set element arrays to zero.
- void Init (const Side ∗sd)
  Set side arrays to zero.

7.21.1 Detailed Description

To build element equations for 2-D linearized elasticity using 3-node triangles.

This class enables building finite element arrays for linearized isotropic elasticity problem in 2-D domains using 3-Node triangles.

Unilateral contact is handled using a penalty function. Note that members calculating element arrays have as an argument a real `coef` that is multiplied by the contribution of the current element. This makes possible testing different algorithms.

7.21.2 Constructor & Destructor Documentation

Elas2DT3 ( )

Default Constructor.

Constructs an empty equation.

Elas2DT3 (Mesh & *ms*)

Constructor using Mesh data.

Parameters

in	*ms*	Mesh instance

Elas2DT3 (const Element * *el*)

Constructor using element data.

Parameters

el	Pointer to Element instance

Elas2DT3 (const Side * *sd*)

Constructor using side data.

Parameters

sd	Pointer to Side instance

Elas2DT3 (const Element * *el*, const Vect< real_t > & *u*, real_t *time* = 0.)

Constructor using element, previous time solution `u` and time value.

Parameters

in	*el*	Pointer to element.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value [Default: 0].

Elas2DT3 (const Element ∗ *el*, const Vect< real_t > & *u*, real_t *time*, real_t *deltat*, int *scheme*)

Constructor for an element (transient case) with specification of time integration scheme.

Parameters

in	*el*	Pointer to element.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value.
in	*deltat*	Time step.
in	*scheme*	Time Integration Scheme: To be chosen among the enumerated values: • `FORWARD_EULER`: Forward Euler scheme • `BACKWARD_EULER`: Backward Euler scheme, • `CRANK_NICOLSON`: Crank-Nicolson Euler scheme.

Elas2DT3 (const Side ∗ *sd*, const Vect< real_t > & *u*, real_t *time* = `0.`)

Constructor using side, previous time solution `u` and time value.

Parameters

in	*sd*	Pointer to side.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value [Default: `0`].

Elas2DT3 (const Side ∗ *sd*, const Vect< real_t > & *u*, real_t *time*, real_t *deltat*, int *scheme*)

Constructor for a side (transient case) with specification of time integration scheme.

Parameters

in	*sd*	Pointer to side.
in	*u*	Vect instance that contains solution at previous time step.
in	*time*	Current time value [Default: `0`].
in	*deltat*	Time step.
in	*scheme*	Time Integration Scheme

7.21.3 Member Function Documentation

void Media (real_t *E*, real_t *nu*, real_t *rho*)

Set media properties.
Useful to override material properties deduced from mesh file.

void LMassToLHS (real_t *coef* = 1.) `[virtual]`

Add element lumped mass contribution to matrix after multiplication by `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 3, 6, 2, 4 >.

void LMassToRHS (real_t *coef* = 1.) `[virtual]`

Add element lumped mass contribution to right-hand side after multiplication by `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 3, 6, 2, 4 >.

void LMass (real_t *coef* = 1.) `[virtual]`

Add element lumped mass contribution to matrix and right-hand side after multiplication by `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 3, 6, 2, 4 >.

void MassToLHS (real_t *coef* = 1.) `[virtual]`

Add element consistent mass contribution to matrix after multiplication by `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 3, 6, 2, 4 >.

void MassToRHS (real_t *coef* = 1.) `[virtual]`

Add element consistent mass contribution to right-hand side after multiplication by `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 3, 6, 2, 4 >.

void Mass (real_t *coef* = 1.) [virtual]

Add element consistent mass contribution to matrix and right-hand side after multiplication by `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 3, 6, 2, 4 >.

void Deviator (real_t *coef* = 1.) [virtual]

Add element deviatoric matrix to left-hand side after multiplication by `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 3, 6, 2, 4 >.

void DeviatorToRHS (real_t *coef* = 1.) [virtual]

Add element deviatoric contribution to right-hand side after multiplication by `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 3, 6, 2, 4 >.

void Dilatation (real_t *coef* = 1.) [virtual]

Add element dilatational contribution to left-hand side after multiplication by `coef`

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1].

Reimplemented from Equa_Solid< real_t, 3, 6, 2, 4 >.

void DilatationToRHS (real_t *coef* = 1.) [virtual]

Add element dilatational contribution to right-hand side after multiplication by `coef`
To use for explicit formulations

Parameters

in	*coef*	Coefficient to multiply by added term [Default: 1]

Reimplemented from Equa_Solid< real_t, 3, 6, 2, 4 >.

void BodyRHS (UserData< real_t > & *ud*)

Add body right-hand side term to right-hand side after multiplication by `coef`
Body forces are deduced from UserData instance `ud`

void BodyRHS (const Vect< real_t > & *f*, int *opt* = GLOBAL_ARRAY)

Add body right-hand side term to right hand side.

Parameters

in	*f*	Vector containing source at element nodes (DOF by DOF)
in	*opt*	Vector is local (`LOCAL_ARRAY`) with size `6` or global (`GLOBAL_ARRAY`) with size = Number of element DOF [Default: `GLOBAL_ARRAY`].

void BoundaryRHS (UserData< real_t > & *ud*)

Add boundary right-hand side term to right hand side after multiplication by `coef`

Parameters

in	*ud*	UserData instance defining boundary forces

void BoundaryRHS (const Vect< real_t > & *f*)

Add boundary right-hand side term to right hand side.

Parameters

in	*f*	Vect instance that contains constant traction to impose to side.

int SignoriniContact (UserData< real_t > & *ud*, real_t *coef* = *1.e07*)

Penalty Signorini contact side contribution to matrix and right-hand side.

Parameters

in	*ud*	UserData instance defining contact data
in	*coef*	Penalty value by which the added term is multiplied [Default: `1.e07`]

Returns

= `0` if no contact is achieved on this side, `1` otherwise

int SignoriniContact (Vect< real_t > & *f*, real_t *coef* = *1.e07*)

Penalty Signorini contact side contribution to matrix and right-hand side.

Parameters

in	*f*	Vect instance that contains contact data
in	*coef*	Penalty value by which the added term is multiplied [Default: `1.e07`]

Returns

= `0` if no contact is achieved on this side, `1` otherwise

void Reaction (Vect< real_t > & *r*)

Calculate reactions.
This function can be invoked in postprocessing

Parameters

in	*r*	Reaction on the side

void ContactPressure (const Vect< real_t > & *f*, real_t *penal*, Point< real_t > & *p*)

Calculate contact pressure.
This function can be invoked in postprocessing

Parameters

in	*f*	
in	*penal*	Penalty parameter that was used to impose contact condition
out	*p*	Contact pressure

void Strain (Vect< real_t > & *eps*)

Calculate strains in element.
This function can be invoked in postprocessing.

void Stress (Vect< real_t > & *s*, real_t & *vm*)

Calculate principal stresses and Von-Mises stress in element.

Parameters

in	*s*	vector of principal stresses
in	*vm*	Von-Mises stress. This function can be invoked in postprocessing.

void Periodic (real_t *coef* = *1.e20*)

Add contribution of periodic boundary condition (by a penalty technique).

Boundary nodes where periodic boundary conditions are to be imposed must have codes equal to `PERIODIC_A` on one side and `PERIODIC_B` on the opposite side.

Parameters

`in`	*coef*	Value of penalty parameter [Default: `1.e20`]

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*el*	Reference to current element instance
`in`	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *`NODE_DOF`*, int *dof* = *`0`*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

`in`	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
`in`	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = *NODE_FIELD*, int *flag* = *0*) `[inherited]`

Localize Element Vector.

Parameters

`in`	*b*	Global vector to be localized
`in`	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
`in`	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & A) [inherited]

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & v) [inherited]

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > ∗ A) [inherited]

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & A) [inherited]

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *IDENT_PREC*) `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > ∗ *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

7.21.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

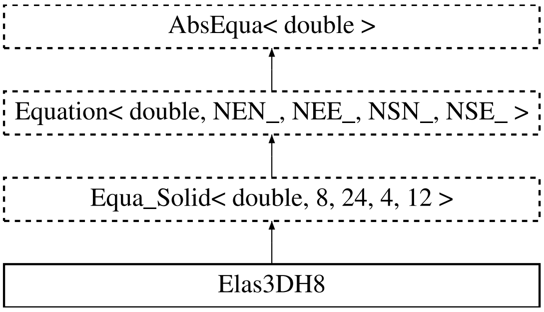
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.22 Elas3DH8 Class Reference

To build element equations for 3-D linearized elasticity using 8-node hexahedra.

Inheritance diagram for Elas3DH8:



Public Member Functions

- Elas3DH8 ()

  Default Constructor.
- Elas3DH8 (const Element ∗el)

  Constructor using element data.
- Elas3DH8 (const Side ∗sd)

  Constructor using side data.
- Elas3DH8 (const Element ∗element, const Vect< real_t > &u, const real_t &time=0.)

  Constructor using element, previous time solution u and time value.
- Elas3DH8 (const Side ∗side, const Vect< real_t > &u, const real_t &time=0.)

  Constructor using side, previous time solution u and time value.
- ∼Elas3DH8 ()

  Destructor.
- void LMassToLHS (real_t coef=1.)

  Add element lumped mass contribution to matrix after multiplication by coef.
- void LMassToRHS (real_t coef=1.)

  Add element lumped mass contribution to right-hand side after multiplication by coef.
- void LMass (real_t coef)

  Add element lumped mass contribution to right-hand and left-hand sides after multiplication by coef.
- void Mass (real_t coef=1.)

  Add element lumped mass contribution to matrix and right-hand side after multiplication by coef.
- void Deviator (real_t coef=1.)

  Add element deviatoric matrix to left-hand side after multiplication by coef.
- void DeviatorToRHS (real_t coef=1.)

  Add element deviatoric matrix to right-hand side after multiplication by coef.
- void Dilatation (real_t coef=1.)

  Add element dilatational contribution to left hand-side after multiplication by coef.
- void DilatationToRHS (real_t coef=1.)

  Add element dilatational contribution to right hand-side after multiplication by coef.
- void BodyRHS (UserData< real_t > &ud)

  Add body right-hand side term to right hand side.
- void BoundaryRHS (const Vect< real_t > &f)

  Add boundary right-hand side term to right hand side.
- void BodyRHS (const Vect< real_t > &bf, int opt=LOCAL_ARRAY)

  Add body right-hand side term to right hand side.
- virtual void MassToLHS (real_t coef=1)

Add consistent mass contribution to left-hand side.

- virtual void MassToRHS (real_t coef=1)

  Add consistent mass contribution to right-hand side.
- void setLumpedMass ()

  Add lumped mass contribution to left and right-hand sides taking into account time integration scheme.
- void setMass ()

  Add consistent mass contribution to left and right-hand sides taking into account time integration scheme.
- virtual void Stiffness (real_t coef=1)

  Add stiffness matrix to left-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- virtual void StiffnessToRHS (real_t coef=1)

  Add stiffness matrix to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default: 1].*
- void setDilatation ()

  Add dilatation matrix to left and/or right-hand side taking into account time.
- void setDeviator ()

  Add deviator matrix to left and/or right-hand side taking into account time integration scheme.
- void setStiffness ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void updateBC (const Element &el, const Vect< double > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< double > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< double > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< double > &b, LocalVect< double, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< double > &b, LocalVect< double, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< double > &b, LocalVect< double, NE↩N_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< double > &b, LocalVect< double, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< double > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< double > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< double > *A)

  Assemble element matrix into global one.

- void ElementAssembly (PETScMatrix< double > &A)
  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< double > &b)
  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< double > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< double > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< double > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< double > &A)
  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< double > &A)
  Assemble element matrix into global one.
- void ElementAssembly (Vect< double > &v)
  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< double > &A)
  Assemble side matrix into global one.
- void SideAssembly (PETScVect< double > &b)
  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< double > *A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< double > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< double > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< double > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< double > &v)
  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< double > *A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< double > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< double > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< double > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< double > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< double > &x, Vect< double > &b)
  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< double > &x, Vect< double > &b)
  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const
  Return number of element nodes.

- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< double > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< double > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< double > *A, Vect< double > &b, Vect< double > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< double, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< double, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< double, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< double, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< double, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< double, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Young (const real_t &E)

  Set (constant) Young modulus.
- void Young (const string &exp)

  Set Young modulus given by an algebraic expression.
- void Poisson (const real_t &nu)

  Set (constant) Poisson ratio.
- void Poisson (const string &exp)

  Set Poisson ratio given by an algebraic expression.
- void Density (const real_t &rho)

  Set (constant) density.
- void Density (const string &exp)

  Set density given by an algebraic expression.
- void setMaterial ()

Set material properties.

- void Init (const Element *el)

  Set element arrays to zero.

- void Init (const Side *sd)

  Set side arrays to zero.

7.22.1 Detailed Description

To build element equations for 3-D linearized elasticity using 8-node hexahedra.

This class enables building finite element arrays for linearized isotropic elasticity problem in 3-D domains using 8-Node hexahedra.

Note that members calculating element arrays have as an argument a double `coef` that is multiplied by the contribution of the current element. This makes possible testing different algorithms.

7.22.2 Constructor & Destructor Documentation

Elas3DH8 ( )

Default Constructor.

Constructs an empty equation.

7.22.3 Member Function Documentation

void BodyRHS (UserData< real_t > & *ud*)

Add body right-hand side term to right hand side.

Body forces are deduced from UserData instance *ud*.

void BoundaryRHS (const Vect< real_t > & *f*)

Add boundary right-hand side term to right hand side.

Parameters

in	*f*	Vector containing traction (boundary force) at sides

void BodyRHS (const Vect< real_t > & *bf*, int *opt* = LOCAL_ARRAY)

Add body right-hand side term to right hand side.

Parameters

in	*bf*	Vector containing source at element nodes (DOF by DOF).
in	*opt*	Vector is local (*LOCAL_ARRAY*) with size 24 or global (*GLOBAL_ARRAY*) with size = Number of element DOF.

virtual void MassToLHS (real_t *coef* = *1*) `[virtual]`, `[inherited]`

Add consistent mass contribution to left-hand side.

Parameters

in	*coef*	coefficient to multiply by the matrix before adding [Default: 1]

virtual void MassToRHS (real_t *coef* = *1*) [virtual], [inherited]

Add consistent mass contribution to right-hand side.

Parameters

in	*coef*	coefficient to multiply by the vector before adding [Default: 1]

void updateBC (const Element & *el*, const Vect< double > & *bc*) [inherited]

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< double > & *bc*) [inherited]

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) [inherited]

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides

Parameters

in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< double > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< double > & *b*, LocalVect< double , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< double > & *b*, LocalVect< double , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< double > & *b*, LocalVect< double , NEN_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< double > & *b*, LocalVect< double , NSE_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< double > & *b*, int *dof_type* = *NODE_FIELD*, int *flag* = *0*) [inherited]

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< double > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< double > ∗ *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< double > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< double > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< double > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< double > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< double > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< double > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< double > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< double > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< double > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< double > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< double > * *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< double > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< double > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< double > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< double > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< double > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< double > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< double > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< double > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< double > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< double > & *x*, Vect< double > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< double > & *x*, Vect< double > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *IDENT_PREC* **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< double > ∗ *A*, Vect< double > & *b*, Vect< double > & *x*) `[inherited]`

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

7.22.4 Member Data Documentation

LocalVect<double ,NEE_> ePrev `[inherited]`

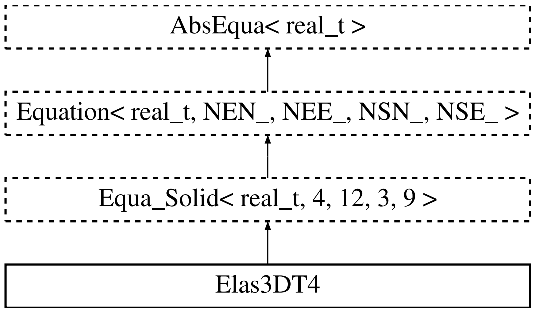
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.23 Elas3DT4 Class Reference

To build element equations for 3-D linearized elasticity using 4-node tetrahedra.

Inheritance diagram for Elas3DT4:



Public Member Functions

- Elas3DT4 ()

  Default Constructor.
- Elas3DT4 (const Element ∗el)

  Constructor using element data.
- Elas3DT4 (const Side ∗sd)

  Constructor using side data.
- Elas3DT4 (const Element ∗element, const Vect< real_t > &u, const real_t &time=0.)

  Constructor using element and previous time data.
- Elas3DT4 (const Side ∗side, const Vect< real_t > &u, const real_t &time=0.)

  Constructor using side and previous time data.
- ∼Elas3DT4 ()

  Destructor.
- void Media (real_t E, real_t nu, real_t rho)

  Set Media properties.
- void LMassToLHS (real_t coef=1)

  Add element lumped mass contribution to matrix after multiplication by coef.
- void LMassToRHS (real_t coef=1)

  Add element lumped mass contribution to right-hand side after multiplication by coef.
- void LMass (real_t coef)

  Add element lumped mass contribution to matrix and right-hand side after multiplication by coef.
- void Deviator (real_t coef=1.)

  Add element deviatoric matrix to left hand-side after multiplication by coef.
- void DeviatorToRHS (real_t coef=1.)

  Add element deviatoric matrix to right hand-side after multiplication by coef.
- void Dilatation (real_t coef=1.)

  Add element dilatational contribution to left-hand side after multiplication by coef.
- void DilatationToRHS (real_t coef=1.)

  Add element dilatational contribution to right-hand side after multiplication by coef.
- void BodyRHS (UserData< real_t > &ud)

  Add body right-hand side term to right hand side after multiplication by coef.

- void BodyRHS (const Vect< real_t > &f, int opt=LOCAL_ARRAY)

  Add body right-hand side term to right hand side.
- void BoundaryRHS (const Vect< real_t > &f)

  Add boundary right-hand side term to right hand side.
- void buildEigen (SkSMatrix< real_t > &K, Vect< real_t > &M)

  Build global stiffness and mass matrices for the eigen system.
- virtual void MassToLHS (real_t coef=1)

  Add consistent mass contribution to left-hand side.
- virtual void MassToRHS (real_t coef=1)

  Add consistent mass contribution to right-hand side.
- void setLumpedMass ()

  Add lumped mass contribution to left and right-hand sides taking into account time integration scheme.
- void setMass ()

  Add consistent mass contribution to left and right-hand sides taking into account time integration scheme.
- virtual void Mass (real_t coef=1)

  Add consistent mass matrix to left-hand side after multiplication by `coef` [Default: 1].
- virtual void Stiffness (real_t coef=1)

  Add stiffness matrix to left-hand side taking into account time integration scheme, after multiplication by `coef` [Default: 1].
- virtual void StiffnessToRHS (real_t coef=1)

  Add stiffness matrix to right-hand side taking into account time integration scheme, after multiplication by `coef` [Default: 1].
- void setDilatation ()

  Add dilatation matrix to left and/or right-hand side taking into account time.
- void setDeviator ()

  Add deviator matrix to left and/or right-hand side taking into account time integration scheme.
- void setStiffness ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.

- void SideVector (const Vect< real_t > &b)
  Localize Side Vector.
- void ElementNodeCoordinates ()
  Localize coordinates of element nodes.
- void SideNodeCoordinates ()
  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)
  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)
  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)
  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)
  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)
  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > *A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)
  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > *A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (TrMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const
  Return number of element nodes.
- size_t getNbEq () const
  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)
  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)
  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)
  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const
  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()
  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)
  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > *A, Vect< real_t > &b, Vect< real_t > &x)
  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat
  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat
  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev
  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS
  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes
  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS
  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Young (const real_t &E)
  Set (constant) Young modulus.
- void Young (const string &exp)
  Set Young modulus given by an algebraic expression.
- void Poisson (const real_t &nu)

Set (constant) Poisson ratio.

- void Poisson (const string &exp)

  Set Poisson ratio given by an algebraic expression.
- void Density (const real_t &rho)

  Set (constant) density.
- void Density (const string &exp)

  Set density given by an algebraic expression.
- void setMaterial ()

  Set material properties.
- void Init (const Element *el)

  Set element arrays to zero.
- void Init (const Side *sd)

  Set side arrays to zero.

7.23.1 Detailed Description

To build element equations for 3-D linearized elasticity using 4-node tetrahedra.

This class enables building finite element arrays for linearized isotropic elasticity problem in 3-D domains using 4-Node tetrahedra.

7.23.2 Member Function Documentation

void Media (real_t *E*, real_t *nu*, real_t *rho*)

Set Media properties.

Parameters

in	*E*	Young's modulus
in	*nu*	Poisson ratio
in	*rho*	Density

void BodyRHS (UserData< real_t > & *ud*)

Add body right-hand side term to right hand side after multiplication by *coef*.

Body forces are deduced from UserData instance *ud*.

void BodyRHS (const Vect< real_t > & *f*, int *opt* = LOCAL_ARRAY)

Add body right-hand side term to right hand side.

Parameters

in	*f*	Vect instance containing source at element nodes (DOF by DOF).
in	*opt*	Vector is local (LOCAL_ARRAY) with size 12 or global (GLOBAL_ARRAY) with size = Number of element DOF.

void BoundaryRHS (const Vect< real_t > & *f*)

Add boundary right-hand side term to right hand side.

Parameters

in	*f*	Vect instance that contains constant traction to impose to side.

void buildEigen (SkSMatrix< real_t > & *K*, Vect< real_t > & *M*)

Build global stiffness and mass matrices for the eigen system.
Case where the mass matrix is lumped

Parameters

in	*K*	Stiffness matrix
in	*M*	Vector containing diagonal mass matrix

virtual void MassToLHS (real_t *coef* = *1*) `[virtual]`, `[inherited]`

Add consistent mass contribution to left-hand side.

Parameters

in	*coef*	coefficient to multiply by the matrix before adding [Default: 1]

virtual void MassToRHS (real_t *coef* = *1*) `[virtual]`, `[inherited]`

Add consistent mass contribution to right-hand side.

Parameters

in	*coef*	coefficient to multiply by the vector before adding [Default: 1]

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & v) `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & A) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & b) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix$<$ real_t $>$ $*A$) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix$<$ real_t $>$ & A) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix$<$ real_t $>$ & A) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix$<$ real_t $>$ & A) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, **Preconditioner** *pc* = *`IDENT_PREC`* **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > ∗ *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

`in`	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	*b*	Vector containing right-hand side
`in,out`	*x*	Vector containing initial guess of solution on input, actual solution on output

7.23.3 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

LocalVect instance containing local vector associated to current element.
This vector has been stored as the one at previous iteration or previous time step

7.24 Element Class Reference

To store and treat finite element geometric information.

Public Member Functions

- Element ()
  Default constructor.
- Element (size_t label, const string &shape)
  Constructor initializing label, shape of element.
- Element (size_t label, int shape)
  Constructor initializing label, shape of element.
- Element (size_t label, const string &shape, int c)
  Constructor initializing label, shape and code of element.
- Element (size_t label, int shape, int c)
  Constructor initializing label, shape and code of element.
- Element (const Element &el)
  Copy constructor.
- ∼Element ()
  Destructor.
- void setLabel (size_t i)
  Define label of element.
- void setCode (int c)
  Define code of element.
- void setCode (const string &exp, int code)
  Define code by a boolean algebraic expression invoking coordinates of element nodes.
- void Add (Node ∗node)
  Insert a node at end of list of nodes of element.
- void Add (Node ∗node, int n)
  Insert a node and set its local node number.

- void Replace (size_t label, Node *node)

  Replace a node at a given local label.
- void Replace (size_t label, Side *side)

  Replace a side at a given local label.
- void Add (Side *sd)

  Assign Side to Element.
- void Add (Side *sd, int k)

  Assign Side to Element with assigned local label.
- void Add (Element *el)

  Add a neighbor element.
- void set (Element *el, int n)

  Add a neighbor element and set its label.
- void setDOF (size_t i, size_t dof)

  Define label of DOF.
- void setCode (size_t dof, int code)

  Assign code to a DOF.
- void setNode (size_t i, Node *node)

  Assign a node given by its pointer as the i-th node of element.
- void setNbDOF (size_t i)

  Set number of degrees of freedom of element.
- void setFirstDOF (size_t i)

  Set label of first DOF in element.
- int getShape () const

  Return element shape.
- size_t getLabel () const

  Return label of element.
- size_t n () const

  Return label of element.
- int getCode () const

  Return code of element.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbVertices () const

  Return number of element vertices.
- size_t getNbSides () const

  Return number of element sides (Constant version)
- size_t getNbEq () const

  Return number of element equations.
- size_t getNbDOF () const

  return element nb of DOF
- size_t getDOF (size_t i=1) const

  Return element DOF label.
- size_t getFirstDOF () const

  Return element first DOF label.
- size_t getNodeLabel (size_t n) const

  Return global label of node of local label `i`*.*

- size_t getSideLabel (size_t n) const

  Return global label of side of local label `i`.
- Node * getPtrNode (size_t i) const

  Return pointer to node of label `i` (Local labelling).
- Node * operator() (size_t i) const

  Operator ().
- Side * getPtrSide (size_t i) const

  Return pointer to side of label `i` (Local labelling).
- int Contains (const Node *nd) const

  Say if element contains given node.
- int Contains (const Node &nd) const

  Say if element contains given node.
- int Contains (const Side *sd) const

  Say if element contains given side.
- int Contains (const Side &sd) const

  Say if element contains given side.
- Element * getNeighborElement (size_t i) const

  Return pointer to element Neighboring element.
- size_t getNbNeigElements () const

  Return number of neigboring elements.
- real_t getMeasure () const

  Return measure of element.
- Point< real_t > getUnitNormal (size_t i) const

  Return outward unit normal to i-th side of element.
- bool isOnBoundary () const

  Say if current element is a boundary element or not.
- Node * operator() (size_t i)

  Operator ().
- int setSide (size_t n, size_t *nd)

  Initialize information on element sides.
- bool isActive () const

  Return `true` or `false` whether element is active or not.
- int getLevel () const

  Return element level Element level decreases when element is refined (starting from 0). If the level is 0, then the element has no father.
- void setChild (Element *el)

  Assign element as child of current one and assign current element as father This function is principally used when refining is invoked (e.g. for mesh adaption)
- Element * getChild (size_t i) const

  Return pointer to i-th child element Return null pointer is no childs.
- size_t getNbChilds () const

  Return number of children of element.
- Element * getParent () const

  Return pointer to parent element Return null if no parent.
- size_t IsIn (const Node *nd)

  Check if a given node belongs to current element.

7.24.1 Detailed Description

To store and treat finite element geometric information.

Class Element enables defining an element of a finite element mesh. The element is given in particular by its shape and a list of nodes. Each node can be accessed by the member function getPtrNode. Moreover, class Mesh can generate for each element its list of sides. The string that defines the element shape must be chosen according to the following list :

Remarks

Once a Mesh instance is constructed, one has access for each Element of the mesh to pointers to element sides provided the member function getAllSides of Mesh has been invoked. With this, an element can be tested to see if it is on the boundary, i.e. if it has at least one side on the boundary

7.24.2 Constructor & Destructor Documentation

Element (size_t *label*, const string & *shape*)

Constructor initializing label, shape of element.

Parameters

in	*label*	Label to assign to element.
in	*shape*	Shape of element (See class description).

Element (size_t *label*, int *shape*)

Constructor initializing label, shape of element.

Parameters

in	*label*	Label to assign to element.
in	*shape*	Shape of element (See enum ElementShape in Mesh)

Element (size_t *label*, const string & *shape*, int *c*)

Constructor initializing label, shape and code of element.

Parameters

in	*label*	Label to assign to element.
in	*shape*	Shape of element (See class description).
in	*c*	Code to assign to element (useful for media properties).

Element (size_t *label*, int *shape*, int *c*)

Constructor initializing label, shape and code of element.

Parameters

in	*label*	Label to assign to element.
in	*shape*	Shape of element (See enum ElementShape in Mesh).
in	*c*	Code to assign to element (useful for media properties).

7.24.3 Member Function Documentation

void setLabel (size_t *i*)

Define label of element.

Parameters

in	*i*	Label to assign to element

void setCode (int *c*)

Define code of element.

Parameters

in	*c*	Code to assign to element.

void setCode (const string & *exp*, int *code*)

Define code by a boolean algebraic expression invoking coordinates of element nodes.

Parameters

in	*exp*	Boolean algebraic expression as required by `fparser`
in	*code*	Code to assign to node if the algebraic expression is true

void Add (Node ∗ *node*)

Insert a node at end of list of nodes of element.

Parameters

in	*node*	Pointer to Node instance.

void Add (Node ∗ *node*, int *n*)

Insert a node and set its local node number.

Parameters

	node	[in] Pointer to Node instance
in	*n*	Element node number to assign

void Replace (size_t *label*, Node * *node*)

Replace a node at a given local label.

Parameters

in	*label*	Node to replace.
in	*node*	Pointer to Node instance to copy to current instance.

void Replace (size_t *label*, Side * *side*)

Replace a side at a given local label.

Parameters

in	*label*	Side to replace.
in	*side*	Pointer to Side instance to copy to current instance.

void Add (Side * *sd*)

Assign Side to Element.

Parameters

in	*sd*	Pointer to Side instance.

void Add (Side * *sd*, int *k*)

Assign Side to Element with assigned local label.

Parameters

in	*sd*	Pointer to Side instance.
in	*k*	Local label.

void Add (Element * *el*)

Add a neighbor element.

Parameters

in	*el*	Pointer to Element instance

void set (Element ∗ *el*, int *n*)

Add a neighbor element and set its label.

Parameters

in	*el*	Pointer to Element instance
in	*n*	Neighbor element number to assign

void setDOF (size_t *i*, size_t *dof*)

Define label of DOF.

Parameters

in	*i*	Index of DOF.
in	*dof*	Label of DOF to assign.

void setCode (size_t *dof*, int *code*)

Assign code to a DOF.

Parameters

in	*dof*	Index of dof for assignment.
in	*code*	Code to assign.

Node∗ operator() (size_t *i*) const

Operator ().
Return pointer to node of local label `i`.

int Contains (const Node ∗ *nd*) const

Say if element contains given node.
This function tests if the element contains a node with the same pointer at the sought one

Parameters

in	*nd*	Pointer to Node instance

Returns

Local node label in element. If 0, the element does not contain this node

int Contains (const Node & *nd*) const

Say if element contains given node.
This function tests if the element contains a node with the same label at the sought one

Parameters

in	*nd*	Reference to Node instance

Returns

Local node label in element. If 0, the element does not contain this node

int Contains (const Side ∗ *sd*) const

Say if element contains given side.
This function tests if the element contains a side with the same pointer at the sought one

Parameters

in	*sd*	Pointer to Side instance

Returns

Local side label in element. If 0, the element does not contain this side

int Contains (const Side & *sd*) const

Say if element contains given side.
This function tests if the element contains a side with the same label at the sought one

Parameters

in	*sd*	Reference to Side instance

Returns

Local side label in element. If 0, the element does not contain this side

Element∗ getNeighborElement (size_t *i*) const

Return pointer to element Neighboring element.

Parameters

in	*i*	Index of element to look for.

Note

> This method returns valid information only if the Mesh member function Mesh::getElement←NeighborElements() has been called before.

size_t getNbNeigElements ( ) const

Return number of neigboring elements.

Note

> This method returns valid information only if the Mesh member function Mesh::getElement←NeighborElements() has been called before.

real_t getMeasure ( ) const

Return measure of element.
This member function returns length, area or volume of element. In case of quadrilaterals and hexahedrals it returns determinant of Jacobian of mapping between reference and actual element

Point<real_t> getUnitNormal (size_t *i*) const

Return outward unit normal to i-th side of element.
Sides are ordered [node_1,node_2], [node_2,node_3], ...

bool isOnBoundary ( ) const

Say if current element is a boundary element or not.

Note

> this information is available only if boundary elements were determined i.e. if member function Mesh::getBoundarySides or Mesh::getAllSides has been invoked before.

Node* operator() (size_t *i*)

Operator ().
Return pointer to node of local label `i`.

int setSide (size_t *n*, size_t * *nd*)

Initialize information on element sides.
This function is to be used to initialize loops over sides.

Parameters

in	*n*	Label of side.
in	*nd*	Array of pointers to nodes of the side (`nd[0], nd[1], ...` point to first, second nodes, ...

void setChild (Element * *el*)

Assign element as child of current one and assign current element as father This function is principally used when refining is invoked (e.g. for mesh adaption)

Parameters

in	*el*	Pointer to element to assign

size_t IsIn (const Node * *nd*)

Check if a given node belongs to current element.

Parameters

in	*nd*	Pointer to node to locate

Returns

local label of node if this one is found, 0 otherwise

7.25 ElementList Class Reference

Class to construct a list of elements having some common properties.

Public Member Functions

- ElementList (Mesh &ms)

  Constructor using a Mesh instance.
- ∼ElementList ()

  Destructor.
- void selectCode (int code)

  Select elements having a given code.
- void unselectCode (int code)

  Unselect elements having a given code.
- void selectLevel (int level)

  Select elements having a given level.
- size_t getNbElements () const

  Return number of selected elements.
- void top ()

  Reset list of elements at its top position (Non constant version)
- void top () const

  Reset list of elements at its top position (Constant version)
- Element * get ()

  Return pointer to current element and move to next one (Non constant version)
- Element * get () const

  Return pointer to current element and move to next one (Constant version)

7.25.1 Detailed Description

Class to construct a list of elements having some common properties.

This class enables choosing multiple selection criteria by using function `select...` However, the intersection of these properties must be empty.

7.25.2 Member Function Documentation

void unselectCode (int *code*)

Unselect elements having a given code.

Parameters

`in`	*code*	Code of elements to exclude

void selectLevel (int *level*)

Select elements having a given level.

Parameters

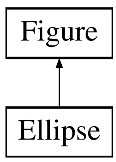
`in`	*level*	Level of elements to select

Elements having a given level (for mesh adaption) are selected in a list

7.26 Ellipse Class Reference

To store and treat an ellipsoidal figure.

Inheritance diagram for Ellipse:



Public Member Functions

- Ellipse ()

  Default constructor.
- Ellipse (Point< real_t > c, real_t a, real_t b, int code=1)

  Constructor with given data.
- real_t getSignedDistance (const Point< real_t > &p) const

  Return signed distance of a given point from the current ellipse.
- Ellipse & operator+= (Point< real_t > a)

  Operator +=
- Ellipse & operator+= (real_t a)

  Operator ∗=

- void setCode (int code)

  Choose a code for the domain defined by the figure.
- void getSignedDistance (const Grid &g, Vect< real_t > &d) const

  Calculate signed distance to current figure with respect to grid points.
- real_t dLine (const Point< real_t > &p, const Point< real_t > &a, const Point< real_t > &b) const

  Compute signed distance from a line.

7.26.1 Detailed Description

To store and treat an ellipsoidal figure.

7.26.2 Constructor & Destructor Documentation

Ellipse ( )

Default constructor.
Constructs an ellipse with semimajor axis = 1, and semiminor axis = 1

Ellipse (Point< real_t > *c*, real_t *a*, real_t *b*, int *code* = *1*)

Constructor with given data.

Parameters

in	*c*	Coordinates of center
in	*a*	Semimajor axis
in	*b*	Semiminor axis
in	*code*	Code to assign to the generated figure [Default: 1]

7.26.3 Member Function Documentation

real_t getSignedDistance (const Point< real_t > & *p*) const `[virtual]`

Return signed distance of a given point from the current ellipse.
The computed distance is negative if `p` lies in the ellipse, positive if it is outside, and 0 on its boundary

Parameters

in	*p*	Point<double> instance

Reimplemented from Figure.

Ellipse& operator+= (Point< real_t > *a*)

Operator +=
Translate ellipse by a vector `a`

Ellipse& operator+= (real_t *a*)

Operator *=
Scale ellipse by a factor `a`

void getSignedDistance (const Grid & *g*, Vect< real_t > & *d*) const `[inherited]`

Calculate signed distance to current figure with respect to grid points.

Parameters

in	*g*	Grid instance
in	*d*	Vect instance containing calculated distance from each grid index to Figure

Remarks

Vector `d` doesn't need to be sized before invoking this function

real_t dLine (const Point< real_t > & *p*, const Point< real_t > & *a*, const Point< real_t > & *b*) const `[inherited]`

Compute signed distance from a line.

Parameters

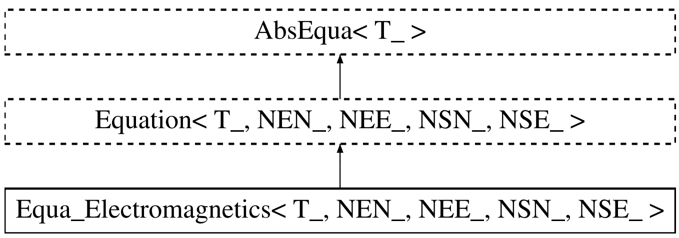
in	*p*	Point for which distance is computed
in	*a*	First vertex of line
in	*b*	Second vertex of line

Returns

Signed distance

7.27 Equa_Electromagnetics< T_, NEN_, NEE_, NSN_, NSE_ > Class Template Reference

Abstract class for Electromagnetics Equation classes.
Inheritance diagram for Equa_Electromagnetics< T_, NEN_, NEE_, NSN_, NSE_ >:



Public Member Functions

- void updateBC (const Element &el, const Vect< T_ > &bc)

Update Right-Hand side by taking into account essential boundary conditions.

- void updateBC (const Vect< T_ > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.

- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.

- void LocalNodeVector (Vect< T_ > &b)

  Localize Element Vector from a Vect instance.

- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEE_ > &be)

  Localize Element Vector from a Vect instance.

- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.

- void ElementNodeVectorSingleDOF (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be)

  Localize Element Vector from a Vect instance.

- void ElementSideVector (const Vect< T_ > &b, LocalVect< T_, NSE_ > &be)

  Localize Element Vector from a Vect instance.

- void ElementVector (const Vect< T_ > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.

- void SideVector (const Vect< T_ > &b)

  Localize Side Vector.

- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.

- void SideNodeCoordinates ()

  Localize coordinates of side nodes.

- void ElementAssembly (Matrix< T_ > *A)

  Assemble element matrix into global one.

- void ElementAssembly (PETScMatrix< T_ > &A)

  Assemble element matrix into global one.

- void ElementAssembly (PETScVect< T_ > &b)

  Assemble element right-hand side vector into global one.

- void ElementAssembly (BMatrix< T_ > &A)

  Assemble element matrix into global one.

- void ElementAssembly (SkSMatrix< T_ > &A)

  Assemble element matrix into global one.

- void ElementAssembly (SkMatrix< T_ > &A)

  Assemble element matrix into global one.

- void ElementAssembly (SpMatrix< T_ > &A)

  Assemble element matrix into global one.

- void ElementAssembly (TrMatrix< T_ > &A)

  Assemble element matrix into global one.

- void ElementAssembly (Vect< T_ > &v)

  Assemble element vector into global one.

- void SideAssembly (PETScMatrix< T_ > &A)

  Assemble side matrix into global one.

- void SideAssembly (PETScVect< T_ > &b)

  Assemble side right-hand side vector into global one.

- void SideAssembly (Matrix< T_ > *A)

Assemble side (edge or face) matrix into global one.

- void SideAssembly (SkSMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.

- void SideAssembly (SkMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.

- void SideAssembly (SpMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.

- void SideAssembly (Vect< T_ > &v)

  Assemble side (edge or face) vector into global one.

- void DGElementAssembly (Matrix< T_ > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (SkSMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (SkMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (SpMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (TrMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void AxbAssembly (const Element &el, const Vect< T_ > &x, Vect< T_ > &b)

  Assemble product of element matrix by element vector into global vector.

- void AxbAssembly (const Side &sd, const Vect< T_ > &x, Vect< T_ > &b)

  Assemble product of side matrix by side vector into global vector.

- size_t getNbNodes () const

  Return number of element nodes.

- size_t getNbEq () const

  Return number of element equations.

- void setInitialSolution (const Vect< T_ > &u)

  Set initial solution (previous time step)

- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.

- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.

- Mesh & getMesh () const

  Return reference to Mesh instance.

- LinearSolver< T_ > & getLinearSolver ()

  Return reference to linear solver instance.

- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.

- int SolveLinearSystem (Matrix< T_ > *A, Vect< T_ > &b, Vect< T_ > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< T_, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< T_, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< T_, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< T_, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< T_, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< T_, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void MagneticPermeability (const real_t &mu)

  Set (constant) magnetic permeability.
- void MagneticPermeability (const string &exp)

  Set magnetic permeability given by an algebraic expression.
- void ElectricConductivity (const real_t &sigma)

  Set (constant) electric conductivity.
- void ElectricConductivity (const string &exp)

  set electric conductivity given by an algebraic expression
- void ElectricResistivity (const real_t &rho)

  Set (constant) electric resistivity.
- void ElectricResistivity (const string &exp)

  Set electric resistivity given by an algebraic expression.
- void setMaterial ()

  Set material properties.
- void Init (const Element ∗el)

  Set element arrays to zero.
- void Init (const Side ∗sd)

  Set side arrays to zero.

7.27.1 Detailed Description

template<class T_, size_t NEN_, size_t NEE_, size_t NSN_, size_t NSE_>
class OFELI::Equa_Electromagnetics< T_, NEN_, NEE_, NSN_, NSE_ >

Abstract class for Electromagnetics Equation classes.

Template Parameters

<T_>	data type (double, float, ...)
<NEN>	Number of element nodes
<NEE←_>	Number of element equations

Template Parameters

<NSN_>	Number of side nodes
<NSE_>	Number of side equations

7.27.2 Member Function Documentation

void updateBC (const Element & *el*, const Vect< T_ > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*el*	Reference to current element instance
`in`	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< T_ > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = `NODE_DOF`, int *dof* = `0`) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

`in`	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
`in`	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< T_ > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< T_ > & *b*, LocalVect< T_, NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< T_ > & *b*, int *dof_type* = *NODE_FIELD*, int *flag* = *0*) `[inherited]`

Localize Element Vector.

Parameters

`in`	*b*	Global vector to be localized
`in`	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
`in`	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< T_ > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< T_ > ∗ *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< T_ > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< T_ > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< T_ > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< T_ > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< T_ > ∗ *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< T_ > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< T_ > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< T_ > & *x*, Vect< T_ > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< T_ > & *x*, Vect< T_ > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = IDENT_PREC) `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< T_ > * *A*, Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

7.27.3 Member Data Documentation

LocalVect<T_,NEE_> ePrev `[inherited]`

LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.28 Equa_Fluid< T_, NEN_, NEE_, NSN_, NSE_ > Class Template Reference

Abstract class for Fluid Dynamics Equation classes.

Inheritance diagram for Equa_Fluid< T_, NEN_, NEE_, NSN_, NSE_ >:

AbsEqua< T_ >

Equation< T_, NEN_, NEE_, NSN_, NSE_ >

Equa_Fluid< T_, NEN_, NEE_, NSN_, NSE_ >

Public Member Functions

- Equa_Fluid ()

  Default constructor.
- virtual ~Equa_Fluid ()

  Destructor.
- void updateBC (const Element &el, const Vect< T_ > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< T_ > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< T_ > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< T_ > &b, LocalVect< T_, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< T_ > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< T_ > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< T_ > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< T_ > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< T_ > &A)

Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< T_ > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< T_ > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< T_ > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< T_ > *A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< T_ > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< T_ > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< T_ > &x, Vect< T_ > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< T_ > &x, Vect< T_ > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< T_ > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

Define mesh and renumber DOFs after removing imposed ones.

- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< T_ > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< T_ > ∗A, Vect< T_ > &b, Vect< T_ > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< T_, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< T_, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< T_, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< T_, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< T_, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< T_, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Viscosity (const real_t &visc)

  Set (constant) Viscosity.
- void Viscosity (const string &exp)

  Set viscosity given by an algebraic expression.
- void Density (const real_t &dens)

  Set (constant) Viscosity.
- void Density (const string &exp)

  Set Density given by an algebraic expression.
- void ThermalExpansion (const real_t ∗e)

  Set (constant) thermal expansion coefficient.
- void ThermalExpansion (const string &exp)

  Set thermal expansion coefficient given by an algebraic expression.
- void setMaterial ()

  Set material properties.
- void Init (const Element ∗el)

  Set element arrays to zero.
- void Init (const Side ∗sd)

  Set side arrays to zero.

7.28.1 Detailed Description

template<class T_ = real_t, size_t NEN_ = 3, size_t NEE_ = 3, size_t NSN_ = 2, size_t NSE_ = 2>
class OFELI::Equa_Fluid< T_, NEN_, NEE_, NSN_, NSE_ >

Abstract class for Fluid Dynamics Equation classes.

Template Parameters

<T_>	data type (double, float, ...)
<NEN>	Number of element nodes
<NEE↩_>	Number of element equations
<NSN↩_>	Number of side nodes
<NSE_>	Number of side equations

7.28.2 Constructor & Destructor Documentation

Equa_Fluid ( )

Default constructor.
Constructs an empty equation.

7.28.3 Member Function Documentation

void updateBC (const Element & *el*, const Vect< T_ > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*el*	Reference to current element instance
`in`	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< T_ > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *`NODE_DOF`*, int *dof* = *`0`*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< T_ > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< T_ > & *b*, LocalVect< T_, NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< T_ > & *b*, int *dof_type* = *NODE_FIELD*, int *flag* = *0*) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< T_ > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0]`, `_x[1]`, ... which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0]`, `_x[1]`, ... which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< T_ > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< T_ > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< T_ > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< T_ > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< T_ > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< T_ > ∗ *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< T_ > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< T_ > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< T_ > & *x*, Vect< T_ > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< T_ > & *x*, Vect< T_ > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = IDENT_PREC) `[inherited]`

Choose solver for the linear system.

Parameters

`in`	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
`in`	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< T_ > $*$ *A*, Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Solve the linear system.

Parameters

`in`	A	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	b	Vector containing right-hand side
`in,out`	x	Vector containing initial guess of solution on input, actual solution on output

7.28.4 Member Data Documentation

LocalVect<T_,NEE_> ePrev `[inherited]`

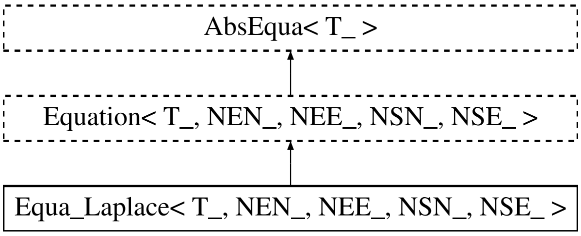
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.29 Equa_Laplace< T_, NEN_, NEE_, NSN_, NSE_ > Class Template Reference

Abstract class for classes about the Laplace equation.

Inheritance diagram for Equa_Laplace< T_, NEN_, NEE_, NSN_, NSE_ >:



Public Member Functions

- Equa_Laplace ()

  Default constructor.
- virtual ~Equa_Laplace ()

  Destructor.
- virtual void build ()

  Solve the equation.
- virtual void buildEigen (int opt=0)

  Build matrices for an eigenvalue problem.
- void build (EigenProblemSolver &e)

  Build the linear system for an eigenvalue problem.
- void updateBC (const Element &el, const Vect< T_ > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< T_ > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< T_ > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< T_ > &b, LocalVect< T_, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< T_ > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< T_ > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

Localize coordinates of element nodes.

- void SideNodeCoordinates ()

    Localize coordinates of side nodes.

- void ElementAssembly (Matrix< T_ > *A)

    Assemble element matrix into global one.

- void ElementAssembly (PETScMatrix< T_ > &A)

    Assemble element matrix into global one.

- void ElementAssembly (PETScVect< T_ > &b)

    Assemble element right-hand side vector into global one.

- void ElementAssembly (BMatrix< T_ > &A)

    Assemble element matrix into global one.

- void ElementAssembly (SkSMatrix< T_ > &A)

    Assemble element matrix into global one.

- void ElementAssembly (SkMatrix< T_ > &A)

    Assemble element matrix into global one.

- void ElementAssembly (SpMatrix< T_ > &A)

    Assemble element matrix into global one.

- void ElementAssembly (TrMatrix< T_ > &A)

    Assemble element matrix into global one.

- void ElementAssembly (Vect< T_ > &v)

    Assemble element vector into global one.

- void SideAssembly (PETScMatrix< T_ > &A)

    Assemble side matrix into global one.

- void SideAssembly (PETScVect< T_ > &b)

    Assemble side right-hand side vector into global one.

- void SideAssembly (Matrix< T_ > *A)

    Assemble side (edge or face) matrix into global one.

- void SideAssembly (SkSMatrix< T_ > &A)

    Assemble side (edge or face) matrix into global one.

- void SideAssembly (SkMatrix< T_ > &A)

    Assemble side (edge or face) matrix into global one.

- void SideAssembly (SpMatrix< T_ > &A)

    Assemble side (edge or face) matrix into global one.

- void SideAssembly (Vect< T_ > &v)

    Assemble side (edge or face) vector into global one.

- void DGElementAssembly (Matrix< T_ > *A)

    Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (SkSMatrix< T_ > &A)

    Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (SkMatrix< T_ > &A)

    Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (SpMatrix< T_ > &A)

    Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (TrMatrix< T_ > &A)

    Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void AxbAssembly (const Element &el, const Vect< T_ > &x, Vect< T_ > &b)

Assemble product of element matrix by element vector into global vector.

- void AxbAssembly (const Side &sd, const Vect< T_ > &x, Vect< T_ > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< T_ > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< T_ > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< T_ > ∗A, Vect< T_ > &b, Vect< T_ > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< T_, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< T_, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< T_, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< T_, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< T_, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< T_, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Init (const Element ∗el)

  Set element arrays to zero.
- void Init (const Side ∗sd)

  Set side arrays to zero.

7.29.1 Detailed Description

template<class T_, size_t NEN_, size_t NEE_, size_t NSN_, size_t NSE_>
class OFELI::Equa_Laplace< T_, NEN_, NEE_, NSN_, NSE_ >

Abstract class for classes about the Laplace equation.

Template Arguments:

- **T_** : data type (double, float, ...)
- **NEN_** : Number of element nodes
- **NEE_** : Number of element equations
- **NSN_** : Number of side nodes
- **NSE_** : Number of side equations

7.29.2 Constructor & Destructor Documentation

Equa_Laplace ( )

Default constructor.

Constructs an empty equation.

7.29.3 Member Function Documentation

void build (EigenProblemSolver & *e*)

Build the linear system for an eigenvalue problem.

Parameters

in	*e*	Reference to used EigenProblemSolver instance

void updateBC (const Element & *el*, const Vect< T_ > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< T_ > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< T_ > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEE_ > & *be*)
`[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.
`in`	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< T_ > & *b*, LocalVect< T_, NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< T_ > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

`in`	*b*	Global vector to be localized

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< T_ > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.

Coordinates are stored in array `_x[0]`, `_x[1]`, ... which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< T_ > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< T_ > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< T_ > & v) `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< T_ > & A) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< T_ > & b) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< T_ > * A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< T_ > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< T_ > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< T_ > & *x*, Vect< T_ > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< T_ > & *x*, Vect< T_ > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = IDENT_PREC) `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< T_ > * A, Vect< T_ > & b, Vect< T_ > & x) `[inherited]`

Solve the linear system.

Parameters

`in`	A	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	b	Vector containing right-hand side
`in,out`	x	Vector containing initial guess of solution on input, actual solution on output

7.29.4 Member Data Documentation

LocalVect<T_,NEE_> ePrev `[inherited]`

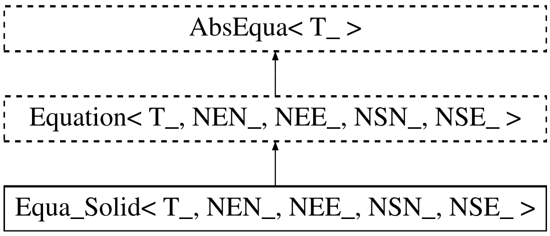
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.30 Equa_Solid< T_, NEN_, NEE_, NSN_, NSE_ > Class Template Reference

Abstract class for Solid Mechanics Finite Element classes.

Inheritance diagram for Equa_Solid< T_, NEN_, NEE_, NSN_, NSE_ >:



Public Member Functions

- Equa_Solid ()

  Default constructor.
- virtual ~Equa_Solid ()

  Destructor.
- virtual void LMassToLHS (real_t coef=1)

  Add lumped mass contribution to left-hand side.
- virtual void LMassToRHS (real_t coef=1)

  Add lumped mass contribution to right-hand side.
- virtual void MassToLHS (real_t coef=1)

  Add consistent mass contribution to left-hand side.
- virtual void MassToRHS (real_t coef=1)

  Add consistent mass contribution to right-hand side.
- void setLumpedMass ()

  Add lumped mass contribution to left and right-hand sides taking into account time integration scheme.

- void setMass ()

  Add consistent mass contribution to left and right-hand sides taking into account time integration scheme.
- virtual void Mass (real_t coef=1)

  Add consistent mass matrix to left-hand side after multiplication by `coef` *[Default:* `1`*].*
- virtual void LMass (real_t coef=1)

  Add lumped mass matrix to left-hand side after multiplication by `coef` *[Default:* `1`*].*
- virtual void Deviator (real_t coef=1)

  Add deviator matrix to left-hand side taking into account time integration scheme, after multiplication by `coef` *[Default:* `1`*].*
- virtual void Dilatation (real_t coef=1)

  Add dilatation matrix to left-hand side taking into account time integration scheme, after multiplication by `coef` *[Default:* `1`*].*
- virtual void DilatationToRHS (real_t coef=1)

  Add dilatation vector to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default:* `1`*].*
- virtual void DeviatorToRHS (real_t coef=1)

  Add deviator vector to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default:* `1`*].*
- virtual void Stiffness (real_t coef=1)

  Add stiffness matrix to left-hand side taking into account time integration scheme, after multiplication by `coef` *[Default:* `1`*].*
- virtual void StiffnessToRHS (real_t coef=1)

  Add stiffness matrix to right-hand side taking into account time integration scheme, after multiplication by `coef` *[Default:* `1`*].*
- void setDilatation ()

  Add dilatation matrix to left and/or right-hand side taking into account time.
- void setDeviator ()

  Add deviator matrix to left and/or right-hand side taking into account time integration scheme.
- void setStiffness ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.
- void updateBC (const Element &el, const Vect< T_ > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< T_ > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< T_ > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< T_ > &b, LocalVect< T_, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< T_ > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.

- void SideVector (const Vect< T_ > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< T_ > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< T_ > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< T_ > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< T_ > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< T_ > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< T_ > *A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< T_ > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< T_ > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (TrMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< T_ > &x, Vect< T_ > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< T_ > &x, Vect< T_ > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< T_ > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< T_ > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< T_ > *A, Vect< T_ > &b, Vect< T_ > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< T_, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< T_, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< T_, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< T_, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< T_, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< T_, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Young (const real_t &E)

  Set (constant) Young modulus.
- void Poisson (const real_t &nu)

  Set (constant) Poisson ratio.
- void Density (const real_t &rho)

Set (constant) density.

- void Young (const string &exp)

  Set Young modulus given by an algebraic expression.
- void Poisson (const string &exp)

  Set Poisson ratio given by an algebraic expression.
- void Density (const string &exp)

  Set density given by an algebraic expression.
- void setMaterial ()

  Set material properties.
- void Init (const Element ∗el)

  Set element arrays to zero.
- void Init (const Side ∗sd)

  Set side arrays to zero.

7.30.1 Detailed Description

template<class T_, size_t NEN_, size_t NEE_, size_t NSN_, size_t NSE_>
class OFELI::Equa_Solid< T_, NEN_, NEE_, NSN_, NSE_ >

Abstract class for Solid Mechanics Finite Element classes.

Template Parameters

<T_>	data type (double, float, ...)
<NEN>	Number of element nodes
<NEE_>	Number of element equations
<NSN_>	Number of side nodes
<NSE_>	Number of side equations

7.30.2 Constructor & Destructor Documentation

Equa_Solid ( )

Default constructor.
Constructs an empty equation.

7.30.3 Member Function Documentation

virtual void LMassToLHS (real_t *coef* = *1*) `[virtual]`

Add lumped mass contribution to left-hand side.

Parameters

in	*coef*	coefficient to multiply by the matrix before adding [Default: 1]

Reimplemented in Elas2DT3, Elas2DQ4, Beam3DL2, Elas3DH8, Elas3DT4, and Bar2DL2.

virtual void LMassToRHS (real_t *coef* = *1*) `[virtual]`

Add lumped mass contribution to right-hand side.

Parameters

`in`	*coef*	coefficient to multiply by the vector before adding [Default: `1`]

Reimplemented in Elas2DT3, Elas2DQ4, Beam3DL2, Elas3DH8, Elas3DT4, and Bar2DL2.

virtual void MassToLHS (real_t *coef* = *1*) `[virtual]`

Add consistent mass contribution to left-hand side.

Parameters

`in`	*coef*	coefficient to multiply by the matrix before adding [Default: `1`]

Reimplemented in Elas2DT3, Beam3DL2, and Bar2DL2.

virtual void MassToRHS (real_t *coef* = *1*) `[virtual]`

Add consistent mass contribution to right-hand side.

Parameters

`in`	*coef*	coefficient to multiply by the vector before adding [Default: `1`]

Reimplemented in Elas2DT3, Beam3DL2, and Bar2DL2.

void updateBC (const Element & *el*, const Vect< T_ > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*el*	Reference to current element instance
`in`	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< T_ > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = `NODE_DOF`, int *dof* = `0`) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< T_ > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< T_ > & *b*, LocalVect< T_, NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< T_ > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides

Parameters

in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< T_ > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix$<$ T_ $>$ $*$ A) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< T_ > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< T_ > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< T_ > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< T_ > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< T_ > * *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< T_ > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< T_ > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< T_ > & *x*, Vect< T_ > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< T_ > & *x*, Vect< T_ > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = IDENT_PREC) `[inherited]`

Choose solver for the linear system.

Parameters

`in`	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
`in`	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< T_ > ∗ *A*, Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Solve the linear system.

Parameters

`in`	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	*b*	Vector containing right-hand side
`in,out`	*x*	Vector containing initial guess of solution on input, actual solution on output

7.30.4 Member Data Documentation

LocalVect<T_,NEE_> ePrev `[inherited]`

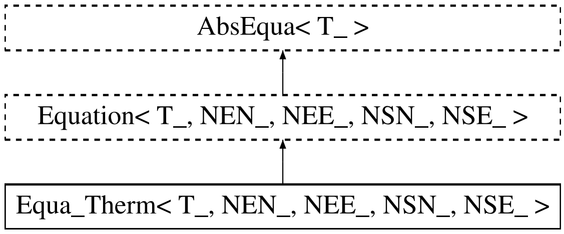
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.31 Equa_Therm< T_, NEN_, NEE_, NSN_, NSE_ > Class Template Reference

Abstract class for Heat transfer Finite Element classes.

Inheritance diagram for Equa_Therm< T_, NEN_, NEE_, NSN_, NSE_ >:



Public Member Functions

- Equa_Therm ()

  Default constructor.
- virtual ~Equa_Therm ()

  Destructor.
- virtual void setStab ()

  Set stabilized formulation.
- virtual void LCapacityToLHS (real_t coef=1)

  Add lumped capacity contribution to left-hand side.
- virtual void LCapacityToRHS (real_t coef=1)

  Add lumped capacity contribution to right-hand side.
- virtual void CapacityToLHS (real_t coef=1)

  Add consistent capacity contribution to left-hand side.
- virtual void CapacityToRHS (real_t coef=1)

  Add consistent capacity contribution to right-hand side.
- void setLumpedCapacity ()

  Add lumped capacity contribution to left and right-hand sides taking into account time integration scheme.
- void setCapacity ()

  Add consistent capacity contribution to left and right-hand sides taking into account time integration scheme.
- virtual void Diffusion (real_t coef=1.)

  Add diffusion term to left-hand side.
- virtual void DiffusionToRHS (real_t coef=1.)

  Add diffusion term to right-hand side.
- void setDiffusion ()

  Add diffusion contribution to left and/or right-hand side taking into account time integration scheme.
- virtual void Convection (real_t coef=1.)

  Add convection term to left-hand side.
- virtual void ConvectionToRHS (real_t coef=1.)

  Add convection term to right-hand side.
- void setConvection ()

  Add convection contribution to left and/or right-hand side taking into account time integration scheme.

- virtual void BodyRHS (const Vect< real_t > &bf, int opt=GLOBAL_ARRAY)

  Add body right-hand side term to right-hand side.
- virtual void BoundaryRHS (const Vect< real_t > &sf, int opt=GLOBAL_ARRAY)

  Add boundary right-hand side term to right-hand side.
- void build ()

  Build the linear system of equations.
- void build (TimeStepping &s)

  Build the linear system of equations.
- void build (EigenProblemSolver &e)

  Build the linear system for an eigenvalue problem.
- int runTransient ()

  Run one time step.
- int runOneTimeStep ()

  Run one time step.
- int run ()

  Run the equation.
- void setRhoCp (const real_t &rhocp)

  Set product of Density by Specific heat (constants)
- void setConductivity (const real_t &diff)

  Set (constant) thermal conductivity.
- void RhoCp (const string &exp)

  Set product of Density by Specific heat given by an algebraic expression.
- void Conduc (const string &exp)

  Set thermal conductivity given by an algebraic expression.
- void updateBC (const Element &el, const Vect< T_ > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< T_ > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< T_ > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< T_ > &b, LocalVect< T_, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< T_ > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< T_ > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.

- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< T_ > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< T_ > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< T_ > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< T_ > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< T_ > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< T_ > *A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< T_ > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< T_ > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< T_ > &x, Vect< T_ > &b)

  Assemble product of element matrix by element vector into global vector.

- void AxbAssembly (const Side &sd, const Vect< T_ > &x, Vect< T_ > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< T_ > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< T_ > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< T_ > *A, Vect< T_ > &b, Vect< T_ > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< T_, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< T_, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< T_, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< T_, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< T_, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< T_, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void setMaterial ()

  Set material properties.
- void Init (const Element *el)

  Set element arrays to zero.
- void Init (const Side *sd)

  Set side arrays to zero.

7.31.1 Detailed Description

template<class T_, size_t NEN_, size_t NEE_, size_t NSN_, size_t NSE_>
class OFELI::Equa_Therm< T_, NEN_, NEE_, NSN_, NSE_ >

Abstract class for Heat transfer Finite Element classes.

Template Parameters

<T_>	data type (real_t, float, ...)
<NEN>	Number of element nodes
<NEE_>	Number of element equations
<NSN_>	Number of side nodes
<NSE_>	Number of side equations

7.31.2 Constructor & Destructor Documentation

Equa_Therm ( )

Default constructor.
Constructs an empty equation.

7.31.3 Member Function Documentation

virtual void setStab ( ) `[virtual]`

Set stabilized formulation.
Stabilized variational formulations are to be used when the Pclet number is large. By default, no stabilization is used.

virtual void LCapacityToLHS (real_t *coef* = *1*) `[virtual]`

Add lumped capacity contribution to left-hand side.

Parameters

`in`	*coef*	coefficient to multiply by the matrix before adding [Default: `1`]

Reimplemented in DC2DT3, DC3DT4, DC3DAT3, and DC1DL2.

virtual void LCapacityToRHS (real_t *coef* = *1*) `[virtual]`

Add lumped capacity contribution to right-hand side.

Parameters

`in`	*coef*	coefficient to multiply by the vector before adding [Default: `1`]

Reimplemented in DC2DT3, DC3DT4, DC3DAT3, and DC1DL2.

virtual void CapacityToLHS (real_t *coef* = *1*) `[virtual]`

Add consistent capacity contribution to left-hand side.

Parameters

Parameters

in	*coef*	coefficient to multiply by the matrix before adding [Default: 1]

Reimplemented in DC2DT3, DC3DT4, DC3DAT3, and DC1DL2.

virtual void CapacityToRHS (real_t *coef* = *1*) `[virtual]`

Add consistent capacity contribution to right-hand side.

Parameters

in	*coef*	coefficient to multiply by the vector before adding [Default: 1]

Reimplemented in DC2DT3, DC3DT4, DC3DAT3, and DC1DL2.

virtual void BodyRHS (const Vect< real_t > & *bf*, int *opt* = GLOBAL_ARRAY) `[virtual]`

Add body right-hand side term to right-hand side.

Parameters

in	*bf*	Vector containing source at element nodes.
in	*opt*	Vector is local (`LOCAL_ARRAY`) with size 3 or global (`GLOBAL_ARRAY`) with size = Number of nodes [Default: `GLOBAL_ARRAY`].

Reimplemented in DC2DT3, DC3DT4, DC2DT6, DC1DL2, and DC3DAT3.

virtual void BoundaryRHS (const Vect< real_t > & *sf*, int *opt* = GLOBAL_ARRAY) `[virtual]`

Add boundary right-hand side term to right-hand side.

Parameters

in	*sf*	Vector containing source at side nodes.
in	*opt*	Vector is local (`LOCAL_ARRAY`) with size 3 or global (`GLOBAL_ARRAY`) with size = Number of nodes [Default: `GLOBAL_ARRAY`].

Reimplemented in DC2DT3, DC3DT4, DC2DT6, DC1DL2, and DC3DAT3.

void build ( )

Build the linear system of equations.
Before using this function, one must have properly selected appropriate options for:

- The choice of a steady state or transient analysis. By default, the analysis is stationary
- In the case of transient analysis, the choice of a time integration scheme and a lumped or consistent capacity matrix. If transient analysis is chosen, the lumped capacity matrix

option is chosen by default, and the implicit Euler scheme is used by default for time integration.

void build (TimeStepping & *s*)

Build the linear system of equations.
Before using this function, one must have properly selected appropriate options for:

- The choice of a steady state or transient analysis. By default, the analysis is stationary
- In the case of transient analysis, the choice of a time integration scheme and a lumped or consistent capacity matrix. If transient analysis is chosen, the lumped capacity matrix option is chosen by default, and the implicit Euler scheme is used by default for time integration.

Parameters

in	*s*	Reference to used TimeStepping instance

void build (EigenProblemSolver & *e*)

Build the linear system for an eigenvalue problem.

Parameters

in	*e*	Reference to used EigenProblemSolver instance

int runTransient ( )

Run one time step.
This function performs one time step in equation solving. It is to be used only if a *TRANSIENT* analysis is required.

Returns

Return error from the linear system solver

int runOneTimeStep ( )

Run one time step.
This function performs one time step in equation solving. It is identical to the function run↩ Transient.

Returns

Return error from the linear system solver

int run ( )

Run the equation.

If the analysis (see function setAnalysis) is `STEADY_STATE`, then the function solves the stationary equation.
If the analysis is `TRANSIENT`, then the function performs time stepping until the final time is reached.

void updateBC (const Element & *el*, const Vect< T_ > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< T_ > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< T_ > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< T_ > & *b*, LocalVect< T_, NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< T_ > & *b*, int *dof_type* = *NODE_FIELD*, int *flag* = *0*) `[inherited]`

Localize Element Vector.

Parameters

`in`	*b*	Global vector to be localized
`in`	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
`in`	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< T_ > & *b*) `[inherited]`

Localize Side Vector.

Parameters

`in`	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

> This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

> This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

> This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< T_ > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

> The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

> The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< T_ > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< T_ > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< T_ > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< T_ > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< T_ > ∗ *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< T_ > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< T_ > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< T_ > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< T_ > & *x*, Vect< T_ > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< T_ > & *x*, Vect< T_ > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = IDENT_PREC) `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver

Parameters

in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< T_ > ∗ *A*, Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

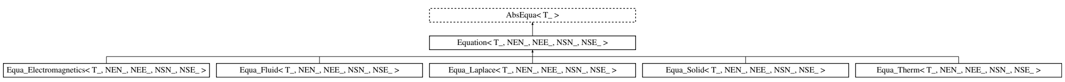
7.31.4 Member Data Documentation

LocalVect<T_,NEE_> ePrev `[inherited]`

LocalVect instance containing local vector associated to current element.
This vector has been stored as the one at previous iteration or previous time step

7.32 Equation< T_, NEN_, NEE_, NSN_, NSE_ > Class Template Reference

Abstract class for all equation classes.
Inheritance diagram for Equation< T_, NEN_, NEE_, NSN_, NSE_ >:



Public Member Functions

- Equation ()
- Equation (Mesh &mesh)

  Constructor with mesh instance.
- Equation (Mesh &mesh, Vect< T_ > &b, real_t &t, real_t &ts)

  Constructor with mesh instance, matrix and right-hand side.
- Equation (const Element ∗el)

  Constructor using Element data.

- Equation (const Side ∗sd)

  Constructor using Side data.
- Equation (const Element ∗el, const Vect< T_ > &u, real_t time=0)

  Constructor using element data, solution at previous time step and time value.
- Equation (const Side ∗sd, const Vect< T_ > &u, real_t time=0)

  Constructor using side data, solution at previous time step and time value.
- virtual ∼Equation ()

  Destructor.
- void updateBC (const Element &el, const Vect< T_ > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< T_ > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< T_ > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< T_ > &b, LocalVect< T_, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< T_ > &b, LocalVect< T_, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< T_ > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< T_ > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< T_ > ∗A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< T_ > &A)

  Assemble element matrix into global one.
- void SideAssembly (PETScMatrix< T_ > &A)

  Assemble side matrix into global one.
- void ElementAssembly (PETScVect< T_ > &b)

  Assemble element right-hand side vector into global one.
- void SideAssembly (PETScVect< T_ > &b)

  Assemble side right-hand side vector into global one.
- void ElementAssembly (BMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< T_ > &A)

  Assemble element matrix into global one.

- void ElementAssembly (SkMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< T_ > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< T_ > &A)

  Assemble element matrix into global one.
- void DGElementAssembly (Matrix< T_ > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< T_ > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void SideAssembly (Matrix< T_ > *A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< T_ > &A)

  Assemble side (edge or face) matrix into global one.
- void ElementAssembly (Vect< T_ > &v)

  Assemble element vector into global one.
- void SideAssembly (Vect< T_ > &v)

  Assemble side (edge or face) vector into global one.
- void AxbAssembly (const Element &el, const Vect< T_ > &x, Vect< T_ > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< T_ > &x, Vect< T_ > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< T_ > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< T_ > & getLinearSolver ()

  Return reference to linear solver instance.

- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< T_ > *A, Vect< T_ > &b, Vect< T_ > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< T_, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< T_, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< T_, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< T_, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< T_, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< T_, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Init (const Element *el)

  Set element arrays to zero.
- void Init (const Side *sd)

  Set side arrays to zero.

7.32.1 Detailed Description

template<class T_, size_t NEN_, size_t NEE_, size_t NSN_, size_t NSE_>
class OFELI::Equation< T_, NEN_, NEE_, NSN_, NSE_ >

Abstract class for all equation classes.
Template Arguments:

- **T_** : data type (real_t, float, ...)
- **NEN_** : Number of element nodes
- **NEE_** : Number of element equations
- **NSN_** : Number of side nodes
- **NSN_** : Number of side equations

7.32.2 Constructor & Destructor Documentation

Equation ( )

Default constructor. Constructs an "empty" equation

Equation (Mesh & *mesh*)

Constructor with mesh instance.

Parameters

in	*mesh*	Mesh instance

Equation (Mesh & *mesh*, Vect< T_ > & *b*, real_t & *t*, real_t & *ts*)

Constructor with mesh instance, matrix and right-hand side.

Parameters

in	*mesh*	Mesh instance
in	*b*	Vect instance containing Right-hand side.
in	*t*	Time value
in	*ts*	Time step

Equation (const Element ∗ *el*)

Constructor using Element data.

Parameters

in	*el*	Pointer to Element

Equation (const Element ∗ *el*, const Vect< T_ > & *u*, real_t *time* = 0)

Constructor using element data, solution at previous time step and time value.

Parameters

in	*el*	Pointer to element
in	*u*	Vect instance containing solution at previous time step
in	*time*	Time value (Default value is 0)

Equation (const Side ∗ *sd*, const Vect< T_ > & *u*, real_t *time* = 0)

Constructor using side data, solution at previous time step and time value.

Parameters

in	*sd*	Pointer to side
in	*u*	Vect instance containing solution at previous time step
in	*time*	Time value (Default value is 0)

7.32.3 Member Function Documentation

void updateBC (const Element & *el*, const Vect< T_ > & *bc*)

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< T_ > & *bc*)

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*)

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< T_ > & *b*)

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEE_ > & *be*)

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*)

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementNodeVector (const Vect< T_ > & *b*, LocalVect< T_, NEN_ > & *be*, int *dof*)

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementSideVector (const Vect< T_ > & *b*, LocalVect< T_, NSE_ > & *be*)

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< T_ > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`)

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< T_ > & *b*)

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( )

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( )

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< T_ > * *A*)

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< T_ > & *A*)

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< T_ > & *A*)

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void ElementAssembly (PETScVect< T_ > & *b*)

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScVect< T_ > & *b*)

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void ElementAssembly (BMatrix< T_ > & *A*)

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< T_ > & *A*)

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< T_ > & *A*)

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< T_ > & *A*)

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< T_ > & *A*)

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (Matrix< T_ > ∗ *A*)

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< T_ > & *A*)

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< T_ > & *A*)

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< T_ > & *A*)

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< T_ > & *A*)

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (Matrix< T_ > * *A*)

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< T_ > & *A*)

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< T_ > & *A*)

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< T_ > & *A*)

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void ElementAssembly (Vect< T_ > & *v*)

Assemble element vector into global one.

Parameters

`in`	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (Vect< T_ > & *v*)

Assemble side (edge or face) vector into global one.

Parameters

`in`	*v*	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void AxbAssembly (const Element & *el*, const Vect< T_ > & *x*, Vect< T_ > & *b*)

Assemble product of element matrix by element vector into global vector.

Parameters

`in`	*el*	Reference to Element instance
`in`	*x*	Global vector to multiply by (Vect instance)
`out`	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< T_ > & *x*, Vect< T_ > & *b*)

Assemble product of side matrix by side vector into global vector.

Parameters

`in`	*sd*	Reference to Side instance
`in`	*x*	Global vector to multiply by (Vect instance)
`out`	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*)

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:
- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = IDENT_PREC) `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< T_ > * *A*, Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Solve the linear system.

Parameters

`in`	A	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	b	Vector containing right-hand side
`in,out`	x	Vector containing initial guess of solution on input, actual solution on output

7.32.4 Member Data Documentation

LocalVect<T_,NEE_> ePrev

LocalVect instance containing local vector associated to current element.
This vector has been stored as the one at previous iteration or previous time step

7.33 Estimator Class Reference

To calculate an a posteriori estimator of the solution.

Public Member Functions

- Estimator ()
  Default Constructor.
- Estimator (Mesh &m)
  Constructor using finite element mesh.
- ~Estimator ()
  Destructor.
- void setError (const Vect< real_t > &u)
  Calculate error using Vect solution vector u.
- real_t getAverage () const
  Return averaged error.
- Mesh & getMesh () const
  Return a reference to the finite element mesh.

Public Attributes

- Vect< real_t > Err
  Elementwise vector error.

7.33.1 Detailed Description

To calculate an a posteriori estimator of the solution.
This class enables calculating an estimator of a solution in order to evaluate reliability. Estimation uses the so-called Zienkiewicz-Zhu estimator.

7.34 FastMarching2D Class Reference

To run a Fast Marching Method on 2-D structured uniform grids.

Public Member Functions

- FastMarching2D ()

    Default constructor.
- FastMarching2D (const Grid &g, Vect< real_t > &ls)

    Constructor using grid and level set function.
- FastMarching2D (const Grid &g, Vect< real_t > &ls, Vect< real_t > &F)

    Constructor using grid, level set function and velocity to extend.
- ∼FastMarching2D ()

    Destructor.
- void execute ()

    Execute Fast Marching Procedure.
- void Check ()

    Check distance function.

7.34.1 Detailed Description

To run a Fast Marching Method on 2-D structured uniform grids.

This class enables running a Fast Marching procedure to calculate the signed distance function and extend a given front speed.

7.34.2 Constructor & Destructor Documentation

FastMarching2D (const Grid & *g*, Vect< real_t > & *ls*)

Constructor using grid and level set function.

Parameters

in	*g*	Instance of class Grid
in	*ls*	Vector containing the level set function at grid nodes. The values are *0* on the interface (from which the distance is computed), positive on one side and negative on the other side. They must contain the signed distance on the nodes surrounding the interface but can take any value on other nodes, provided they have the right sign.

FastMarching2D (const Grid & *g*, Vect< real_t > & *ls*, Vect< real_t > & *F*)

Constructor using grid, level set function and velocity to extend.

Parameters

in	*g*	Instance of class Grid

Parameters

in	*ls*	Vector containing the level set function at grid nodes. The values are 0 on the interface (from which the distance is computed), positive on one side and negative on the other side. They must contain the signed distance on the nodes surrounding the interface but can take any value on other nodes, provided their sign is right.
in	*F*	Vector containing the front speed at grid nodes. Only values on nodes surrounding the interface are relevant.

7.34.3 Member Function Documentation

void execute ( )

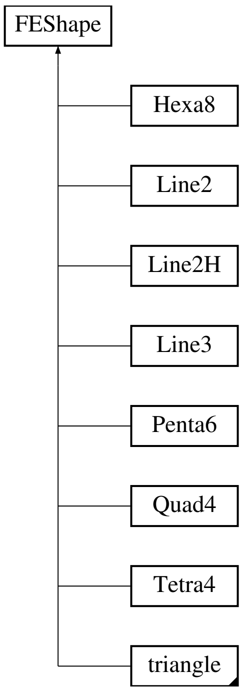
Execute Fast Marching Procedure.

Once this function was called, the vector `ls` used in the constructor will contain the signed distance function and `F` will contain the extended speed.

7.35 FEShape Class Reference

Parent class from which inherit all finite element shape classes.

Inheritance diagram for FEShape:



Public Member Functions

- FEShape ()

  Default Constructor.
- FEShape (const Element ∗el)

  Constructor for an element.

- FEShape (const Side ∗sd)

  Constructor for a side.
- virtual ∼FEShape ()

  Destructor.
- real_t Sh (size_t i) const

  Return shape function of node `i` at given point.
- real_t Sh (size_t i, Point< real_t > s) const

  Calculate shape function of node `i` at a given point `s`.
- Point< real_t > DSh (size_t i) const

  Return derivatives of shape function of node `i` at a given point.
- real_t getDet () const

  Return determinant of jacobian.
- Point< real_t > getCenter () const

  Return coordinates of center of element.
- Point< real_t > getLocalPoint () const

  Localize a point in the element.
- Point< real_t > getLocalPoint (const Point< real_t > &s) const

  Localize a point in the element.

7.35.1 Detailed Description

Parent class from which inherit all finite element shape classes.

7.35.2 Constructor & Destructor Documentation

FEShape (const Element ∗ *el*)

Constructor for an element.

Parameters

in	*el*	Pointer to element

FEShape (const Side ∗ *sd*)

Constructor for a side.

Parameters

in	*sd*	Pointer to side

7.35.3 Member Function Documentation

real_t Sh (size_t *i*, Point< real_t > *s*) const

Calculate shape function of node `i` at a given point `s`.

Parameters

in	*i*	Local node label

Parameters

in	*s*	Point in the reference triangle where the shape function is evaluated

Point<real_t> DSh (size_t *i*) const

Return derivatives of shape function of node `i` at a given point.

If the transformation (Reference element -> Actual element) is not affine, member function `setLocal()` must have been called before in order to calcuate relevant quantities.

Parameters

in	*i*	Partial derivative index (1, 2 or 3)

real_t getDet ( ) const

Return determinant of jacobian.

If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint ( ) const

Localize a point in the element.

Return actual coordinates in the reference element. If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint (const Point< real_t > & *s*) const

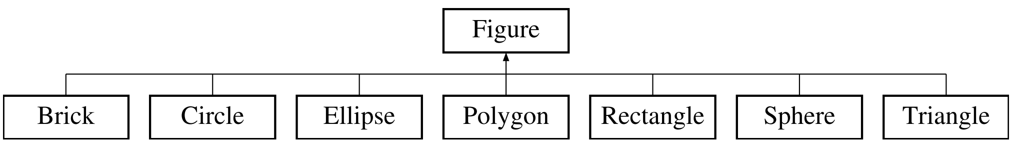
Localize a point in the element.

Return actual coordinates where `s` are coordinates in the reference element.

7.36 Figure Class Reference

To store and treat a figure (or shape) information.

Inheritance diagram for Figure:



Public Member Functions

- Figure ()

  Default constructor.
- Figure (const Figure &f)

  Copy constructor.

- virtual ~Figure ()
  Destructor.
- void setCode (int code)
  Choose a code for the domain defined by the figure.
- virtual real_t getSignedDistance (const Point< real_t > &p) const
  Return signed distance from a given point to current figure.
- Figure & operator= (const Figure &f)
  Operator =.
- void getSignedDistance (const Grid &g, Vect< real_t > &d) const
  Calculate signed distance to current figure with respect to grid points.
- real_t dLine (const Point< real_t > &p, const Point< real_t > &a, const Point< real_t > &b) const
  Compute signed distance from a line.

7.36.1 Detailed Description

To store and treat a figure (or shape) information.

This class is essentially useful to construct data for mesh generators and for distance calculations.

7.36.2 Member Function Documentation

virtual real_t getSignedDistance (const Point< real_t > & *p*) const `[virtual]`

Return signed distance from a given point to current figure.

Parameters

in	*p*	Point instance from which distance is computed

Reimplemented in Polygon, Triangle, Ellipse, Sphere, Circle, Brick, and Rectangle.

void getSignedDistance (const Grid & *g*, Vect< real_t > & *d*) const

Calculate signed distance to current figure with respect to grid points.

Parameters

in	*g*	Grid instance
in	*d*	Vect instance containing calculated distance from each grid index to Figure

Remarks

Vector `d` doesn't need to be sized before invoking this function

real_t dLine (const Point< real_t > & *p*, const Point< real_t > & *a*, const Point< real_t > & *b*) const

Compute signed distance from a line.

Parameters

in	*p*	Point for which distance is computed
in	*a*	First vertex of line
in	*b*	Second vertex of line

Returns

Signed distance

7.37 FMM2D Class Reference

class for the fast marching 2-D algorithm
Inherits FMM.

Public Member Functions

- FMM2D (const Grid &g, Vect< real_t > *phi, bool HA)

  Constructor.
- void InitHeap (Heap &NarrowPt)
- void solve ()

  Execute Fast Marching Procedure.
- void Evaluate (IPoint &pt, int sign)

  compute the distance from node to interface
- void ExtendSpeed (Vect< real_t > &F)

  Extend the speed function to the whole grid.
- real_t check_error ()

  Check error by comparing with the gradient norm.

7.37.1 Detailed Description

class for the fast marching 2-D algorithm
This class manages the 2-D Fast Marching method

7.37.2 Constructor & Destructor Documentation

FMM2D (const Grid & *g*, Vect< real_t > * *phi*, bool *HA*)

Constructor.

Parameters

in	*g*	Instance of class Grid
in	*phi*	Vector containing the level set function at grid nodes. The values are `0` on the interface (from which the distance is computed), positive on one side and negative on the other side. They must contain the signed distance on the nodes surrounding the interface but can take any value on other nodes, provided they have the right sign.
in	*HA*	true if the program must be executed with high accuracy, false otherwise

7.37.3 Member Function Documentation

void InitHeap (Heap & *NarrowPt*)

Initialize the heap

Parameters

`in,out`	*NarrowPt*	Heap containing Narrow points

void Evaluate (IPoint & *pt*, int *sign*)

compute the distance from node to interface

Parameters

`in`	*pt*	node to treat
`in`	*sign*	Node sign

Returns

distance from node `pt` to interface

void ExtendSpeed (Vect< real_t > & *F*)

Extend the speed function to the whole grid.

Parameters

`in,out`	*F*	Vector containing the speed at interface nodes on input and extended speed to all grid nodes

real_t check_error ( )

Check error by comparing with the gradient norm.
This function returns discrete L^2 and Max. errors

7.38 FMM3D Class Reference

class for the 3-D fast marching algorithm
Inherits FMM.

Public Member Functions

- FMM3D (const Grid &g, Vect< real_t > *phi, bool HA)

  Constructor.
- void InitHeap (Heap &NarrowPt)

  Initialize heap.

- void solve ()

    Execute Fast Marching Procedure.
- void Evaluate (IPoint &pt, int sign)

    Compute the distance from node to interface.
- void ExtendSpeed (Vect< real_t > &F)

    Extend the speed function to the whole grid.
- real_t check_error ()

    Check error by comparing with the gradient norm.

7.38.1 Detailed Description

class for the 3-D fast marching algorithm

This class manages the 3-D Fast Marching Method

7.38.2 Constructor & Destructor Documentation

FMM3D (const Grid & *g*, Vect< real_t > * *phi*, bool *HA*)

Constructor.

Parameters

`in`	*g*	Instance of class Grid
`in`	*phi*	Vector containing the level set function at grid nodes. The values are `0` on the interface (from which the distance is computed), positive on one side and negative on the other side. They must contain the signed distance on the nodes surrounding the interface but can take any value on other nodes, provided they have the right sign.
`in`	*HA*	true if the program must be executed with high accuracy, false otherwise

7.38.3 Member Function Documentation

void InitHeap (Heap & *NarrowPt*)

Initialize heap.

Parameters

NarrowPt	

void Evaluate (IPoint & *pt*, int *sign*)

Compute the distance from node to interface.

Parameters

`in`	*pt*	node to treat
`in`	*sign*	the node's sign

Returns

distance from node `pt` to interface

void ExtendSpeed (Vect< real_t > & *F*)

Extend the speed function to the whole grid.

Parameters

`in,out`	*F*	Vector containing the speed at interface nodes on input and extended speed at whole grid nodes

real_t check_error ( )

Check error by comparing with the gradient norm.
This function prints discrete L^2 and Max. errors

7.39 FMMSolver Class Reference

The Fast Marching Method solver.

Public Member Functions

- FMMSolver (const Grid &g, Vect< real_t > &phi, bool ha=false)

  Constructor.
- ~FMMSolver ()

  Destructor.
- void solve ()

  Execute the fast marching program.
- void ExtendSpeed (Vect< real_t > &F)

  Extend speed by Sethian's method.
- real_t check_error ()

  Return the consistency error of the method.

7.39.1 Detailed Description

The Fast Marching Method solver.

This class enables computing the signed distance function with respect to an interface. It works in 2-D and 3-D on a structured grid. The class is an interface for client. It points to FMM

7.39.2 Constructor & Destructor Documentation

FMMSolver (const Grid & *g*, Vect< real_t > & *phi*, bool *ha* = `false`)

Constructor.

Parameters

`in`	*g*	Instance of class Grid defining the grid on which the distance is computed.

Parameters

in	*phi*	Vector containing the level set function at grid nodes. The vector entries are 0 on the interface (from which the distance is computed), positive on one side and negative on the other side. They must contain the signed distance on the nodes surrounding the interface. These values identify by linear interpolation the interface position. The vector entries can take any value on other grid nodes, provided they have the right sign.
in	*ha*	true if high accuracy FMM is active. The high accuracy version is more accurate but requires more accurate values on the nodes neighbouring the interface.

7.39.3 Member Function Documentation

void ExtendSpeed (Vect< real_t > & *F*)

Extend speed by Sethian's method.

The method consists in calculating a speed `F` such that its gradient is orthogonal to the gradient of the level set function

Parameters

in,out	*F*	Speed function where on input the value of the function is meaningful on the interface. On output `F` contains the extended speed

real_t check_error ( )

Return the consistency error of the method.

Consistency is measured by computing the discrete value of the norm of the gradient of the signed distance and subtracting the obtained norm from 1. The absolute value of the result is returned.

7.40 Funct Class Reference

A simple class to parse real valued functions.

Public Member Functions

- Funct ()

  Default constructor.
- Funct (string v)

  Constructor for a function of one variable.
- Funct (string v1, string v2)

  Constructor for a function of two variables.
- Funct (string v1, string v2, string v3)

  Constructor for a function of three variables.
- Funct (string v1, string v2, string v3, string v4)

  Constructor for a function of four variables.
- ~Funct ()

Destructor.

- real_t operator() (real_t x) const

  Operator () to evaluate the function with one variable x
- real_t operator() (real_t x, real_t y) const

  Operator () to evaluate the function with two variables x, y
- real_t operator() (real_t x, real_t y, real_t z) const

  Operator () to evaluate the function with three variables x, y, z
- real_t operator() (real_t x, real_t y, real_t z, real_t t) const

  Operator () to evaluate the function with four variables x, y, z
- void operator= (string e)

  Operator =.

7.40.1 Detailed Description

A simple class to parse real valued functions.
Functions must have 1, 2, 3 or at most 4 variables.

Warning

Data in the file must be listed in the following order:

```
for x=x_0,...,x_I
    for y=y_0,...,y_J
        for z=z_0,...,z_K
            read v(x,y,z)
```

7.40.2 Constructor & Destructor Documentation

Funct (string *v*)

Constructor for a function of one variable.

Parameters

in	*v*	Name of the variable

Funct (string *v1*, string *v2*)

Constructor for a function of two variables.

Parameters

in	*v1*	Name of the first variable
in	*v2*	Name of the second variable

Funct (string *v1*, string *v2*, string *v3*)

Constructor for a function of three variables.

Parameters

in	*v1*	Name of the first variable

Parameters

in	*v2*	Name of the second variable
in	*v3*	Name of the third variable

Funct (string *v1*, string *v2*, string *v3*, string *v4*)

Constructor for a function of four variables.

Parameters

in	*v1*	Name of the first variable
in	*v2*	Name of the second variable
in	*v3*	Name of the third variable
in	*v4*	Name of the fourth variable

7.40.3 Member Function Documentation

void operator= (string *e*)

Operator =.
Define the function by an algebraic expression following regexp rules

Parameters

in	*e*	Algebraic expression defining the function.

7.41 Gauss Class Reference

Calculate data for Gauss integration.

Public Member Functions

- Gauss ()

  Default constructor.
- Gauss (size_t np)

  Constructor using number of Gauss points.
- void setTriangle (LocalVect< real_t, 7 > &w, LocalVect< Point< real_t >, 7 > &x)

  Choose integration on triangle (7-point formula)
- real_t x (size_t i) const

  Return coordinate of i-th Gauss-Legendre point.
- const Point< real_t > & xt (size_t i) const

  Return coordinates of points in the reference triangle.
- real_t w (size_t i) const

  Return weight of i-th Gauss-Legendre point.

7.41.1 Detailed Description

Calculate data for Gauss integration.

7.41.2 Member Function Documentation

void setTriangle (LocalVect< real_t, 7 > & *w*, LocalVect< Point< real_t >, 7 > & *x*)

Choose integration on triangle (7-point formula)
If this is not selected, Gauss integration formula on `[-1,1]` is calculated.

7.42 Grid Class Reference

To manipulate structured grids.

Public Member Functions

- Grid ()
  Construct a default grid with 10 intervals in each direction.
- Grid (real_t xm, real_t xM, size_t npx)
  Construct a 1-D structured grid given its extremal coordinates and number of intervals.
- Grid (real_t xm, real_t xM, real_t ym, real_t yM, size_t npx, size_t npy)
  Construct a 2-D structured grid given its extremal coordinates and number of intervals.
- Grid (Point< real_t > m, Point< real_t > M, size_t npx, size_t npy)
  Construct a 2-D structured grid given its extremal coordinates and number of intervals.
- Grid (real_t xm, real_t xM, real_t ym, real_t yM, real_t zm, real_t zM, size_t npx, size_t npy, size_t npz)
  Construct a 3-D structured grid given its extremal coordinates and number of intervals.
- Grid (Point< real_t > m, Point< real_t > M, size_t npx, size_t npy, size_t npz)
  Construct a 3-D structured grid given its extremal coordinates and number of intervals.
- void setXMin (const Point< real_t > &x)
  Set min. coordinates of the domain.
- void setXMax (const Point< real_t > &x)
- void setDomain (real_t xmin, real_t xmax)
  Set Dimensions of the domain: 1-D case.
- void setDomain (real_t xmin, real_t xmax, real_t ymin, real_t ymax)
  Set Dimensions of the domain: 2-D case.
- void setDomain (real_t xmin, real_t xmax, real_t ymin, real_t ymax, real_t zmin, real_t zmax)
  Set Dimensions of the domain: 3-D case.
- void setDomain (Point< real_t > xmin, Point< real_t > xmax)
  Set Dimensions of the domain: 3-D case.
- const Point< real_t > & getXMin () const
  Return min. Coordinates of the domain.
- const Point< real_t > & getXMax () const
  Return max. Coordinates of the domain.
- void setN (size_t nx, size_t ny=0, size_t nz=0)
  Set number of grid intervals in the x, y and z-directions.
- size_t getNx () const
  Return number of grid intervals in the x-direction.

- size_t getNy () const

  Return number of grid intervals in the y-direction.
- size_t getNz () const

  Return number of grid intervals in the z-direction.
- real_t getHx () const

  Return grid size in the x-direction.
- real_t getHy () const

  Return grid size in the y-direction.
- real_t getHz () const

  Return grid size in the z-direction.
- Point< real_t > getCoord (size_t i) const

  Return coordinates a point with label `i` *in a 1-D grid.*
- Point< real_t > getCoord (size_t i, size_t j) const

  Return coordinates a point with label `(i,j)` *in a 2-D grid.*
- Point< real_t > getCoord (size_t i, size_t j, size_t k) const

  Return coordinates a point with label `(i,j,k)` *in a 3-D grid.*
- real_t getX (size_t i) const

  Return x-coordinate of point with index `i`
- real_t getY (size_t j) const

  Return y-coordinate of point with index `j`
- real_t getZ (size_t k) const

  Return z-coordinate of point with index `k`
- Point2D< real_t > getXY (size_t i, size_t j) const

  Return coordinates of point with indices `(i,j)`
- Point< real_t > getXYZ (size_t i, size_t j, size_t k) const

  Return coordinates of point with indices `(i,j,k)`
- real_t getCenter (size_t i) const

  Return coordinates of center of a 1-D cell with indices `i`, `i+1`
- Point< real_t > getCenter (size_t i, size_t j) const

  Return coordinates of center of a 2-D cell with indices `(i,j)`, `(i+1,j)`, `(i+1,j+1)`, `(i,j+1)`
- Point< real_t > getCenter (size_t i, size_t j, size_t k) const

  Return coordinates of center of a 3-D cell with indices `(i,j,k)`, `(i+1,j,k)`, `(i+1,j+1,k)`, `(i,j+1,k)`, `(i,j,k+1)`, `(i+1,j,k+1)`, `(i+1,j+1,k+1)`, `(i,j+1,k+1)`
- void setCode (string exp, int code)

  Set a code for some grid points.
- void setCode (int side, int code)

  Set a code for grid points on sides.
- int getCode (int side) const

  Return code for a side number.
- int getCode (size_t i, size_t j) const

  Return code for a grid point.
- int getCode (size_t i, size_t j, size_t k) const

  Return code for a grid point.
- size_t getDim () const

  Return space dimension.
- void Deactivate (size_t i)

  Change state of a cell from active to inactive (1-D grid)

- void Deactivate (size_t i, size_t j)

  Change state of a cell from active to inactive (2-D grid)
- void Deactivate (size_t i, size_t j, size_t k)

  Change state of a cell from active to inactive (2-D grid)
- int isActive (size_t i) const

  Say if cell is active or not (1-D grid)
- int isActive (size_t i, size_t j) const

  Say if cell is active or not (2-D grid)
- int isActive (size_t i, size_t j, size_t k) const

  Say if cell is active or not (3-D grid)

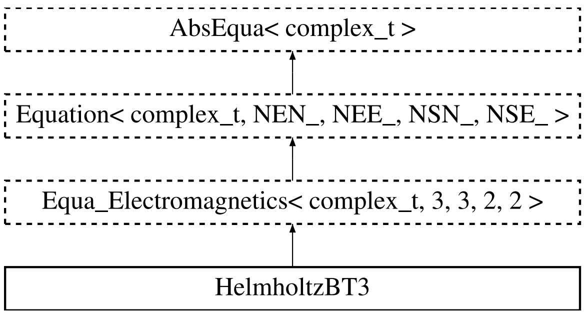
7.42.1 Detailed Description

To manipulate structured grids.

7.43 HelmholtzBT3 Class Reference

Builds finite element arrays for Helmholtz equations in a bounded media using 3-Node triangles.

Inheritance diagram for HelmholtzBT3:



Public Member Functions

- HelmholtzBT3 ()

  Default Constructor.
- HelmholtzBT3 (Element *el)

  Constructor using element data.
- HelmholtzBT3 (Side *sd)

  Constructor using side data.
- ~HelmholtzBT3 ()

  Destructor.
- void LHS (real_t wave_nb)

  Add element Left-Hand Side.
- void BoundaryRHS (UserData< complex_t > &ud)

  Add element Right-Hand Side using a UserData instance.
- void updateBC (const Element &el, const Vect< complex_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< complex_t > &bc)

Update Right-Hand side by taking into account essential boundary conditions.

- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< complex_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< complex_t > &b, LocalVect< complex_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< complex_t > &b, LocalVect< complex_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< complex_t > &b, LocalVect< complex_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< complex_t > &b, LocalVect< complex_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< complex_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< complex_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< complex_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< complex_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< complex_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< complex_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< complex_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< complex_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< complex_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< complex_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< complex_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< complex_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< complex_t > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< complex_t > *A)

Assemble side (edge or face) matrix into global one.

- void SideAssembly (SkSMatrix< complex_t > &A)

  Assemble side (edge or face) matrix into global one.

- void SideAssembly (SkMatrix< complex_t > &A)

  Assemble side (edge or face) matrix into global one.

- void SideAssembly (SpMatrix< complex_t > &A)

  Assemble side (edge or face) matrix into global one.

- void SideAssembly (Vect< complex_t > &v)

  Assemble side (edge or face) vector into global one.

- void DGElementAssembly (Matrix< complex_t > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (SkSMatrix< complex_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (SkMatrix< complex_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (SpMatrix< complex_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (TrMatrix< complex_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void AxbAssembly (const Element &el, const Vect< complex_t > &x, Vect< complex_t > &b)

  Assemble product of element matrix by element vector into global vector.

- void AxbAssembly (const Side &sd, const Vect< complex_t > &x, Vect< complex_t > &b)

  Assemble product of side matrix by side vector into global vector.

- size_t getNbNodes () const

  Return number of element nodes.

- size_t getNbEq () const

  Return number of element equations.

- void setInitialSolution (const Vect< complex_t > &u)

  Set initial solution (previous time step)

- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.

- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.

- Mesh & getMesh () const

  Return reference to Mesh instance.

- LinearSolver< complex_t > & getLinearSolver ()

  Return reference to linear solver instance.

- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.

- int SolveLinearSystem (Matrix< complex_t > *A, Vect< complex_t > &b, Vect< complex_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< complex_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< complex_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< complex_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< complex_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< complex_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< complex_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void MagneticPermeability (const real_t &mu)

  Set (constant) magnetic permeability.
- void MagneticPermeability (const string &exp)

  Set magnetic permeability given by an algebraic expression.
- void ElectricConductivity (const real_t &sigma)

  Set (constant) electric conductivity.
- void ElectricConductivity (const string &exp)

  set electric conductivity given by an algebraic expression
- void ElectricResistivity (const real_t &rho)

  Set (constant) electric resistivity.
- void ElectricResistivity (const string &exp)

  Set electric resistivity given by an algebraic expression.
- void setMaterial ()

  Set material properties.
- void Init (const Element *el)

  Set element arrays to zero.
- void Init (const Side *sd)

  Set side arrays to zero.

7.43.1 Detailed Description

Builds finite element arrays for Helmholtz equations in a bounded media using 3-Node triangles. Problem being formulated in time harmonics, the solution is complex valued.

7.43.2 Member Function Documentation

void updateBC (const Element & *el*, const Vect< complex_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< complex_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = `NODE_DOF`, int *dof* = `0`) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

`in`	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
`in`	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< complex_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< complex_t > & *b*, LocalVect< complex_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< complex_t > & *b*, LocalVect< complex_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.
`in`	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< complex_t > & *b*, LocalVect< complex_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< complex_t > & *b*, LocalVect< complex_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< complex_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< complex_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0]`, `_x[1]`, `...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< complex_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< complex_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< complex_t > & v) `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< complex_t > & A) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< complex_t > & b) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< complex_t > * A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< complex_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< complex_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< complex_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< complex_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< complex_t > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< complex_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< complex_t > & *x*, Vect< complex_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< complex_t > & *x*, Vect< complex_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *`IDENT_PREC`* **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< complex_t > ∗ *A*, Vect< complex_t > & *b*, Vect< complex_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

`in`	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	*b*	Vector containing right-hand side
`in,out`	*x*	Vector containing initial guess of solution on input, actual solution on output

7.43.3 Member Data Documentation

LocalVect<complex_t ,NEE_> ePrev `[inherited]`

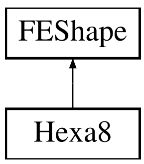
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.44 Hexa8 Class Reference

Defines a three-dimensional 8-node hexahedral finite element using Q1-isoparametric interpolation.

Inheritance diagram for Hexa8:



Public Member Functions

- Hexa8 ()

  Default Constructor.
- Hexa8 (const Element ∗el)

  Constructor when data of Element el are given.
- ∼Hexa8 ()

  Destructor.
- void setLocal (const Point< real_t > &s)

  Initialize local point coordinates in element.
- Point< real_t > DSh (size_t i)

  Return x, y and z partial derivatives of shape function of node i at a given point.
- void atGauss1 (LocalVect< Point< real_t >, 8 > &dsh, real_t &w)

  Calculate shape function derivatives and integration weights for 1-point Gauss rule.
- void atGauss2 (LocalMatrix< Point< real_t >, 8, 8 > &dsh, LocalVect< real_t, 8 > &w)

  Calculate shape function derivatives and integration weights for 2x2x2-point Gauss rule.
- real_t getMaxEdgeLength () const

  Return maximal edge length.

- real_t getMinEdgeLength () const

  Return minimal edge length.
- real_t Sh (size_t i) const

  Return shape function of node `i` at given point.
- real_t Sh (size_t i, Point< real_t > s) const

  Calculate shape function of node `i` at a given point `s`.
- Point< real_t > DSh (size_t i) const

  Return derivatives of shape function of node `i` at a given point.
- real_t getDet () const

  Return determinant of jacobian.
- Point< real_t > getCenter () const

  Return coordinates of center of element.
- Point< real_t > getLocalPoint () const

  Localize a point in the element.
- Point< real_t > getLocalPoint (const Point< real_t > &s) const

  Localize a point in the element.

7.44.1 Detailed Description

Defines a three-dimensional 8-node hexahedral finite element using Q1-isoparametric interpolation.

The reference element is the cube `[-1,1]*[-1,1]*[-1,1]`. The user must take care to the fact that determinant of jacobian and other quantities depend on the point in the reference element where they are calculated. For this, before any utilization of shape functions or jacobian, function **getLocal(s)** must be invoked.

7.44.2 Member Function Documentation

void setLocal (const Point< real_t > & *s*)

Initialize local point coordinates in element.

Parameters

in	*s*	Point in the reference element This function computes jacobian, shape functions and their partial derivatives at `s`. Other member functions only return these values.

Point<real_t> DSh (size_t *i*)

Return `x`, `y` and `z` partial derivatives of shape function of node `i` at a given point.

Member function *setLocal* must have been called before in order to calculate relevant quantities.

real_t Sh (size_t *i*, Point< real_t > *s*) const `[inherited]`

Calculate shape function of node `i` at a given point `s`.

Parameters

in	*i*	Local node label

Parameters

in	*s*	Point in the reference triangle where the shape function is evaluated

Point<real_t> DSh (size_t *i*) const `[inherited]`

Return derivatives of shape function of node `i` at a given point.

If the transformation (Reference element -> Actual element) is not affine, member function `setLocal()` must have been called before in order to calcuate relevant quantities.

Parameters

in	*i*	Partial derivative index (1, 2 or 3)

real_t getDet ( ) const `[inherited]`

Return determinant of jacobian.

If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint ( ) const `[inherited]`

Localize a point in the element.

Return actual coordinates in the reference element. If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint (const Point< real_t > & *s*) const `[inherited]`

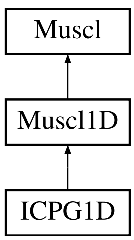
Localize a point in the element.

Return actual coordinates where `s` are coordinates in the reference element.

7.45 ICPG1D Class Reference

Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 1-D.

Inheritance diagram for ICPG1D:



Public Types

Public Member Functions

- ICPG1D (Mesh &ms)

Constructor using Mesh instance.
- ICPG1D (Mesh &ms, Vect< real_t > &r, Vect< real_t > &v, Vect< real_t > &p)

  Constructor using mesh and initial data.
- ~ICPG1D ()

  Destructor.
- void setReconstruction ()

  Set reconstruction from class Muscl.
- real_t runOneTimeStep ()

  Advance one time step.
- void Forward (const Vect< real_t > &flux, Vect< real_t > &field)

  Add flux to field.
- void setSolver (SolverType solver)

  Choose solver type.
- void setGamma (real_t gamma)

  Set value of constant Gamma for gases.
- void setCv (real_t Cv)

  Set value of Cv (specific heat at constant volume)
- void setCp (real_t Cp)

  Set value of C_p (specific heat at constant pressure)
- void setKappa (real_t Kappa)

  Set value of constant Kappa.
- real_t getGamma () const

  Return value of constant Gamma.
- real_t getCv () const

  Return value of C_v (specific heat at constant volume)
- real_t getCp () const

  Return value of C_p (specific heat at constant pressure)
- real_t getKappa () const

  Return value of constant Kappa.
- void getMomentum (Vect< real_t > &m) const

  Get vector of momentum at elements.
- void getInternalEnergy (Vect< real_t > &ie) const

  Get vector of internal energy at elements.
- void getTotalEnergy (Vect< real_t > &te) const

  Get vector of total energy at elements.
- void getSoundSpeed (Vect< real_t > &s) const

  Get vector of sound speed at elements.
- void getMach (Vect< real_t > &m) const

  Get vector of elementwise Mach number.
- void setInitialCondition_shock_tube (const LocalVect< real_t, 3 > &BcG, const LocalVect< real_t, 3 > &BcD, real_t x0)

  Initial condition corresponding to the shock tube.
- void setInitialCondition (const LocalVect< real_t, 3 > &u)

  A constant initial condition.
- void setBC (const Side &sd, real_t u)

  Assign a boundary condition as a constant to a given side.
- void setBC (int code, real_t a)

Assign a boundary condition value.

- void setBC (real_t a)

  Assign a boundary condition value.
- void setBC (const Side &sd, const LocalVect< real_t, 3 > &u)

  Assign a Dirichlet boundary condition vector.
- void setBC (int code, const LocalVect< real_t, 3 > &U)

  Assign a Dirichlet boundary condition vector.
- void setBC (const LocalVect< real_t, 3 > &u)

  Assign a Dirichlet boundary condition vector.
- void setInOutflowBC (const Side &sd, const LocalVect< real_t, 3 > &u)

  Impose a constant inflow or outflow boundary condition on a given side.
- void setInOutflowBC (int code, const LocalVect< real_t, 3 > &u)

  Impose a constant inflow or outflow boundary condition on sides with a given code.
- void setInOutflowBC (const LocalVect< real_t, 3 > &u)

  Impose a constant inflow or outflow boundary condition on boundary sides.
- real_t getMeanLength () const

  Return mean length.
- real_t getMaximumLength () const

  Return maximal length.
- real_t getMinimumLength () const

  Return mimal length.
- real_t getTauLim () const

  Return mean length.
- void print_mesh_stat ()

  Output mesh information.
- void setTimeStep (real_t dt)

  Assign time step value.
- real_t getTimeStep () const

  Return time step value.
- void setCFL (real_t CFL)

  Assign CFL value.
- real_t getCFL () const

  Return CFL value.
- void setReferenceLength (real_t dx)

  Assign reference length value.
- real_t getReferenceLength () const

  Return reference length.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- void setVerbose (int v)

  Set verbosity parameter.
- bool setReconstruction (const Vect< real_t > &U, Vect< real_t > &LU, Vect< real_t > &RU, size_t dof)

  Function to reconstruct by the Muscl method.
- void setMethod (const Method &s)

  Choose a flux solver.
- void setSolidZoneCode (int c)

Choose a code for solid zone.

- bool getSolidZone () const

  Return flag for presence of solid zones.

- int getSolidZoneCode () const

  Return code of solid zone, 0 if this one is not present.

- void setLimiter (Limiter l)

  Choose a flux limiter.

7.45.1 Detailed Description

Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 1-D.
Solution method is a second-order MUSCL Finite Volume scheme

7.45.2 Member Enumeration Documentation

enum Method `[inherited]`

Enumeration for flux choice.

Enumerator

FIRST_ORDER_METHOD First Order upwind method

MULTI_SLOPE_Q_METHOD Multislope Q method

MULTI_SLOPE_M_METHOD Multislope M method

enum Limiter `[inherited]`

Enumeration of flux limiting methods.

Enumerator

MINMOD_LIMITER MinMod limiter

VANLEER_LIMITER Van Leer limiter

SUPERBEE_LIMITER Superbee limiter

VANALBADA_LIMITER Van Albada limiter

MAX_LIMITER Max limiter

enum SolverType `[inherited]`

Enumeration of various solvers for the Riemann problem.

Enumerator

ROE_SOLVER Roe solver

VFROE_SOLVER Finite Volume Roe solver

LF_SOLVER LF solver

RUSANOV_SOLVER Rusanov solver

HLL_SOLVER HLL solver

HLLC_SOLVER HLLC solver

MAX_SOLVER Max solver

7.45.3 Constructor & Destructor Documentation

ICPG1D (Mesh & *ms*, Vect< real_t > & *r*, Vect< real_t > & *v*, Vect< real_t > & *p*)

Constructor using mesh and initial data.

Parameters

`in`	*ms*	Reference to Mesh instance
`in`	*r*	Vector containing initial (elementwise) density
`in`	*v*	Vector containing initial (elementwise) velocity
`in`	*p*	Vector containing initial (elementwise) pressure

7.45.4 Member Function Documentation

void Forward (const Vect< real_t > & *flux*, Vect< real_t > & *field*)

Add flux to field.
If this function is used, the user must call getFlux himself

Parameters

`in`	*flux*	Vector containing fluxes at sides (points)
`out`	*field*	Vector containing solution vector

void getMomentum (Vect< real_t > & *m*) const

Get vector of momentum at elements.

Parameters

`in,out`	*m*	Vect instance that contains on output element momentum

void getInternalEnergy (Vect< real_t > & *ie*) const

Get vector of internal energy at elements.

Parameters

`in,out`	*ie*	Vect instance that contains on output element internal energy

void getTotalEnergy (Vect< real_t > & *te*) const

Get vector of total energy at elements.

Parameters

`in,out`	*te*	Vect instance that contains on output element total energy

void getSoundSpeed (Vect< real_t > & *s*) const

Get vector of sound speed at elements.

Parameters

in,out	*s*	Vect instance that contains on output element sound speed

void getMach (Vect< real_t > & *m*) const

Get vector of elementwise Mach number.

Parameters

in,out	*m*	Vect instance that contains on output element Mach number

void setInitialCondition (const LocalVect< real_t, 3 > & *u*)

A constant initial condition.

Parameters

in	*u*	LocalVect instance containing density, velocity and pressure

void setBC (const Side & *sd*, real_t *u*)

Assign a boundary condition as a constant to a given side.

Parameters

in	*sd*	Side to which the value is assigned
in	*u*	Value to assign

void setBC (int *code*, real_t *a*)

Assign a boundary condition value.

Parameters

in	*code*	Code value to which boundary condition is assigned
in	*a*	Value to assign to sides that have code `code`

void setBC (real_t *a*)

Assign a boundary condition value.

Parameters

in	*a*	Value to assign to all boundary sides

void setBC (const Side & *sd*, const LocalVect< real_t, 3 > & *u*)

Assign a Dirichlet boundary condition vector.

Parameters

in	*sd*	Side instance to which the values are assigned
in	*u*	LocalVect instance that contains values to assign to the side

void setBC (int *code*, const LocalVect< real_t, 3 > & *U*)

Assign a Dirichlet boundary condition vector.

Parameters

in	*code*	Side code for which the values are assigned
in	*U*	LocalVect instance that contains values to assign to sides with code *code*

void setBC (const LocalVect< real_t, 3 > & *u*)

Assign a Dirichlet boundary condition vector.

Parameters

in	*u*	LocalVect instance that contains values to assign to all boundary sides

void setInOutflowBC (const Side & *sd*, const LocalVect< real_t, 3 > & *u*)

Impose a constant inflow or outflow boundary condition on a given side.

Parameters

in	*sd*	Instance of Side on which the condition is prescribed
in	*u*	LocalVect instance that contains values to assign to the side

void setInOutflowBC (int *code*, const LocalVect< real_t, 3 > & *u*)

Impose a constant inflow or outflow boundary condition on sides with a given code.

Parameters

in	*code*	Value of code for which the condition is prescribed

Parameters

in	*u*	LocalVect instance that contains values to assign to the sides

void setInOutflowBC (const LocalVect< real_t, 3 > & *u*)

Impose a constant inflow or outflow boundary condition on boundary sides.

Parameters

in	*u*	LocalVect instance that contains values to assign to the sides

void setTimeStep (real_t *dt*) `[inherited]`

Assign time step value.

Parameters

in	*dt*	Time step value

void setCFL (real_t *CFL*) `[inherited]`

Assign CFL value.

Parameters

in	*CFL*	Value of CFL

void setReferenceLength (real_t *dx*) `[inherited]`

Assign reference length value.

Parameters

in	*dx*	Value of reference length

void setVerbose (int *v*) `[inherited]`

Set verbosity parameter.

Parameters

in	*v*	Value of verbosity parameter

bool setReconstruction (const Vect< real_t > & *U*, Vect< real_t > & *LU*, Vect< real_t > & *RU*, size_t *dof*) `[inherited]`

Function to reconstruct by the Muscl method.

Parameters

in	*U*	Field to reconstruct
out	*LU*	Left gradient vector
out	*RU*	Right gradient vector
in	*dof*	Label of dof to reconstruct

void setMethod (const Method & *s*) `[inherited]`

Choose a flux solver.

Parameters

in	*s*	Solver to choose

void setLimiter (Limiter *l*) `[inherited]`

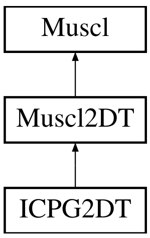
Choose a flux limiter.

Parameters

in	*l*	Limiter to choose

7.46 ICPG2DT Class Reference

Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 2-D.
Inheritance diagram for ICPG2DT:



Public Types

Public Member Functions

- ICPG2DT (Mesh &ms)

  Constructor using mesh instance.

- ICPG2DT (Mesh &ms, Vect< real_t > &r, Vect< real_t > &v, Vect< real_t > &p)

  Constructor using mesh and initial data.
- ∼ICPG2DT ()

  Destructor.
- void setReconstruction ()

  Reconstruct.
- real_t runOneTimeStep ()

  Advance one time step.
- void Forward (const Vect< real_t > &Flux, Vect< real_t > &Field)

  Add Flux to Field.
- real_t getFlux ()

  Get flux.
- void setSolver (SolverType s)

  Choose solver.
- void setGamma (real_t gamma)

  Set Gamma value.
- void setCv (real_t Cv)

  Set value of heat capacity at constant volume.
- void setCp (real_t Cp)

  Set value of heat capacity at constant pressure.
- void setKappa (real_t Kappa)

  Set Kappa value.
- real_t getGamma () const

  Return value of Gamma.
- real_t getCv () const

  Return value of heat capacity at constant volume.
- real_t getCp () const

  Return value of heat capacity at constant pressure.
- real_t getKappa () const

  Return value of Kappa.
- Mesh & getMesh ()

  Return reference to mesh instance.
- void getMomentum (Vect< real_t > &m) const

  Calculate elementwise momentum.
- void getInternalEnergy (Vect< real_t > &e) const

  Calculate elementwise internal energy.
- void getTotalEnergy (Vect< real_t > &e) const

  Return elementwise total energy.
- void getSoundSpeed (Vect< real_t > &s) const

  Return elementwise sound speed.
- void getMach (Vect< real_t > &m) const

  Return elementwise Mach number.
- void setBC (const Side &sd, real_t a)

  Prescribe a constant boundary condition at given side.
- void setBC (int code, real_t a)

  Prescribe a constant boundary condition for a given code.

- void setBC (real_t u)

  Prescribe a constant boundary condition on all boundary sides.
- void setBC (const Side &sd, const LocalVect< real_t, 4 > &u)

  Prescribe a constant boundary condition at a given side.
- void setBC (int code, const LocalVect< real_t, 4 > &u)

  Prescribe a constant boundary condition for a given code.
- void setBC (const LocalVect< real_t, 4 > &u)

  Prescribe a constant boundary condition at all boundary sides.
- real_t getR (size_t i) const

  Return density at given element label.
- real_t getV (size_t i, size_t j) const
- real_t getP (size_t i) const

  Return pressure at given element label.
- bool setReconstruction (const Vect< real_t > &U, Vect< real_t > &LU, Vect< real_t > &RU, size_t dof)

  Function to reconstruct by the Muscl method.
- void setTimeStep (real_t dt)

  Assign time step value.
- real_t getTimeStep () const

  Return time step value.
- void setCFL (real_t CFL)

  Assign CFL value.
- real_t getCFL () const

  Return CFL value.
- void setReferenceLength (real_t dx)

  Assign reference length value.
- real_t getReferenceLength () const

  Return reference length.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- void setVerbose (int v)

  Set verbosity parameter.
- void setMethod (const Method &s)

  Choose a flux solver.
- void setSolidZoneCode (int c)

  Choose a code for solid zone.
- bool getSolidZone () const

  Return flag for presence of solid zones.
- int getSolidZoneCode () const

  Return code of solid zone, 0 if this one is not present.
- void setLimiter (Limiter l)

  Choose a flux limiter.

Protected Member Functions

- void Initialize ()

  Construction of normals to sides.

7.46.1 Detailed Description

Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 2-D.
Solution method is a second-order MUSCL Finite Volume scheme on triangles

7.46.2 Member Enumeration Documentation

enum Method `[inherited]`

Enumeration for flux choice.

Enumerator

FIRST_ORDER_METHOD First Order upwind method
MULTI_SLOPE_Q_METHOD Multislope Q method
MULTI_SLOPE_M_METHOD Multislope M method

enum Limiter `[inherited]`

Enumeration of flux limiting methods.

Enumerator

MINMOD_LIMITER MinMod limiter
VANLEER_LIMITER Van Leer limiter
SUPERBEE_LIMITER Superbee limiter
VANALBADA_LIMITER Van Albada limiter
MAX_LIMITER Max limiter

enum SolverType `[inherited]`

Enumeration of various solvers for the Riemann problem.

Enumerator

ROE_SOLVER Roe solver
VFROE_SOLVER Finite Volume Roe solver
LF_SOLVER LF solver
RUSANOV_SOLVER Rusanov solver
HLL_SOLVER HLL solver
HLLC_SOLVER HLLC solver
MAX_SOLVER Max solver

7.46.3 Constructor & Destructor Documentation

ICPG2DT (Mesh & *ms*, Vect< real_t > & *r*, Vect< real_t > & *v*, Vect< real_t > & *p*)

Constructor using mesh and initial data.

Parameters

in	*ms*	Mesh instance
in	*r*	Initial density vector (as instance of Vect)
in	*v*	Initial velocity vector (as instance of Vect)
in	*p*	Initial pressure vector (as instance of Vect)

7.46.4 Member Function Documentation

void setReconstruction ( )

Reconstruct.
exit(3) if reconstruction fails

void Forward (const Vect< real_t > & *Flux*, Vect< real_t > & *Field*)

Add Flux to Field.
If this function is used, the function getFlux must be called

void setSolver (SolverType *s*)

Choose solver.

Parameters

in	*s*	Index of solver in the enumerated variable SolverType Available values are: `ROE_SOLVER`, `VFROE_SOLVER`, `LF_SOLVER`, `RUSANOV_SOLVER`, `HLL_SOLVER`, `HLLC_SOLVER`, `MAX_SOLVER`

void setBC (const Side & *sd*, real_t *a*)

Prescribe a constant boundary condition at given side.

Parameters

in	*sd*	Reference to Side instance
in	*a*	Value to prescribe

void setBC (int *code*, real_t *a*)

Prescribe a constant boundary condition for a given code.

Parameters

in	*code*	Code for which value is imposed
in	*a*	Value to prescribe

void setBC (real_t *u*)

Prescribe a constant boundary condition on all boundary sides.

Parameters

in	*u*	Value to prescribe

void setBC (const Side & *sd*, const LocalVect< real_t, 4 > & *u*)

Prescribe a constant boundary condition at a given side.

Parameters

in	*sd*	Reference to Side instance
in	*u*	Vector (instance of class LocalVect) with as components the constant values to prescribe for the four fields (`r`, `vx`, `vy`, `p`)

void setBC (int *code*, const LocalVect< real_t, 4 > & *u*)

Prescribe a constant boundary condition for a given code.

Parameters

in	*code*	Code for which value is imposed
in	*u*	Vector (instance of class LocalVect) with as components the constant values to prescribe for the four fields (`r`, `vx`, `vy`, `p`)

void setBC (const LocalVect< real_t, 4 > & *u*)

Prescribe a constant boundary condition at all boundary sides.

Parameters

in	*u*	Vector (instance of class LocalVect) with as components the constant values to prescribe for the four fields (`r`, `vx`, `vy`, `p`)

real_t getR (size_t *i*) const

Return density at given element label.

Parameters

in	*i*	Element label

real_t getV (size_t *i*, size_t *j*) const

Return velocity at given element label

Parameters

in	*i*	Element label
in	*j*	component index (1 or 2)

real_t getP (size_t *i*) const

Return pressure at given element label.

Parameters

in	*i*	Element label

bool setReconstruction (const Vect< real_t > & *U*, Vect< real_t > & *LU*, Vect< real_t > & *RU*, size_t *dof*) `[inherited]`

Function to reconstruct by the Muscl method.

Parameters

in	*U*	Field to reconstruct
out	*LU*	Left gradient vector
out	*RU*	Right gradient vector
in	*dof*	Label of dof to reconstruct

void Initialize ( ) `[protected]`, `[inherited]`

Construction of normals to sides.

Convention: for a given side, getPtrElement(1) is the left element and getPtrElement(2) is the right element. The normal goes from left to right. For boundary sides, the normal points outward.

void setTimeStep (real_t *dt*) `[inherited]`

Assign time step value.

Parameters

in	*dt*	Time step value

void setCFL (real_t *CFL*) `[inherited]`

Assign CFL value.

Parameters

in	*CFL*	Value of CFL

void setReferenceLength (real_t *dx*) `[inherited]`

Assign reference length value.

Parameters

in	*dx*	Value of reference length

void setVerbose (int *v*) `[inherited]`

Set verbosity parameter.

Parameters

in	*v*	Value of verbosity parameter

void setMethod (const Method & *s*) `[inherited]`

Choose a flux solver.

Parameters

in	*s*	Solver to choose

void setLimiter (Limiter *l*) `[inherited]`

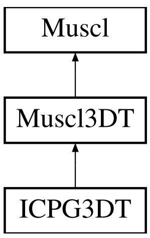
Choose a flux limiter.

Parameters

in	*l*	Limiter to choose

7.47 ICPG3DT Class Reference

Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 3-D.
Inheritance diagram for ICPG3DT:



Public Types

Public Member Functions

- ICPG3DT (Mesh &ms)

  Constructor using mesh data.

- ICPG3DT (Mesh &ms, Vect< real_t > &r, Vect< real_t > &v, Vect< real_t > &p)

  Constructor using mesh and initial data.
- ~ICPG3DT ()

  Destructor.
- void setReconstruction ()

  Reconstruct.
- real_t runOneTimeStep ()

  Advance one time step.
- void Forward (const Vect< real_t > &flux, Vect< real_t > &field)

  Add flux to field.
- real_t getFlux ()

  Return flux.
- void setReferenceLength (real_t dx)

  Assign a reference length.
- void setTimeStep (real_t dt)

  Assign a time step.
- void setCFL (real_t CFL)

  Assign CFL value.
- real_t getReferenceLength () const

  Return reference length.
- real_t getTimeStep () const

  Return time step.
- real_t getCFL () const

  Return CFL.
- void setGamma (real_t gamma)

  Set γ value.
- void setCv (real_t Cv)

  Set value of C_v (Heat capacity at constant volume)
- void setCp (real_t Cp)

  Set value of C_p (Heat capacity at constant pressure)
- void setKappa (real_t Kappa)

  Set Kappa value.
- real_t getGamma () const

  Return value of γ.
- real_t getCv () const

  Return value of C_v (Heat capacity at constant volume)
- real_t getCp () const

  Return value of C_p (Heat capacity at constant pressure)
- real_t getKappa () const

  Return value of κ.
- Mesh & getMesh ()

  Return reference to mesh instance.
- Mesh * getPtrMesh ()

  Return pointer to mesh.
- void getMomentum (Vect< real_t > &m) const

  Calculate elementwise momentum.

- void getInternalEnergy (Vect< real_t > &e) const

  Calculate elementwise internal energy.
- void getTotalEnergy (Vect< real_t > &e) const

  Return elementwise total energy.
- void getSoundSpeed (Vect< real_t > &s) const

  Return elementwise sound speed.
- void getMach (Vect< real_t > &m) const

  Return elementwise Mach number.
- bool setReconstruction (const Vect< real_t > &U, Vect< real_t > &LU, Vect< real_t > &RU, size_t dof)

  Function to reconstruct by the Muscl method.
- real_t getMinimumFaceArea () const

  Return minimum area of faces in the mesh.
- real_t getMinimumElementVolume () const

  Return minimum volume of elements in the mesh.
- real_t getMaximumFaceArea () const

  Return maximum area of faces in the mesh.
- real_t getMaximumElementVolume () const

  Return maximum volume of elements in the mesh.
- real_t getMeanFaceArea () const

  Return mean area of faces in the mesh.
- real_t getMeanElementVolume () const

  Return mean volume of elements in the mesh.
- real_t getMinimumEdgeLength () const

  Return minimum length of edges in the mesh.
- real_t getMinimumVolumebyArea () const

  Return minimum volume by area in the mesh.
- real_t getMaximumEdgeLength () const

  Return maximum length of edges in the mesh.
- real_t getTauLim () const

  Return value of tau lim.
- real_t getComega () const

  Return value of Comega.
- void setbetalim (real_t bl)

  Assign value of beta lim.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- void setVerbose (int v)

  Set verbosity parameter.
- void setMethod (const Method &s)

  Choose a flux solver.
- void setSolidZoneCode (int c)

  Choose a code for solid zone.
- bool getSolidZone () const

  Return flag for presence of solid zones.
- int getSolidZoneCode () const

  Return code of solid zone, 0 if this one is not present.
- void setLimiter (Limiter l)

  Choose a flux limiter.

7.47.1 Detailed Description

Class to solve the Inviscid compressible fluid flows (Euler equations) for perfect gas in 3-D.
Solution method is a second-order MUSCL Finite Volume scheme with tetrahedra

7.47.2 Member Enumeration Documentation

enum Method `[inherited]`

Enumeration for flux choice.

Enumerator

- ***FIRST_ORDER_METHOD*** First Order upwind method
- ***MULTI_SLOPE_Q_METHOD*** Multislope Q method
- ***MULTI_SLOPE_M_METHOD*** Multislope M method

enum Limiter `[inherited]`

Enumeration of flux limiting methods.

Enumerator

- ***MINMOD_LIMITER*** MinMod limiter
- ***VANLEER_LIMITER*** Van Leer limiter
- ***SUPERBEE_LIMITER*** Superbee limiter
- ***VANALBADA_LIMITER*** Van Albada limiter
- ***MAX_LIMITER*** Max limiter

enum SolverType `[inherited]`

Enumeration of various solvers for the Riemann problem.

Enumerator

- ***ROE_SOLVER*** Roe solver
- ***VFROE_SOLVER*** Finite Volume Roe solver
- ***LF_SOLVER*** LF solver
- ***RUSANOV_SOLVER*** Rusanov solver
- ***HLL_SOLVER*** HLL solver
- ***HLLC_SOLVER*** HLLC solver
- ***MAX_SOLVER*** Max solver

7.47.3 Constructor & Destructor Documentation

ICPG3DT (Mesh & *ms*)

Constructor using mesh data.

Parameters

in	*ms*	Mesh instance

ICPG3DT (Mesh & *ms*, Vect< real_t > & *r*, Vect< real_t > & *v*, Vect< real_t > & *p*)

Constructor using mesh and initial data.

Parameters

in	*ms*	Mesh instance
in	*r*	Elementwise initial density vector (as instance of Element Vect)
in	*v*	Elementwise initial velocity vector (as instance of Element Vect)
in	*p*	Elementwise initial pressure vector (as instance of Element Vect)

7.47.4 Member Function Documentation

void setReconstruction ( )

Reconstruct.
exit(3) if reconstruction failed

bool setReconstruction (const Vect< real_t > & *U*, Vect< real_t > & *LU*, Vect< real_t > & *RU*, size_t *dof*) `[inherited]`

Function to reconstruct by the Muscl method.

Parameters

in	*U*	Field to reconstruct
out	*LU*	Left gradient vector
out	*RU*	Right gradient vector
in	*dof*	Label of dof to reconstruct

void setVerbose (int *v*) `[inherited]`

Set verbosity parameter.

Parameters

in	*v*	Value of verbosity parameter

void setMethod (const Method & *s*) `[inherited]`

Choose a flux solver.

Parameters

in	*s*	Solver to choose

void setLimiter (Limiter *l*) `[inherited]`

Choose a flux limiter.

Parameters

in	*l*	Limiter to choose

7.48 IOField Class Reference

Enables working with files in the XML Format.
Inherits XMLParser.

Public Types

Public Member Functions

- IOField ()

  Default constructor.
- IOField (const string &file, AccessType access, bool compact=true)

  Constructor using file name.
- IOField (const string &mesh_file, const string &file, Mesh &ms, AccessType access, bool compact=true)

  Constructor using file name, mesh file and mesh.
- IOField (const string &file, Mesh &ms, AccessType access, bool compact=true)

  Constructor using file name and mesh.
- IOField (const string &file, AccessType access, const string &name)

  Constructor using file name and field name.
- ∼IOField ()

  Destructor.
- void setMeshFile (const string &file)

  Set mesh file.
- void open ()

  Open file.
- void open (const string &file, AccessType access)

  Open file.
- void close ()

  Close file.
- void put (Mesh &ms)

  Store mesh in file.
- void put (const Vect< real_t > &v)

  Store Vect instance v in file.
- void put (const PETScVect< real_t > &v)

  Store PETScVect instance v in file.
- real_t get (Vect< real_t > &v)

  Get Vect v instance from file.
- int get (Vect< real_t > &v, const string &name)

  Get Vect v instance from file if the field has the given name.

- int get (DMatrix< real_t > &A, const string &name)

  Get DMatrix `A` instance from file if the field has the given name.
- int get (DSMatrix< real_t > &A, const string &name)

  Get DSMatrix `A` instance from file if the field has the given name.
- int get (Vect< real_t > &v, real_t t)

  Get Vect `v` instance from file corresponding to a specific time value.
- void saveGMSH (string output_file, string mesh_file)

  *Save field vectors in a file using **GMSH** format.*

7.48.1 Detailed Description

Enables working with files in the XML Format.

This class has methods to store vectors in files and read from files.

7.49 IPF Class Reference

To read project parameters from a file in IPF format.

Public Member Functions

- IPF ()

  Default constructor.
- IPF (const string &file)

  Constructor that gives the data file name.
- IPF (const string &prog, const string &file)

  Constructor that reads parameters in file `file` and prints header information for the calling program `prog`. It reads parameters in `IPF` Format from this file.
- ~IPF ()

  Destructor.
- real_t getDisplay ()

  Display acquired parameters.
- int getVerbose () const

  *Return parameter read using keyword **Verbose**.*
- int getOutput () const

  *Return parameter read using keyword **Output**.*
- int getSave () const

  *Return parameter read using keyword **Save**.*
- int getPlot () const

  *Return parameter read using keyword **Plot**.*
- int getBC () const

  *Return parameter read using keyword **BC**.*
- int getBF () const

  *Return parameter read using keyword **BF**.*
- int getSF () const

  *Return parameter read using keyword **SF**.*
- int getInit () const

  *Return parameter read using keyword **Init**.*
- int getData () const

*Return parameter read using keyword **Data**.*
- size_t getNbSteps () const

  *Return parameter read using keyword **NbSteps**.*
- size_t getNbIter () const

  *Return parameter read using keyword **NbIter**.*
- real_t getTimeStep () const

  *Return parameter read using keyword **TimeStep**.*
- real_t getMaxTime () const

  *Return parameter read using keyword **MaxTime**.*
- real_t getTolerance () const

  *Return parameter read using keyword **Tolerance**.*
- int getIntPar (size_t n=1) const

  Return n-th parameter read using keyword `IntPar`
- string getStringPar (size_t n=1) const

  *Return n-th parameter read using keyword **StringPar**.*
- real_t getDoublePar (size_t n=1) const

  *Return n-th parameter read using keyword **DoublePar**.*
- Point< real_t > getPointDoublePar (size_t n=1) const

  *Return n-th parameter read using keyword **PointDoublePar**.*
- complex_t getComplexPar (size_t n=1) const

  *Return n-th parameter read using keyword **StringPar**.*
- string getString (const string &label) const

  Return parameter corresponding to a given label, when its value is a string.
- string getString (const string &label, string def) const

  Return parameter corresponding to a given label, when its value is a string.
- int getInteger (const string &label) const

  Return parameter corresponding to a given label, when its value is an integer.
- int getInteger (const string &label, int def) const

  Return parameter corresponding to a given label, when its value is an integer.
- real_t getDouble (const string &label) const

  Return parameter corresponding to a given label, when its value is a real_t.
- real_t getDouble (const string &label, real_t def) const

  Return parameter corresponding to a given label, when its value is a real_t.
- complex_t getComplex (const string &label) const

  Return parameter corresponding to a given label, when its value is a complex number.
- complex_t getComplex (const string &label, complex_t def) const

  Return parameter corresponding to a given label, when its value is a complex number.
- int contains (const string &label) const

  check if the project file contains a given parameter
- void get (const string &label, Vect< real_t > &a) const

  Read an array of real values, corresponding to a given label.
- real_t getArraySize (const string &label, size_t j) const

  Return an array entry for a given label.
- void get (const string &label, int &a) const

  Return integer parameter corresponding to a given label.
- void get (const string &label, real_t &a) const

Return real parameter corresponding to a given label.
- void get (const string &label, complex_t &a) const
  Return complex parameter corresponding to a given label.
- void get (const string &label, string &a) const
  Return string parameter corresponding to a given label.
- string getProject () const
  *Return parameter read using keyword **Project**.*
- string getDomainFile () const
  *Return pameter using keyword **Mesh**.*
- string getMeshFile (size_t i=1) const
  *Return i-th parameter read using keyword **mesh_file**.*
- string getInitFile () const
  *Return parameter read using keyword **InitFile**.*
- string getRestartFile () const
  *Return parameter read using keyword **RestartFile**.*
- string getBCFile () const
  *Return parameter read using keyword **BCFile**.*
- string getBFFile () const
  *Return parameter read using keyword **BFFile**.*
- string getSFFile () const
  *Return parameter read using keyword **SFFile**.*
- string getSaveFile () const
  *Return parameter read using keyword **SaveFile**.*
- string getPlotFile (int i=1) const
  *Return i-th parameter read using keyword **PlotFile**.*
- string getPrescriptionFile (int i=1) const
  *Return parameter read using keyword **DataFile**.*
- string getAuxFile (size_t i=1) const
  *Return i-th parameter read using keyword **Auxfile**.*
- string getDensity () const
  Return expression (to be parsed, function of x, y, z, t) for density function.
- string getElectricConductivity () const
  Return expression (to be parsed, function of x, y, z, t) for electric conductivity.
- string getElectricPermittivity () const
  Return expression (to be parsed, function of x, y, z, t) for electric permittivity.
- string getMagneticPermeability () const
  Return expression (to be parsed, function of x, y, z, t) for magnetic permeability.
- string getPoissonRatio () const
  Return expression (to be parsed, function of x, y, z, t) for Poisson ratio.
- string getThermalConductivity () const
  Return expression (to be parsed, function of x, y, z, t) for thermal conductivity.
- string getRhoCp () const
  Return expression (to be parsed, function of x, y, z, t) for density $*$ specific heat.
- string getViscosity () const
  Return expression (to be parsed, function of x, y, z, t) for viscosity.
- string getYoungModulus () const
  Return expression (to be parsed, function of x, y, z, t) for Young's modulus.

7.49.1 Detailed Description

To read project parameters from a file in IPF format.

This class can be used to acquire various parameters from a parameter file of IPF (Input Project File). The declaration of an instance of this class avoids reading data in your main program. The acquired parameters are retrieved through information members of the class. Note that all the parameters have default values

7.49.2 Constructor & Destructor Documentation

IPF (const string & *file*)

Constructor that gives the data file name.

It reads parameters in IPF Format from this file.

7.49.3 Member Function Documentation

int getOutput ( ) const

Return parameter read using keyword **Output**.

This parameter can be used to control output behavior in a program.

int getSave ( ) const

Return parameter read using keyword **Save**.

This parameter can be used to control result saving in a program (*e.g.* for a restarting purpose).

int getPlot ( ) const

Return parameter read using keyword **Plot**.

This parameter can be used to control result saving for plotting in a program.

int getBC ( ) const

Return parameter read using keyword **BC**.

This parameter can be used to set a boundary condition flag.

int getBF ( ) const

Return parameter read using keyword **BF**.

This parameter can be used to set a body force flag.

int getSF ( ) const

Return parameter read using keyword **SF**.

This parameter can be used to set a surface force flag.

int getInit ( ) const

Return parameter read using keyword **Init**.

This parameter can be used to set an initial data flag.

int getData ( ) const

Return parameter read using keyword **Data**.
This parameter can be used to set a various data flag.

size_t getNbSteps ( ) const

Return parameter read using keyword **NbSteps**.
This parameter can be used to read a number of time steps.

size_t getNbIter ( ) const

Return parameter read using keyword **NbIter**.
This parameter can be used to read a number of iterations.

real_t getTimeStep ( ) const

Return parameter read using keyword **TimeStep**.
This parameter can be used to read a time step value.

real_t getMaxTime ( ) const

Return parameter read using keyword **MaxTime**.
This parameter can be used to read a maximum time value.

real_t getTolerance ( ) const

Return parameter read using keyword **Tolerance**.
This parameter can be used to read a tolerance value to control convergence.

int getIntPar (size_t *n* = *1*) const

Return `n`-th parameter read using keyword `IntPar`
Here we have at most 20 integer extra parameters that can be used for any purpose. Default value for `n` is `1`

string getStringPar (size_t *n* = *1*) const

Return *n-th* parameter read using keyword **StringPar**.
Here we have at most 20 integer extra parameters that can be used for any purpose. Default value for `n` is `1`

real_t getDoublePar (size_t *n* = *1*) const

Return `n`-th parameter read using keyword **DoublePar**.
Here we have at most 20 integer extra parameters that can be used for any purpose. Default value for `n` is `1`

Point<real_t> getPointDoublePar (size_t *n* = *1*) const

Return `n`-th parameter read using keyword **PointDoublePar**.
Here we have at most 20 integer extra parameters that can be used for any purpose. Default value for `n` is `1`

complex_t getComplexPar (size_t *n* = 1) const

Return n-th parameter read using keyword **StringPar**.
Here we have at most 20 integer extra parameters that can be used for any purpose. Default value for n is 1

string getString (const string & *label*) const

Return parameter corresponding to a given label, when its value is a string.

Parameters

in	*label*	Label that identifies the string (read from input file) If this label is not found an error message is displayed and program stops

string getString (const string & *label*, string *def*) const

Return parameter corresponding to a given label, when its value is a string.
Case where a default value is provided

Parameters

in	*label*	Label that identifies the string (read from input file)
in	*def*	Default value: Value to assign if the sought parameter is not found

int getInteger (const string & *label*) const

Return parameter corresponding to a given label, when its value is an integer.

Parameters

in	*label*	Label that identifies the integer number (read from input file) If this label is not found an error message is displayed and program stops

int getInteger (const string & *label*, int *def*) const

Return parameter corresponding to a given label, when its value is an integer.
Case where a default value is provided

Parameters

in	*label*	Label that identifies the integer number (read from input file).
in	*def*	Default value: Value to assign if the sought parameter is not found

real_t getDouble (const string & *label*) const

Return parameter corresponding to a given label, when its value is a real_t.

Parameters

in	*label*	Label that identifies the real number (read from input file). If this label is not found an error message is displayed and program stops.

real_t getDouble (const string & *label*, real_t *def*) const

Return parameter corresponding to a given label, when its value is a real_t.
Case where a default value is provided

Parameters

in	*label*	Label that identifies the real number (read from input file)
in	*def*	Default value: Value to assign if the sought parameter is not found

complex_t getComplex (const string & *label*) const

Return parameter corresponding to a given label, when its value is a complex number.

Parameters

in	*label*	Label that identifies the complex number (read from input file) If this label is not found an error message is displayed and program stops

complex_t getComplex (const string & *label*, complex_t *def*) const

Return parameter corresponding to a given label, when its value is a complex number.
Case where a default value is provided

Parameters

in	*label*	Label that identifies the complex number (read from input file)
in	*def*	Default value: Value to assign if the sought parameter is not found

int contains (const string & *label*) const

check if the project file contains a given parameter

Parameters

in	*label*	Label that identifies the label to seek in file

Returns

`0` if the parameter is not found, `n` if the parameter is found, where `n` is the parameter index in the parameter list

void get (const string & *label*, Vect< real_t > & *a*) const

Read an array of real values, corresponding to a given label.

Parameters

in	*label*	Label that identifies the array (read from input file).
in	*a*	Vector that contain the array. The vector is properly resized before filling.

Remarks

If this label is not found an error message is displayed.

real_t getArraySize (const string & *label*, size_t *j*) const

Return an array entry for a given label.

Parameters

in	*label*	Label that identifies the array (read from input file).
in	*j*	Index of entry in the array (Starting from 1)

Remarks

If this label is not found an error message is displayed and program stops.

void get (const string & *label*, int & *a*) const

Return integer parameter corresponding to a given label.

Parameters

in	*label*	Label that identifies the integer number (read from input file).
out	*a*	Returned value. If this label is not found an error message is displayed and program stops. Note: This member function can be used instead of getInteger

void get (const string & *label*, real_t & *a*) const

Return real parameter corresponding to a given label.

Parameters

in	*label*	Label that identifies the real (real_t) number (read from input file).
out	*a*	Returned value. If this label is not found an error message is displayed and program stops. Note: This member function can be used instead of getReal_T

void get (const string & *label*, complex_t & *a*) const

Return complex parameter corresponding to a given label.

Parameters

in	*label*	Label that identifies the complex number (read from input file).
out	*a*	Returned value. If this label is not found an error message is displayed and program stops.

void get (const string & *label*, string & *a*) const

Return string parameter corresponding to a given label.

Parameters

in	*label*	Label that identifies the atring (read from input file).
out	*a*	Returned value. Note: This member function can be used instead of getString If this label is not found an error message is displayed and program stops. Note: This member function can be used instead of getString

string getProject ( ) const

Return parameter read using keyword **Project**.
This parameter can be used to read a project's name.

string getMeshFile (size_t *i* = 1) const

Return `i`-th parameter read using keyword **mesh_file**.
Here we have at most 10 integer extra parameters that can be used for any purpose. Default value for `i` is `1`

string getInitFile ( ) const

Return parameter read using keyword **InitFile**.
This parameter can be used to read an initial data file name.

string getRestartFile ( ) const

Return parameter read using keyword **RestartFile**.
This parameter can be used to read a restart file name.

string getBCFile ( ) const

Return parameter read using keyword **BCFile**.
This parameter can be used to read a boundary condition file name.

string getBFFile ( ) const

Return parameter read using keyword **BFFile**.
This parameter can be used to read a body force file name.

string getSFFile ( ) const

Return parameter read using keyword **SFFile**.
This parameter can be used to read a source force file name.

string getSaveFile ( ) const

Return parameter read using keyword **SaveFile**.
This parameter can be used to read a save file name.

string getPlotFile (int *i* = *1*) const

Return `i`-th parameter read using keyword **PlotFile**.
Here we have at most 10 integer extra parameters that can be used for plot file names. Default value for `i` is `1`

string getPrescriptionFile (int *i* = *1*) const

Return parameter read using keyword **DataFile**.
This parameter can be used to read a Prescription file.

string getAuxFile (size_t *i* = *1*) const

Return `i`-th parameter read using keyword **Auxfile**.
Here we have at most 10 integer extra parameters that can be used for any auxiliary file names. Default value for `i` is `1`

7.50 Iter< T_ > Class Template Reference

Class to drive an iterative process.

Public Member Functions

- Iter ()

  Default Constructor.
- Iter (int max_it, real_t toler, int verbose=0)

  Constructor with iteration parameters.
- ~Iter ()

  Destructor.
- void setMaxIter (int max_it)

  Set maximal number of iterations.
- void setTolerance (real_t toler)

  Set tolerance value for convergence.
- void setVerbose (int v)

  Set verbosity parameter.
- bool check (Vect< T_ > &u, const Vect< T_ > &v, int opt=2)

  Check convergence.

7.50.1 Detailed Description

template<class T_>
class OFELI::Iter< T_ >

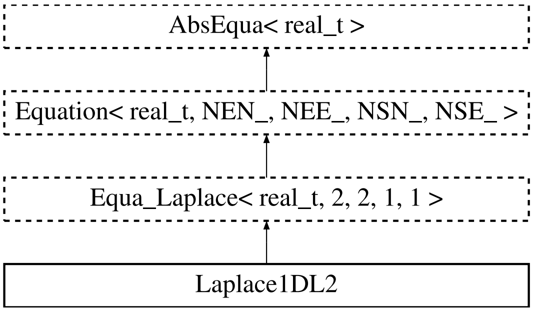
Class to drive an iterative process.

This template class enables monitoring any iterative process. It simply sets default values for tolerance, maximal number of iterations and enables checking convergence using two successive iterates.

7.51 Laplace1DL2 Class Reference

To build element equation for a 1-D elliptic equation using the 2-Node line element (P_1).

Inheritance diagram for Laplace1DL2:



Public Member Functions

- Laplace1DL2 (Element *el)

    Constructor for an element.
- Laplace1DL2 (Mesh &ms, Vect< real_t > &u)
- ~Laplace1DL2 ()

    Destructor.
- void Matrix (real_t coef=1.)

    Add finite element matrix to left hand side.
- void BodyRHS (const Vect< real_t > &f)

    Add Right-Hand Side Contribution.
- void BoundaryRHS (int n, real_t p)

    Add Neumann contribution to Right-Hand Side.
- void setBoundaryCondition (real_t f, int lr)

    Set Dirichlet boundary data.
- void setTraction (real_t f, int lr)

    Set Traction data.
- int run ()
- virtual void build ()

    Solve the equation.
- void build (EigenProblemSolver &e)

    Build the linear system for an eigenvalue problem.
- virtual void buildEigen (int opt=0)

    Build matrices for an eigenvalue problem.

- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)

  Assemble side right-hand side vector into global one.

- void SideAssembly (Matrix< real_t > *A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > *A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

    LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

    LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

    LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

    LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes

    LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS

    LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Init (const Element *el)

    Set element arrays to zero.
- void Init (const Side *sd)

    Set side arrays to zero.

7.51.1 Detailed Description

To build element equation for a 1-D elliptic equation using the 2-Node line element (P_1).

7.51.2 Constructor & Destructor Documentation

Laplace1DL2 (Mesh & *ms*, Vect< real_t > & *u*)

Constructor using mesh instance and solution vector

Parameters

in	*ms*	Mesh instance
in,out	*u*	Vect instance that contains, after execution of **run()** the solution

7.51.3 Member Function Documentation

void Matrix (real_t *coef* = 1.)

Add finite element matrix to left hand side.

Parameters

in	*coef*	Value to multiply by the added matrix

void BodyRHS (const Vect< real_t > & *f*)

Add Right-Hand Side Contribution.

Parameters

in	*f*	Vector containing the source given function at mesh nodes

void BoundaryRHS (int *n*, real_t *p*)

Add Neumann contribution to Right-Hand Side.

Parameters

in	*n*	Parameter to select equal to 0 if the condition is at the left end of the domain and different if it is at the right of it
in	*p*	Value of flux to add

Note

This member function is to be called only for the first or last element

void setBoundaryCondition (real_t *f*, int *lr*)

Set Dirichlet boundary data.

Parameters

in	*f*	Value to assign
in	*lr*	Option to choose location of the value (-1: Left end, 1: Right end)

void setTraction (real_t *f*, int *lr*)

Set Traction data.

Parameters

in	*f*	Value of traction (Neumann boundary condition)
in	*lr*	Option to choose location of the traction (-1: Left end, 1: Right end)

int run ( )

Run solution procedure This function is to be called when the constructor **Laplace1DL2(mesh,u)** is used.

Returns

return code for the solution of the linear system

void build (EigenProblemSolver & *e*) `[inherited]`

Build the linear system for an eigenvalue problem.

Parameters

in	*e*	Reference to used EigenProblemSolver instance

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = *NODE_FIELD*, int *flag* = *0*) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > ∗ *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *IDENT_PREC*) `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver

Parameters

in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > ∗ *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

7.51.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

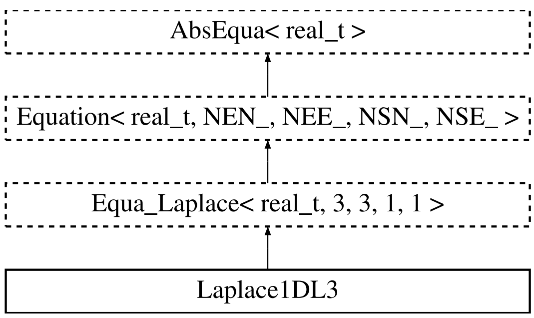
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.52 Laplace1DL3 Class Reference

To build element equation for the 1-D elliptic equation using the 3-Node line (P_2).

Inheritance diagram for Laplace1DL3:



Public Member Functions

- Laplace1DL3 (Mesh &ms, Vect< real_t > &u)

- Laplace1DL3 (Element *el)

  Constructor for an element.
- ~Laplace1DL3 ()

  Destructor.
- void Matrix (real_t coef=1.)

  Add finite element matrix to left hand side.
- void BodyRHS (const Vect< real_t > &f)

  Add Right-hand side contribution.
- void BoundaryRHS (int n, real_t p)

  Add Neumann contribution to Right-Hand Side.
- void setTraction (real_t f, int lr)

  Set Traction data.
- int run ()
- virtual void build ()

  Solve the equation.
- void build (EigenProblemSolver &e)

  Build the linear system for an eigenvalue problem.
- virtual void buildEigen (int opt=0)

  Build matrices for an eigenvalue problem.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)
  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)
  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)
  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)
  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)
  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > ∗A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)
  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)
  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > ∗A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)
  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)
  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const
  Return number of element nodes.
- size_t getNbEq () const

Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > ∗A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Init (const Element ∗el)

  Set element arrays to zero.
- void Init (const Side ∗sd)

  Set side arrays to zero.

7.52.1 Detailed Description

To build element equation for the 1-D elliptic equation using the 3-Node line (P_2).

7.52.2 Constructor & Destructor Documentation

Laplace1DL3 (Mesh & *ms*, Vect< real_t > & *u*)

Constructor using mesh instance and solution vector

Parameters

in	*ms*	Mesh instance
in,out	*u*	Vect instance that contains, after execution of **run()** the solution

7.52.3 Member Function Documentation

void Matrix (real_t *coef* = 1.)

Add finite element matrix to left hand side.

Parameters

in	*coef*	Value to multiply by the added matrix

void BodyRHS (const Vect< real_t > & *f*)

Add Right-hand side contribution.

Parameters

in	*f*	Vector of right-hand side of the Poisson equation at nodes

void BoundaryRHS (int *n*, real_t *p*)

Add Neumann contribution to Right-Hand Side.

Parameters

in	*n*	Parameter to select equal to 0 if the condition is at the left end of the domain and different if it is at the right of it
in	*p*	Value of flux to add

Note

This member function is to be invoked only for the first or last element

void setTraction (real_t *f*, int *lr*)

Set Traction data.

Parameters

in	*f*	Value of traction (Neumann boundary condition)
in	*lr*	Option to choose location of the traction (-1: Left end, 1: Right end)

int run ( )

Run solution procedure This function is to be called when the constructor **Laplace1DL2(mesh,u)** is used.

Returns

return code for the solution of the linear system

void build (EigenProblemSolver & *e*) `[inherited]`

Build the linear system for an eigenvalue problem.

Parameters

in	*e*	Reference to used EigenProblemSolver instance

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = `NODE_DOF`, int *dof* = `0`) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = *NODE_FIELD*, int *flag* = *0*) [inherited]

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > ∗ *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *IDENT_PREC*) `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > * *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

7.52.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

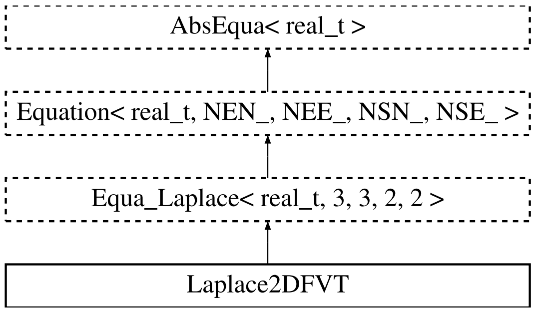
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.53 Laplace2DFVT Class Reference

To build and solve the Laplace equation using a standard Finite Volume method.

Inheritance diagram for Laplace2DFVT:



Public Member Functions

- Laplace2DFVT (Mesh &ms, Vect< real_t > &b, Vect< real_t > &u)

  Standard constructor.
- Laplace2DFVT (Mesh &ms, SpMatrix< real_t > &A, Vect< real_t > &b)

  Standard constructor.
- ∼Laplace2DFVT ()

  Destructor.
- int checkDelaunay (int verb=0)

  Check whether triangles are Delaunay ones.
- void build (const Vect< real_t > &f)

  Build the linear system of equations.
- int run (const Vect< real_t > &f)

  Build and solve the linear system of equations.
- void LHS (const Element ∗e1, const Element ∗e2)

  Calculate left-hand side.
- void RHS (const Vect< real_t > &f)

  Add right-hand side Contribution.
- virtual void build ()

  Solve the equation.
- void build (EigenProblemSolver &e)

  Build the linear system for an eigenvalue problem.
- virtual void buildEigen (int opt=0)

  Build matrices for an eigenvalue problem.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.

- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > *A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.

- void SideAssembly (Vect< real_t > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > ∗A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > ∗A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Init (const Element *el)

  Set element arrays to zero.
- void Init (const Side *sd)

  Set side arrays to zero.

7.53.1 Detailed Description

To build and solve the Laplace equation using a standard Finite Volume method.

7.53.2 Constructor & Destructor Documentation

Laplace2DFVT (Mesh & *ms*, Vect< real_t > & *b*, Vect< real_t > & *u*)

Standard constructor.

Parameters

in	*ms*	Mesh instance
in	*b*	Vect instance that contains Right-hand side
in	*u*	Vect instance that contains solution

Laplace2DFVT (Mesh & *ms*, SpMatrix< real_t > & *A*, Vect< real_t > & *b*)

Standard constructor.

Parameters

in	*ms*	Mesh instance. The mesh must have been assigned the attribute `ELEMENT_DOF` to say that unknowns are supported by elements.
in	*A*	Problem matrix to be stored in sparse format (class SpMatrix)
in	*b*	Vect instance that contains Right-hand side

7.53.3 Member Function Documentation

int checkDelaunay (int *verb* = *0*)

Check whether triangles are Delaunay ones.

Parameters

in	*verb*	Output (>0) or not (0) list of failing elements

Returns

ret Number of Non Delaunay triangles

void build (EigenProblemSolver & *e*) `[inherited]`

Build the linear system for an eigenvalue problem.

Parameters

in	*e*	Reference to used EigenProblemSolver instance

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = `NODE_DOF`, int *dof* = `0`) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides

Parameters

`in`	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.
`in`	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector b is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) [inherited]

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = NODE_FIELD, int *flag* = 0) [inherited]

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • NODE_FIELD, DOFs are supported by nodes [Default] • ELEMENT_FIELD, DOFs are supported by elements • SIDE_FIELD, DOFs are supported by sides
in	*flag*	Option to set: • = 0, All DOFs are taken into account [Default] • != 0, Only DOF number dof is handled in the system The resulting local vector can be accessed by attribute ePrev.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > ∗ *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > ∗ *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & v) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * A) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

`in`	*el*	Reference to Element instance
`in`	*x*	Global vector to multiply by (Vect instance)
`out`	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

`in`	*sd*	Reference to Side instance
`in`	*x*	Global vector to multiply by (Vect instance)
`out`	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

`in`	*exp*	Algebraic expression
`in`	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = *IDENT_PREC*) `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > ∗ *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

7.53.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

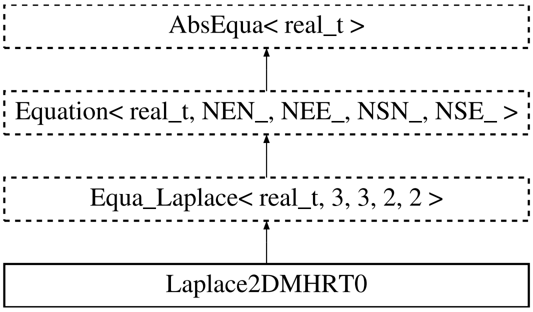
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.54 Laplace2DMHRT0 Class Reference

To build element equation for the 2-D elliptic equation using the Mixed Hybrid finite element at lowest degree (Raviart-Thomas $\mathtt{RT}_0$).

Inheritance diagram for Laplace2DMHRT0:



Public Member Functions

- Laplace2DMHRT0 ()

  Default Constructor.
- Laplace2DMHRT0 (Mesh &ms, SpMatrix< real_t > &A, Vect< real_t > &b)

  Constructor with problem data.
- ~Laplace2DMHRT0 ()

  Destructor.
- void setDiffusivity (const LocalMatrix< real_t, 2, 2 > &K)

  Define Diffusivity (or permeability) matrix.
- void build ()

  Build global matrix and right-hand side.
- void Post (const Vect< real_t > &lambda, const Vect< real_t > &f, Vect< real_t > &v, Vect< Point< real_t > > &p, Vect< real_t > &u)

  Perform post calculations.
- int solve (Vect< real_t > &u)

  Solve the linear system of equations using the Conjugate Gradient iterative method.
- void build (EigenProblemSolver &e)

  Build the linear system for an eigenvalue problem.
- virtual void buildEigen (int opt=0)

  Build matrices for an eigenvalue problem.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

Localize Element Vector from a Vect instance.

- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > ∗A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > ∗A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > ∗A)

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

- void DGElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > *A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Init (const Element ∗el)

  Set element arrays to zero.
- void Init (const Side ∗sd)

  Set side arrays to zero.

7.54.1 Detailed Description

To build element equation for the 2-D elliptic equation using the Mixed Hybrid finite element at lowest degree (Raviart-Thomas $\mathtt{RT}_0$).

7.54.2 Constructor & Destructor Documentation

Laplace2DMHRT0 ( )

Default Constructor.
Constructs an empty equation.

Laplace2DMHRT0 (Mesh & *ms*, SpMatrix< real_t > & *A*, Vect< real_t > & *b*)

Constructor with problem data.

Parameters

in	*ms*	Mesh instance
in	*A*	Problem matrix in Sparse format. This matrix must be zeroed before calling the constructor
in	*b*	Problem right-hand side

7.54.3 Member Function Documentation

void setDiffusivity (const LocalMatrix< real_t, 2, 2 > & *K*)

Define Diffusivity (or permeability) matrix.
By default (if this function is not called) the identity matrix (Laplace equation) is used.

Parameters

in	*K*	Diffusivity matrix as **LocalMatrix** instance. Must be symmetric positive definite

void build ( ) `[virtual]`

Build global matrix and right-hand side.

The problem matrix and right-hand side are the ones used in the constructor. They are updated in this member function.

Reimplemented from Equa_Laplace< real_t, 3, 3, 2, 2 >.

void Post (const Vect< real_t > & *lambda*, const Vect< real_t > & *f*, Vect< real_t > & *v*, Vect< Point< real_t > > & *p*, Vect< real_t > & *u*)

Perform post calculations.

Parameters

in	*lambda*	Solution (Lagrange multiplier) calculated at edges
in	*f*	Vect instance containing the right-hand side of the Laplace equation
in	*v*	Vect instance containing solution at mesh nodes
in	*p*	Vect instance containing gradient at elements
in	*u*	Vect instance containing solution at elements

int solve (Vect< real_t > & *u*)

Solve the linear system of equations using the Conjugate Gradient iterative method.
The matrix is preconditioned by an ILU method.

Parameters

out	*u*	Vector containing the solution at all sides (Sides where boundary conditions are prescribed are included).

Returns

Number of performed iterations in the CG method. Note that the maximal number is `1000` and the tolerance is `1.e-8`

void build (EigenProblemSolver & *e*) `[inherited]`

Build the linear system for an eigenvalue problem.

Parameters

in	*e*	Reference to used EigenProblemSolver instance

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

`in`	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = `NODE_DOF`, int *dof* = `0`) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

`in`	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
`in`	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.
`in`	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * A) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & A) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & b) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & A) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & v) `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & A) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & b) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * *A*) [inherited]

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) [inherited]

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) [inherited]

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) [inherited]

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration ***ls*****, Preconditioner** ***pc*** **=** *`IDENT_PREC`* **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > ∗ *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

in	A	Pointer to matrix of the system (Instance of class SpMatrix)
in	b	Vector containing right-hand side
in,out	x	Vector containing initial guess of solution on input, actual solution on output

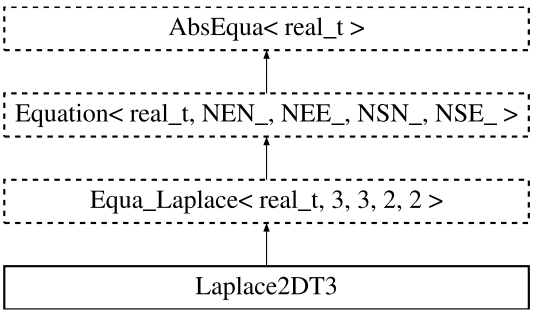
7.54.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

LocalVect instance containing local vector associated to current element.
This vector has been stored as the one at previous iteration or previous time step

7.55 Laplace2DT3 Class Reference

To build element equation for the Laplace equation using the 2-D triangle element ($\mathtt{P}_1$).
Inheritance diagram for Laplace2DT3:



Public Member Functions

- Laplace2DT3 (Mesh &ms)

  Constructor with mesh.
- Laplace2DT3 (Mesh &ms, SpMatrix< real_t > &A, Vect< real_t > &b)

  Constructor with problem data.
- Laplace2DT3 (Mesh &ms, Vect< real_t > &b)

  Constructor using mesh and solution vector.
- Laplace2DT3 (Element ∗el)

  Constructor for an element.
- Laplace2DT3 (Side ∗sd)

  Constructor for a side.
- ∼Laplace2DT3 ()

  Destructor.
- void LHS (real_t coef=1.)

Add finite element matrix to left-hand side.
- void BodyRHS (const Vect< real_t > &f)

  Add body source term to right-hand side.
- void BoundaryRHS (const Vect< real_t > &h)

  Add boundary source term to right-hand side.
- void setSource (const Vect< real_t > &f)

  Define Source right-hand side of the equation.
- void build ()

  Build global matrix and right-hand side.
- void buildEigen (int opt=0)

  Build global stiffness and mass matrices for the eigen system.
- void Post (const Vect< real_t > &u, Vect< Point< real_t > > &p)

  Perform post calculations.
- int solve (Vect< real_t > &u)

  Solve the linear system of equations using the Conjugate Gradient iterative method.
- void Axb (const Vect< real_t > &x, Vect< real_t > &b)

  Compute the product of the stiffness matrix by a given vector.
- void build (EigenProblemSolver &e)

  Build the linear system for an eigenvalue problem.
- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > *A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

Return number of element equations.

- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)

- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.

- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.

- Mesh & getMesh () const

  Return reference to Mesh instance.

- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.

- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.

- int SolveLinearSystem (Matrix< real_t > *A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.

- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.

- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.

- LocalVect< real_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.

- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.

- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Init (const Element *el)

  Set element arrays to zero.

- void Init (const Side *sd)

  Set side arrays to zero.

7.55.1 Detailed Description

To build element equation for the Laplace equation using the 2-D triangle element (P_1).

7.55.2 Constructor & Destructor Documentation

Laplace2DT3 (Mesh & *ms*)

Constructor with mesh.

Parameters

in	*ms*	Mesh instance

Laplace2DT3 (Mesh & *ms*, SpMatrix< real_t > & *A*, Vect< real_t > & *b*)

Constructor with problem data.

Parameters

in	*ms*	Mesh instance
in	*A*	Problem matrix in Sparse format. This matrix must be zeroed before calling the constructor
in	*b*	Problem right-hand side

Laplace2DT3 (Mesh & *ms*, Vect< real_t > & *b*)

Constructor using mesh and solution vector.

Parameters

in	*ms*	Mesh instance
in	*b*	Problem right-hand side

7.55.3 Member Function Documentation

void LHS (real_t *coef* = `1.`)

Add finite element matrix to left-hand side.

Parameters

in	*coef*	Value to multiply by the added matrix

void BodyRHS (const Vect< real_t > & *f*)

Add body source term to right-hand side.

Parameters

in	*f*	Vector containing the source given function at mesh nodes

void BoundaryRHS (const Vect< real_t > & *h*)

Add boundary source term to right-hand side.

Parameters

in	*h*	Vector containing the source given function at mesh nodes

void setSource (const Vect< real_t > & *f*)

Define Source right-hand side of the equation.

Parameters

f	[in] Vector containing source values at nodes

void build ( ) `[virtual]`

Build global matrix and right-hand side.

The problem matrix and right-hand side are the ones used in the constructor. They are updated in this member function.

Reimplemented from Equa_Laplace< real_t, 3, 3, 2, 2 >.

void buildEigen (int *opt* = *0*) `[virtual]`

Build global stiffness and mass matrices for the eigen system.

Parameters

in	*opt*	Flag to choose a lumed mass matrix (0) or consistent (1) [Default: 0]

Reimplemented from Equa_Laplace< real_t, 3, 3, 2, 2 >.

void Post (const Vect< real_t > & *u*, Vect< Point< real_t > > & *p*)

Perform post calculations.

Parameters

in	*u*	Solution at nodes
out	*p*	Vector containing gradient at elements

int solve (Vect< real_t > & *u*)

Solve the linear system of equations using the Conjugate Gradient iterative method.

The matrix is preconditioned by an ILU method.

Parameters

in	*u*	Vector containing the solution at all sides (Sides where boundary conditions are prescribed are included).

Returns

Number of performed iterations in the CG method. Note that the maximal number is `1000` and the tolerance is `1.e-8`

void Axb (const Vect< real_t > & *x*, Vect< real_t > & *b*)

Compute the product of the stiffness matrix by a given vector.

Parameters

in	*x*	Vector by which the matrix is multiplied
in	*b*	Product vector

void build (EigenProblemSolver & *e*) `[inherited]`

Build the linear system for an eigenvalue problem.

Parameters

in	*e*	Reference to used EigenProblemSolver instance

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

`in`	*b*	Global vector to be localized
`in`	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
`in`	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > ∗ *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & A) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	A	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & v) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * A) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) [inherited]

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) [inherited]

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) [inherited]

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) [inherited]

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

`in`	*el*	Reference to Element instance
`in`	*x*	Global vector to multiply by (Vect instance)
`out`	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

`in`	*sd*	Reference to Side instance
`in`	*x*	Global vector to multiply by (Vect instance)
`out`	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

`in`	*exp*	Algebraic expression
`in`	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = `IDENT_PREC` **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > * *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

in	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess of solution on input, actual solution on output

7.55.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

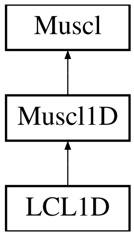
LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.56 LCL1D Class Reference

Class to solve the linear conservation law (Hyperbolic equation) in 1-D by a MUSCL Finite Volume scheme.

Inheritance diagram for LCL1D:



Public Types

Public Member Functions

- LCL1D (Mesh &m)

  Constructor using mesh instance.
- LCL1D (Mesh &m, Vect< real_t > &U)

  Constructor.
- ~LCL1D ()

  Destructor.
- Vect< real_t > & getFlux ()

  Return sidewise fluxes.
- void setInitialCondition (Vect< real_t > &u)

  Assign initial condition by a vector.
- void setInitialCondition (real_t u)

  Assign a constant initial condition.
- void setReconstruction ()

  Run MUSCL reconstruction.
- real_t runOneTimeStep ()

  Run one time step of the linear conservation law.
- void setBC (real_t u)

  Set Dirichlet boundary condition.
- void setBC (const Side &sd, real_t u)

  Set Dirichlet boundary condition.
- void setBC (int code, real_t u)

  Set Dirichlet boundary condition.
- void setVelocity (Vect< real_t > &v)

  Set convection velocity.
- void setVelocity (real_t v)

  Set (constant) convection velocity.
- void setReferenceLength (real_t dx)

  Assign reference length value.
- real_t getReferenceLength () const

  Return reference length.

- void Forward (const Vect< real_t > &Flux, Vect< real_t > &Field)

  Computation of the primal variable n->n+1.
- real_t getMeanLength () const

  Return mean length.
- real_t getMaximumLength () const

  Return maximal length.
- real_t getMinimumLength () const

  Return mimal length.
- real_t getTauLim () const

  Return mean length.
- void print_mesh_stat ()

  Output mesh information.
- void setTimeStep (real_t dt)

  Assign time step value.
- real_t getTimeStep () const

  Return time step value.
- void setCFL (real_t CFL)

  Assign CFL value.
- real_t getCFL () const

  Return CFL value.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- void setVerbose (int v)

  Set verbosity parameter.
- bool setReconstruction (const Vect< real_t > &U, Vect< real_t > &LU, Vect< real_t > &RU, size_t dof)

  Function to reconstruct by the Muscl method.
- void setMethod (const Method &s)

  Choose a flux solver.
- void setSolidZoneCode (int c)

  Choose a code for solid zone.
- bool getSolidZone () const

  Return flag for presence of solid zones.
- int getSolidZoneCode () const

  Return code of solid zone, 0 if this one is not present.
- void setLimiter (Limiter l)

  Choose a flux limiter.

7.56.1 Detailed Description

Class to solve the linear conservation law (Hyperbolic equation) in 1-D by a MUSCL Finite Volume scheme.

7.56.2 Member Enumeration Documentation

enum Method `[inherited]`

Enumeration for flux choice.

Enumerator

- ***FIRST_ORDER_METHOD*** First Order upwind method
- ***MULTI_SLOPE_Q_METHOD*** Multislope Q method
- ***MULTI_SLOPE_M_METHOD*** Multislope M method

enum Limiter `[inherited]`

Enumeration of flux limiting methods.

Enumerator

- ***MINMOD_LIMITER*** MinMod limiter
- ***VANLEER_LIMITER*** Van Leer limiter
- ***SUPERBEE_LIMITER*** Superbee limiter
- ***VANALBADA_LIMITER*** Van Albada limiter
- ***MAX_LIMITER*** Max limiter

enum SolverType `[inherited]`

Enumeration of various solvers for the Riemann problem.

Enumerator

- ***ROE_SOLVER*** Roe solver
- ***VFROE_SOLVER*** Finite Volume Roe solver
- ***LF_SOLVER*** LF solver
- ***RUSANOV_SOLVER*** Rusanov solver
- ***HLL_SOLVER*** HLL solver
- ***HLLC_SOLVER*** HLLC solver
- ***MAX_SOLVER*** Max solver

7.56.3 Member Function Documentation

void setInitialCondition (Vect< real_t > & *u*)

Assign initial condition by a vector.

Parameters

in	*u*	Vector containing initial condition

void setInitialCondition (real_t *u*)

Assign a constant initial condition.

Parameters

in	*u*	Constant value for the initial condition

real_t runOneTimeStep ( )

Run one time step of the linear conservation law.

Returns

Value of the time step

void setBC (real_t *u*)

Set Dirichlet boundary condition.
Assign a constant value u to all boundary sides

void setBC (const Side & *sd*, real_t *u*)

Set Dirichlet boundary condition.
Assign a constant value to a side

Parameters

in	*sd*	Side to which value is prescibed
in	*u*	Value to prescribe

void setBC (int *code*, real_t *u*)

Set Dirichlet boundary condition.
Assign a constant value sides with a given code

Parameters

in	*code*	Code of sides to which value is prescibed
in	*u*	Value to prescribe

void setVelocity (Vect< real_t > & *v*)

Set convection velocity.

Parameters

in	*v*	Vect instance containing velocity

void Forward (const Vect< real_t > & *Flux*, Vect< real_t > & *Field*)

Computation of the primal variable n->n+1.

Vector **Flux** contains elementwise fluxes issued from the Riemann problem, calculated with, as left element, **getNeighborElement(1)** and right element **getNeighborElement(2)** if **getNeighbor↩ Element(2)** doesn't exist, we are on a boundary and we prescribe a symmetry condition

void setTimeStep (real_t *dt*) `[inherited]`

Assign time step value.

Parameters

in	*dt*	Time step value

void setCFL (real_t *CFL*) `[inherited]`

Assign CFL value.

Parameters

in	*CFL*	Value of CFL

void setVerbose (int *v*) `[inherited]`

Set verbosity parameter.

Parameters

in	*v*	Value of verbosity parameter

bool setReconstruction (const Vect< real_t > & *U*, Vect< real_t > & *LU*, Vect< real_t > & *RU*, size_t *dof*) `[inherited]`

Function to reconstruct by the Muscl method.

Parameters

in	*U*	Field to reconstruct
out	*LU*	Left gradient vector
out	*RU*	Right gradient vector
in	*dof*	Label of dof to reconstruct

void setMethod (const Method & *s*) `[inherited]`

Choose a flux solver.

Parameters

in	*s*	Solver to choose

void setLimiter (Limiter *l*) `[inherited]`

Choose a flux limiter.

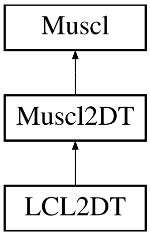
Parameters

in	*l*	Limiter to choose

7.57 LCL2DT Class Reference

Class to solve the linear hyperbolic equation in 2-D by a MUSCL Finite Volume scheme on triangles.

Inheritance diagram for LCL2DT:



Public Types

Public Member Functions

- LCL2DT (Mesh &m)

  Constructor using Mesh instance.
- LCL2DT (Mesh &m, Vect< real_t > &U)

  Constructor using mesh and initial data.
- ~LCL2DT ()

  Destructor.
- Vect< real_t > & getFlux ()

  Return sidewise flux vector.
- void setInitialCondition (Vect< real_t > &u)

  Set elementwise initial condition.
- void setInitialCondition (real_t u)

  Set a constant initial condition.
- void setReconstruction ()

  Reconstruct flux using Muscl scheme.
- real_t runOneTimeStep ()

  Run one time step of the linear conservation law.
- void setBC (real_t u)

  Set Dirichlet boundary condition.
- void setBC (const Side &sd, real_t u)

  Set Dirichlet boundary condition.
- void setBC (int code, real_t u)

  Set Dirichlet boundary condition.

- void setVelocity (const Vect< real_t > &v)

  Set convection velocity.
- void setVelocity (const LocalVect< real_t, 2 > &v)

  Set (constant) convection velocity.
- void Forward (const Vect< real_t > &Flux, Vect< real_t > &Field)

  Computation of the primal variable n->n+1.
- bool setReconstruction (const Vect< real_t > &U, Vect< real_t > &LU, Vect< real_t > &RU, size_t dof)

  Function to reconstruct by the Muscl method.
- void setTimeStep (real_t dt)

  Assign time step value.
- real_t getTimeStep () const

  Return time step value.
- void setCFL (real_t CFL)

  Assign CFL value.
- real_t getCFL () const

  Return CFL value.
- void setReferenceLength (real_t dx)

  Assign reference length value.
- real_t getReferenceLength () const

  Return reference length.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- void setVerbose (int v)

  Set verbosity parameter.
- void setMethod (const Method &s)

  Choose a flux solver.
- void setSolidZoneCode (int c)

  Choose a code for solid zone.
- bool getSolidZone () const

  Return flag for presence of solid zones.
- int getSolidZoneCode () const

  Return code of solid zone, 0 if this one is not present.
- void setLimiter (Limiter l)

  Choose a flux limiter.

Protected Member Functions

- void Initialize ()

  Construction of normals to sides.

7.57.1 Detailed Description

Class to solve the linear hyperbolic equation in 2-D by a MUSCL Finite Volume scheme on triangles.

7.57.2 Member Enumeration Documentation

enum Method `[inherited]`

Enumeration for flux choice.

Enumerator

- ***FIRST_ORDER_METHOD*** First Order upwind method
- ***MULTI_SLOPE_Q_METHOD*** Multislope Q method
- ***MULTI_SLOPE_M_METHOD*** Multislope M method

enum Limiter `[inherited]`

Enumeration of flux limiting methods.

Enumerator

- ***MINMOD_LIMITER*** MinMod limiter
- ***VANLEER_LIMITER*** Van Leer limiter
- ***SUPERBEE_LIMITER*** Superbee limiter
- ***VANALBADA_LIMITER*** Van Albada limiter
- ***MAX_LIMITER*** Max limiter

enum SolverType `[inherited]`

Enumeration of various solvers for the Riemann problem.

Enumerator

- ***ROE_SOLVER*** Roe solver
- ***VFROE_SOLVER*** Finite Volume Roe solver
- ***LF_SOLVER*** LF solver
- ***RUSANOV_SOLVER*** Rusanov solver
- ***HLL_SOLVER*** HLL solver
- ***HLLC_SOLVER*** HLLC solver
- ***MAX_SOLVER*** Max solver

7.57.3 Constructor & Destructor Documentation

LCL2DT (Mesh & *m*, Vect< real_t > & *U*)

Constructor using mesh and initial data.

Parameters

in	*m*	Reference to Mesh instance
in	*U*	Vector containing initial (elementwise) solution

7.57.4 Member Function Documentation

void setInitialCondition (Vect< real_t > & *u*)

Set elementwise initial condition.

Parameters

in	*u*	Vect instance containing initial condition values

void setInitialCondition (real_t *u*)

Set a constant initial condition.

Parameters

in	*u*	Value of initial condition to assign to all elements

real_t runOneTimeStep ( )

Run one time step of the linear conservation law.

Returns

Value of the time step

void setBC (real_t *u*)

Set Dirichlet boundary condition.
Assign a constant value `u` to all boundary sides

void setBC (const Side & *sd*, real_t *u*)

Set Dirichlet boundary condition.
Assign a constant value to a side

Parameters

in	*sd*	Side to which value is prescibed
in	*u*	Value to prescribe

void setBC (int *code*, real_t *u*)

Set Dirichlet boundary condition.
Assign a constant value sides with a given code

Parameters

in	*code*	Code of sides to which value is prescibed
in	*u*	Value to prescribe

void setVelocity (const Vect< real_t > & *v*)

Set convection velocity.

Parameters

in	*v*	Vect instance containing velocity

void setVelocity (const LocalVect< real_t, 2 > & *v*)

Set (constant) convection velocity.

Parameters

in	*v*	Vector containing constant velocity to prescribe

void Forward (const Vect< real_t > & *Flux*, Vect< real_t > & *Field*)

Computation of the primal variable n->n+1.

Vector *Flux* contains elementwise fluxes issued from the Riemann problem, calculated with, as left element, **getNeighborElement(1)** and right element **getNeighborElement(2)** if **getNeighbor←Element(2)** doesn't exist, we are on a boundary and we prescribe a symmetry condition

bool setReconstruction (const Vect< real_t > & *U*, Vect< real_t > & *LU*, Vect< real_t > & *RU*, size_t *dof*) `[inherited]`

Function to reconstruct by the Muscl method.

Parameters

in	*U*	Field to reconstruct
out	*LU*	Left gradient vector
out	*RU*	Right gradient vector
in	*dof*	Label of dof to reconstruct

void Initialize ( ) `[protected]`, `[inherited]`

Construction of normals to sides.

Convention: for a given side, getPtrElement(1) is the left element and getPtrElement(2) is the right element. The normal goes from left to right. For boundary sides, the normal points outward.

void setTimeStep (real_t *dt*) `[inherited]`

Assign time step value.

Parameters

in	*dt*	Time step value

void setCFL (real_t *CFL*) `[inherited]`

Assign CFL value.

Parameters

`in`	*CFL*	Value of CFL

void setReferenceLength (real_t *dx*) `[inherited]`

Assign reference length value.

Parameters

`in`	*dx*	Value of reference length

void setVerbose (int *v*) `[inherited]`

Set verbosity parameter.

Parameters

`in`	*v*	Value of verbosity parameter

void setMethod (const Method & *s*) `[inherited]`

Choose a flux solver.

Parameters

`in`	*s*	Solver to choose

void setLimiter (Limiter *l*) `[inherited]`

Choose a flux limiter.

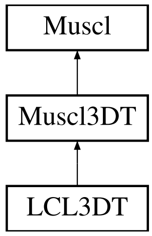
Parameters

`in`	*l*	Limiter to choose

7.58 LCL3DT Class Reference

Class to solve the linear conservation law equation in 3-D by a MUSCL Finite Volume scheme on tetrahedra.

Inheritance diagram for LCL3DT:



Public Types

Public Member Functions

- LCL3DT (Mesh &m)

  Constructor using mesh.
- LCL3DT (Mesh &m, Vect< real_t > &U)

  Constructor using mesh and initial field.
- ∼LCL3DT ()

  Destructor.
- void setInitialCondition (Vect< real_t > &u)

  Set elementwise initial condition.
- void setInitialCondition (real_t u)

  Set a constant initial condition.
- void setReconstruction ()

  Reconstruct flux using Muscl scheme.
- real_t runOneTimeStep ()

  Run one time step.
- void setBC (real_t u)

  Set Dirichlet boundary condition. Assign a constant value `u` *to all boundary sides.*
- void setBC (const Side &sd, real_t u)

  Set Dirichlet boundary condition.
- void setBC (int code, real_t u)

  Set Dirichlet boundary condition.
- void setVelocity (const Vect< real_t > &v)

  Set convection velocity.
- void setVelocity (const LocalVect< real_t, 3 > &v)

  Set (constant) convection velocity.
- void setReferenceLength (real_t dx)

  Assign reference length value.
- real_t getReferenceLength () const

  Return reference length.
- void Forward (const Vect< real_t > &Flux, Vect< real_t > &Field)

  Computation of the primal variable n->n+1.
- bool setReconstruction (const Vect< real_t > &U, Vect< real_t > &LU, Vect< real_t > &RU, size_t dof)

  Function to reconstruct by the Muscl method.
- real_t getMinimumFaceArea () const

  Return minimum area of faces in the mesh.

- real_t getMinimumElementVolume () const

  Return minimum volume of elements in the mesh.
- real_t getMaximumFaceArea () const

  Return maximum area of faces in the mesh.
- real_t getMaximumElementVolume () const

  Return maximum volume of elements in the mesh.
- real_t getMeanFaceArea () const

  Return mean area of faces in the mesh.
- real_t getMeanElementVolume () const

  Return mean volume of elements in the mesh.
- real_t getMinimumEdgeLength () const

  Return minimum length of edges in the mesh.
- real_t getMinimumVolumebyArea () const

  Return minimum volume by area in the mesh.
- real_t getMaximumEdgeLength () const

  Return maximum length of edges in the mesh.
- real_t getTauLim () const

  Return value of tau lim.
- real_t getComega () const

  Return value of Comega.
- void setbetalim (real_t bl)

  Assign value of beta lim.
- void setTimeStep (real_t dt)

  Assign time step value.
- real_t getTimeStep () const

  Return time step value.
- void setCFL (real_t CFL)

  Assign CFL value.
- real_t getCFL () const

  Return CFL value.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- void setVerbose (int v)

  Set verbosity parameter.
- void setMethod (const Method &s)

  Choose a flux solver.
- void setSolidZoneCode (int c)

  Choose a code for solid zone.
- bool getSolidZone () const

  Return flag for presence of solid zones.
- int getSolidZoneCode () const

  Return code of solid zone, 0 if this one is not present.
- void setLimiter (Limiter l)

  Choose a flux limiter.

7.58.1 Detailed Description

Class to solve the linear conservation law equation in 3-D by a MUSCL Finite Volume scheme on tetrahedra.

7.58.2 Member Enumeration Documentation

enum Method `[inherited]`

Enumeration for flux choice.

Enumerator

FIRST_ORDER_METHOD First Order upwind method

MULTI_SLOPE_Q_METHOD Multislope Q method

MULTI_SLOPE_M_METHOD Multislope M method

enum Limiter `[inherited]`

Enumeration of flux limiting methods.

Enumerator

MINMOD_LIMITER MinMod limiter

VANLEER_LIMITER Van Leer limiter

SUPERBEE_LIMITER Superbee limiter

VANALBADA_LIMITER Van Albada limiter

MAX_LIMITER Max limiter

enum SolverType `[inherited]`

Enumeration of various solvers for the Riemann problem.

Enumerator

ROE_SOLVER Roe solver

VFROE_SOLVER Finite Volume Roe solver

LF_SOLVER LF solver

RUSANOV_SOLVER Rusanov solver

HLL_SOLVER HLL solver

HLLC_SOLVER HLLC solver

MAX_SOLVER Max solver

7.58.3 Constructor & Destructor Documentation

LCL3DT (Mesh & *m*, Vect< real_t > & *U*)

Constructor using mesh and initial field.

Parameters

in	*m*	Reference to Mesh instance
in	*U*	Vector containing initial (elementwise) solution

7.58.4 Member Function Documentation

void setInitialCondition (Vect< real_t > & *u*)

Set elementwise initial condition.

Parameters

in	*u*	Vect instance containing initial condition values

void setInitialCondition (real_t *u*)

Set a constant initial condition.

Parameters

in	*u*	Value of initial condition to assign to all elements

void setBC (const Side & *sd*, real_t *u*)

Set Dirichlet boundary condition.
Assign a constant value to a side

Parameters

in	*sd*	Side to which value is prescibed
in	*u*	Value to prescribe

void setBC (int *code*, real_t *u*)

Set Dirichlet boundary condition.
Assign a constant value sides with a given code

Parameters

in	*code*	Code of sides to which value is prescibed
in	*u*	Value to prescribe

void setVelocity (const Vect< real_t > & *v*)

Set convection velocity.

Parameters

in	*v*	Vect instance containing velocity

void setVelocity (const LocalVect< real_t, 3 > & *v*)

Set (constant) convection velocity.

Parameters

in	*v*	Vector containing constant velocity to prescribe

void Forward (const Vect< real_t > & *Flux*, Vect< real_t > & *Field*)

Computation of the primal variable n->n+1.

Vector `Flux` contains elementwise fluxes issued from the Riemann problem, calculated with, as left element, **getNeighborElement(1)** and right element **getNeighborElement(2)** if **getNeighbor↩ Element(2)** doesn't exist, we are on a boundary and we prescribe a symmetry condition

bool setReconstruction (const Vect< real_t > & *U*, Vect< real_t > & *LU*, Vect< real_t > & *RU*, size_t *dof*) `[inherited]`

Function to reconstruct by the Muscl method.

Parameters

in	*U*	Field to reconstruct
out	*LU*	Left gradient vector
out	*RU*	Right gradient vector
in	*dof*	Label of dof to reconstruct

void setTimeStep (real_t *dt*) `[inherited]`

Assign time step value.

Parameters

in	*dt*	Time step value

void setCFL (real_t *CFL*) `[inherited]`

Assign CFL value.

Parameters

in	*CFL*	Value of CFL

void setVerbose (int *v*) `[inherited]`

Set verbosity parameter.

Parameters

in	*v*	Value of verbosity parameter

void setMethod (const Method & *s*) [inherited]

Choose a flux solver.

Parameters

in	*s*	Solver to choose

void setLimiter (Limiter *l*) [inherited]

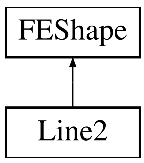
Choose a flux limiter.

Parameters

in	*l*	Limiter to choose

7.59 Line2 Class Reference

To describe a 2-Node planar line finite element.
Inheritance diagram for Line2:



Public Member Functions

- Line2 ()
  Default Constructor.
- Line2 (const Element ∗el)
  Constructor for an element.
- Line2 (const Side ∗side)
  Constructor for a side.
- Line2 (const Edge ∗edge)
  Constructor for an edge.
- ∼Line2 ()
  Destructor.
- real_t getLength () const
  Return element length.
- Point< real_t > getNormal () const

Return unit normal vector to line.
- Point< real_t > getTangent () const

  Return unit tangent vector to line.
- real_t Sh (size_t i, real_t s) const

  Calculate shape function of a given node at a given point.
- real_t DSh (size_t i) const

  Calculate partial derivative of shape function of a node.
- Point< real_t > getRefCoord (const Point< real_t > &x)

  Return reference coordinates of a point x in element.
- bool isIn (const Point< real_t > &x)

  Check whether point x is in current line element or not.
- real_t getInterpolate (const Point< real_t > &x, const LocalVect< real_t, 2 > &v)

  Return interpolated value at a given point.
- real_t Sh (size_t i) const

  Return shape function of node i at given point.
- real_t Sh (size_t i, Point< real_t > s) const

  Calculate shape function of node i at a given point s.
- real_t getDet () const

  Return determinant of jacobian.
- Point< real_t > getCenter () const

  Return coordinates of center of element.
- Point< real_t > getLocalPoint () const

  Localize a point in the element.
- Point< real_t > getLocalPoint (const Point< real_t > &s) const

  Localize a point in the element.

7.59.1 Detailed Description

To describe a 2-Node planar line finite element.

Defines geometric quantities associated to 2-node linear segment element `P1` in the space. The reference element is the segment `[-1,1]`. Note that the line length is not checked unless the function check is called.

7.59.2 Constructor & Destructor Documentation

Line2 (const Element * *el*)

Constructor for an element.

Parameters

in	*el*	Pointer to element

Line2 (const Side * *side*)

Constructor for a side.

Parameters

in	*side*	Pointer to side

Line2 (const Edge * *edge*)

Constructor for an edge.

Parameters

in	*edge*	Pointer to edge

7.59.3 Member Function Documentation

real_t Sh (size_t *i*, real_t *s*) const

Calculate shape function of a given node at a given point.

Parameters

in	*i*	Node number (1 or 2).
in	*s*	Localization of point in natural coordinates (must be between `-1` and `1`).

real_t DSh (size_t *i*) const

Calculate partial derivative of shape function of a node.

Parameters

in	*i*	Node number (1 or 2).

Point<real_t> getRefCoord (const Point< real_t > & *x*)

Return reference coordinates of a point `x` in element.
Only the x-coordinate of the returned value has a meaning

real_t getInterpolate (const Point< real_t > & *x*, const LocalVect< real_t, 2 > & *v*)

Return interpolated value at a given point.

Parameters

in	*x*	Point where interpolation is evaluated (in the reference element).
out	*v*	Computed value.

real_t Sh (size_t *i*, Point< real_t > *s*) const `[inherited]`

Calculate shape function of node `i` at a given point `s`.

Parameters

in	*i*	Local node label

Parameters

in	*s*	Point in the reference triangle where the shape function is evaluated

real_t getDet ( ) const [inherited]

Return determinant of jacobian.

If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<**real_t**> **getLocalPoint ( ) const** [inherited]

Localize a point in the element.

Return actual coordinates in the reference element. If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<**real_t**> **getLocalPoint (const Point**< **real_t** > **&** *s* **) const** [inherited]

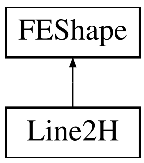
Localize a point in the element.

Return actual coordinates where s are coordinates in the reference element.

7.60 Line2H Class Reference

To describe a 2-Node Hermite planar line finite element.

Inheritance diagram for Line2H:



Public Member Functions

- Line2H ()

  Default Constructor.
- Line2H (const Element ∗el)

  Constructor for an element.
- Line2H (const Side ∗side)

  Constructor for a side.
- ∼Line2H ()

  Destructor.
- Point< real_t > getLocalPoint (real_t s) const

  Localize a point in the element.
- real_t Sh (size_t i, real_t s) const

  Return shape function value of node `i` *at given point* `s`
- real_t DSh (size_t i, real_t s) const

  Return first derivative (along the abscissa) of shape function of node `i` *at a given point.*

- real_t D2Sh (size_t i, real_t s) const

  Return second derivatives (along the abscissa) of shape function of node `i`
- real_t getDet () const

  Return determinant of jacobian.
- real_t getLength ()

  Return element length.
- real_t check () const

  Check line length and number of line nodes.
- real_t Sh (size_t i) const

  Return shape function of node `i` *at given point.*
- real_t Sh (size_t i, Point< real_t > s) const

  Calculate shape function of node `i` *at a given point* `s`*.*
- Point< real_t > DSh (size_t i) const

  Return derivatives of shape function of node `i` *at a given point.*
- Point< real_t > getCenter () const

  Return coordinates of center of element.
- Point< real_t > getLocalPoint () const

  Localize a point in the element.
- Point< real_t > getLocalPoint (const Point< real_t > &s) const

  Localize a point in the element.

7.60.1 Detailed Description

To describe a 2-Node Hermite planar line finite element.

Defines geometric quantities associated to 2-node segment element in the space using Hermite (C^1) interpolation. The interpolation functions are polynomials of degree `3`. The reference element is the segment `[-1,1]`. The unknowns are supported by extremities of the interval: each extremity supports two unknowns, the function and its line derivative.

7.60.2 Member Function Documentation

Point<real_t> getLocalPoint (real_t *s*) const

Localize a point in the element.

For a point `s` in the reference element, return coordinates in the real element.

real_t check ( ) const

Check line length and number of line nodes.

Returns

- > `0`: `m` is the length
- `= 0`: zero length (=> Error)

real_t Sh (size_t *i*, Point< real_t > *s*) const `[inherited]`

Calculate shape function of node `i` at a given point `s`.

Parameters

in	*i*	Local node label
in	*s*	Point in the reference triangle where the shape function is evaluated

Point<real_t> DSh (size_t *i*) const `[inherited]`

Return derivatives of shape function of node `i` at a given point.

If the transformation (Reference element -> Actual element) is not affine, member function `setLocal()` must have been called before in order to calcuate relevant quantities.

Parameters

in	*i*	Partial derivative index (1, 2 or 3)

Point<real_t> getLocalPoint ( ) const `[inherited]`

Localize a point in the element.

Return actual coordinates in the reference element. If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint (const Point< real_t > & *s*) const `[inherited]`

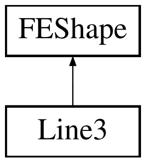
Localize a point in the element.

Return actual coordinates where `s` are coordinates in the reference element.

7.61 Line3 Class Reference

To describe a 3-Node quadratic planar line finite element.

Inheritance diagram for Line3:



Public Member Functions

- Line3 ()

  Default Constructor.
- Line3 (const Element ∗el)

  Constructor for an element.
- Line3 (const Side ∗sd)

  Constructor for a side.
- ∼Line3 ()

  Destructor.

- void setLocal (real_t s)

  Initialize local point coordinates in element.
- real_t DSh (size_t i) const

  Return derivatives of shape function of node i at a given point.
- Point< real_t > getLocalPoint () const

  Return actual coordinates of localized point.
- real_t Sh (size_t i) const

  Return shape function of node `i` at given point.
- real_t Sh (size_t i, Point< real_t > s) const

  Calculate shape function of node `i` at a given point `s`.
- real_t getDet () const

  Return determinant of jacobian.
- Point< real_t > getCenter () const

  Return coordinates of center of element.
- Point< real_t > getLocalPoint (const Point< real_t > &s) const

  Localize a point in the element.

7.61.1 Detailed Description

To describe a 3-Node quadratic planar line finite element.

Defines geometric quantities associated to 3-node quadratic element `P2` in the space. The reference element is the segment `[-1,1]`. The user must take care to the fact that determinant of jacobian and other quantities depend on the point in the reference element where they are calculated. For this, before any utilization of shape functions or jacobian, function **setLocal()** must be invoked.

Element nodes are ordered as the following: the left one, the central one and the right one.

7.61.2 Member Function Documentation

real_t Sh (size_t *i*, Point< real_t > *s*) const `[inherited]`

Calculate shape function of node `i` at a given point `s`.

Parameters

in	*i*	Local node label
in	*s*	Point in the reference triangle where the shape function is evaluated

real_t getDet ( ) const `[inherited]`

Return determinant of jacobian.

If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint (const Point< real_t > & *s*) const `[inherited]`

Localize a point in the element.

Return actual coordinates where `s` are coordinates in the reference element.

7.62 LinearSolver< T_ > Class Template Reference

Class to solve systems of linear equations by iterative methods.

Public Member Functions

- LinearSolver ()

  Default Constructor.
- LinearSolver (int max_it, real_t tolerance, int verbose)

  Constructor with iteration parameters.
- LinearSolver (SpMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x)

  Constructor using matrix, right-hand side and solution vector.
- LinearSolver (SkMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x)

  Constructor using skyline-stored matrix, right-hand side and solution vector.
- LinearSolver (TrMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x)

  Constructor using a tridiagonal matrix, right-hand side and solution vector.
- LinearSolver (BMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x)

  Constructor using a banded matrix, right-hand side and solution vector.
- LinearSolver (DMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x)

  Constructor using a dense matrix, right-hand side and solution vector.
- LinearSolver (DSMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x)

  Constructor using a dense symmetric matrix, right-hand side and solution vector.
- LinearSolver (SkSMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x)

  Constructor using skyline-stored symmetric matrix, right-hand side and solution vector.
- LinearSolver (SkMatrix< T_ > &A, Vect< T_ > &b, Vect< T_ > &x)

  Constructor using matrix, right-hand side.
- virtual ~LinearSolver ()

  Destructor.
- void setVerbose (int verb)

  Set message level.
- void setMaxIter (int m)

  Set Maximum number of iterations.
- void setTolerance (real_t tol)

  Set tolerance value.
- void setSolution (Vect< T_ > &x)

  Set solution vector.
- void setRHS (Vect< T_ > &b)

  Set right-hand side vector.
- void setMatrix (OFELI::Matrix< T_ > *A)

  Set matrix in the case of a pointer to Matrix.
- void setMatrix (SpMatrix< T_ > &A)

  Set matrix in the case of a pointer to matrix.
- void setMatrix (SkMatrix< T_ > &A)

  Set matrix in the case of a skyline matrix.
- void set (SpMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x)

  Set matrix, right-hand side and initial guess.
- void setSolver (Iteration s, Preconditioner p=DIAG_PREC)

Set solver and preconditioner.

- int getSolver () const

  Return solver code.

- int solve (SpMatrix< T_ > &A, const Vect< T_ > &b, Vect< T_ > &x, Iteration s, Preconditioner p=DIAG_PREC)

  Solve equations using system data, prescribed solver and preconditioner.

- int solve (Iteration s, Preconditioner p=DIAG_PREC)

  Solve equations using prescribed solver and preconditioner.

- int solve ()

  Solve equations all arguments must have given by other member functions.

- void setFact ()

  Factorize matrix.

- void setNoFact ()

  Do not factorize matrix.

7.62.1 Detailed Description

template<class T_>
class OFELI::LinearSolver< T_ >

Class to solve systems of linear equations by iterative methods.

7.62.2 Constructor & Destructor Documentation

LinearSolver ( )

Default Constructor.
Initializes default parameters and pointers to 0.

LinearSolver (int *max_it*, real_t *tolerance*, int *verbose*)

Constructor with iteration parameters.

Parameters

in	*max_it*	Maximal number of iterations
in	*tolerance*	Tolerance for convergence (measured in relative weighted 2-Norm) in input, effective discrepancy in output.
in	*verbose*	Information output parameter • `0`: No output • `1`: Output iteration information, • 2 and greater: Output iteration information and solution at each iteration.

LinearSolver (SpMatrix< T_ > & *A*, const Vect< T_ > & *b*, Vect< T_ > & *x*)

Constructor using matrix, right-hand side and solution vector.

Parameters

in	A	Reference to instance of class SpMatrix
in	b	Vect instance that contains the right-hand side
in,out	x	Vect instance that contains initial guess on input and solution on output

LinearSolver (SkMatrix< T_ > & A, const Vect< T_ > & b, Vect< T_ > & x)

Constructor using skyline-stored matrix, right-hand side and solution vector.

Parameters

in	A	SkMatrix instance that contains matrix
in	b	Vect instance that contains the right-hand side
in,out	x	Vect instance that contains initial guess on input and solution on output

LinearSolver (TrMatrix< T_ > & A, const Vect< T_ > & b, Vect< T_ > & x)

Constructor using a tridiagonal matrix, right-hand side and solution vector.

Parameters

in	A	TrMatrix instance that contains matrix
in	b	Vect instance that contains the right-hand side
in,out	x	Vect instance that contains initial guess on input and solution on output

LinearSolver (BMatrix< T_ > & A, const Vect< T_ > & b, Vect< T_ > & x)

Constructor using a banded matrix, right-hand side and solution vector.

Parameters

in	A	BMatrix instance that contains matrix
in	b	Vect instance that contains the right-hand side
in,out	x	Vect instance that contains initial guess on input and solution on output

LinearSolver (DMatrix< T_ > & A, const Vect< T_ > & b, Vect< T_ > & x)

Constructor using a dense matrix, right-hand side and solution vector.

Parameters

in	A	DMatrix instance that contains matrix
in	b	Vect instance that contains the right-hand side
in,out	x	Vect instance that contains initial guess on input and solution on output

LinearSolver (DSMatrix< T_ > & *A*, const Vect< T_ > & *b*, Vect< T_ > & *x*)

Constructor using a dense symmetric matrix, right-hand side and solution vector.

Parameters

in	*A*	DSMatrix instance that contains matrix
in	*b*	Vect instance that contains the right-hand side
in,out	*x*	Vect instance that contains initial guess on input and solution on output

LinearSolver (SkSMatrix< T_ > & *A*, const Vect< T_ > & *b*, Vect< T_ > & *x*)

Constructor using skyline-stored symmetric matrix, right-hand side and solution vector.

Parameters

in	*A*	SkMatrix instance that contains matrix
in	*b*	Vect instance that contains the right-hand side
in,out	*x*	Vect instance that contains initial guess on input and solution on output

LinearSolver (SkMatrix< T_ > & *A*, Vect< T_ > & *b*, Vect< T_ > & *x*)

Constructor using matrix, right-hand side.

Parameters

in	*A*	SkMatrix instance that contains matrix
in	*b*	Vect instance that contains the right-hand side
in,out	*x*	Vect instance that contains the initial guess on input and solution on output

7.62.3 Member Function Documentation

void setVerbose (int *verb*)

Set message level.
Default value is 0

void setMaxIter (int *m*)

Set Maximum number of iterations.
Default value is 1000

void setMatrix (OFELI::Matrix< T_ > * *A*)

Set matrix in the case of a pointer to Matrix.

Parameters

in	*A*	Pointer to abstract Matrix class

void setMatrix (SpMatrix< T_ > & *A*)

Set matrix in the case of a pointer to matrix.

Parameters

in	*A*	Pointer to abstract Matrix class

void setMatrix (SkMatrix< T_ > & *A*)

Set matrix in the case of a skyline matrix.

Parameters

in	*A*	Matrix as instance of class SkMatrix

void set (SpMatrix< T_ > & *A*, const Vect< T_ > & *b*, Vect< T_ > & *x*)

Set matrix, right-hand side and initial guess.

Parameters

in	*A*	Reference to matrix as a SpMatrix instance
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess on input and solution on output

void setSolver (Iteration *s*, Preconditioner *p* = DIAG_PREC)

Set solver and preconditioner.

Parameters

in	*s*	Solver identification parameter. To be chosen in the enumeration variable Iteration: `DIRECT_SOLVER`, `CG_SOLVER`, `CGS_SOLVER`, `BICG_SOLVER`, `BICG_STAB_SOLVER`, `GMRES_SOLVER`, `QMR_SOLVER`
in	*p*	Preconditioner identification parameter. By default, the diagonal preconditioner is used. To be chosen in the enumeration variable Preconditioner: `IDENT_PREC`, `DIAG_PREC`, `SSOR_PREC`, `ILU_PREC` [Default: `ILU_PREC`]

Note

The argument p has no effect if the solver is `DIRECT_SOLVER`

int solve (SpMatrix< T_ > & *A*, const Vect< T_ > & *b*, Vect< T_ > & *x*, Iteration *s*, Preconditioner *p* = DIAG_PREC)

Solve equations using system data, prescribed solver and preconditioner.

Parameters

in	*A*	Reference to matrix as a SpMatrix instance
in	*b*	Vector containing right-hand side
in,out	*x*	Vector containing initial guess on input and solution on output
in	*s*	Solver identification parameter To be chosen in the enumeration variable Iteration: `DIRECT_SOLVER`, `CG_SOLVER`, `CGS_SOLVER`, `BICG_SOLVER`, `BICG_STAB_SOLVER`, `GMRES_SOLVER`, `QMR_SOLVER` [Default: `CGS_SOLVER`]
in	*p*	Preconditioner identification parameter. To be chosen in the enumeration variable Preconditioner: `IDENT_PREC`, `DIAG_PREC`, `SSOR_PREC`, `ILU_PREC`, `DILU_PREC` [Default: `DIAG_PREC`]

Remarks

The argument p has no effect if the solver is `DIRECT_SOLVER`

Warning

If the library `eigen` is used, only the preconditioners `IDENT_PREC`, `DIAG_PREC` and `ILU_PREC` are available.

int solve ( )

Solve equations all arguments must have given by other member functions.

Solver and preconditioner parameters must have been set by function setSolver. Otherwise, default values are set.

7.63 LocalMatrix< T_, NR_, NC_ > Class Template Reference

Handles small size matrices like element matrices, with a priori known size.

Public Member Functions

- LocalMatrix ()

  Default constructor.
- LocalMatrix (const LocalMatrix< T_, NR_, NC_ > &m)

  Copy constructor.
- LocalMatrix (Element *el, const SpMatrix< T_ > &a)

  Constructor of a local matrix associated to element from a SpMatrix.
- LocalMatrix (Element *el, const SkMatrix< T_ > &a)

  Constructor of a local matrix associated to element from a SkMatrix.
- LocalMatrix (Element *el, const SkSMatrix< T_ > &a)

  Constructor of a local matrix associated to element from a SkSMatrix.
- ∼LocalMatrix ()

  Destructor.
- T_ & operator() (size_t i, size_t j)

  Operator () (Non constant version)

- T_ operator() (size_t i, size_t j) const

  Operator () (Constant version)
- void Localize (Element *el, const SpMatrix< T_ > &a)

  Initialize matrix as element matrix from global SpMatrix.
- void Localize (Element *el, const SkMatrix< T_ > &a)

  Initialize matrix as element matrix from global SkMatrix.
- void Localize (Element *el, const SkSMatrix< T_ > &a)

  Initialize matrix as element matrix from global SkSMatrix.
- LocalMatrix< T_, NR_, NC_ > & operator= (const LocalMatrix< T_, NR_, NC_ > &m)

  Operator =
- LocalMatrix< T_, NR_, NC_ > & operator= (const T_ &x)

  Operator =
- LocalMatrix< T_, NR_, NC_ > & operator+= (const LocalMatrix< T_, NR_, NC_ > &m)

  Operator +=
- LocalMatrix< T_, NR_, NC_ > & operator-= (const LocalMatrix< T_, NR_, NC_ > &m)

  Operator -=
- LocalVect< T_, NR_ > operator* (LocalVect< T_, NC_ > &x)

  *Operator **
- LocalMatrix< T_, NR_, NC_ > & operator+= (const T_ &x)

  Operator +=
- LocalMatrix< T_, NR_, NC_ > & operator-= (const T_ &x)

  Operator -=
- LocalMatrix< T_, NR_, NC_ > & operator*= (const T_ &x)

  *Operator *=*
- LocalMatrix< T_, NR_, NC_ > & operator/= (const T_ &x)

  Operator /=
- void MultAdd (const LocalVect< T_, NC_ > &x, LocalVect< T_, NR_ > &y)

  Multiply matrix by vector and add result to vector.
- void MultAddScal (const T_ &a, const LocalVect< T_, NC_ > &x, LocalVect< T_, NR_ > &y)

  Multiply matrix by scaled vector and add result to vector.
- void Mult (const LocalVect< T_, NC_ > &x, LocalVect< T_, NR_ > &y)

  Multiply matrix by vector.
- void Symmetrize ()

  Symmetrize matrix.
- int Factor ()

  Factorize matrix.
- int Solve (LocalVect< T_, NR_ > &b)

  Forward and backsubstitute to solve a linear system.
- int FactorAndSolve (LocalVect< T_, NR_ > &b)

  Factorize matrix and solve linear system.
- void Invert (LocalMatrix< T_, NR_, NC_ > &A)

  Calculate inverse of matrix.
- T_ getInnerProduct (const LocalVect< T_, NC_ > &x, const LocalVect< T_, NR_ > &y)

  Calculate inner product witrh respect to matrix.
- T_ * get ()

  Return pointer to matrix as a C-array.

7.63.1 Detailed Description

template<class T_, size_t NR_, size_t NC_>
class OFELI::LocalMatrix< T_, NR_, NC_ >

Handles small size matrices like element matrices, with a priori known size.

The template class LocalMatrix treats small size matrices. Typically, this class is recommended to store element and side arrays.
Internally, no dynamic storage is used.

Template Parameters

*T_*	Data type (double, float, complex<double>, ...)
*NR_*	number of rows of matrix
*NC_*	number of columns of matrix

7.63.2 Member Function Documentation

T_& operator() (size_t *i*, size_t *j*)

Operator () (Non constant version)

Returns entry at row `i` and column `j`.

T_ operator() (size_t *i*, size_t *j*) const

Operator () (Constant version)

Returns entry at row `i` and column `j`.

7.64 LocalVect< T_, N_ > Class Template Reference

Handles small size vectors like element vectors.

Public Member Functions

- LocalVect ()

  Default constructor.
- LocalVect (const T_ *a)

  Constructor using a C-array.
- LocalVect (const Element *el)

  Constructor using Element pointer.
- LocalVect (const Side *sd)

  Constructor using Side pointer.
- LocalVect (const LocalVect< T_, N_ > &v)

  Copy constructor.
- LocalVect (const Element *el, const Vect< T_ > &v, int opt=0)

  Constructor of an element vector from a global Vect instance.

- LocalVect (const Side *sd, const Vect< T_ > &v, int opt=0)

  Constructor of a side vector from a global Vect instance.
- ~LocalVect ()

  Destructor.
- void getLocal (const Element &el, const Vect< T_ > &v, int type)

  Localize an element vector from a global Vect instance.
- void Localize (const Element *el, const Vect< T_ > &v, size_t k=0)

  Localize an element vector from a global Vect instance.
- void Localize (const Side *sd, const Vect< T_ > &v, size_t k=0)

  Localize a side vector from a global Vect instance.
- T_ & operator[ ] (size_t i)

  Operator [] (Non constant version).
- T_ operator[ ] (size_t i) const

  Operator [] (Constant version).
- T_ & operator() (size_t i)

  Operator () (Non constant version).
- T_ operator() (size_t i) const

  Operator () (Constant version).
- Element * El ()

  Return pointer to Element if vector was constructed using an element and `NULL` otherwise.
- Side * Sd ()

  Return pointer to Side if vector was constructed using a side and `NULL` otherwise.
- LocalVect< T_, N_ > & operator= (const LocalVect< T_, N_ > &v)

  Operator =
- LocalVect< T_, N_ > & operator= (const T_ &x)

  Operator =
- LocalVect< T_, N_ > & operator+= (const LocalVect< T_, N_ > &v)

  Operator +=
- LocalVect< T_, N_ > & operator+= (const T_ &a)

  Operator +=
- LocalVect< T_, N_ > & operator-= (const LocalVect< T_, N_ > &v)

  Operator -=
- LocalVect< T_, N_ > & operator-= (const T_ &a)

  Operator -=
- LocalVect< T_, N_ > & operator*= (const T_ &a)

  *Operator *=*
- LocalVect< T_, N_ > & operator/= (const T_ &a)

  Operator /=
- T_ * get ()

  Return pointer to vector as a C-Array.
- T_ operator, (const LocalVect< T_, N_ > &v) const

  Return Dot (scalar) product of two vectors.

7.64.1 Detailed Description

template<class T_, size_t N_>
class OFELI::LocalVect< T_, N_ >

Handles small size vectors like element vectors.

The template class LocalVect treats small size vectors. Typically, this class is recommended to store element and side arrays. Operators =, [] and () are overloaded so that one can write for instance:

```
LocalVect<double,10> u, v;
v = -1.0;
u = v;
u(3) = -2.0;
```

to set vector **v** entries to **-1**, copy vector **v** into vector **u** and assign third entry of **v** to **-2**. Notice that entries of **v** are here **v(1)**, **v(2)**, ..., **v(10)**, *i.e.* vector entries start at index **1**.
Internally, no dynamic storage is used.

Template Parameters

*T_*	Data type (double, float, complex<double>, ...)
*N_*	Vector size

7.64.2 Member Function Documentation

T_& operator[] (size_t *i*)

Operator `[]` (Non constant version).
`v[i]` starts at `v[0]` to `v[size()-1]`

T_ operator[] (size_t *i*) const

Operator `[]` (Constant version).
`v[i]` starts at `v[0]` to `v[size()-1]`

T_& operator() (size_t *i*)

Operator `()` (Non constant version).
`v(i)` starts at `v(1)` to `v(size())`. `v(i)` is the same element as `v[i-1]`

T_ operator() (size_t *i*) const

Operator `()` (Constant version).
`v(i)` starts at `v(1)` to `v(size())` `v(i)` is the same element as `v[i-1]`

7.65 Material Class Reference

To treat material data. This class enables reading material data in material data files. It also returns these informations by means of its members.

Public Member Functions

- Material ()

  Default consructor.
- Material (const Material &m)

  Copy constructor.
- ~Material ()

  Destructor.
- int set (int m, const string &name)

  Associate to material code number `n` *the material named* `name`
- string getName (int m) const

  Return material name for material with code `m`
- int getCode (size_t i) const

  Return material code for `i`*-th material.*
- size_t getNbMat () const

  Return Number of read materials.
- void setCode (int m)

  Associate code `m` *to current material.*
- int check (int c)
- real_t Density ()

  Return constant density.
- real_t Density (const Point< real_t > &x, real_t t)

  Return density at point `x` *and time* `t`
- real_t SpecificHeat ()

  Return constant specific heat.
- real_t SpecificHeat (const Point< real_t > &x, real_t t)

  Return specific heat at point `x` *and time* `t`
- real_t ThermalConductivity ()

  Return constant thermal conductivity.
- real_t ThermalConductivity (const Point< real_t > &x, real_t t)

  Return thermal conductivity at point `x` *and time* `t`
- real_t MeltingTemperature ()

  Return constant melting temperature.
- real_t MeltingTemperature (const Point< real_t > &x, real_t t)

  Return melting temperature at point `x` *and time* `t`
- real_t EvaporationTemperature ()

  Return constant evaporation temperature.
- real_t EvaporationTemperature (const Point< real_t > &x, real_t t)

  Return evaporation temperature at point `x` *and time* `t`
- real_t ThermalExpansion ()

  Return constant thermal expansion coefficient.
- real_t ThermalExpansion (const Point< real_t > &x, real_t t)

  Return thermal expansion coefficient at point `x` *and time* `t`
- real_t LatentHeatForMelting ()

  Return constant latent heat for melting.
- real_t LatentHeatForMelting (const Point< real_t > &x, real_t t)

  Return latent heat for melting at point `x` *and time* `t`

- real_t LatentHeatForEvaporation ()
  Return constant latent heat for evaporation.
- real_t LatentHeatForEvaporation (const Point< real_t > &x, real_t t)
  Return latent heat for evaporation at point x and time t
- real_t DielectricConstant ()
  Return constant dielectric constant.
- real_t DielectricConstant (const Point< real_t > &x, real_t t)
  Return dielectric constant at point x and time t
- real_t ElectricConductivity ()
  Return constant electric conductivity.
- real_t ElectricConductivity (const Point< real_t > &x, real_t t)
  Return electric conductivity at point x and time t
- real_t ElectricResistivity ()
  Return constant electric resistivity.
- real_t ElectricResistivity (const Point< real_t > &x, real_t t)
  Return electric resistivity at point x and time t
- real_t MagneticPermeability ()
  Return constant magnetic permeability.
- real_t MagneticPermeability (const Point< real_t > &x, real_t t)
  Return magnetic permeability at point x and time t
- real_t Viscosity ()
  Return constant viscosity.
- real_t Viscosity (const Point< real_t > &x, real_t t)
  Return viscosity at point x and time t
- real_t YoungModulus ()
  Return constant Young modulus.
- real_t YoungModulus (const Point< real_t > &x, real_t t)
  Return Young modulus at point x and time t
- real_t PoissonRatio ()
  Return constant Poisson ratio.
- real_t PoissonRatio (const Point< real_t > &x, real_t t)
  Return Poisson ratio at point x and time t
- real_t Property (int i)
  Return constant i-th property.
- real_t Property (int i, const Point< real_t > &x, real_t t)
  Return i-th property at point x and time t
- Material & operator= (const Material &m)
  Operator =.

7.65.1 Detailed Description

To treat material data. This class enables reading material data in material data files. It also returns these informations by means of its members.

7.65.2 Constructor & Destructor Documentation

Material ( )

Default consructor.
It initializes the class and searches for the path where are material data files.

7.65.3 Member Function Documentation

int set (int *m*, const string & *name*)

Associate to material code number `n` the material named `name`

Returns

Number of materials

string getName (int *m*) const

Return material name for material with code `m`

If such a material is not found, return a blank string.

int check (int *c*)

Check if material code `c` is present.

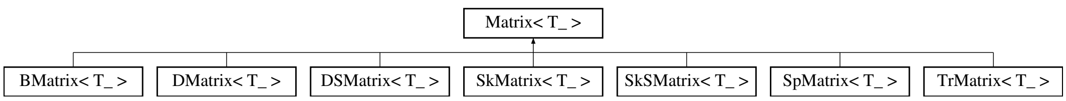
Returns

`0` if succeeded, `1` if not.

7.66 Matrix< T_ > Class Template Reference

Virtual class to handle matrices for all storage formats.

Inheritance diagram for Matrix< T_ >:



Public Member Functions

- Matrix ()

  Default constructor.
- Matrix (const Matrix< T_ > &m)

  Copy Constructor.
- virtual ~Matrix ()

  Destructor.
- size_t getNbRows () const

  Return number of rows.
- size_t getNbColumns () const

  Return number of columns.
- void setPenal (real_t p)

  Set Penalty Parameter (For boundary condition prescription).
- void setDiagonal ()

  Set the matrix as diagonal.
- T_ getDiag (size_t k) const

  Return `k`-th diagonal entry of matrix.
- size_t size () const

Return matrix dimension (Number of rows and columns).

- virtual void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const =0

  Multiply matrix by vector `x` *and add to* `y`
- virtual void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const =0

  Multiply matrix by vector `a*x` *and add to* `y`
- virtual void Mult (const Vect< T_ > &x, Vect< T_ > &y) const =0

  Multiply matrix by vector `x` *and save in* `y`
- virtual void TMult (const Vect< T_ > &v, Vect< T_ > &w) const =0

  Multiply transpose of matrix by vector `x` *and save in* `y`
- virtual void Axpy (T_ a, const Matrix< T_ > *x)=0

  Add to matrix the product of a matrix by a scalar.
- void setDiagonal (Mesh &mesh)

  Initialize matrix storage in the case where only diagonal terms are stored.
- void Assembly (const Element &el, T_ *a)

  Assembly of element matrix into global matrix.
- void Assembly (const Element &el, const DMatrix< T_ > &a)

  Assembly of element matrix into global matrix.
- void Assembly (const Side &sd, T_ *a)

  Assembly of side matrix into global matrix.
- void Assembly (const Side &sd, const DMatrix< T_ > &a)

  Assembly of side matrix into global matrix.
- void Prescribe (Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.
- void Prescribe (int dof, int code, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.
- void Prescribe (Vect< T_ > &b, int flag=0)

  Impose by a penalty method a homegeneous (=0) essential boundary condition.
- void Prescribe (size_t dof, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition when only one DOF is treated.
- void PrescribeSide ()

  Impose by a penalty method an essential boundary condition when DOFs are supported by sides.
- virtual void add (size_t i, size_t j, const T_ &val)=0

  Add `val` *to entry* `(i,j)`*.*
- virtual int Factor ()=0

  Factorize matrix. Available only if the storage class enables it.
- virtual int solve (Vect< T_ > &b)=0

  Solve the linear system by a direct method.
- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve system with factorized matrix (forward and back substitution).
- int FactorAndSolve (Vect< T_ > &b)

  Factorize matrix and solve the linear system.
- int FactorAndSolve (const Vect< T_ > &b, Vect< T_ > &x)

  Factorize matrix and solve the linear system.
- size_t getLength () const

  Return number of stored terms in matrix.
- int isDiagonal () const

Say if matrix is diagonal or not.

- int isFactorized () const

  Say if matrix is factorized or not.
- virtual size_t getColInd (size_t i) const

  Return Column index for column `i` (See the description for class SpMatrix).
- virtual size_t getRowPtr (size_t i) const

  Return Row pointer for row `i` (See the description for class SpMatrix).
- virtual void set (size_t i, size_t j, const T_ &val)=0

  Assign a value to an entry of the matrix.
- virtual T_ & operator() (size_t i, size_t j)=0

  Operator () (Non constant version).
- virtual T_ operator() (size_t i, size_t j) const =0

  Operator () (Non constant version).
- T_ operator() (size_t i) const

  Operator () with one argument (Constant version).
- T_ & operator() (size_t i)

  Operator () with one argument (Non Constant version).
- T_ & operator[ ] (size_t k)

  Operator [] (Non constant version).
- T_ operator[ ] (size_t k) const

  Operator [] (Constant version).
- Matrix & operator= (Matrix< T_ > &m)

  Operator =.
- Matrix & operator+= (const Matrix< T_ > &m)

  Operator +=.
- Matrix & operator-= (const Matrix< T_ > &m)

  Operator -=.
- Matrix & operator= (const T_ &x)

  Operator =.
- Matrix & operator*= (const T_ &x)

  *Operator *=.*
- Matrix & operator+= (const T_ &x)

  Operator +=.
- Matrix & operator-= (const T_ &x)

  Operator -=.
- virtual T_ get (size_t i, size_t j) const =0

  Return entry `(i,j)` of matrix if this one is stored, `0` else.

7.66.1 Detailed Description

template<class T_>
class OFELI::Matrix< T_ >

Virtual class to handle matrices for all storage formats.

Template Parameters

<T↩_>	Data type (real_t, float, complex<real_t>, ...)

7.66.2 Constructor & Destructor Documentation

Matrix ( )

Default constructor.
Initializes a zero-size matrix.

7.66.3 Member Function Documentation

T_ getDiag (size_t *k*) const

Return `k`-th diagonal entry of matrix.
First entry is given by **getDiag(1)**.

virtual void Axpy (T_ *a*, const Matrix< T_ > * *x*) `[pure virtual]`

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*x*	Matrix by which `a` is multiplied. The result is added to current instance

Implemented in SpMatrix< T_ >, DSMatrix< T_ >, DMatrix< T_ >, SkSMatrix< T_ >, SkMatrix< T_ >, TrMatrix< T_ >, and BMatrix< T_ >.

void setDiagonal (Mesh & *mesh*)

Initialize matrix storage in the case where only diagonal terms are stored.
This member function is to be used for explicit time integration schemes

void Assembly (const Element & *el*, T_ * *a*)

Assembly of element matrix into global matrix.
Case where element matrix is given by a C-array.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a C-array

void Assembly (const Element & *el*, const DMatrix< T_ > & *a*)

Assembly of element matrix into global matrix.
Case where element matrix is given by a DMatrix instance.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a DMatrix instance

void Assembly (const Side & *sd*, T_ * *a*)

Assembly of side matrix into global matrix.
Case where side matrix is given by a C-array.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a C-array instance

void Assembly (const Side & *sd*, const DMatrix< T_ > & *a*)

Assembly of side matrix into global matrix.
Case where side matrix is given by a DMatrix instance.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a DMatrix instance

void Prescribe (Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = 0)

Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **setPenal**(..).

Parameters

in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (int *dof*, int *code*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = 0)

Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **setPenal**(..).

Parameters

in	*dof*	Degree of freedom for which a boundary condition is to be enforced
in	*code*	Code for which a boundary condition is to be enforced
in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (Vect< T_ > & *b*, int *flag* = 0)

Impose by a penalty method a homegeneous (=0) essential boundary condition.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

Parameters

in,out	*b*	Vect instance that contains right-hand side.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (size_t *dof*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = 0)

Impose by a penalty method an essential boundary condition when only one DOF is treated.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. This gunction is to be used if only one DOF per node is treated in the linear system. The penalty parameter is by default equal to 1.e20. It can be modified by member function setPenal.

Parameters

in	*dof*	Label of the concerned degree of freedom (DOF).
in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void PrescribeSide ( )

Impose by a penalty method an essential boundary condition when DOFs are supported by sides.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set↩ Penal**(..).

virtual int solve (Vect< T_ > & *b*) `[pure virtual]`

Solve the linear system by a direct method.

This is available only if the storage class enables it and if matrix has been primarily factorized (See **isFactorized**).

Implemented in SpMatrix< T_ >, DMatrix< T_ >, SkSMatrix< T_ >, SkMatrix< T_ >, DS↩ Matrix< T_ >, BMatrix< T_ >, and TrMatrix< T_ >.

int solve (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve system with factorized matrix (forward and back substitution).

Parameters

in	*b*	Vect instance that contains right-hand side
out	*x*	Vect instance that contains solution

Returns

-

- `0` if solution was normally performed
- `n` if the `n`-th pivot is null
  Solution is performed only is factorization has previously been invoked.

int FactorAndSolve (Vect< T_ > & *b*)

Factorize matrix and solve the linear system.

This is available only if the storage cass enables it.

Parameters

in,out	*b*	Vect instance that contains right-hand side on input and solution on output

int FactorAndSolve (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Factorize matrix and solve the linear system.

This is available only if the storage class enables it.

Parameters

in	*b*	Vect instance that contains right-hand side
out	*x*	Vect instance that contains solution

Returns

- `0` if solution was normally performed
- `n` if the n-th pivot is nul

int isFactorized ( ) const

Say if matrix is factorized or not.
If the matrix was not factorized, the class does not allow solving by a direct solver.

virtual void set (size_t *i*, size_t *j*, const T_ & *val*) `[pure virtual]`

Assign a value to an entry of the matrix.

Parameters

in	*i*	Row index
in	*j*	Column index
in	*val*	Value to assign

Implemented in SpMatrix< T_ >, SkSMatrix< T_ >, DMatrix< T_ >, SkMatrix< T_ >, TrMatrix< T_ >, BMatrix< T_ >, and DSMatrix< T_ >.

virtual T_& operator() (size_t *i*, size_t *j*) `[pure virtual]`

Operator () (Non constant version).
Returns the `(i,j)` entry of the matrix.

Parameters

in	*i*	Row index
in	*j*	Column index

Implemented in SpMatrix< T_ >, DMatrix< T_ >, SkSMatrix< T_ >, SkMatrix< T_ >, DSMatrix< T_ >, TrMatrix< T_ >, and BMatrix< T_ >.

virtual T_ operator() (size_t *i*, size_t *j*) const `[pure virtual]`

Operator () (Non constant version).
Returns the `(i,j)` entry of the matrix.

Parameters

in	*i*	Row index
in	*j*	Column index

Implemented in SpMatrix< T_ >, DMatrix< T_ >, SkSMatrix< T_ >, SkMatrix< T_ >, DSMatrix< T_ >, TrMatrix< T_ >, and BMatrix< T_ >.

T_ operator() (size_t *i*) const

Operator () with one argument (Constant version).

Returns `i`-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	*i*	entry index

T_& operator() (size_t *i*)

Operator () with one argument (Non Constant version).

Returns `i`-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	*i*	entry index

T_& operator[ ] (size_t *k*)

Operator [] (Non constant version).

Returns `k`-th stored element in matrix Index `k` starts at `0`.

T_ operator[ ] (size_t *k*) const

Operator [] (Constant version).

Returns `k`-th stored element in matrix Index `k` starts at `0`.

Matrix& operator= (Matrix< T_ > & *m*)

Operator =.

Copy matrix `m` to current matrix instance.

Matrix& operator+= (const Matrix< T_ > & *m*)

Operator +=.

Add matrix `m` to current matrix instance.

Matrix& operator-= (const Matrix< T_ > & *m*)

Operator -=.

Subtract matrix `m` from current matrix instance.

Matrix& operator= (const T_ & *x*)

Operator =.

Assign constant value `x` to all matrix entries.

Matrix& operator*= (const T_ & *x*)

Operator *=.
Premultiply matrix entries by constant value x

Matrix& operator+= (const T_ & *x*)

Operator +=.
Add constant value x to all matrix entries.

Matrix& operator-= (const T_ & *x*)

Operator -=.
Subtract constant value x from all matrix entries.

7.67 Mesh Class Reference

To store and manipulate finite element meshes.

Public Member Functions

- Mesh ()

  Default constructor (Empty mesh)
- Mesh (const string &file, bool bc=false, int opt=NODE_DOF, int nb_dof=1)

  Constructor using a mesh file.
- Mesh (real_t L, size_t nb_el, size_t p=1, size_t nb_dof=1)

  Constructor for a 1-D mesh. The domain is the interval [0,L].
- Mesh (const Grid &g, int opt=QUADRILATERAL)

  Constructor for a uniform finite difference grid given by and instance of class Grid.
- Mesh (const Grid &g, int shape, int opt)

  Constructor of dual mesh for a uniform finite difference grid given by and instance of class Grid.
- Mesh (real_t xmin, real_t xmax, size_t ne, int c1, int c2, int opt=0)

  Constructor for a uniform 1-D finite element mesh.
- Mesh (real_t xmin, real_t xmax, real_t ymin, real_t ymax, size_t nx, size_t ny, int c1, int c2, int c3, int c4, int opt=0)

  Constructor for a uniform 2-D structured finite element mesh.
- Mesh (const Mesh &m, const Point< real_t > &x_bl, const Point< real_t > &x_tr)

  Constructor that extracts the mesh of a rectangular region from an initial mesh.
- Mesh (const Mesh &mesh, int opt, size_t dof1, size_t dof2, bool bc=false)

  Constructor that copies the input mesh and selects given degrees of freedom.
- Mesh (const Mesh &ms)

  Copy Constructor.
- ~Mesh ()

  Destructor.
- void setDim (size_t dim)

  Define space dimension. Normally, between 1 and 3.
- void setVerbose (int verb)

  Define Verbose Parameter. Controls output details.
- void Add (Node *nd)

Add a node to mesh.
- void Add (Element *el)

  Add an element to mesh.
- void Add (Side *sd)

  Add a side to mesh.
- void Add (Edge *ed)

  Add an edge to mesh.
- Mesh & operator*= (real_t a)

  *Operator *=*
- void get (const string &mesh_file)

  Read mesh data in file.
- void get (const string &mesh_file, int ff, int nb_dof=1)

  Read mesh data in file with giving its format.
- void setDOFSupport (int opt, int nb_nodes=1)

  Define supports of degrees of freedom.
- void setNbDOFPerNode (size_t nb_dof=1)

  Define number of degrees of freedom for each node.
- void setPointInDomain (Point< real_t > x)

  Define a point in the domain. This function makes sense only if boundary mesh is given without internal mesh (Case of Boundary Elements)
- void removeImposedDOF ()

  Eliminate equations corresponding to imposed DOF.
- size_t NumberEquations (size_t dof=0)

  Renumber Equations.
- size_t NumberEquations (size_t dof, int c)

  Renumber Equations.
- int getAllSides (int opt=0)

  Determine all mesh sides.
- size_t getNbSideNodes () const

  Return the number of nodes on each side.
- size_t getNbElementNodes () const

  Return the number of nodes in each element.
- int getBoundarySides ()

  Determine all boundary sides.
- int createBoundarySideList ()

  Create list of boundary sides.
- int getBoundaryNodes ()

  Determine all boundary nodes.
- int createInternalSideList ()

  Create list of internal sides (not on the boundary).
- int getAllEdges ()

  Determine all edges.
- void getNodeNeighborElements ()

  Create node neighboring elements.
- void getElementNeighborElements ()

  Create element neighboring elements.
- void setMaterial (int code, const string &mname)

Associate material to code of element.

- void Reorder (size_t m=GRAPH_MEMORY)

  Renumber mesh nodes according to reverse Cuthill Mc Kee algorithm.
- void Add (size_t num, real_t ∗x)

  Add a node by giving its label and an array containing its coordinates.
- void DeleteNode (size_t label)

  Remove a node given by its label.
- void DeleteElement (size_t label)

  Remove an element given by its label.
- void DeleteSide (size_t label)

  Remove a side given by its label.
- void Delete (Node ∗nd)

  Remove a node given by its pointer.
- void Delete (Element ∗el)

  Remove a node given by its pointer.
- void Delete (Side ∗sd)

  Remove a side given by its pointer.
- void Delete (Edge ∗ed)

  Remove an edge given by its pointer.
- void RenumberNode (size_t n1, size_t n2)

  Renumber a node.
- void RenumberElement (size_t n1, size_t n2)

  Renumber an element.
- void RenumberSide (size_t n1, size_t n2)

  Renumber a side.
- void RenumberEdge (size_t n1, size_t n2)

  Renumber an edge.
- void setNodeView (size_t n1, size_t n2)

  Set viewing window for nodes.
- void setElementView (size_t n1, size_t n2)

  Set viewing window for elements.
- void setSideView (size_t n1, size_t n2)

  Set viewing window for sides.
- void setEdgeView (size_t n1, size_t n2)

  Set viewing window for edges.
- void setList (const std::vector< Node ∗ > &nl)

  Initialize list of mesh nodes using the input vector.
- void setList (const std::vector< Element ∗ > &el)

  Initialize list of mesh elements using the input vector.
- void setList (const std::vector< Side ∗ > &sl)

  Initialize list of mesh sides using the input vector.
- void Rescale (real_t sx, real_t sy=0., real_t sz=0.)

  Rescale mesh by multiplying node coordinates by constants.
- int getVerbose () const

  Return Verbose Parameter.
- size_t getDim () const

Return space dimension.

- size_t getNbNodes () const

  Return number of nodes.
- size_t getNbMarkedNodes () const

  Return number of marked nodes.
- size_t getNbVertices () const

  Return number of vertices.
- size_t getNbDOF () const

  Return total number of degrees of freedom (DOF)
- size_t getNbEq () const

  Return number of equations.
- size_t getNbEq (int i) const

  Return number of equations for the i-th set of degrees of freedom.
- size_t getNbElements () const

  Return number of elements.
- size_t getNbSides () const

  Return number of sides.
- size_t getNbEdges () const

  Return number of sides.
- size_t getNbBoundarySides () const

  Return number of boundary sides.
- size_t getNbInternalSides () const

  Return number of internal sides.
- size_t getNbMat () const

  Return number of materials.
- void AddMidNodes (int g=0)

  Add mid-side nodes.
- Point< real_t > getMaxCoord () const

  Return maximum coordinates of nodes.
- Point< real_t > getMinCoord () const

  Return minimum coordinates of nodes.
- void set (Node ∗nd)

  Replace node in the mesh.
- void set (Element ∗el)

  Replace element in the mesh.
- void set (Side ∗sd)

  Choose side in the mesh.
- bool NodesAreDOF () const

  Return information about DOF type.
- bool SidesAreDOF () const

  Return information about DOF type.
- bool EdgesAreDOF () const

  Return information about DOF type.
- bool ElementsAreDOF () const

  Return information about DOF type.
- int getDOFSupport () const

Return information on dof support Return an integer according to enumerated values: NODE_DOF, EL↩ EMENT_DOF SIDE_DOF.

- void put (const string &mesh_file) const

  Write mesh data on file.
- void save (const string &mesh_file) const

  Write mesh data on file in various formats.
- void Bput (const string &mesh_file) const

  Write mesh data on a binary file.
- bool withImposedDOF () const

  Return true if imposed DOF count in equations, false if not.
- bool isStructured () const

  Return true is mesh is structured, false if not.
- size_t getNodeNewLabel (size_t n) const

  Return new label of node of a renumbered node.
- void getList (vector< Node * > &nl) const

  Fill vector `nl` with list of pointers to nodes.
- void getList (vector< Element * > &el) const

  Fill vector `el` with list of pointers to elements.
- void getList (vector< Side * > &sl) const

  Fill vector `sl` with list of pointers to sides.
- Node * getPtrNode (size_t i) const

  Return pointer to node with label `i`.
- Node & getNode (size_t i) const

  Return refenrece to node with label `i`
- Element * getPtrElement (size_t i) const

  Return pointer to element with label `i`
- Element & getElement (size_t i) const

  Return reference to element with label `i`
- Side * getPtrSide (size_t i) const

  Return pointer to side with label `i`
- Side & getSide (size_t i) const

  Return reference to side with label `i`
- Edge * getPtrEdge (size_t i) const

  Return pointer to edge with label `i`
- Edge & getEdge (size_t i) const

  Return reference to edge with label `i`
- size_t getNodeLabel (size_t i) const

  Return label of `i`-th node.
- size_t getElementLabel (size_t i) const

  Return label of `i`-th element.
- size_t getSideLabel (size_t i) const

  Return label of `i`-th side.
- size_t getEdgeLabel (size_t i) const

  Return label of `i`-th edge.
- void topNode () const

  Reset list of nodes at its top position (Non constant version)
- void topBoundaryNode () const

Reset list of boundary nodes at its top position (Non constant version)

- void topMarkedNode () const

  Reset list of marked nodes at its top position (Non constant version)
- void topElement () const

  Reset list of elements at its top position (Non constant version)
- void topSide () const

  Reset list of sides at its top position (Non constant version)
- void topBoundarySide () const

  Reset list of boundary sides at its top position (Non constant version)
- void topInternalSide () const

  Reset list of intrenal sides at its top position (Non constant version)
- void topEdge () const

  Reset list of edges at its top position (Non constant version)
- void topBoundaryEdge () const

  Reset list of boundary edges at its top position (Non constant version)
- Node ∗ getNode () const

  Return pointer to current node and move to next one (Non constant version)
- Node ∗ getBoundaryNode () const

  Return pointer to current boundary node and move to next one (Non constant version)
- Node ∗ getMarkedNode () const

  Return pointer to current marked node and move to next one (Non constant version)
- Element ∗ getElement () const

  Return pointer to current element and move to next one (Non constant version)
- Element ∗ getActiveElement () const

  Return pointer to current element and move to next one (Non constant version)
- Side ∗ getSide () const

  Return pointer to current side and move to next one (Non constant version)
- Side ∗ getBoundarySide () const

  Return pointer to current boundary side and move to next one (Non constant version)
- Side ∗ getInternalSide () const

  Return pointer to current internal side and move to next one (Non constant version)
- Edge ∗ getEdge () const

  Return pointer to current edge and move to next one (Non constant version)
- Edge ∗ getBoundaryEdge () const

  Return pointer to current boundary edge and move to next one (Non constant version)
- int getShape () const

  Determine shape of elements Return Shape index (see enum ElementShape) if all elements have the same shape, 0 if not.
- Element ∗ operator() (size_t i) const

  Operator () : Return pointer to i-th element.
- Node ∗ operator[ ] (size_t i) const

  Operator [] : Return pointer to i-th node.
- size_t operator() (size_t i, size_t n) const

  Operator () : Return pointer to i-th node of n-th element.
- Mesh & operator= (Mesh &ms)

  Operator = : Assign a Mesh instance.

Friends

- void Refine (Mesh &in_mesh, Mesh &out_mesh)

  Refine mesh. Subdivide each triangle into 4 subtriangles. This member function is valid for 2-D triangular meshes only.

7.67.1 Detailed Description

To store and manipulate finite element meshes.

Class Mesh enables defining as an object a finite element mesh. A finite element mesh is characterized by its nodes, elements and sides. Each of these types of data constitutes a class in the OFELI library.

The standard procedure to introduce the finite element mesh is to provide an input file containing its data. For this, we have defined our own mesh data file (following the XML syntax). Of course, a developer can write his own function to read his finite element mesh file using the methods in Mesh.

7.67.2 Constructor & Destructor Documentation

Mesh (const string & *file*, bool *bc* = `false`, int *opt* = `NODE_DOF`, int *nb_dof* = `1`)

Constructor using a mesh file.

Parameters

`in`	*file*	File containing mesh data. The extension of the file yields the file format: The extension .m implies OFELI file format and .msh implies GMSH msh file.
`in`	*bc*	Flag to remove (true) or not (false) imposed Degrees of Freedom [default: false]
`in`	*opt*	Type of DOF support: To choose among enumerated values `NODE_DOF`, `SIDE_DOF` or `ELEMENT_DOF`. Say if degrees of freedom (unknowns) are supported by nodes, sides or elements.
`in`	*nb_dof*	Number of degrees of freedom per node [Default: `1`]. This value is meaningful only if other format than OFELI's one is used. Otherwise, the information is contained in the OFELI file format.

Mesh (real_t *L*, size_t *nb_el*, size_t *p* = `1`, size_t *nb_dof* = `1`)

Constructor for a 1-D mesh. The domain is the interval [0,L].

Parameters

`in`	*L*	Length of the interval
`in`	*nb_el*	Number of elements to generate
`in`	*p*	Degree of finite element polynomial (Default = 1)
`in`	*nb_dof*	Number of degrees of freedom for each node (Default = 1)

Mesh (const Grid & *g*, int *opt* = `QUADRILATERAL`)

Constructor for a uniform finite difference grid given by and instance of class Grid.

Parameters

in	*g*	Grid instance
in	*opt*	Optional value to say which type of elements to generate • TRIANGLE: Mesh elements are triangles • QUADRILATERAL: Mesh elements are quadrilaterals [default]

Mesh (const Grid & *g*, int *shape*, int *opt*)

Constructor of dual mesh for a uniform finite difference grid given by and instance of class Grid.

Parameters

in	*g*	Grid instance
in	*shape*	Value to say which type of elements to generate • TRIANGLE: Mesh elements are triangles • QUADRILATERAL: Mesh elements are quadrilaterals [default]
in	*opt*	This argument can take any value. It is here only to distinguish from the other constructor using Grid instance.

Remarks

This constructor is to be used to obtain a dual mesh from a structured grid. It is mainly useful if a cell centered finite volume method is used.

Mesh (real_t *xmin*, real_t *xmax*, size_t *ne*, int *c1*, int *c2*, int *opt* = `0`)

Constructor for a uniform 1-D finite element mesh.
The domain is the line (xmin,xmax)

Parameters

in	*xmin*	Minimal coordinate
in	*xmax*	Maximal coordinate
in	*ne*	Number of elements
in	*c1*	Code for the first node (x=xmin)
in	*c2*	Code for the last node (x=xmax)
in	*opt*	Flag to generate elements as well (if not zero) [Default: 0].

Remarks

The option opt can be set to 0 if the user intends to use finite differences.

Mesh (real_t *xmin,* **real_t** *xmax,* **real_t** *ymin,* **real_t** *ymax,* **size_t** *nx,* **size_t** *ny,* **int** *c1,* **int** *c2,* **int** *c3,* **int** *c4,* **int** *opt* = `0` **)**

Constructor for a uniform 2-D structured finite element mesh.
The domain is the rectangle (xmin,xmax)x(ymin,ymax)

Parameters

`in`	*xmin*	Minimal x-coordinate
`in`	*xmax*	Maximal x-coordinate
`in`	*ymin*	Minimal y-coordinate
`in`	*ymax*	Maximal y-coordinate
`in`	*nx*	Number of subintervals on the x-axis
`in`	*ny*	Number of subintervals on the y-axis
`in`	*c1*	Code for nodes generated on the line y=0
`in`	*c2*	Code for nodes generated on the line x=Lx
`in`	*c3*	Code for nodes generated on the line y=Ly
`in`	*c4*	Code for nodes generated on the line x=0
`in`	*opt*	Flag to generate elements as well (if not zero) [Default: 0]. If the flag is not 0, it can take one of the enumerated values: TRIANGLE or QUADRILATERAL, with obvious meaning.

Remarks

The option opt can be set to 0 if the user intends to use finite differences.

Mesh (const Mesh & *m,* **const Point< real_t > &** *x_bl,* **const Point< real_t > &** *x_tr* **)**

Constructor that extracts the mesh of a rectangular region from an initial mesh.
This constructor is useful for zooming purposes for instance.

Parameters

`in`	*m*	Initial mesh from which the submesh is extracted
`in`	*x_bl*	Coordinate of bottom left vertex of the rectangle
`in`	*x_tr*	Coordinate of top right vertex of the rectangle

Mesh (const Mesh & *mesh,* **int** *opt,* **size_t** *dof1,* **size_t** *dof2,* **bool** *bc* = `false` **)**

Constructor that copies the input mesh and selects given degrees of freedom.
This constructor is to be used for coupled problems where each subproblem uses a choice of degrees of freedom.

Parameters

in	*mesh*	Initial mesh from which the submesh is extracted
in	*opt*	Type of DOF support: To choose among enumerated values `NODE_DOF`, `SIDE_DOF` or `ELEMENT_DOF`.
in	*dof1*	Label of first degree of freedom to select to the output mesh
in	*dof2*	Label of last degree of freedom to select to the output mesh
in	*bc*	Flag to remove (`true`) or not (`false`) imposed Degrees of Freedom [Default: `false`]

Mesh (const Mesh & *ms*)

Copy Constructor.

Parameters

in	*ms*	Mesh instance to copy

7.67.3 Member Function Documentation

void setDim (size_t *dim*)

Define space dimension. Normally, between 1 and 3.

Parameters

in	*dim*	Space dimension to set (must be between 1 and 3)

void setVerbose (int *verb*)

Define Verbose Parameter. Controls output details.

Parameters

in	*verb*	verbosity parameter (Must be between 0 and 10)

void Add (Node * *nd*)

Add a node to mesh.

Parameters

in	*nd*	Pointer to Node to add

void Add (Element * *el*)

Add an element to mesh.

Parameters

in	*el*	Pointer to Element to add

void Add (Side * *sd*)

Add a side to mesh.

Parameters

in	*sd*	Pointer to Side to add

void Add (Edge * *ed*)

Add an edge to mesh.

Parameters

in	*ed*	Pointer to Edge to add

Mesh& operator*= (real_t *a*)

Operator *=
Rescale mesh coordinates by myltiplying by a factor

Parameters

in	*a*	Value to multiply by

void get (const string & *mesh_file*)

Read mesh data in file.
Mesh file must be in `OFELI` format. See "File Formats" page

Parameters

in	*mesh_file*	Mesh file name

void get (const string & *mesh_file*, int *ff*, int *nb_dof* = 1)

Read mesh data in file with giving its format.
File format can be chosen among a variety of choices. See "File Formats" page

Parameters

in	*mesh_file*	Mesh file name
in	*ff*	File format: Integer to chose among enumerated values: `OFELI_FF`, `GMSH`, `MATLAB`, `EASYMESH`, `GAMBIT`, `BAMG`, `NETGEN`, `TRIANGLE_FF`
in	*nb_dof*	Number of degrees of freedom per node (Default value: 1)

void setDOFSupport (int *opt*, int *nb_nodes* = *1*)

Define supports of degrees of freedom.

Parameters

in	*opt*	DOF type: • `NODE_DOF`: Degrees of freedom are supported by nodes • `SIDE_DOF`: Degrees of freedom are supported by sides • `EDGE_DOF`: Degrees of freedom are supported by edges • `ELEMENT_DOF`: Degrees of freedom are supported by elements
in	*nb_nodes*	Number of nodes on sides or elements (default=1). This parameter is useful only if dofs are supported by sides or elements

Note

> This member function creates all mesh sides if the option `ELEMENT_DOF` or `SIDE_DOF` is selected. So it not necessary to call getAllSides() after

void setNbDOFPerNode (size_t *nb_dof* = *1*)

Define number of degrees of freedom for each node.

Parameters

in	*nb_dof*	Number of degrees of freedom (unknowns) for each mesh node (Default value is 1)

Note

> This function first declares nodes as unknown supports, sets the number of degrees of freedom and renumbers equations

void setPointInDomain (Point< real_t > *x*)

Define a point in the domain. This function makes sense only if boundary mesh is given without internal mesh (Case of Boundary Elements)

Parameters

in	*x*	Coordinates of point to define

size_t NumberEquations (size_t *dof* = 0)

Renumber Equations.

Parameters

in	*dof*	Label of degree of freedom for which numbering is performed. Default value (0) means that all degrees of freedom are taken into account

size_t NumberEquations (size_t *dof*, int *c*)

Renumber Equations.

Parameters

in	*dof*	Label of degree of freedom for which numbering is performed.
in	*c*	code for which degrees of freedom are enforced.

int getAllSides (int *opt* = 0)

Determine all mesh sides.

Returns

Number of all sides.

int getBoundarySides ( )

Determine all boundary sides.

Returns

Number of boundary sides.

int createBoundarySideList ( )

Create list of boundary sides.

This function is useful to loop over boundary sides without testing Once this one is called, the function getNbBoundarySides() is available. Moreover, looping over boundary sides is available via the member functions topBoundarySide() and getBoundarySide()

Returns

Number of boundary sides.

int getBoundaryNodes ( )

Determine all boundary nodes.

Returns

n Number of boundary nodes.

int createInternalSideList ( )

Create list of internal sides (not on the boundary).

This function is useful to loop over internal sides without testing Once this one is called, the function getNbInternalSides() is available. Moreover, looping over internal sides is available via the member functions topInternalSide() and getInternalSide()

Returns

n Number of internal sides.

int getAllEdges ( )

Determine all edges.

Returns

Number of all edges.

void getNodeNeighborElements ( )

Create node neighboring elements.

This function is generally useful when, for a numerical method, one looks for a given node to the list of elements that share this node. Once this function is invoked, one can retrieve the list of neighboring elements of any node (Node::getNeigEl)

void getElementNeighborElements ( )

Create element neighboring elements.

This function creates for each element the list of elements that share a side with it. Once this function is invoked, one can retrieve the list of neighboring elements of any element (Element↩::getNeigborElement)

void setMaterial (int *code*, const string & *mname*)

Associate material to code of element.

Parameters

in	*code*	Element code for which material is assigned
in	*mname*	Name of material

void Reorder (size_t *m* = GRAPH_MEMORY)

Renumber mesh nodes according to reverse Cuthill Mc Kee algorithm.

Parameters

in	*m*	Memory size needed for matrix graph (default value is GRAPH_MEMORY, see OFELI_Config.h)

void Add (size_t *num*, real_t ∗ *x*)

Add a node by giving its label and an array containing its coordinates.

Parameters

in	*num*	Label of node to add
in	*x*	C-array of node coordinates

void DeleteNode (size_t *label*)

Remove a node given by its label.
This function does not release the space previously occupied

Parameters

in	*label*	Label of node to delete

void DeleteElement (size_t *label*)

Remove an element given by its label.
This function does not release the space previously occupied

Parameters

in	*label*	Label of element to delete

void DeleteSide (size_t *label*)

Remove a side given by its label.
This function does not release the space previously occupied

Parameters

in	*label*	Label of side to delete

void Delete (Node ∗ *nd*)

Remove a node given by its pointer.
This function does not release the space previously occupied

Parameters

in	*nd*	Pointer to node to delete

void Delete (Element ∗ *el*)

Remove a node given by its pointer.
This function does not release the space previously occupied

Parameters

in	*el*	Pointer to element to delete

void Delete (Side ∗ *sd*)

Remove a side given by its pointer.
This function does not release the space previously occupied

Parameters

in	*sd*	Pointer to side to delete

void Delete (Edge ∗ *ed*)

Remove an edge given by its pointer.
This function does not release the space previously occupied

Parameters

in	*ed*	Pointer to edge to delete

void RenumberNode (size_t *n1*, size_t *n2*)

Renumber a node.

Parameters

in	*n1*	Old label
in	*n2*	New label

void RenumberElement (size_t *n1*, size_t *n2*)

Renumber an element.

Parameters

in	*n1*	Old label
in	*n2*	New label

void RenumberSide (size_t *n1*, size_t *n2*)

Renumber a side.

Parameters

in	*n1*	Old label
in	*n2*	New label

void RenumberEdge (size_t *n1*, size_t *n2*)

Renumber an edge.

Parameters

in	*n1*	Old label
in	*n2*	New label

void setNodeView (size_t *n1*, size_t *n2*)

Set viewing window for nodes.

Parameters

in	*n1*	First node to view
in	*n2*	last node to view

void setElementView (size_t *n1*, size_t *n2*)

Set viewing window for elements.

Parameters

in	*n1*	First element to view
in	*n2*	last element to view

void setSideView (size_t *n1*, size_t *n2*)

Set viewing window for sides.

Parameters

in	*n1*	First side to view
in	*n2*	last side to view

void setEdgeView (size_t *n1*, size_t *n2*)

Set viewing window for edges.

Parameters

in	*n1*	First edge to view
in	*n2*	last edge to view

void setList (const std::vector< Node * > & *nl*)

Initialize list of mesh nodes using the input vector.

Parameters

in	*nl*	vector instance that contains the list of pointers to nodes

void setList (const std::vector< Element * > & *el*)

Initialize list of mesh elements using the input vector.

Parameters

in	*el*	vector instance that contains the list of pointers to elements

void setList (const std::vector< Side * > & *sl*)

Initialize list of mesh sides using the input vector.

Parameters

in	*sl*	vector instance that contains the list of pointers to sides

void Rescale (real_t *sx*, real_t *sy* = `0.`, real_t *sz* = `0.`)

Rescale mesh by multiplying node coordinates by constants.
This function can be used e.g. for changing coordinate units

Parameters

in	*sx*	Factor to multiply by `x` coordinates
in	*sy*	Factor to multiply by `y` coordinates [Default: `sx`]
in	*sz*	Factor to multiply by `z` coordinates [Default: `sx`]

size_t getNbBoundarySides ( ) const

Return number of boundary sides.
This function is valid if member function **getAllSides** or **getBoundarySides** has been invoked before

size_t getNbInternalSides ( ) const

Return number of internal sides.
This function is valid if member functions **getAllSides** and **createInternalSideList** have been invoked before

void AddMidNodes (int *g* = 0)

Add mid-side nodes.
This is function is valid for triangles only

Parameters

in	*g*	Option to say of barycentre node is to be added (>0) or not (=0)

void set (Node ∗ *nd*)

Replace node in the mesh.
If the node label exists already, the existing node pointer will be replaced by the current one. If not, an error message is displayed.

Parameters

in	*nd*	Pointer to node

void set (Element ∗ *el*)

Replace element in the mesh.
If the element label exists already, the existing element pointer will be replaced by the current one. If not, an error message is displayed.

Parameters

in	*el*	Pointer to element

void set (Side ∗ *sd*)

Choose side in the mesh.
If the side label exists already, the existing side pointer will be replaced by the current one. If not, an error message is displayed.

Parameters

in	*sd*	Pointer to side

bool NodesAreDOF ( ) const

Return information about DOF type.

Returns

true if DOF are supported by nodes, `false` otherwise

bool SidesAreDOF ( ) const

Return information about DOF type.

Returns

true if DOF are supported by sides, `false` otherwise

bool EdgesAreDOF ( ) const

Return information about DOF type.

Returns

true if DOF are supported by edges, `false` otherwise

bool ElementsAreDOF ( ) const

Return information about DOF type.

Returns

true if DOF are supported by elements, `false` otherwise

void put (const string & *mesh_file*) const

Write mesh data on file.

Parameters

`in`	*mesh_file*	Mesh file name

void save (const string & *mesh_file*) const

Write mesh data on file in various formats.
File format depends on the extension in file name

Parameters

`in`	*mesh_file*	Mesh file name If the extension is '.m', the output file is an OFELI file If the extension is '.gpl', the output file is a Gnuplot file If the extension is '.msh' or '.geo', the output file is a Gmsh file If the extension is '.vtk', the output file is a VTK file

void Bput (const string & *mesh_file*) const

Write mesh data on a binary file.

Parameters

in	*mesh_file*	Mesh file name

void getList (vector< Node * > & *nl*) const

Fill vector `nl` with list of pointers to nodes.

Parameters

out	*nl*	Instance of class vector that contain on output the list

void getList (vector< Element * > & *el*) const

Fill vector `el` with list of pointers to elements.

Parameters

out	*el*	Instance of class vector that contain on output the list

void getList (vector< Side * > & *sl*) const

Fill vector `sl` with list of pointers to sides.

Parameters

out	*sl*	Instance of class vector that contain on output the list

size_t getNodeLabel (size_t *i*) const

Return label of `i`-th node.

Parameters

in	*i*	Node index

size_t getElementLabel (size_t *i*) const

Return label of `i`-th element.

Parameters

in	*i*	Element index

size_t getSideLabel (size_t *i*) const

Return label of `i`-th side.

Parameters

in	*i*	Side index

size_t getEdgeLabel (size_t *i*) const

Return label of `i`-th edge.

Parameters

in	*i*	Edge index

Element∗ getActiveElement ( ) const

Return pointer to current element and move to next one (Non constant version)

This function returns pointer to the current element only is this one is active. Otherwise it goes to the next active element (To be used when adaptive meshing is involved)

7.67.4 Friends And Related Function Documentation

void Refine (Mesh & *in_mesh,* Mesh & *out_mesh*) `[friend]`

Refine mesh. Subdivide each triangle into 4 subtriangles. This member function is valid for 2-D triangular meshes only.

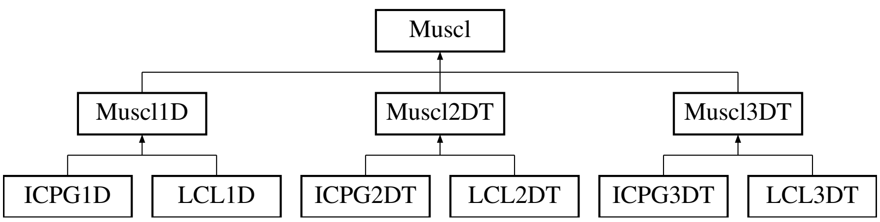
Parameters

in	*in_mesh*	Input mesh
out	*out_mesh*	Output mesh

7.68 Muscl Class Reference

Parent class for hyperbolic solvers with Muscl scheme.

Inheritance diagram for Muscl:



Public Types

Public Member Functions

- Muscl (Mesh &m)

  Constructor using mesh instance.
- virtual ~Muscl ()

  Destructor.
- void setTimeStep (real_t dt)

  Assign time step value.
- real_t getTimeStep () const

  Return time step value.
- void setCFL (real_t CFL)

  Assign CFL value.
- real_t getCFL () const

  Return CFL value.
- void setReferenceLength (real_t dx)

  Assign reference length value.
- real_t getReferenceLength () const

  Return reference length.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- void setVerbose (int v)

  Set verbosity parameter.
- bool setReconstruction (const Vect< real_t > &U, Vect< real_t > &LU, Vect< real_t > &RU, size_t dof)

  Function to reconstruct by the Muscl method.
- void setMethod (const Method &s)

  Choose a flux solver.
- void setSolidZoneCode (int c)

  Choose a code for solid zone.
- bool getSolidZone () const

  Return flag for presence of solid zones.
- int getSolidZoneCode () const

  Return code of solid zone, 0 if this one is not present.
- void setLimiter (Limiter l)

  Choose a flux limiter.

7.68.1 Detailed Description

Parent class for hyperbolic solvers with Muscl scheme.

Everything here is common for both 2D and 3D muscl methods ! Virtual functions are implemented in Muscl2D and Muscl3D classes

7.68.2 Member Enumeration Documentation

enum Method

Enumeration for flux choice.

Enumerator

FIRST_ORDER_METHOD First Order upwind method
MULTI_SLOPE_Q_METHOD Multislope Q method
MULTI_SLOPE_M_METHOD Multislope M method

enum Limiter

Enumeration of flux limiting methods.

Enumerator

MINMOD_LIMITER MinMod limiter
VANLEER_LIMITER Van Leer limiter
SUPERBEE_LIMITER Superbee limiter
VANALBADA_LIMITER Van Albada limiter
MAX_LIMITER Max limiter

enum SolverType

Enumeration of various solvers for the Riemann problem.

Enumerator

ROE_SOLVER Roe solver
VFROE_SOLVER Finite Volume Roe solver
LF_SOLVER LF solver
RUSANOV_SOLVER Rusanov solver
HLL_SOLVER HLL solver
HLLC_SOLVER HLLC solver
MAX_SOLVER Max solver

7.68.3 Member Function Documentation

void setTimeStep (real_t *dt*)

Assign time step value.

Parameters

`in`	*dt*	Time step value

void setCFL (real_t *CFL*)

Assign CFL value.

Parameters

in	*CFL*	Value of CFL

void setReferenceLength (real_t *dx*)

Assign reference length value.

Parameters

in	*dx*	Value of reference length

void setVerbose (int *v*)

Set verbosity parameter.

Parameters

in	*v*	Value of verbosity parameter

bool setReconstruction (const Vect< real_t > & *U*, Vect< real_t > & *LU*, Vect< real_t > & *RU*, size_t *dof*)

Function to reconstruct by the Muscl method.

Parameters

in	*U*	Field to reconstruct
out	*LU*	Left gradient vector
out	*RU*	Right gradient vector
in	*dof*	Label of dof to reconstruct

void setMethod (const Method & *s*)

Choose a flux solver.

Parameters

in	*s*	Solver to choose

void setLimiter (Limiter *l*)

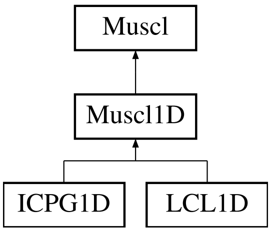
Choose a flux limiter.

Parameters

in	*l*	Limiter to choose

7.69 Muscl1D Class Reference

Class for 1-D hyperbolic solvers with Muscl scheme.
Inheritance diagram for Muscl1D:



Public Types

Public Member Functions

- Muscl1D (Mesh &m)

  Constructor using mesh instance.
- ~Muscl1D ()

  Destructor.
- real_t getMeanLength () const

  Return mean length.
- real_t getMaximumLength () const

  Return maximal length.
- real_t getMinimumLength () const

  Return mimal length.
- real_t getTauLim () const

  Return mean length.
- void print_mesh_stat ()

  Output mesh information.
- void setTimeStep (real_t dt)

  Assign time step value.
- real_t getTimeStep () const

  Return time step value.
- void setCFL (real_t CFL)

  Assign CFL value.
- real_t getCFL () const

  Return CFL value.
- void setReferenceLength (real_t dx)

  Assign reference length value.
- real_t getReferenceLength () const

  Return reference length.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- void setVerbose (int v)

  Set verbosity parameter.

- bool setReconstruction (const Vect< real_t > &U, Vect< real_t > &LU, Vect< real_t > &RU, size_t dof)

    Function to reconstruct by the Muscl method.
- void setMethod (const Method &s)

    Choose a flux solver.
- void setSolidZoneCode (int c)

    Choose a code for solid zone.
- bool getSolidZone () const

    Return flag for presence of solid zones.
- int getSolidZoneCode () const

    Return code of solid zone, 0 if this one is not present.
- void setLimiter (Limiter l)

    Choose a flux limiter.

7.69.1 Detailed Description

Class for 1-D hyperbolic solvers with Muscl scheme.

7.69.2 Member Enumeration Documentation

enum Method `[inherited]`

Enumeration for flux choice.

Enumerator

FIRST_ORDER_METHOD First Order upwind method

MULTI_SLOPE_Q_METHOD Multislope Q method

MULTI_SLOPE_M_METHOD Multislope M method

enum Limiter `[inherited]`

Enumeration of flux limiting methods.

Enumerator

MINMOD_LIMITER MinMod limiter

VANLEER_LIMITER Van Leer limiter

SUPERBEE_LIMITER Superbee limiter

VANALBADA_LIMITER Van Albada limiter

MAX_LIMITER Max limiter

enum SolverType `[inherited]`

Enumeration of various solvers for the Riemann problem.

Enumerator

ROE_SOLVER Roe solver

VFROE_SOLVER Finite Volume Roe solver

LF_SOLVER LF solver

RUSANOV_SOLVER Rusanov solver

HLL_SOLVER HLL solver

HLLC_SOLVER HLLC solver

MAX_SOLVER Max solver

7.69.3 Member Function Documentation

void setTimeStep (real_t *dt*) `[inherited]`

Assign time step value.

Parameters

in	*dt*	Time step value

void setCFL (real_t *CFL*) `[inherited]`

Assign CFL value.

Parameters

in	*CFL*	Value of CFL

void setReferenceLength (real_t *dx*) `[inherited]`

Assign reference length value.

Parameters

in	*dx*	Value of reference length

void setVerbose (int *v*) `[inherited]`

Set verbosity parameter.

Parameters

in	*v*	Value of verbosity parameter

bool setReconstruction (const Vect< real_t > & *U*, Vect< real_t > & *LU*, Vect< real_t > & *RU*, size_t *dof*) `[inherited]`

Function to reconstruct by the Muscl method.

Parameters

in	*U*	Field to reconstruct

Parameters

out	*LU*	Left gradient vector
out	*RU*	Right gradient vector
in	*dof*	Label of dof to reconstruct

void setMethod (const Method & *s*) `[inherited]`

Choose a flux solver.

Parameters

in	*s*	Solver to choose

void setLimiter (Limiter *l*) `[inherited]`

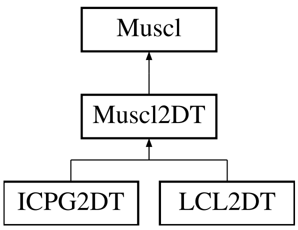
Choose a flux limiter.

Parameters

in	*l*	Limiter to choose

7.70 Muscl2DT Class Reference

Class for 2-D hyperbolic solvers with Muscl scheme.
Inheritance diagram for Muscl2DT:



Public Types

Public Member Functions

- Muscl2DT (Mesh &m)

  Constructor using mesh.
- ∼Muscl2DT ()

  Destructor.
- bool setReconstruction (const Vect< real_t > &U, Vect< real_t > &LU, Vect< real_t > &RU, size_t dof)

  Function to reconstruct by the Muscl method.
- void setTimeStep (real_t dt)

Assign time step value.

- real_t getTimeStep () const

  Return time step value.
- void setCFL (real_t CFL)

  Assign CFL value.
- real_t getCFL () const

  Return CFL value.
- void setReferenceLength (real_t dx)

  Assign reference length value.
- real_t getReferenceLength () const

  Return reference length.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- void setVerbose (int v)

  Set verbosity parameter.
- void setMethod (const Method &s)

  Choose a flux solver.
- void setSolidZoneCode (int c)

  Choose a code for solid zone.
- bool getSolidZone () const

  Return flag for presence of solid zones.
- int getSolidZoneCode () const

  Return code of solid zone, 0 if this one is not present.
- void setLimiter (Limiter l)

  Choose a flux limiter.

Protected Member Functions

- void Initialize ()

  Construction of normals to sides.

7.70.1 Detailed Description

Class for 2-D hyperbolic solvers with Muscl scheme.

7.70.2 Member Enumeration Documentation

enum Method `[inherited]`

Enumeration for flux choice.

Enumerator

FIRST_ORDER_METHOD First Order upwind method

MULTI_SLOPE_Q_METHOD Multislope Q method

MULTI_SLOPE_M_METHOD Multislope M method

enum Limiter `[inherited]`

Enumeration of flux limiting methods.

Enumerator

MINMOD_LIMITER MinMod limiter

VANLEER_LIMITER Van Leer limiter

SUPERBEE_LIMITER Superbee limiter

VANALBADA_LIMITER Van Albada limiter

MAX_LIMITER Max limiter

enum SolverType `[inherited]`

Enumeration of various solvers for the Riemann problem.

Enumerator

ROE_SOLVER Roe solver

VFROE_SOLVER Finite Volume Roe solver

LF_SOLVER LF solver

RUSANOV_SOLVER Rusanov solver

HLL_SOLVER HLL solver

HLLC_SOLVER HLLC solver

MAX_SOLVER Max solver

7.70.3 Member Function Documentation

bool setReconstruction (const Vect< real_t > & *U*, Vect< real_t > & *LU*, Vect< real_t > & *RU*, size_t *dof*)

Function to reconstruct by the Muscl method.

Parameters

in	*U*	Field to reconstruct
out	*LU*	Left gradient vector
out	*RU*	Right gradient vector
in	*dof*	Label of dof to reconstruct

void Initialize ( ) `[protected]`

Construction of normals to sides.

Convention: for a given side, getPtrElement(1) is the left element and getPtrElement(2) is the right element. The normal goes from left to right. For boundary sides, the normal points outward.

void setTimeStep (real_t *dt*) `[inherited]`

Assign time step value.

Parameters

`in`	*dt*	Time step value

void setCFL (real_t *CFL*) `[inherited]`

Assign CFL value.

Parameters

`in`	*CFL*	Value of CFL

void setReferenceLength (real_t *dx*) `[inherited]`

Assign reference length value.

Parameters

`in`	*dx*	Value of reference length

void setVerbose (int *v*) `[inherited]`

Set verbosity parameter.

Parameters

`in`	*v*	Value of verbosity parameter

void setMethod (const Method & *s*) `[inherited]`

Choose a flux solver.

Parameters

`in`	*s*	Solver to choose

void setLimiter (Limiter *l*) `[inherited]`

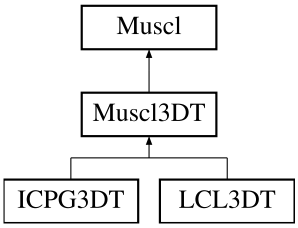
Choose a flux limiter.

Parameters

`in`	*l*	Limiter to choose

7.71 Muscl3DT Class Reference

Class for 3-D hyperbolic solvers with Muscl scheme using tetrahedra.
Inheritance diagram for Muscl3DT:



Public Types

Public Member Functions

- Muscl3DT (Mesh &m)

  Constructor using mesh.
- ∼Muscl3DT ()

  Destructor.
- bool setReconstruction (const Vect< real_t > &U, Vect< real_t > &LU, Vect< real_t > &RU, size_t dof)

  Function to reconstruct by the Muscl method.
- real_t getMinimumFaceArea () const

  Return minimum area of faces in the mesh.
- real_t getMinimumElementVolume () const

  Return minimum volume of elements in the mesh.
- real_t getMaximumFaceArea () const

  Return maximum area of faces in the mesh.
- real_t getMaximumElementVolume () const

  Return maximum volume of elements in the mesh.
- real_t getMeanFaceArea () const

  Return mean area of faces in the mesh.
- real_t getMeanElementVolume () const

  Return mean volume of elements in the mesh.
- real_t getMinimumEdgeLength () const

  Return minimum length of edges in the mesh.
- real_t getMinimumVolumebyArea () const

  Return minimum volume by area in the mesh.
- real_t getMaximumEdgeLength () const

  Return maximum length of edges in the mesh.
- real_t getTauLim () const

  Return value of tau lim.
- real_t getComega () const

  Return value of Comega.
- void setbetalim (real_t bl)

  Assign value of beta lim.

- void setTimeStep (real_t dt)

  Assign time step value.
- real_t getTimeStep () const

  Return time step value.
- void setCFL (real_t CFL)

  Assign CFL value.
- real_t getCFL () const

  Return CFL value.
- void setReferenceLength (real_t dx)

  Assign reference length value.
- real_t getReferenceLength () const

  Return reference length.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- void setVerbose (int v)

  Set verbosity parameter.
- void setMethod (const Method &s)

  Choose a flux solver.
- void setSolidZoneCode (int c)

  Choose a code for solid zone.
- bool getSolidZone () const

  Return flag for presence of solid zones.
- int getSolidZoneCode () const

  Return code of solid zone, 0 if this one is not present.
- void setLimiter (Limiter l)

  Choose a flux limiter.

7.71.1 Detailed Description

Class for 3-D hyperbolic solvers with Muscl scheme using tetrahedra.

7.71.2 Member Enumeration Documentation

enum Method `[inherited]`

Enumeration for flux choice.

Enumerator

FIRST_ORDER_METHOD First Order upwind method

MULTI_SLOPE_Q_METHOD Multislope Q method

MULTI_SLOPE_M_METHOD Multislope M method

enum Limiter `[inherited]`

Enumeration of flux limiting methods.

Enumerator

MINMOD_LIMITER MinMod limiter

VANLEER_LIMITER Van Leer limiter

SUPERBEE_LIMITER Superbee limiter

VANALBADA_LIMITER Van Albada limiter

MAX_LIMITER Max limiter

enum SolverType `[inherited]`

Enumeration of various solvers for the Riemann problem.

Enumerator

ROE_SOLVER Roe solver

VFROE_SOLVER Finite Volume Roe solver

LF_SOLVER LF solver

RUSANOV_SOLVER Rusanov solver

HLL_SOLVER HLL solver

HLLC_SOLVER HLLC solver

MAX_SOLVER Max solver

7.71.3 Member Function Documentation

bool setReconstruction (const Vect< real_t > & *U*, Vect< real_t > & *LU*, Vect< real_t > & *RU*, size_t *dof*)

Function to reconstruct by the Muscl method.

Parameters

in	*U*	Field to reconstruct
out	*LU*	Left gradient vector
out	*RU*	Right gradient vector
in	*dof*	Label of dof to reconstruct

void setTimeStep (real_t *dt*) `[inherited]`

Assign time step value.

Parameters

in	*dt*	Time step value

void setCFL (real_t *CFL*) `[inherited]`

Assign CFL value.

Parameters

in	*CFL*	Value of CFL

void setReferenceLength (real_t *dx*) `[inherited]`

Assign reference length value.

Parameters

in	*dx*	Value of reference length

void setVerbose (int *v*) `[inherited]`

Set verbosity parameter.

Parameters

in	*v*	Value of verbosity parameter

void setMethod (const Method & *s*) `[inherited]`

Choose a flux solver.

Parameters

in	*s*	Solver to choose

void setLimiter (Limiter *l*) `[inherited]`

Choose a flux limiter.

Parameters

in	*l*	Limiter to choose

7.72 Node Class Reference

To describe a node.

Public Member Functions

- Node ()

Default constructor.
- Node (size_t label, const Point< real_t > &x)

  Constructor with label and coordinates.
- Node (const Node &node)

  Copy Constructor.
- ∼Node ()

  Destructor.
- void setLabel (size_t label)

  Define label of node.
- void setNbDOF (size_t n)

  Define number of DOF.
- void setFirstDOF (size_t n)

  Define First DOF.
- void setCode (size_t dof, int code)

  Define code for a given DOF of node.
- void setCode (const vector< int > &code)

  Define codes for all node DOFs.
- void setCode (int ∗code)

  Define codes for all node DOFs.
- void setCode (const string &exp, int code, size_t dof=1)

  Define code by a boolean algebraic expression invoking node coordinates.
- void setCoord (size_t i, real_t x)

  Set i-th coordinate.
- void DOF (size_t i, size_t dof)

  Define label of DOF.
- void setDOF (size_t &first_dof, size_t nb_dof)

  Define number of DOF.
- void setOnBoundary ()

  Set node as boundary node.
- size_t n () const

  Return label of node.
- size_t getNbDOF () const

  Return number of degrees of freedom (DOF)
- int getCode (size_t dof=1) const

  Return code for a given DOF of node.
- real_t getCoord (size_t i) const

  Return i-th coordinate of node. i = 1..3.
- Point< real_t > getCoord () const

  Return coordinates of node.
- real_t getX () const

  Return x-coordinate of node.
- real_t getY () const

  Return y-coordinate of node.
- real_t getZ () const

  Return z-coordinate of node.
- Point< real_t > getXYZ () const

Return coordinates of node.

- size_t getDOF (size_t i) const

  Return label of i-th dof.
- size_t getNbNeigEl () const

  Return number of neighbor elements.
- Element * getNeigEl (size_t i) const

  Return i-th neighbor element.
- size_t getFirstDOF () const

  Return label of first DOF of node.
- bool isOnBoundary () const

  Say if node is a boundary node.
- void Add (Element *el)

  Add element pointed by `el` as neighbor element to node.
- void setLevel (int level)

  Assign a level to current node.
- int getLevel () const

  Return node level Node level decreases when element is refined (starting from 0). If the level is 0, then the element has no parents.

7.72.1 Detailed Description

To describe a node.

A node is characterized by its label, its coordinates, its number of degrees of freedom (DOF) and codes that are associated to each DOF.

Remarks

Once the mesh is constructed, information on neighboring elements of node can be retrieved (see appropriate member functions). However, the member function getNode↩ NeighborElements of Mesh must have been called before. If this is not the case, the program crashes down since no preliminary checking is done for efficiency reasons.

7.72.2 Constructor & Destructor Documentation

Node ( )

Default constructor.

Initialize data to zero

Node (size_t *label*, const Point< real_t > & *x*)

Constructor with label and coordinates.

Parameters

in	*label*	Label of node
in	*x*	Node coordinates

7.72.3 Member Function Documentation

void setCode (size_t *dof*, int *code*)

Define code for a given DOF of node.

Parameters

in	*dof*	DOF index
in	*code*	Code to assign to DOF

void setCode (const vector< int > & *code*)

Define codes for all node DOFs.

Parameters

in	*code*	vector instance that contains code for each DOF of current node

void setCode (int * *code*)

Define codes for all node DOFs.

Parameters

in	*code*	C-array that contains code for each DOF of current node

void setCode (const string & *exp*, int *code*, size_t *dof* = 1)

Define code by a boolean algebraic expression invoking node coordinates.

Parameters

in	*exp*	Boolean algebraic expression as required by `fparser`
in	*code*	Code to assign to node if the algebraic expression is true
in	*dof*	Degree of Freedom for which code is assigned [Default: 1]

void setCoord (size_t *i*, real_t *x*)

Set i-th coordinate.

Parameters

in	*i*	Coordinate index (1..3)
in	*x*	Coordinate value

void DOF (size_t *i*, size_t *dof*)

Define label of DOF.

Parameters

in	*i*	DOF index
in	*dof*	Label of DOF

void setDOF (size_t & *first_dof*, size_t *nb_dof*)

Define number of DOF.

Parameters

in,out	*first_dof*	Label of the first DOF in input that is actualized
in	*nb_dof*	Number of DOF

void setOnBoundary ( )

Set node as boundary node.
This function is mostly internally used (Especially in class Mesh)

int getCode (size_t *dof* = *1*) const

Return code for a given DOF of node.

Parameters

in	*dof*	label of degree of freedom for which code is to be returned. Default value is 1.

Point<real_t> getCoord ( ) const

Return coordinates of node.
Return value is an instance of class Point

Point<real_t> getXYZ ( ) const

Return coordinates of node.
Return value is an instance of class Point

size_t getNbNeigEl ( ) const

Return number of neighbor elements.
Neighbor elements are those that share node. Note that the returned information is valid only if the Mesh member function **getNodeNeighborElements()** has been invoked before

Element∗ getNeigEl (size_t *i*) const

Return i-th neighbor element.

Note that the returned information is valid only if the Mesh member function **getNode↩ NeighborElements()** has been invoked before

bool isOnBoundary ( ) const

Say if node is a boundary node.

Note this information is available only if boundary sides (and nodes) were determined (See class Mesh).

void setLevel (int *level*)

Assign a level to current node.

This member function is useful for mesh adaption.

Default node's level is zero

7.73 NodeList Class Reference

Class to construct a list of nodes having some common properties.

Public Member Functions

- NodeList (Mesh &ms)

  Constructor using a Mesh instance.
- ∼NodeList ()

  Destructor.
- void selectCode (int code, int dof=1)

  Select nodes having a given code for a given degree of freedom.
- void unselectCode (int code, int dof=1)

  Unselect nodes having a given code for a given degree of freedom.
- void selectCoordinate (real_t x, real_t y=ANY, real_t z=ANY)

  Select nodes having given coordinates.
- size_t getNbNodes () const

  Return number of selected nodes.
- void top ()

  Reset list of nodes at its top position (Non constant version)
- void top () const

  Reset list of nodes at its top position (Constant version)
- Node ∗ get ()

  Return pointer to current node and move to next one (Non constant version)
- Node ∗ get () const

  Return pointer to current node and move to next one (Constant version)

7.73.1 Detailed Description

Class to construct a list of nodes having some common properties.

This class enables choosing multiple selection criteria by using function `select...` However, the intersection of these properties must be empty.

7.73.2 Member Function Documentation

void selectCode (int *code*, int *dof* = *1*)

Select nodes having a given code for a given degree of freedom.

Parameters

`in`	*code*	Code that nodes share
`in`	*dof*	Degree of Freedom label [Default: `1`]

void unselectCode (int *code*, int *dof* = *1*)

Unselect nodes having a given code for a given degree of freedom.

Parameters

`in`	*code*	Code of nodes to exclude
`in`	*dof*	Degree of Freedom label [Default: `1`]

void selectCoordinate (real_t *x*, real_t *y* = *ANY*, real_t *z* = *ANY*)

Select nodes having given coordinates.

Parameters

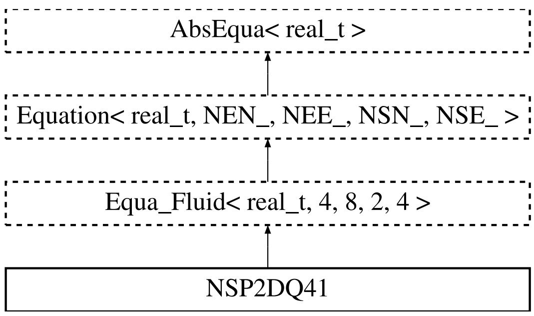
`in`	*x*	x-coordinate that share the selected nodes
`in`	*y*	y-coordinate that share the selected nodes [Default: `ANY`]
`in`	*z*	z-coordinate that share the selected nodes [Default: `ANY`]

Coordinates can be assigned the value `ANY`. This means that any coordinate value is accepted. For instance, to select all nodes with `x=0`, use **selectCoordinate**(0.,ANY,ANY);

7.74 NSP2DQ41 Class Reference

Builds finite element arrays for incompressible Navier-Stokes equations in 2-D domains using Q_1/P_0 element and a penaly formulation for the incompressibility condition.

Inheritance diagram for NSP2DQ41:



Public Member Functions

- NSP2DQ41 ()
  Default Constructor.
- NSP2DQ41 (const Element ∗el)
  Constructor using Element data.
- NSP2DQ41 (const Side ∗sd)
  Constructor using Side data.
- NSP2DQ41 (const Element ∗el, const Vect< real_t > &u, const real_t &time=0.)
  Constructor using element and previous time data.
- NSP2DQ41 (const Side ∗sd, const Vect< real_t > &u, const real_t &time=0.)
  Constructor using side and previous time data.
- ∼NSP2DQ41 ()
  Destructor.
- void Viscosity (real_t visc)
  Define constant viscosity.
- void Density (real_t dens)
  Define constant density.
- void LMass (real_t coef=1.)
  Add element lumped mass contribution to matrix after multiplication by `coef` *[Default:* `1`*].*
- void Mass (real_t coef=1.)
  Add element consistent mass contribution to matrix after multiplication by `coef` *[Default:* `1`*].*
- void Viscous (real_t coef=1.)
  Add element viscous contribution to matrix after multiplication by `coef` *[Default:* `1`*].*
- void RHS_Viscous (real_t coef=1.)
  Add element viscous contribution to right-hand side after multiplication by `coef` *[Default:* `1`*].*
- void Penal (real_t coef=1.)
  Add element penalty contribution to matrix after multiplication by `coef` *[Default:* `1`*].*
- void LHS1_Convection (real_t coef=1.)
  Add convection contribution to left-hand side after multiplication by `coef` *[Default:* `1`*].*
- void LHS2_Convection (real_t coef=1.)
  Add convection contribution to left-hand side after multiplication by `coef` *[Default:* `1`*].*
- void RHS_Convection (real_t coef=1.)
  Add convection contribution to right-hand side after multiplication by `coef` *[Default:* `1`*].*
- void BodyRHS (UserData< real_t > &ud)
  Add body right-hand side term to right-hand side.
- void BoundaryRHS (UserData< real_t > &ud)
  Add boundary right-hand side term to right-hand side.
- void Periodic (real_t coef=1.e20)
  Add contribution of periodic boundary condition (by a penalty technique).
- real_t Pressure (real_t coef=1.)
  Calculate element pressure by penalization after multiplication by `coef` *[Default:* `1`*].*
- void updateBC (const Element &el, const Vect< real_t > &bc)
  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)
  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)

  Assemble side right-hand side vector into global one.
- void SideAssembly (Matrix< real_t > *A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)

Assemble side (edge or face) matrix into global one.

- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > *A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

LocalVect instance containing local right-hand side vector associated to current element.

- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.

- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Viscosity (const real_t &visc)

  Set (constant) Viscosity.

- void Viscosity (const string &exp)

  Set viscosity given by an algebraic expression.

- void Density (const real_t &dens)

  Set (constant) Viscosity.

- void Density (const string &exp)

  Set Density given by an algebraic expression.

- void ThermalExpansion (const real_t *e)

  Set (constant) thermal expansion coefficient.

- void ThermalExpansion (const string &exp)

  Set thermal expansion coefficient given by an algebraic expression.

- void setMaterial ()

  Set material properties.

- void Init (const Element *el)

  Set element arrays to zero.

- void Init (const Side *sd)

  Set side arrays to zero.

7.74.1 Detailed Description

Builds finite element arrays for incompressible Navier-Stokes equations in 2-D domains using Q_1/P_0 element and a penaly formulation for the incompressibility condition.

7.74.2 Constructor & Destructor Documentation

NSP2DQ41 ( )

Default Constructor.
Builds an empty equation

NSP2DQ41 (const Element * *el*)

Constructor using Element data.

Parameters

in	*el*	Pointer to Element instance

NSP2DQ41 (const Side * *sd*)

Constructor using Side data.

Parameters

in	*sd*	Pointer to Side instance

NSP2DQ41 (const Element * *el*, const Vect< real_t > & *u*, const real_t & *time* = 0.)

Constructor using element and previous time data.

Parameters

in	*el*	Pointer to Element instance
in	*u*	Vector that contains velocity at previous time step
in	*time*	Time value [Default: `0.`]

NSP2DQ41 (const Side * *sd*, const Vect< real_t > & *u*, const real_t & *time* = 0.)

Constructor using side and previous time data.

Parameters

in	*sd*	Pointer to Side instance
in	*u*	Vector that contains velocity at previous time step
in	*time*	Time value [Default: `0.`]

7.74.3 Member Function Documentation

void LHS1_Convection (real_t *coef* = 1.)

Add convection contribution to left-hand side after multiplication by `coef` [Default: `1`].
First term, explicit velocity, implicit velocity derivatives

void LHS2_Convection (real_t *coef* = 1.)

Add convection contribution to left-hand side after multiplication by `coef` [Default: `1`].
Second term, implicit velocity, explicit velocity derivatives

void BodyRHS (UserData< real_t > & *ud*)

Add body right-hand side term to right-hand side.

Parameters

in	*ud*	UserData instance that defines data

void BoundaryRHS (UserData< real_t > & *ud*)

Add boundary right-hand side term to right-hand side.

Parameters

in	*ud*	UserData instance that defines data

void Periodic (real_t *coef* = *1.e20* **)**

Add contribution of periodic boundary condition (by a penalty technique).

Boundary nodes where periodic boundary conditions are to be imposed must have codes equal to `PERIODIC_A` on one side and `PERIODIC_B` on the opposite side.

Parameters

in	*coef*	Value of penalty parameter [Default: `1.e20`].

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, **int *dof* =** *0* **)** `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides

Parameters

in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.
in	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

`in`	*b*	Global vector to be localized
`in`	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
`in`	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > ∗ *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) [inherited]

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) [inherited]

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) [inherited]

Assemble element matrix into global one.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect< real_t > & *v*) [inherited]

Assemble element vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	*v*	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > ∗ *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

`in`	*el*	Reference to Element instance
`in`	*x*	Global vector to multiply by (Vect instance)
`out`	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

`in`	*sd*	Reference to Side instance
`in`	*x*	Global vector to multiply by (Vect instance)
`out`	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

`in`	*exp*	Algebraic expression
`in`	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, Preconditioner *pc* = `IDENT_PREC` **)** `[inherited]`

Choose solver for the linear system.

Parameters

`in`	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
`in`	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > ∗ *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

`in`	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	*b*	Vector containing right-hand side
`in,out`	*x*	Vector containing initial guess of solution on input, actual solution on output

7.74.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

LocalVect instance containing local vector associated to current element.

This vector has been stored as the one at previous iteration or previous time step

7.75 ODESolver Class Reference

To solve a system of ordinary differential equations.

Public Member Functions

- ODESolver ()

  Default constructor.
- ODESolver (TimeScheme s, real_t time_step=theTimeStep, real_t final_time=theFinalTime, size_t nb_eq=1)

  Constructor using time discretization data.
- ~ODESolver ()

  Destructor.
- void set (TimeScheme s, real_t time_step=theTimeStep, real_t final_time=theFinalTime)

  Define data of the differential equation or system.
- void setNbEq (size_t nb_eq)

  Set the number of equations [Default: 1].
- void setCoef (real_t a0, real_t a1, real_t a2, real_t f)

  Define coefficients in the case of a scalar differential equation.
- void setCoef (string a0, string a1, string a2, string f)

  Define coefficients in the case of a scalar differential equation.
- void setF (string F)

  Set time derivative, given as an algebraic expression, for a nonlinear ODE.
- void setRK4RHS (real_t f)

  Set intermediate right-hand side vector for the Runge-Kutta method.
- void setRK4RHS (Vect< real_t > &f)

  Set intermediate right-hand side vector for the Runge-Kutta method.
- void setInitial (Vect< real_t > &u)

  Set initial condition for a first-oder system of differential equations.
- void setInitial (Vect< real_t > &u, Vect< real_t > &v)

  Set initial condition for a second-order system of differential equations.
- void setInitialRHS (Vect< real_t > &f)

  Set initial RHS for a system of differential equations.
- void setInitial (real_t u, real_t v)

  Set initial condition for a second-order ordinary differential equation.
- void setInitial (real_t u)

  Set initial condition for a first-order ordinary differential equation.
- void setInitialRHS (real_t f)

  Set initial right-hand side for a single differential equation.
- void setMatrices (DMatrix< real_t > &A0, DMatrix< real_t > &A1)

  Define matrices for a system of first-order ODEs.
- void setMatrices (DMatrix< real_t > &A0, DMatrix< real_t > &A1, DMatrix< real_t > &A2)

  Define matrices for a system of second ODEs.
- void setRHS (Vect< real_t > &b)

  Set right-hand side vector for a system of ODE.
- void setRHS (real_t f)

  Set right-hand side for a linear ODE.

- void setRHS (string f)

  Set right-hand side value for a linear ODE.
- void setNewmarkParameters (real_t beta, real_t gamma)

  Define parameters for the Newmarxk scheme.
- void setConstantMatrix ()

  Say that matrix problem is constant.
- void setNonConstantMatrix ()

  Say that matrix problem is variable.
- void setLinearSolver (Iteration s=DIRECT_SOLVER, Preconditioner p=DIAG_PREC)

  Set linear solver data.
- void setVerbose (int v=0)

  Set verbosity parameter:
- real_t runOneTimeStep ()

  Run one time step.
- void run (bool opt=false)

  Run the time stepping procedure.
- LinearSolver< real_t > & getLSolver ()

  Return LinearSolver instance.
- real_t get () const

  Return solution in the case of a scalar equation.

7.75.1 Detailed Description

To solve a system of ordinary differential equations.

The class ODESolver enables solving by a numerical scheme a system or ordinary differential equations taking one of the forms:

- A linear system of differential equations of the first-order:
  A_1(t)u'(t) + A_0(t)u(t) = f(t)
- A linear system of differential equations of the second-order:
  A_2(t)u"(t) + A_1(t)u'(t) + A_0(t)u(t) = f(t)
- A system of ordinary differential equations of the form:
  u'(t) = f(t,u(t))

The following time integration schemes can be used:

- Forward Euler scheme (value: *FORWARD_EULER*) for first-order systems
- Backward Euler scheme (value: *BACKWARD_EULER*) for first-order linear systems
- Crank-Nicolson (value: *CRANK_NICOLSON*) for first-order linear systems
- Heun (value: *HEUN*) for first-order systems
- 2nd Order Adams-Bashforth (value: *AB2*) for first-order systems
- 4-th order Runge-Kutta (value: *RK4*) for first-order systems
- 2nd order Backward Differentiation Formula (value: *BDF2*) for linear first-order systems
- Newmark (value: *NEWMARK*) for linear second-order systems with constant matrices

7.75.2 Constructor & Destructor Documentation

ODESolver (TimeScheme *s*, real_t *time_step* = theTimeStep, real_t *final_time* = theFinalTime, size_t *nb_eq* = *1*)

Constructor using time discretization data.

Parameters

in	*s*	Choice of the scheme: To be chosen in the enumerated variable *TimeScheme* (see the presentation of the class)
in	*time_step*	Value of the time step. This value will be modified if an adaptive method is used. The default value for this parameter if the value given by the global variable `theTimeStep`
in	*final_time*	Value of the final time (time starts at 0). The default value for this parameter is the value given by the global variable `theFinalTime`
in	*nb_eq*	Number of differential equations (size of the system) [Default: `1`]

7.75.3 Member Function Documentation

void set (TimeScheme *s*, real_t *time_step* = theTimeStep, real_t *final_time* = theFinalTime)

Define data of the differential equation or system.

Parameters

in	*s*	Choice of the scheme: To be chosen in the enumerated variable *TimeScheme* (see the presentation of the class)
in	*time_step*	Value of the time step. This value will be modified if an adaptive method is used. The default value for this parameter if the value given by the global variable `theTimeStep`
in	*final_time*	Value of the final time (time starts at 0). The default value for this parameter is the value given by the global variable `theFinalTime`

void setNbEq (size_t *nb_eq*)

Set the number of equations [Default: `1`].

This function is to be used if the default constructor was used

void setCoef (real_t *a0*, real_t *a1*, real_t *a2*, real_t *f*)

Define coefficients in the case of a scalar differential equation.

This function enables giving coefficients of the differential equation as an algebraic expression of time t (see the function fparse)

Parameters

in	*a0*	Coefficient of the 0-th order term
in	*a1*	Coefficient of the 1-st order term
in	*a2*	Coefficient of the 2-nd order term

Parameters

in	*f*	Value of the right-hand side

Note

Naturally, the equation is of the first order if *a2=0*

void setCoef (string *a0*, string *a1*, string *a2*, string *f*)

Define coefficients in the case of a scalar differential equation.

Parameters

in	*a0*	Coefficient of the 0-th order term
in	*a1*	Coefficient of the 1-st order term
in	*a2*	Coefficient of the 2-nd order term
in	*f*	Value of the right-hand side

Note

Naturally, the equation if of the first order if *a2=0*

void setF (string *F*)

Set time derivative, given as an algebraic expression, for a nonlinear ODE.

This function enables prescribing the value of the 1-st derivative for a 1st order ODE or the 2nd one for a 2nd-order ODE. It is to be used for nonlinear ODEs of the form y'(t) = f(t,y(t)) or y''(t) = f(t,y(t),y'(t))
In the case of a system of ODEs, this function can be called once for each equation, given in the order of the unknowns

void setRK4RHS (real_t *f*)

Set intermediate right-hand side vector for the Runge-Kutta method.

Parameters

in	*f*	

void setRK4RHS (Vect< real_t > & *f*)

Set intermediate right-hand side vector for the Runge-Kutta method.

Parameters

in	*f*	right-hand side vector

void setInitial (Vect< real_t > & *u*)

Set initial condition for a first-oder system of differential equations.

Parameters

in	*u*	Vector containing initial condition for the unknown

void setInitial (Vect< real_t > & *u*, Vect< real_t > & *v*)

Set initial condition for a second-order system of differential equations.

Giving the right-hand side at initial time is somtimes required for high order methods like Runge-Kutta

Parameters

in	*u*	Vector containing initial condition for the unknown
in	*v*	Vector containing initial condition for the time derivative of the unknown

void setInitialRHS (Vect< real_t > & *f*)

Set initial RHS for a system of differential equations.

Giving the right-hand side at initial time is somtimes required for high order methods like Runge-Kutta

Parameters

in	*f*	Vector containing right-hand side at initial time. This vector is helpful for high order methods

void setInitial (real_t *u*, real_t *v*)

Set initial condition for a second-order ordinary differential equation.

Parameters

in	*u*	Initial condition (unknown) value
in	*v*	Initial condition (time derivative of the unknown) value

void setInitial (real_t *u*)

Set initial condition for a first-order ordinary differential equation.

Parameters

in	*u*	Initial condition (unknown) value

void setInitialRHS (real_t *f*)

Set initial right-hand side for a single differential equation.

Parameters

in	*f*	Value of right-hand side at initial time. This value is helpful for high order methods

void setMatrices (DMatrix< real_t > & *A0*, DMatrix< real_t > & *A1*)

Define matrices for a system of first-order ODEs.
Matrices are given as references to class DMatrix.

Parameters

in	*A0*	Reference to matrix in front of the 0-th order term (no time derivative)
in	*A1*	Reference to matrix in front of the 1-st order term (first time derivative)

Remarks

This function has to be called at each time step

void setMatrices (DMatrix< real_t > & *A0*, DMatrix< real_t > & *A1*, DMatrix< real_t > & *A2*)

Define matrices for a system of second ODEs.
Matrices are given as references to class DMatrix.

Parameters

in	*A0*	Reference to matrix in front of the 0-th order term (no time derivative)
in	*A1*	Reference to matrix in front of the 1-st order term (first time derivative)
in	*A2*	Reference to matrix in front of the 2-nd order term (second time derivative)

Remarks

This function has to be called at each time step

void setRHS (Vect< real_t > & *b*)

Set right-hand side vector for a system of ODE.

Parameters

in	*b*	Vect instance containing right-hand side for a linear system of ordinary differential equations

void setRHS (real_t *f*)

Set right-hand side for a linear ODE.

Parameters

in	*f*	Value of the right-hand side for a linear ordinary differential equation

void setNewmarkParameters (real_t *beta*, real_t *gamma*)

Define parameters for the Newmarxk scheme.

Parameters

in	*beta*	Parameter beta [Default: `0.25`]
in	*gamma*	Parameter gamma [Default: `0.5`]

void setConstantMatrix ( )

Say that matrix problem is constant.

This is useful if the linear system is solved by a factorization method but has no effect otherwise

void setNonConstantMatrix ( )

Say that matrix problem is variable.

This is useful if the linear system is solved by a factorization method but has no effect otherwise

void setLinearSolver (Iteration *s* = DIRECT_SOLVER, Preconditioner *p* = DIAG_PREC)

Set linear solver data.

Parameters

in	*s*	Solver identification parameter. To be chosen in the enumeration variable Iteration: DIRECT_SOLVER, CG_SOLVER, CGS_SOLVER, BICG_SOLVER, BICG_STAB_SOLVER, GMRES_SOLVER, QMR_SOLVER [Default: `DIRECT_SOLVER`]
in	*p*	Preconditioner identification parameter. To be chosen in the enumeration variable Preconditioner: IDENT_PREC, DIAG_PREC, ILU_PREC [Default: `DIAG_PREC`]

Note

The argument *p* has no effect if the solver is DIRECT_SOLVER

void setVerbose (int *v* = *0*)

Set verbosity parameter:

- = 0, No output

- = 1, Print step label and time value
- = 2, Print step label, time value, time step and integration scheme

real_t runOneTimeStep ( )

Run one time step.

Returns

Value of new time step if this one is updated

void run (bool *opt* = `false`)

Run the time stepping procedure.

Parameters

in	*opt*	Flag to say if problem matrix is constant while time stepping (true) or not (Default value is false)

Note

This argument is not used if the time stepping scheme is explicit

7.76 Partition Class Reference

To partition a finite element mesh into balanced submeshes.

Public Member Functions

- Partition ()
  Default constructor.
- Partition (Mesh &mesh, size_t n, int verb=0)
  Constructor to partition a mesh into submeshes.
- Partition (Mesh &mesh, int n, vector< int > &epart, int verb=0)
  Constructor using already created submeshes.
- ~Partition ()
  Destructor.
- size_t getNbSubMeshes () const
  Return number of submeshes.
- size_t getNbNodes (size_t i) const
  Return number of nodes in given submesh.
- size_t getNbElements (size_t i) const
  Return number of elements in given submesh.
- Mesh * getMesh ()
  Return the global Mesh instance.
- Mesh * getMesh (size_t i)
  Return the submesh of label `i`

- size_t getNodeLabelInSubMesh (size_t sm, size_t label) const
  Return node label in subdomain by giving its label in initial mesh.
- size_t getElementLabelInSubMesh (size_t sm, size_t label) const
  Return element label in subdomain by giving its label in initial mesh.
- size_t getNodeLabelInMesh (size_t sm, size_t label) const
  Return node label in initial mesh by giving its label in submesh.
- size_t getElementLabelInMesh (size_t sm, size_t label) const
  Return element label in initial mesh by giving its label in submesh.
- size_t getNbInterfaceSides (size_t sm) const
  Return Number of interface sides for a given sub-mesh.
- size_t getSubMesh (size_t sm, size_t i) const
  Return index of submesh that contains the `i`-th side label in sub-mesh `sm`
- Mesh & getSubMesh (size_t i) const
  Return reference to submesh.
- size_t getFirstSideLabel (size_t sm, size_t i) const
  Return i-th side label in a given submesh.
- size_t getSecondSideLabel (size_t sm, size_t i) const
  Return side label in the neighbouring submesh corresponding to `i`-th side label in sub-mesh `sm`
- int getNbConnectInSubMesh (int n, int s) const
  Get number of connected nodes in a submesh.
- int getNbConnectOutSubMesh (int n, int s) const
  Get number of connected nodes out of a submesh.
- void put (size_t n, string file) const
  Save a submesh in file.
- void setVerbose (int verb)
  Set Message Level.
- void set (Mesh &mesh, size_t n)
  Set Mesh instance.

Friends

- ostream & operator<< (ostream &s, const Partition &p)
  Output class information.

7.76.1 Detailed Description

To partition a finite element mesh into balanced submeshes.

Class Partition enables partitioning a given mesh into a given number of submeshes with a minimal connectivity. Partition uses the well known `metis` library that is included in the OFELI library. A more detailed description of metis can be found in the web site:
`http://www.csit.fsu.edu/~burkardt/c_src/metis/metis.html`

7.76.2 Constructor & Destructor Documentation

Partition (Mesh & *mesh*, size_t *n*, int *verb* = `0`)

Constructor to partition a mesh into submeshes.

Parameters

in	*mesh*	Mesh instance
in	*n*	Number of submeshes
in	*verb*	Verbosity parameter [Default: 0]

Partition (Mesh & *mesh*, int *n*, vector< int > & *epart*, int *verb* = 0)

Constructor using already created submeshes.

Parameters

in	*mesh*	Mesh instance
in	*n*	Number of submeshes
in	*epart*	Vector containing for each element its submesh label (Running from 0 to `n-1`
in	*verb*	Verbosity parameter [Default: 0]

7.76.3 Member Function Documentation

size_t getNodeLabelInSubMesh (size_t *sm*, size_t *label*) const

Return node label in subdomain by giving its label in initial mesh.

Parameters

in	*sm*	Label of submesh
in	*label*	Label of node in initial mesh

size_t getNodeLabelInMesh (size_t *sm*, size_t *label*) const

Return node label in initial mesh by giving its label in submesh.

Parameters

in	*sm*	Label of submesh
in	*label*	Node label

size_t getSubMesh (size_t *sm*, size_t *i*) const

Return index of submesh that contains the `i`-th side label in sub-mesh `sm`

Parameters

in	*sm*	Submesh index
in	*i*	Side label

Returns

Mesh& getSubMesh (size_t *i*) const

Return reference to submesh.

Parameters

in	*i*	Submesh index

Returns

Reference to corresponding Mesh instance

size_t getFirstSideLabel (size_t *sm*, size_t *i*) const

Return i-th side label in a given submesh.

Parameters

in	*sm*	Index of submesh
in	*i*	Label of side

size_t getSecondSideLabel (size_t *sm*, size_t *i*) const

Return side label in the neighbouring submesh corresponding to `i`-th side label in sub-mesh `sm`

Parameters

in	*sm*	Label of submesh
in	*i*	Side label

int getNbConnectInSubMesh (int *n*, int *s*) const

Get number of connected nodes in a submesh.

Parameters

in	*n*	Label of node for which connections are counted
in	*s*	Label of submesh (starting from 0)

int getNbConnectOutSubMesh (int *n*, int *s*) const

Get number of connected nodes out of a submesh.

Parameters

in	*n*	Label of node for which connections are counted
in	*s*	Label of submesh (starting from 0)

void put (size_t *n*, string *file*) const

Save a submesh in file.

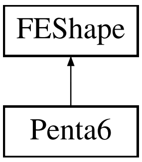
Parameters

in	*n*	Label of submesh
in	*file*	Name of file in which submesh is saved

7.77 Penta6 Class Reference

Defines a 6-node pentahedral finite element using `P1` interpolation in local coordinates `(s.x,s.y)` and `Q1` isoparametric interpolation in local coordinates `(s.x,s.z)` and `(s.y,s.z)`.

Inheritance diagram for Penta6:



Public Member Functions

- Penta6 ()

  Default Constructor.
- Penta6 (const Element ∗element)

  Constructor when data of Element `el` are given.
- ∼Penta6 ()

  Destructor.
- void set (const Element ∗el)

  Choose element by giving its pointer.
- void setLocal (const Point< real_t > &s)

  Initialize local point coordinates in element.
- Point< real_t > DSh (size_t i) const

  Return derivatives of shape function of node `i` at a given point.
- real_t getMaxEdgeLength () const

  Return Maximum length of pentahedron edges.
- real_t getMinEdgeLength () const

  Return Mimimum length of pentahedron edges.
- real_t Sh (size_t i) const

  Return shape function of node `i` at given point.

- real_t Sh (size_t i, Point< real_t > s) const

  Calculate shape function of node `i` at a given point `s`.
- real_t getDet () const

  Return determinant of jacobian.
- Point< real_t > getCenter () const

  Return coordinates of center of element.
- Point< real_t > getLocalPoint () const

  Localize a point in the element.
- Point< real_t > getLocalPoint (const Point< real_t > &s) const

  Localize a point in the element.

7.77.1 Detailed Description

Defines a 6-node pentahedral finite element using `P1` interpolation in local coordinates `(s.x,s.y)` and `Q1` isoparametric interpolation in local coordinates `(s.x,s.z)` and `(s.y,s.z)`.

The reference element is the cartesian product of the standard reference triangle with the line `[-1,1]`. The nodes are ordered as follows: Node 1 in reference element is at s=(1,0,0) Node 2 in reference element is at s=(0,1,0) Node 3 in reference element is at s=(0,0,0) Node 4 in reference element is at s=(1,0,1) Node 5 in reference element is at s=(0,1,1) Node 6 in reference element is at s=(0,0,1)

The user must take care to the fact that determinant of jacobian and other quantities depend on the point in the reference element where they are calculated. For this, before any utilization of shape functions or jacobian, function **setLocal()** must be invoked.

7.77.2 Constructor & Destructor Documentation

Penta6 (const Element * *element*)

Constructor when data of Element `el` are given.

Parameters

in	*element*	Pointer to Element

7.77.3 Member Function Documentation

void setLocal (const Point< real_t > & *s*)

Initialize local point coordinates in element.

Parameters

in	*s*	Point in the reference element This function computes jacobian, shape functions and their partial derivatives at `s`. Other member functions only return these values.

Point<real_t> DSh (size_t *i*) const

Return derivatives of shape function of node `i` at a given point.

Member function **setLocal()** must have been called before in order to calculate relevant quantities.

real_t Sh (size_t *i*, Point< real_t > *s*) const `[inherited]`

Calculate shape function of node `i` at a given point `s`.

Parameters

in	*i*	Local node label
in	*s*	Point in the reference triangle where the shape function is evaluated

real_t getDet ( ) const `[inherited]`

Return determinant of jacobian.

If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint ( ) const `[inherited]`

Localize a point in the element.

Return actual coordinates in the reference element. If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint (const Point< real_t > & *s*) const `[inherited]`

Localize a point in the element.

Return actual coordinates where `s` are coordinates in the reference element.

7.78 PETScMatrix< T_ > Class Template Reference

To handle matrices in sparse storage format using the Petsc library.

Public Member Functions

- PETScMatrix ()

  Default constructor.
- PETScMatrix (size_t nr, size_t nc)

  Constructor that initializes current instance as a dense matrix.
- PETScMatrix (size_t size)

  Constructor that initializes current instance as a dense matrix.
- PETScMatrix (Mesh &mesh, size_t dof=0)

  Constructor using a Mesh instance.
- PETScMatrix (const vector< std::pair< size_t, size_t > > &I, int opt=1)

  Constructor for a square matrix using non zero row and column indices.
- PETScMatrix (const PETScMatrix &m)

  Copy constructor.
- ~PETScMatrix (void)

  Destructor.
- void Identity ()

  Define matrix as identity matrix.

- void Diagonal ()

  Define matrix as a diagonal one.
- void Diagonal (const T_ &a)

  Define matrix as a diagonal one with diagonal entries equal to `a`
- void setAIJ (const vector< int > &nnz)
- void setAIJ_MPI (const vector< int > &diag_nnz, const vector< int > &off_nnz)
- void setMesh (Mesh &mesh, size_t dof=0)

  Determine mesh graph and initialize matrix.
- void setPartition (Partition &p)

  Set a Partition instance in the class.
- void setRank (int np, int r=0)

  Set number of processors and processor rank.
- void setOneDOF ()

  Activate 1-DOF per node option.
- void setSides ()

  Activate Sides option.
- void setSymmetric ()

  Set matrix as a symmetric one.
- void DiagPrescribe (PETScVect< T_ > &b, const PETScVect< T_ > &u)

  Impose by a diagonal method an essential boundary condition using the Mesh instance provided by the constructor.
- void setSize (size_t size)

  Set size of matrix (case where it's a square matrix).
- void setSize (size_t nr, size_t nc)

  Set size (number of rows) of matrix.
- void getRange (int istart, int iend)

  Return the range of matrix rows owned by this processor.
- void setGraph (const vector< std::pair< size_t, size_t > > &I, int opt=1)

  Set graph of matrix by giving a vector of its nonzero entries.
- T_ operator() (size_t i, size_t j) const

  Operator ()
- size_t getNbRows () const

  Return number of matrix rows.
- size_t getNbColumns () const

  Return number of matrix columns.
- size_t getLength () const

  Return length of matrix.
- void getMesh (Mesh &mesh)

  Get Mesh instance whose reference will be stored in current instance of PETScMatrix.
- void Mult (const PETScVect< T_ > &x, PETScVect< T_ > &y) const

  Multiply matrix by vector and save in another one.
- void MultAdd (const PETScVect< T_ > &x, PETScVect< T_ > &y) const

  Multiply matrix by vector `x` *and add to* `y`*.*
- void MultAdd (T_ a, const PETScVect< T_ > &x, PETScVect< T_ > &y) const

  Multiply matrix by vector `a*x` *and add to* `y`*.*
- void set (size_t i, size_t j, const T_ &a)

  Assign a value to an entry of the matrix.

- void add (size_t i, size_t j, const T_ &a)
  Add a value to an entry of the matrix.
- void set (vector< int > &ir, vector< int > &ic, vector< T_ > &val)
  Assign values to a portion of the matrix.
- void operator= (const T_ &a)
  Operator =
- void clear ()
  Set all matrix entries to zero.
- void Laplace1D (real_t h, bool mpi=false)
  Sets the matrix as the one for the Laplace equation in 1-D.
- void Laplace2D (size_t nx, size_t ny, bool mpi=false)
  Sets the matrix as the one for the Laplace equation in 2-D.
- int solve (PETScVect< T_ > &b)
  Solve the linear system of equations.
- int solve (const PETScVect< T_ > &b, PETScVect< T_ > &x)
  Solve the linear system of equations.
- void setSolver (string solver, string prec, real_t toler=1.e-12, int max_it=1000)
  Choose solver and preconditioner for an iterative procedure.
- T_ * get () const
  Return C-Array.
- T_ get (size_t i, size_t j) const
  Return entry `(i,j)` of matrix if this one is stored, `0` otherwise.
- operator Mat () const
  Casting operator.
- PetscReal getNorm1 () const
  Get 1-norm of matrix.
- PetscReal getFrobeniusNorm () const
  Get Frobenius norm of matrix.
- PetscReal getNormMax () const
  Get infinity norm of matrix.
- void Assembly (const Element &el, T_ *a)
  Assembly of element matrix into global matrix.
- void Assembly (const Side &sd, T_ *a)
  Assembly of side matrix into global matrix.
- void setAssembly ()
  Matrix assembly.
- void setMPI ()
  Activate MPI option.

7.78.1 Detailed Description

template<class T_>
class OFELI::PETScMatrix< T_ >

To handle matrices in sparse storage format using the Petsc library.

Warning

This class is available only when OFELI has been installed with Petsc.

Template Parameters

T↩_↩	Data type (double, float, complex<double>, ...)

7.78.2 Constructor & Destructor Documentation

PETScMatrix ( )

Default constructor.
Initialize a zero-dimension matrix

PETScMatrix (size_t *nr*, size_t *nc*)

Constructor that initializes current instance as a dense matrix.
Normally, for a dense matrix this is not the right class.

Parameters

in	*nr*	Number of matrix rows.
in	*nc*	Number of matrix columns.

PETScMatrix (size_t *size*)

Constructor that initializes current instance as a dense matrix.
Normally, for a dense matrix this is not the right class.

Parameters

in	*size*	Number of matrix rows (and columns).

PETScMatrix (Mesh & *mesh*, size_t *dof* = *0*)

Constructor using a Mesh instance.

Parameters

in	*mesh*	Mesh instance from which matrix graph is extracted.
in	*dof*	Option parameter, with default value `0`. `dof=1` means that only one degree of freedom for each node (or element or side) is taken to determine matrix structure. The value `dof=0` means that matrix structure is determined using all DOFs.

PETScMatrix (const vector< std::pair< size_t, size_t > > & *I*, int *opt* = *1*)

Constructor for a square matrix using non zero row and column indices.

Parameters

in	*I*	Vector containing pairs of row and column indices
in	*opt*	Flag indicating if vectors I is cleaned and ordered (opt=1) or not (opt=0). In the latter case, this vector can have the same contents more than once and are not necessarily ordered

7.78.3 Member Function Documentation

void setAIJ (const vector< int > & *nnz*)

Parameters

in	*nnz*	

void setAIJ_MPI (const vector< int > & *diag_nnz*, const vector< int > & *off_nnz*)

Parameters

in	*diag_nnz*	
in	*off_nnz*	

void setMesh (Mesh & *mesh*, size_t *dof* = 0)

Determine mesh graph and initialize matrix.

This member function is called by constructor with the same arguments

Parameters

in	*mesh*	Mesh instance for which matrix graph is determined.
in	*dof*	Option parameter, with default value `0`. `dof=1` means that only one degree of freedom for each node (or element or side) is taken to determine matrix structure. The value `dof=0` means that matrix structure is determined using all DOFs.

void setPartition (Partition & *p*)

Set a Partition instance in the class.

This member function is to be used when parallel computing is considered.

Parameters

in	*p*	Reference to Partition instance

void setRank (int *np*, int *r* = 0)

Set number of processors and processor rank.

Parameters

in	*np*	Total number of processors.
in	*r*	Rank of current processor [Default: 0

Warning

If this member function is not called, only one processor is used and then sequential computing is involved.

void DiagPrescribe (PETScVect< T_ > & *b*, const PETScVect< T_ > & *u*)

Impose by a diagonal method an essential boundary condition using the Mesh instance provided by the constructor.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

Parameters

in,out	*b*	PETScVect instance that contains right-hand side.
in	*u*	PETScVect instance that conatins imposed valued at DOFs where they are to be imposed.

void setSize (size_t *size*)

Set size of matrix (case where it's a square matrix).

Parameters

in	*size*	Number of rows and columns.

void setSize (size_t *nr*, size_t *nc*)

Set size (number of rows) of matrix.

Parameters

in	*nr*	Number of rows
in	*nc*	Number of columns

void getRange (int *istart*, int *iend*)

Return the range of matrix rows owned by this processor.

Parameters

out	*istart*	Index of the first local row
out	*iend*	Index of the last local row

void setGraph (const vector< std::pair< size_t, size_t > > & *I*, int *opt* = *1*)

Set graph of matrix by giving a vector of its nonzero entries.

Parameters

in	*I*	Vector containing pairs of row and column indices
in	*opt*	Flag indicating if vector `I` is cleaned and ordered (`opt=1`: default) or not (`opt=0`). In the latter case, this vector can have the same contents more than once and are not necessarily ordered

T_ operator() (size_t *i*, size_t *j*) const

Operator `()`

Parameters

in	*i*	Row index
in	*j*	Column index

size_t getLength ( ) const

Return length of matrix.
The length is the total number of stored elements in the matrix

void Mult (const PETScVect< T_ > & *x*, PETScVect< T_ > & *y*) const

Multiply matrix by vector and save in another one.

Parameters

in	*x*	Vector to multiply by matrix
out	*y*	Vector that contains on output the result.

void MultAdd (const PETScVect< T_ > & *x*, PETScVect< T_ > & *y*) const

Multiply matrix by vector `x` and add to `y`.

Parameters

in	*x*	Vector to multiply by matrix
out	*y*	Vector to add to the result. `y` contains on output the result.

void MultAdd (T_ *a*, const PETScVect< T_ > & *x*, PETScVect< T_ > & *y*) const

Multiply matrix by vector `a*x` and add to `y`.

Parameters

in	*a*	Constant to multiply by matrix
in	*x*	Vector to multiply by matrix
out	*y*	Vector to add to the result. `y` contains on output the result.

void set (size_t *i*, size_t *j*, const T_ & *a*)

Assign a value to an entry of the matrix.

Parameters

in	*i*	Row index
in	*j*	Column index
in	*a*	Value to assign to `a(i,j)`

void add (size_t *i*, size_t *j*, const T_ & *a*)

Add a value to an entry of the matrix.

Parameters

in	*i*	Row index
in	*j*	Column index
in	*a*	Constant value to add to `a(i,j)`

void set (vector< int > & *ir*, vector< int > & *ic*, vector< T_ > & *val*)

Assign values to a portion of the matrix.

Parameters

in	*ir*	Vector of row indexes to assign (instance of class `vector`)
in	*ic*	Vector of column indexes to assign (instance of class `vector`)
in	*val*	Vector of values to assign (instance of class `vector`)

void operator= (const T_ & *a*)

Operator =

Assign constant value `a` to matrix diagonal entries

void Laplace1D (real_t *h*, bool *mpi* = *false*)

Sets the matrix as the one for the Laplace equation in 1-D.

The matrix is initialized as the one resulting from P_1 finite element discretization of the classical elliptic operator -u'' = f with homogeneous Dirichlet boundary conditions

Remarks

This function is available for real valued matrices only.

Parameters

in	*h*	Mesh size (assumed constant)
in	*mpi*	true if MPI is used for parallel computing, false if not (sequential), [Default: `false`]

void Laplace2D (size_t *nx*, size_t *ny*, bool *mpi* = *false*)

Sets the matrix as the one for the Laplace equation in 2-D.

The matrix is initialized as the one resulting from P_1 finite element discretization of the classical elliptic operator -Delta u = f with homogeneous Dirichlet boundary conditions

Remarks

This function is available for real valued matrices only.

Parameters

in	*nx*	Number of unknowns in the x-direction
in	*ny*	Number of unknowns in the y-direction
in	*mpi*	true if MPI is used for parallel computing, false if not (sequential), [Default: `false`]

int solve (PETScVect< T_ > & *b*)

Solve the linear system of equations.

The default parameters are: the Conjugate Gradient method and the Jacobi method for preconditioner. To change these values, call function setSolver before this function

Parameters

in,out	*b*	Vector that contains right-hand side on input and solution on output

Returns

Number of actual performed iterations

int solve (const PETScVect< T_ > & *b*, PETScVect< T_ > & *x*)

Solve the linear system of equations.

The default parameters are: the Conjugate Gradient method and the Jacobi method for preconditioner. To change these values, call function setSolver before this function

Parameters

`in`	*b*	Vector that contains right-hand side
`out`	*x*	Vector that contains the obtained solution

Returns

Number of actual performed iterations

void setSolver (string *solver,* **string** *prec,* **real_t** *toler* **=** `1.e-12`, **int** *max_it* **=** `1000` **)**

Choose solver and preconditioner for an iterative procedure.

Parameters

in	*solver*	Option to choose iterative solver among the macros (see PETSc documentation for more details): • `KSPRICHARDSON`: The Richardson iterative method (Default damping parameter is `1.0`) • `KSPCHEBYSHEV`: The Chebyshev iterative method • `KSPCG`: The conjugate gradient method [Default] • `KSPCGNE`: The CG method for normal equations (without explicitly forming the product `A^TA` • `KSPGMRES`: The GMRES iterative method (see A Generalized Minimal Residual Algorithm for Solving Nonsymmetric Linear Systems. Y. Saad and M. H. Schultz, SIAM J. Sci. Stat. Comput. Vo|. 7, No. 3, July 1986, pp. 856-869) • `KSPFGMRES`: The Flexible GMRES method (with restart) • `KSPLGMRES`: The 'augmented' standard GMRES method where the subspace uses approximations to the error from previous restart cycles • `KSPTCQMR`: A variant of QMR (quasi minimal residual) developed by Tony Chan • `KSPBCGS`: The BiCGStab (Stabilized version of BiConjugate Gradient Squared) method • `KSPIBCGS`: The IBiCGStab (Improved Stabilized version of BiConjugate Gradient Squared) method in an alternative form to have only a single global reduction operation instead of the usual 3 (or 4) • `KSPFBCGS`: The flexible BiCGStab method. • `KSPCGS`: The CGS (Conjugate Gradient Squared) method • `KSPTFQMR`: A transpose free QMR (quasi minimal residual) • `KSPCR`: The conjugate residuals method • `KSPLSQR`: The LSQR method • `KSPBICG`: The Biconjugate gradient method (similar to running the conjugate gradient on the normal equations) • `KSPMINRES`: The MINRES (Minimum Residual) method • `KSPSYMMLQ`: The SYMMLQ method • `KSPGCR`: The Generalized Conjugate Residual method

Parameters

in	*prec*	Option to choose preconditioner in an enumerated variable • `PCJACOBI`: [Default] Jacobi (*i.e.* diagonal scaling) preconditioning • `PCBJACOBI`: Block Jacobi preconditioning, each block is (approximately) solved with its own KSP object • `PCSOR`: (S)SOR (successive over relaxation, Gauss-Seidel) preconditioning • `PCEISENSTAT`: An implementation of SSOR (symmetric successive over relaxation, symmetric Gauss-Seidel) preconditioning that incorporates Eisenstat's trick to reduce the amount of computation needed • `PCICC`: Incomplete Cholesky factorization preconditioners • `PCILU`: Incomplete factorization preconditioners • `PCASM`: Use the (restricted) additive Schwarz method, each block is (approximately) solved with its own KSP object • `PCLU`: Uses a direct solver, based on LU factorization, as a preconditioner • `PCCHOLESKY`: Uses a direct solver, based on Cholesky factorization, as a preconditioner
in	*toler*	Tolerance for convergence [Default: `1.e-12`]
in	*max↩_it*	Maximum number of allowed iterations [Default: `1000`]

T_∗ get ( ) const

Return C-Array.

Non zero terms of matrix is stored row by row.

T_ get (size_t *i*, size_t *j*) const

Return entry `(i,j)` of matrix if this one is stored, `0` otherwise.

Parameters

in	*i*	Row index
in	*j*	Column index

operator Mat ( ) const

Casting operator.

This member functions enables casting an instance of class PETScMatrix into the `Petsc` matrix type `Mat`. This is useful when one wants to usr any Petsc function that is not available in the wrapper (class PETScWrapper) or PETScMatrix.

void Assembly (const Element & *el*, T_ * *a*)

Assembly of element matrix into global matrix.

Parameters

in	*el*	Reference to element instance
in	*a*	Element matrix as a C-array

void Assembly (const Side & *sd*, T_ * *a*)

Assembly of side matrix into global matrix.

Parameters

in	*sd*	Reference to side instance
in	*a*	Side matrix as a C-array

void setAssembly ( )

Matrix assembly.
This function assembles matrix (begins and ends)

7.79 PETScVect< T_ > Class Template Reference

To handle general purpose vectors using Petsc.

Public Member Functions

- PETScVect ()
  Default Constructor. Initialize a zero-length vector.
- PETScVect (size_t n)
  Constructor setting vector size.
- PETScVect (size_t nx, size_t ny)
  Constructor of a 2-D index vector.
- PETScVect (size_t nx, size_t ny, size_t nz)
  Constructor of a 3-D index vector.
- PETScVect (size_t n, T_ *x)
  Create an instance of class PETScVect as an image of a C/C++ array.
- PETScVect (MPI_Comm comm, size_t n)
  Constructor of a MPI vector using its global size.
- PETScVect (Mesh &m, int nb_dof=0, int dof_type=NODE_FIELD)
  Constructor with a mesh instance.
- PETScVect (Mesh &m, string name, real_t t=0.0, int nb_dof=0, int dof_type=NODE_FIELD)
  Constructor with a mesh instance giving name and time for vector.
- PETScVect (const PETScVect< T_ > &v, const PETScVect< T_ > &bc)
  Constructor using boundary conditions.

- PETScVect (const PETScVect< T_ > &v, size_t nb_dof, size_t first_dof)

  Constructor to select some components of a given vector.
- PETScVect (const PETScVect< T_ > &v)

  Copy constructor.
- PETScVect (const PETScVect< T_ > &v, size_t n)

  Constructor to select one component from a given 2 or 3-component vector.
- PETScVect (size_t d, const PETScVect< T_ > &v, const string &name=" ")

  Constructor that extracts some degrees of freedom (components) from given instance of PETScVect.
- ∼PETScVect ()

  Destructor.
- void set (const T_ ∗v, size_t n)

  Initialize vector with a c-array.
- void setMPI (MPI_Comm comm, size_t n, size_t N)

  Initialize a local vector using MPI.
- void select (const PETScVect< T_ > &v, size_t nb_dof=0, size_t first_dof=1)

  Initialize vector with another PETScVect instance.
- void set (const string &exp, size_t dof=1)

  Initialize vector with an algebraic expression.
- void set (const Mesh &ms, const string &exp, size_t dof=1)

  Initialize vector with an algebraic expression with providing mesh data.
- void set (const PETScVect< real_t > &x, const string &exp)

  Initialize vector with an algebraic expression.
- void setMesh (Mesh &m, int nb_dof=0, int dof_type=NODE_FIELD)

  Define mesh class to size vector.
- size_t size () const

  Return vector (global) size.
- PetscInt getLocalSize () const

  Return vector local size.
- void setSize (size_t nx, size_t ny=1, size_t nz=1)

  Set vector size (for 1-D, 2-D or 3-D cases)
- void setDOFType (int dof_type)

  Set DOF type of vector.
- size_t getNbDOF () const

  Return vector number of degrees of freedom.
- size_t getNb () const

  Return vector number of entities (nodes, elements or sides)
- Mesh & getMesh () const

  Return Mesh instance.
- bool isWithMesh () const

  Return `true` if vector contains a Mesh pointer, `false` if not.
- int getDOFType () const
- void setTime (real_t t)

  Set time value for vector.
- real_t getTime () const

  Get time value for vector.
- void setName (string name)

Set name of vector.

- string getName () const

  Get name of vector.
- PetscScalar getNorm1 () const

  Calculate 1-norm of vector.
- PetscScalar getNorm2 () const

  Calculate 2-norm (Euclidean norm) of vector.
- PetscScalar getWNorm1 () const

  Calculate weighted 1-norm of vector The wighted 1-norm is the 1-Norm of the vector divided by its size.
- PetscScalar getWNorm2 () const

  Calculate weighted 2-norm of vector.
- PetscScalar getNormMax () const

  Calculate Max-norm (Infinite norm) of vector.
- T_ getMin () const

  Calculate Min value of vector entries.
- T_ getMax () const

  Calculate Max value of vector entries.
- size_t getNx () const

  Return number of grid points in the x-direction if grid indexing is set.
- size_t getNy () const

  Return number of grid points in the y-direction if grid indexing is set.
- size_t getNz () const

  Return number of grid points in the z-direction if grid indexing is set.
- void setNodeBC (Mesh &m, int code, T_ val, size_t dof=1)

  Assign a given value to components of vector with given code.
- void setNodeBC (Mesh &m, int code, const string &exp, size_t dof=1)

  Assign a given function (given by an interpretable algebraic expression) to components of vector with given code.
- void setNodeBC (int code, T_ val, size_t dof=1)

  Assign a given value to components of vector with given code.
- void setNodeBC (int code, const string &exp, size_t dof=1)

  Assign a given function (given by an interpretable algebraic expression) to components of vector with given code.
- void removeBC (const Mesh &ms, const PETScVect< T_ > &v, int dof=0)

  Remove boundary conditions.
- void removeBC (const Mesh &ms, const Vect< T_ > &v, int dof=0)

  Remove boundary conditions.
- void removeBC (const PETScVect< T_ > &v, int dof=0)

  Remove boundary conditions.
- void removeBC (const Vect< T_ > &v, int dof=0)

  Remove boundary conditions.
- void transferBC (const PETScVect< T_ > &bc, int dof=0)

  Transfer boundary conditions to the vector.
- void insertBC (Mesh &m, const PETScVect< T_ > &v, const PETScVect< T_ > &bc, int dof=0)

  Insert boundary conditions.
- void insertBC (Mesh &m, const PETScVect< T_ > &v, int dof=0)

Insert boundary conditions.
- void insertBC (const PETScVect< T_ > &v, const PETScVect< T_ > &bc, int dof=0)

  Insert boundary conditions.
- void insertBC (const PETScVect< T_ > &v, int dof=0)

  Insert boundary conditions.
- void Assembly (const Element &el, const T_ *b)

  Assembly of element vector (as C-array) into Vect instance.
- void Assembly (const Side &sd, T_ *b)

  Assembly of side vector (as C-array) into PETScVect instance.
- void getGradient (PETScVect< T_ > &v)

  Evaluate the discrete Gradient vector of the current vector.
- void getGradient (PETScVect< Point< T_ > > &v)

  Evaluate the discrete Gradient vector of the current vector.
- void getCurl (PETScVect< T_ > &v)

  Evaluate the discrete curl vector of the current vector.
- void getCurl (PETScVect< Point< T_ > > &v)

  Evaluate the discrete curl vector of the current vector.
- void getSCurl (PETScVect< T_ > &v)

  Evaluate the discrete scalar curl in 2-D of the current vector.
- void getDivergence (PETScVect< T_ > &v)

  Evaluate the discrete Divergence of the current vector.
- real_t getAverage (const Element &el, int type) const

  Return average value of vector in a given element.
- void save (string file, int opt)

  Save vector in a file according to a given format.
- PETScVect< T_ > & MultAdd (const PETScVect< T_ > &x, const T_ &a)

  Multiply by a constant then add to a vector.
- void Axpy (T_ a, const PETScVect< T_ > &x)

  Add to vector the product of a vector by a scalar.
- void set (size_t i, T_ a)

  Assign a value to an entry for a 1-D vector.
- void set (size_t i, size_t j, T_ a)

  Assign a value to an entry for a 2-D vector.
- void set (size_t i, size_t j, size_t k, T_ a)

  Assign a value to an entry for a 3-D vector.
- void add (size_t i, T_ a)

  Add a value to an entry for a 1-index vector.
- void add (size_t i, size_t j, T_ a)

  Add a value to an entry for a 2-index vector.
- void add (size_t i, size_t j, size_t k, T_ a)

  Assign a value to an entry for a 3-index vector.
- void clear ()

  Set all vector entries to zero.
- T_ operator[ ] (size_t i) const

  Operator []
- T_ operator() (size_t i) const

Operator ()

- T_ operator() (size_t i, size_t j) const

  Operator () with 2-D indexing (Case of a grid vector)
- T_ operator() (size_t i, size_t j, size_t k) const

  Operator () with 3-D indexing (Case of a grid vector)
- PETScVect< T_ > & operator= (const PETScVect< T_ > &v)

  Operator = between vectors.
- PETScVect< T_ > & operator= (const T_ &a)

  Operator =
- PETScVect< T_ > & operator+= (const PETScVect< T_ > &v)

  Operator +=
- PETScVect< T_ > & operator+= (const T_ &a)

  Operator +=
- PETScVect< T_ > & operator-= (const PETScVect< T_ > &v)

  Operator -=
- PETScVect< T_ > & operator-= (const T_ &a)

  Operator -=
- PETScVect< T_ > & operator*= (const T_ &a)

  *Operator *=*
- PETScVect< T_ > & operator/= (const T_ &a)

  Operator /=
- const Mesh & getMeshPtr () const

  Return reference to Mesh instance.
- T_ operator, (const PETScVect< T_ > &v) const

  Return Dot (scalar) product of two vectors.
- operator Vec () const

  Casting operator.
- void setAssembly ()

  Vector assembly.
- void Insert (const vector< int > &ii, const vector< Point< T_ > > &v)

  Insert values into certain locations of the vector.
- void Add (const vector< int > &ii, const vector< T_ > &v)

  Add values into certain locations of the vector.

7.79.1 Detailed Description

template<class T_>
class OFELI::PETScVect< T_ >

To handle general purpose vectors using Petsc.

This template class enables considering vectors of various data types. Operators =, [] and () are overloaded so that one can write for instance:

```
PETScVect<double> u(10), v(10);
v = -1.0;
u = v;
u.set(3,-2.0);
```

to set vector **v** entries to **-1**, copy vector **v** into vector **u** and assign third entry of **v** to **-2**. Note that entries of **v** are here **v(1)**, **v(2)**, ..., **v(10)**, *i.e.* vector entries start at index **1**.

Remarks

A PETScVect instance can be 1-D, 2-D or 3-D, `i.e.` one can have 1, 2 or 3 indices. This is set while the vector is constructed. This can be helpful for instance in the case of a structured grid.

Warning

This class is available only when OFELI has been installed with Petsc In this case, only vectors used for building and solving linear systems need to be instances of PETScVect.

Template Parameters

*T_*	Data type (double, int, complex<double>, ...)

7.79.2 Constructor & Destructor Documentation

PETScVect (size_t *n*)

Constructor setting vector size.

Parameters

in	*n*	Size of vector

PETScVect (size_t *nx*, size_t *ny*)

Constructor of a 2-D index vector.
This constructor can be used for instance for a 2-D grid vector

Parameters

in	*nx*	Size for the first index
in	*ny*	Size for the second index

Remarks

The size of resulting vector is nx*ny

PETScVect (size_t *nx*, size_t *ny*, size_t *nz*)

Constructor of a 3-D index vector.
This constructor can be used for instance for a 3-D grid vector

Parameters

in	*nx*	Size for the first index

Parameters

in	*ny*	Size for the second index
in	*nz*	Size for the third index

Remarks

The size of resulting vector is `nx*ny*nz`

PETScVect (size_t *n*, T_ * *x*)

Create an instance of class PETScVect as an image of a C/C++ array.

Parameters

in	*n*	Dimension of vector to construct
in	*x*	C-array to copy

PETScVect (MPI_Comm *comm*, size_t *n*)

Constructor of a MPI vector using its global size.

Parameters

in	*comm*	Communicator which represents all the processs that PETSc knows about
in	*n*	Global size of vector

PETScVect (Mesh & *m*, int *nb_dof* = *0*, int *dof_type* = *NODE_FIELD*)

Constructor with a mesh instance.

Parameters

in	*m*	Mesh instance
in	*nb_dof*	Number of degrees of freedom per node, element or side If `nb_dof` is set to `0` (default value) the constructor picks this number from the Mesh instance
in	*dof_type*	Type of degrees of freedom. To be given among the enumerated values: `NODE_FIELD`, `ELEMENT_FIELD`, `SIDE_FIELD` or `EDGE_FIELD` [Default: `NODE_FIELD`]

PETScVect (Mesh & *m*, string *name*, real_t *t* = *0.0*, int *nb_dof* = *0*, int *dof_type* = *NODE_FIELD*)

Constructor with a mesh instance giving name and time for vector.

Parameters

in	*m*	Mesh instance

Parameters

in	*name*	Name of the vector
in	*t*	Time value for the vector
in	*nb_dof*	Number of degrees of freedom per node, element or side If `nb_dof` is set to `0` the constructor picks this number from the Mesh instance
in	*dof_type*	Type of degrees of freedom. To be given among the enumerated values: `NODE_FIELD`, `ELEMENT_FIELD`, `SIDE_FIELD` or `EDGE_FIELD` [Default: `NODE_FIELD`]

PETScVect (const PETScVect< T_ > & *v*, const PETScVect< T_ > & *bc*)

Constructor using boundary conditions.

Boundary condition values contained in `bc` are reported to vector `v`

Parameters

in	*v*	PETScVect instance to update
in	*bc*	PETScVect instance containing imposed valued at desired DOF

PETScVect (const PETScVect< T_ > & *v*, size_t *nb_dof*, size_t *first_dof*)

Constructor to select some components of a given vector.

Parameters

in	*v*	PETScVect instance to extract from
in	*nb_dof*	Number of DOF to extract
in	*first_dof*	First DOF to extract For instance, a choice `first_dof=2` and `nb_dof=1` means that the second DOF of each node is copied in the vector

PETScVect (const PETScVect< T_ > & *v*, size_t *n*)

Constructor to select one component from a given 2 or 3-component vector.

Parameters

in	*v*	PETScVect instance to extract from
in	*n*	Component to extract (must be > 1 and < 4 or).

PETScVect (size_t *d*, const PETScVect< T_ > & *v*, const string & *name* = " ")

Constructor that extracts some degrees of freedom (components) from given instance of PETScVect.

This constructor enables constructing a subvector of a given PETScVect instance. It selects a given list of degrees of freedom and put it according to a given order in the instance to construct.

Parameters

in	*d*	Integer number giving the list of degrees of freedom. This number is made of `n` digits where `n` is the number of degrees of freedom. Let us give an example: Assume that the instance `v` has 3 DOF by entity (node, element or side). The choice `d=201` means that the constructed instance has 2 DOF where the first DOF is the third one of `v`, and the second DOF is the first one of f `v`. Consequently, no digit can be larger than the number of DOF the constructed instance. In this example, a choice `d=103` would produce an error message.
in	*v*	PETScVect instance from which extraction is performed.
in	*name*	Name to assign to vector instance [Default: " "].

Warning

Don't give zeros as first digits for the argument `d`. The number is in this case interpreted as octal !!

7.79.3 Member Function Documentation

void set (const T_ ∗ *v*, size_t *n*)

Initialize vector with a c-array.

Parameters

in	*v*	c-array (pointer) to initialize PETScVect
in	*n*	size of array

void setMPI (MPI_Comm *comm*, size_t *n*, size_t *N*)

Initialize a local vector using MPI.

Parameters

in	*comm*	
in	*n*	local size of vector
in	*N*	global size of vector

void select (const PETScVect< T_ > & *v*, size_t *nb_dof* = *0*, size_t *first_dof* = *1*)

Initialize vector with another PETScVect instance.

Parameters

in	*v*	PETScVect instance to extract from
in	*nb_dof*	Number of DOF per node, element or side (By default, 0: Number of degrees of freedom extracted from the Mesh instance)
in	*first_dof*	First DOF to extract (Default: 1) For instance, a choice `first_dof=2` and `nb_dof=1` means that the second DOF of each node is copied in the vector

void set (const string & *exp*, size_t *dof* = *1*)

Initialize vector with an algebraic expression.

Parameters

in	*exp*	Regular algebraic expression that defines a function of x, y and z which are coordinates of nodes.
in	*dof*	Degree of freedom to which the value is assigned [Default: `1`]

void set (const Mesh & *ms*, const string & *exp*, size_t *dof* = *1*)

Initialize vector with an algebraic expression with providing mesh data.

Parameters

in	*ms*	Mesh instance
in	*exp*	Regular algebraic expression that defines a function of x, y and z which are coordinates of nodes.
in	*dof*	Degree of freedom to which the value is assigned [Default: `1`]

void set (const PETScVect< real_t > & *x*, const string & *exp*)

Initialize vector with an algebraic expression.

Parameters

in	*x*	PETScVect instance that contains coordinates of points
in	*exp*	Regular algebraic expression that defines a function of x and i which are coordinates of nodes and indices starting from `1`.

void setMesh (Mesh & *m*, int *nb_dof* = *0*, int *dof_type* = *NODE_FIELD*)

Define mesh class to size vector.

Parameters

in	*m*	Mesh instance
in	*nb_dof*	Number of degrees of freedom per node, element or side If `nb_dof` is set to `0` the constructor picks this number from the Mesh instance
in	*dof_type*	Parameter to precise the type of degrees of freedom. To be chosen among the enumerated values: `NODE_FIELD`, `ELEMENT_FIELD`, `SIDE_FIELD`, `EDGE_FIELD` [Default: `NODE_FIELD`]

PetscInt getLocalSize ( ) const

Return vector local size.

Local size is the size on the current processor

void setSize (size_t *nx*, size_t *ny* = *1*, size_t *nz* = *1*)

Set vector size (for 1-D, 2-D or 3-D cases)
This function allocates memory for the vector but does not initialize its components

Parameters

in	*nx*	Number of grid points in x-direction
in	*ny*	Number of grid points in y-direction [Default: 1]
in	*nz*	Number of grid points in z-direction [Default: 1]

void setDOFType (int *dof_type*)

Set DOF type of vector.
The DOF type combined with number of DOF per component enable determining the size of vector

Parameters

in	*dof_type*	Type of degrees of freedom. Value to be chosen among the enumerated values: `NODE_FIELD`, `ELEMENT_FIELD`, `SIDE_FIELD` or `EDGE_FIELD`

bool isWithMesh ( ) const

Return `true` if vector contains a Mesh pointer, `false` if not.
A PETScVect instance can be constructed using mesh information

int getDOFType ( ) const

Return DOF type of vector

Returns

dof_type Type of degrees of freedom. Value among the enumerated values: `NODE_FIELD`, `ELEMENT_FIELD`, `SIDE_FIELD` or `EDGE_FIELD`

PetscScalar getWNorm2 ( ) const

Calculate weighted 2-norm of vector.
The weighted 2-norm is the 2-Norm of the vector divided by the square root of its size

void setNodeBC (Mesh & *m*, int *code*, T_ *val*, size_t *dof* = *1*)

Assign a given value to components of vector with given code.
Vector components are assumed nodewise

Parameters

in	*m*	Instance of mesh

Parameters

in	*code*	Code for which nodes will be assigned prescribed value
in	*val*	Value to prescribe
in	*dof*	Degree of Freedom for which the value is assigned [default: 1]

void setNodeBC (Mesh & *m*, int *code*, const string & *exp*, size_t *dof* = 1)

Assign a given function (given by an interpretable algebraic expression) to components of vector with given code.
Vector components are assumed nodewise

Parameters

in	*m*	Instance of mesh
in	*code*	Code for which nodes will be assigned prescribed value
in	*exp*	Regular algebraic expression to prescribe
in	*dof*	Degree of Freedom for which the value is assigned [default: 1]

void setNodeBC (int *code*, T_ *val*, size_t *dof* = 1)

Assign a given value to components of vector with given code.
Vector components are assumed nodewise

Parameters

in	*code*	Code for which nodes will be assigned prescribed value
in	*val*	Value to prescribe
in	*dof*	Degree of Freedom for which the value is assigned [Default: 1]

void setNodeBC (int *code*, const string & *exp*, size_t *dof* = 1)

Assign a given function (given by an interpretable algebraic expression) to components of vector with given code.
Vector components are assumed nodewise

Parameters

in	*code*	Code for which nodes will be assigned prescribed value
in	*exp*	Regular algebraic expression to prescribe
in	*dof*	Degree of Freedom for which the value is assigned [Default: 1]

void removeBC (const Mesh & *ms*, const PETScVect< T_ > & *v*, int *dof* = 0)

Remove boundary conditions.

This member function copies to current vector a vector where only non imposed DOF are retained.

Parameters

in	*ms*	Mesh instance
in	*v*	Vector (PETScVect instance to copy from)
in	*dof*	Parameter to say if all degrees of freedom are concerned [Default: `0`] or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom

void removeBC (const Mesh & *ms*, const Vect< T_ > & *v*, int *dof* = *0*)

Remove boundary conditions.

This member function copies to current vector a vector where only non imposed DOF are retained.

Parameters

in	*ms*	Mesh instance
in	*v*	Vector (Vect instance to copy from)
in	*dof*	Parameter to say if all degrees of freedom are concerned [Default: `0`] or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom

void removeBC (const PETScVect< T_ > & *v*, int *dof* = *0*)

Remove boundary conditions.

This member function copies to current vector a vector where only non imposed DOF are retained.

Parameters

in	*v*	Vector (PETScVect instance to copy from)
in	*dof*	Parameter to say if all degrees of freedom are concerned [Default: `0`] or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom.

Remarks

This function is to be used only when the PETScVect instance was constructed by using the Mesh instance

void removeBC (const Vect< T_ > & *v*, int *dof* = *0*)

Remove boundary conditions.

This member function copies to current vector a vector where only non imposed DOF are retained.

Parameters

in	*v*	Vector (Vect instance to copy from)
in	*dof*	Parameter to say if all degrees of freedom are concerned [Default: `0`] or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom.

Remarks

This function is to be used only when the PETScVect instance was constructed by using the Mesh instance

void transferBC (const PETScVect< T_ > & *bc*, int *dof* = `0` **)**

Transfer boundary conditions to the vector.

Parameters

in	*bc*	PETScVect instance from which imposed degrees of freedom are copied to current instance
in	*dof*	Parameter to say if all degrees of freedom are concerned [Default: `0`] or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom.

void insertBC (Mesh & *m*, const PETScVect< T_ > & *v*, const PETScVect< T_ > & *bc*, int *dof* = `0` **)**

Insert boundary conditions.

Parameters

in	*m*	Mesh instance.
in	*v*	PETScVect instance from which free degrees of freedom are copied to current instance.
in	*bc*	PETScVect instance from which imposed degrees of freedom are copied to current instance.
in	*dof*	Parameter to say if all degrees of freedom are concerned [Default: `0`] or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom by node or side

void insertBC (Mesh & *m*, const PETScVect< T_ > & *v*, int *dof* = `0` **)**

Insert boundary conditions.

DOF with imposed boundary conditions are set to zero.

Parameters

in	*m*	Mesh instance.

Parameters

in	*v*	PETScVect instance from which free degrees of freedom are copied to current instance.
in	*dof*	Parameter to say if all degrees of freedom are concerned [Default: `0`] or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom by node or side

void insertBC (const PETScVect< T_ > & *v*, const PETScVect< T_ > & *bc*, int *dof* = *0* **)**

Insert boundary conditions.

Parameters

in	*v*	PETScVect instance from which free degrees of freedom are copied to current instance.
in	*bc*	PETScVect instance from which imposed degrees of freedom are copied to current instance.
in	*dof*	Parameter to say if all degrees of freedom are concerned [Default: `0`] or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom by node or side

void insertBC (const PETScVect< T_ > & *v*, int *dof* = *0* **)**

Insert boundary conditions.

DOF with imposed boundary conditions are set to zero.

Parameters

in	*v*	PETScVect instance from which free degrees of freedom are copied to current instance.
in	*dof*	Parameter to say if all degrees of freedom are concerned [Default: `0`] or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom by node or side

void Assembly (const Element & *el*, const T_ ∗ *b*)

Assembly of element vector (as C-array) into Vect instance.

Parameters

in	*el*	Reference to element instance
in	*b*	Local vector to assemble (C-Array)

void Assembly (const Side & *sd*, T_ ∗ *b*)

Assembly of side vector (as C-array) into PETScVect instance.

Parameters

in	*sd*	Reference to side instance
in	*b*	Local vector to assemble (C-Array)

void getGradient (PETScVect< T_ > & *v*)

Evaluate the discrete Gradient vector of the current vector.

The resulting gradient is stored in a PETScVect instance This function handles node vectors assuming P_1 approximation The gradient is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the gradient, where `v(n,1)`, `v(n,2)` and `v(n,3)` are respectively the `x` and `y` and `z` derivatives at element `n`.

void getGradient (PETScVect< Point< T_ > > & *v*)

Evaluate the discrete Gradient vector of the current vector.

The resulting gradient is stored in a PETScVect instance This function handles node vectors assuming P_1 approximation The gradient is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the gradient, where `v(n,1).x`, `v(n,2).y` and `v(n,3).z` are respectively the `x` and `y` and `z` derivatives at element `n`.

void getCurl (PETScVect< T_ > & *v*)

Evaluate the discrete curl vector of the current vector.

The resulting curl is stored in a PETScVect instance This function handles node vectors assuming P_1 approximation The curl is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the curl, where `v(n,1)`, `v(n,2)` and `v(n,3)` are respectively the `x` and `y` and `z` `curl` components at element `n`.

void getCurl (PETScVect< Point< T_ > > & *v*)

Evaluate the discrete curl vector of the current vector.

The resulting curl is stored in a PETScVect instance This function handles node vectors assuming P_1 approximation The curl is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the curl, where `v(n,1).x`, `v(n,2).y` and `v(n,3).z` are respectively the `x` and `y` and `z` `curl` components at element `n`.

void getSCurl (PETScVect< T_ > & *v*)

Evaluate the discrete scalar curl in 2-D of the current vector.

The resulting curl is stored in a PETScVect instance This function handles node vectors assuming P_1 approximation The curl is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the scalar curl.

void getDivergence (PETScVect< T_ > & *v*)

Evaluate the discrete Divergence of the current vector.

The resulting divergence is stored in a PETScVect instance This function handles node vectors assuming P_1 approximation The divergence is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the divergence.

real_t getAverage (const Element & *el*, int *type*) const

Return average value of vector in a given element.

Parameters

in	*el*	Element instance
in	*type*	Type of element. This is to be chosen among enumerated values: `LINE2`, `TRIANG3`, `QUAD4` `TETRA4`, `HEXA8`

void save (string *file*, int *opt*)

Save vector in a file according to a given format.

Parameters

in	*file*	Output file where to save the vector
in	*opt*	Option to choose file format to save. This is to be chosen among enumerated values: `GMSH`, `GNUPLOT`, `MATLAB`, `TECPLOT` and `VTK`

PETScVect<T_>& MultAdd (const PETScVect< T_ > & *x*, const T_ & *a*)

Multiply by a constant then add to a vector.

Parameters

in	*x*	PETScVect instance to add
in	*a*	Constant to multiply before adding

void Axpy (T_ *a*, const PETScVect< T_ > & *x*)

Add to vector the product of a vector by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*x*	Vect instance by which a is multiplied. The result is added to current instance

void set (size_t *i*, T_ *a*)

Assign a value to an entry for a 1-D vector.

Parameters

in	*i*	Rank index in vector (starts at 1)
in	*a*	Value to assign

void set (size_t *i*, size_t *j*, T_ *a*)

Assign a value to an entry for a 2-D vector.

Parameters

in	*i*	First index in vector (starts at 1)
in	*j*	Second index in vector (starts at 1)
in	*a*	Value to assign

void set (size_t *i*, size_t *j*, size_t *k*, T_ *a*)

Assign a value to an entry for a 3-D vector.

Parameters

in	*i*	First index in vector (starts at 1)
in	*j*	Second index in vector (starts at 1)
in	*k*	Third index in vector (starts at 1)
in	*a*	Value to assign

void add (size_t *i*, T_ *a*)

Add a value to an entry for a 1-index vector.

Parameters

in	*i*	Rank index in vector (starts at 1)

Parameters

in	*a*	Value to assign

void add (size_t *i*, size_t *j*, T_ *a*)

Add a value to an entry for a 2-index vector.

Parameters

in	*i*	First index in vector (starts at `1`)
in	*j*	Second index in vector (starts at `1`)
in	*a*	Value to assign

void add (size_t *i*, size_t *j*, size_t *k*, T_ *a*)

Assign a value to an entry for a 3-index vector.

Parameters

in	*i*	First index in vector (starts at `1`)
in	*j*	Second index in vector (starts at `1`)
in	*k*	Third index in vector (starts at `1`)
in	*a*	Value to assign

T_ operator[] (size_t *i*) const

Operator `[]`

Parameters

in	*i*	Rank index in vector (starts at `0`)

T_ operator() (size_t *i*) const

Operator `()`

Parameters

in	*i*	Rank index in vector (starts at `1`) • `v(i)` starts at `v(1)` to `v(size())` • `v(i)` is the same element as `v[i-1]`

T_ operator() (size_t *i*, size_t *j*) const

Operator () with 2-D indexing (Case of a grid vector)

Parameters

in	*i*	first index in vector (Number of vector components in the x-grid)
in	*j*	second index in vector (Number of vector components in the y-grid) `v(i,j)` starts at `v(1,1)` to `v(getNx(),getNy())`

T_ operator() (size_t *i*, size_t *j*, size_t *k*) const

Operator `()` with 3-D indexing (Case of a grid vector)

Parameters

in	*i*	first index in vector (Number of vector components in the x-grid)
in	*j*	second index in vector (Number of vector components in the y-grid)
in	*k*	third index in vector (Number of vector components in the z-grid) `v(i,j,k)` starts at `v(1,1,1)` to `v(getNx(),getNy(),getNz())`

PETScVect<T_>& operator= (const T_ & *a*)

Operator =
 Assign a constant to vector entries

Parameters

in	*a*	Value to set

PETScVect<T_>& operator+= (const PETScVect< T_ > & *v*)

Operator +=
 Add vector `x` to current vector instance.

Parameters

in	*v*	PETScVect instance to add to instance

PETScVect<T_>& operator+= (const T_ & *a*)

Operator +=
 Add a constant to current vector entries.

Parameters

in	*a*	Value to add to vector entries

PETScVect<T_>& operator-= (const PETScVect< T_ > & *v*)

Operator -=

Parameters

in	*v*	Vect instance to subtract from

PETScVect<T_>& operator-= (const T_ & *a*)

Operator -=

Subtract constant from vector entries.

Parameters

in	*a*	Value to subtract from

PETScVect<T_>& operator*= (const T_ & *a*)

Operator *=

Parameters

in	*a*	Value to multiply by

PETScVect<T_>& operator/= (const T_ & *a*)

Operator /=

Parameters

in	*a*	Value to divide by

T_ operator, (const PETScVect< T_ > & *v*) const

Return Dot (scalar) product of two vectors.

A typical use of this operator is `double a = (v,w)` where `v` and `w` are 2 instances of `PETScVect<double>`

Parameters

in	*v*	PETScVect instance by which the current instance is multiplied

operator Vec ( ) const

Casting operator.

This member functions enables casting an instance of class PETScVect into the `Petsc` vector type `Vec`. This is useful when one wants to usr any Petsc function that is not available in the wrapper (class PETScWrapper) or PETScVect.

void setAssembly ( )

Vector assembly.
This function assembles vector (begins and ends)

void Insert (const vector< int > & *ii*, const vector< Point< T_ > > & *v*)

Insert values into certain locations of the vector.

Parameters

in	*ii*	Vector containing indices where to insert (Note the indices start from 0 like any C-array)
in	*v*	Vector of values to insert, corresponding to indices in ii. Here the vector has entries of type Point<T_>.

void Add (const vector< int > & *ii*, const vector< T_ > & *v*)

Add values into certain locations of the vector.

Parameters

in	*ii*	Vector containing indices where to add (Note the indices start from 0 like any C-array)
in	*v*	Vector of values to add, corresponding to indices in ii

7.80 PETScWrapper< T_ > Class Template Reference

This class is a wrapper to be used when the library Petsc is installed and used with OFELI.

Public Member Functions

- PETScWrapper (int argc, char **args, string help="")
  Constructor with program arguments.
- ~PETScWrapper ()
  Destructor.
- PetscErrorCode getIntOption (string s, PetscInt &n, PetscBool &set) const
  Get an option as an integer number.
- PetscErrorCode getBoolOption (string s, PetscBool &b, PetscBool &set) const
  Get an option as a bool variable.
- PetscMPIInt size () const
  Return wrapper size, i.e. number of processors.
- void setMesh (Mesh &ms)
  Set mesh.
- void setPartition (Partition &p)
  Set mesh partition.

- void setMatrix (PETScMatrix< T_ > &A)

  Define problem matrix.
- void setLinearSystem (PETScMatrix< T_ > &A, PETScVect< T_ > &b, string s=KSPCG, string p=PCJACOBI, real_t tol=1.e-12, size_t max_it=1000)

  Set linear system features.
- void setPreconditioner (string p)

  Choose preconditioner for the iterative procedure.
- void setIterationParameters (real_t tol, size_t max_it)

  Choose iteration parameters.
- void setIterationMethod (string m)

  Choose the iterative method.
- void solve (PETScVect< T_ > &x)

  Solve the linear system.
- void solve (const PETScVect< T_ > &b, PETScVect< T_ > &x)

  Solve the linear system.
- void checkError (PETScVect< T_ > &u) const

  Check residual error.
- int getIterationNumber () const

  Return the number of iterations.
- void setLSTolerances (real_t rel_tol, real_t abs_tol, real_t div_tol=PETSC_DEFAULT, int max↩ _it=PETSC_DEFAULT) const

  Set tolerance parameters for a linear system.
- PetscMPIInt getRank () const

  Return the rank of the current processor.

Friends

- template<class S_ >
  ostream & operator<< (ostream &s, const PETScWrapper< S_ > &w)

  Output wrapper information.

7.80.1 Detailed Description

template<class T_>
class OFELI::PETScWrapper< T_ >

This class is a wrapper to be used when the library Petsc is installed and used with OFELI.

When Petsc is used, an instance of class PETScWrapper is to be declared. It initializes the use of Petsc and enables calling solver functions in Petsc.

Template Parameters

T↩ _↩	Data type (double, int, complex<double>, ...)

When a linear system is invoked, the choice of iterative solvers can be made among the following methods (see Petsc documentation for more details):

- `KSPRICHARDSON`: The Richardson iterative method (Default damping parameter is `1.0`)

- `KSPCHEBYSHEV`: The Chebyshev iterative method
- `KSPCG`: The conjugate gradient method [Default]
- `KSPCGNE`: The CG method for normal equations (without explicitly forming the product `A^TA`
- `KSPGMRES`: [Default] The GMRES iterative method (see A Generalized Minimal Residual Algorithm for Solving Nonsymmetric Linear Systems. Y. Saad and M. H. Schultz, SIAM J. Sci. Stat. Comput., Vo|. 7, No. 3, July 1986, pp. 856-869)
- `KSPFGMRES`: The Flexible GMRES method (with restart)
- `KSPLGMRES`: The 'augmented' standard GMRES method where the subspace uses approximations to the error from previous restart cycles
- `KSPTCQMR`: A variant of QMR (quasi minimal residual) developed by Tony Chan
- `KSPBCGS`: The BiCGStab (Stabilized version of BiConjugate Gradient Squared) method
- `KSPIBCGS`: The IBiCGStab (Improved Stabilized version of BiConjugate Gradient Squared) method in an alternative form to have only a single global reduction operation instead of the usual 3 (or 4)
- `KSPFBCGS`: The flexible BiCGStab method.
- `KSPCGS`: The CGS (Conjugate Gradient Squared) method
- `KSPTFQMR`: A transpose free QMR (quasi minimal residual)
- `KSPCR`: The conjugate residuals method
- `KSPLSQR`: The LSQR method
- `KSPBICG`: The Biconjugate gradient method (similar to running the conjugate gradient on the normal equations)
- `KSPMINRES`: The MINRES (Minimum Residual) method
- `KSPSYMMLQ`: The SYMMLQ method
- `KSPGCR`: The Generalized Conjugate Residual method

When a linear system is invoked, the choice of a preconditioner can be made among the following methods (see Petsc documentation for more details):

- `PCJACOBI`: [Default] Jacobi (*i.e.* diagonal scaling) preconditioning
- `PCBJACOBI`: Block Jacobi preconditioning, each block is (approximately) solved with its own KSP object
- `PCSOR`: (S)SOR (successive over relaxation, Gauss-Seidel) preconditioning
- `PCEISENSTAT`: An implementation of SSOR (symmetric successive over relaxation, symmetric Gauss-Seidel) preconditioning that incorporates Eisenstat's trick to reduce the amount of computation needed
- `PCICC`: Incomplete Cholesky factorization preconditioners
- `PCILU`: Incomplete factorization preconditioners
- `PCASM`: Use the (restricted) additive Schwarz method, each block is (approximately) solved with its own KSP object
- `PCLU`: Uses a direct solver, based on LU factorization, as a preconditioner
- `PCCHOLESKY`: Uses a direct solver, based on Cholesky factorization, as a preconditioner

7.80.2 Constructor & Destructor Documentation

PETScWrapper (int *argc*, char ∗∗ *args*, string *help* = `""`)

Constructor with program arguments.

Parameters

`in`	*argc*	Count of number of command line arguments

Parameters

<table>
<tr>
<td><code>in</code></td>
<td>args</td>
<td>The command line arguments. Here is the list of arguments:

<code>-start_in_debugger [noxterm,dbx,xdb,gdb,...]</code>
Starts program in debugger
<code>-on_error_attach_debugger [noxterm,dbx,xdb,gdb,...]</code>
Starts debugger when error detected
<code>-on_error_emacs <machinename></code> causes emacsclient to jump to error file
. -on_error_abort calls abort() when error detected (no traceback)
<code>-on_error_mpiabort</code> calls MPI_abort() when error detected
. -error_output_stderr prints error messages to stderr instead of the default stdout
<code>-error_output_none</code> does not print the error messages (but handles errors in the same way as if this was not called)
. -debugger_nodes [node1,node2,...] - Indicates nodes to start in debugger
<code>-debugger_pause [sleeptime]</code> (in seconds)
Pauses debugger
<code>-stop_for_debugger</code>
Print message on how to attach debugger manually to process and wait (<code>-debugger_pause</code>) seconds for attachment
<code>-malloc</code>
Indicates use of PETSc error-checking malloc (on by default for debug version of libraries)
<code>-malloc no</code>
Indicates not to use error-checking malloc
<code>-malloc_debug</code>
check for memory corruption at EVERY malloc or free
<code>-malloc_dump</code>
prints a list of all unfreed memory at the end of the run
<code>-malloc_test</code>
like <code>-malloc_dump</code> <code>-malloc_debug</code>, but only active for debugging builds
<code>-fp_trap</code>
Stops on floating point exceptions (Note that on the IBM RS6000 this slows code by at least a factor of 10.)
<code>-no_signal_handler</code>
Indicates not to trap error signals
<code>-shared_tmp</code>
indicates <code>/tmp</code> directory is shared by all processors
<code>-not_shared_tmp</code>

</td>
</tr>
</table>

Parameters

in	*help*	String that contains message to display when argument `-v` is used

Warning

This class is available only when OFELI has been installed with Petsc

∼PETScWrapper ( )

Destructor.
Destroy the KSP context and release memory allocated by petsc

7.80.3 Member Function Documentation

PetscErrorCode getIntOption (string *s*, PetscInt & *n*, PetscBool & *set*) const

Get an option as an integer number.

Parameters

in	*s*	String to preprend the name of the option
out	*n*	Obtained integer value
out	*set*	`true` if found, `false` if not.

PetscErrorCode getBoolOption (string *s*, PetscBool & *b*, PetscBool & *set*) const

Get an option as a bool variable.

Parameters

in	*s*	String to preprend the name of the option
out	*b*	Obtained boolean value
out	*set*	`true` if found, `false` if not.

void setMesh (Mesh & *ms*)

Set mesh.

Parameters

in	*ms*	Mesh instance

void setPartition (Partition & *p*)

Set mesh partition.
This function is to be used for parallel computing

Parameters

in	*p*	Partition instance

void setMatrix (PETScMatrix< T_ > & *A*)

Define problem matrix.

Parameters

in	*A*	PETScMatrix instance that contains matrix

void setLinearSystem (PETScMatrix< T_ > & *A*, PETScVect< T_ > & *b*, string *s* = *KSPCG*, string *p* = *PCJACOBI*, real_t *tol* = *1.e-12*, size_t *max_it* = *1000*)

Set linear system features.

Parameters

in	*A*	PETScMatrix instance that contains matrix
in	*b*	Vector containing the right-hand side
in	*s*	Option to choose iterative solver. See the definition of the class for iterative methods
in	*p*	Option to choose preconditioner. See the definition of the class for available preconditioners.
in	*tol*	Tolerance for convergence of iteration process [Default: `1.e-12`]
in	*max_it*	Maximum number of linear solver iterations [Default: `1000`]

void setPreconditioner (string *p*)

Choose preconditioner for the iterative procedure.

Parameters

in	*p*	Option to choose preconditioner. See the definition of the class for available preconditioners.

void setIterationParameters (real_t *tol*, size_t *max_it*)

Choose iteration parameters.

Parameters

in	*tol*	Tolerance for convergence of iteration process
in	*max_it*	Maximum number of linear solver iterations

void setIterationMethod (string *m*)

Choose the iterative method.

Parameters

in	*m*	Option to choose iterative solver. See the definition of the class for available iterative solvers.

void solve (PETScVect< T_ > & *x*)

Solve the linear system.

If the member functions setIterationMethod and setPreconditioner have not been used, default methods are used

Parameters

in,out	*x*	Vector containing the initial guess on input and, if convergence is achieved, the solution on output

void solve (const PETScVect< T_ > & *b*, PETScVect< T_ > & *x*)

Solve the linear system.

If the member functions setIterationMethod and setPreconditioner have not been used, default methods are used

Parameters

in	*b*	Vector containing the right-hand side
in,out	*x*	Vector containing the initial guess on input and, if convergence is achieved, the solution on output

void checkError (PETScVect< T_ > & *u*) const

Check residual error.

This function computes the residual A∗x - b and outputs the number of iterations

Parameters

out	*u*	Residual vector

void setLSTolerances (real_t *rel_tol*, real_t *abs_tol*, real_t *div_tol* = *PETSC_DEFAULT*, int *max_it* = *PETSC_DEFAULT*) const

Set tolerance parameters for a linear system.

Parameters

in	*rel_tol*	Relative convergence tolerance, relative decrease in the preconditioned residual norm

Parameters

in	*abs_tol*	Absolute convergence tolerance of the preconditioned residual norm
in	*div_tol*	Divergence tolerance: Amount preconditioned residual norm
in	*max←_it*	Maximum number of iterations

7.81 PhaseChange Class Reference

This class enables defining phase change laws for a given material.

Public Member Functions

- virtual ~PhaseChange ()

  Destructor.
- int E2T (real_t &H, real_t &T, real_t &gamma)

  Calculate temperature from enthalpy.
- virtual int EnthalpyToTemperature (real_t &H, real_t &T, real_t &gamma)

  Virtual function to calculate temperature from enthalpy.
- void setMaterial (Material &m, int code)

  Choose Material instance and material code.
- Material & getMaterial () const

  Return reference to Material instance.

7.81.1 Detailed Description

This class enables defining phase change laws for a given material.

These laws are predefined for a certain number of materials. The user can set himself a specific behavior for his own materials by defining a class that inherits from PhaseChange. The derived class must has at least the member function

int EnthalpyToTemperature(real_t &H, real_t &T, real_t &gamma)

7.81.2 Member Function Documentation

int E2T (real_t & *H*, real_t & *T*, real_t & *gamma*)

Calculate temperature from enthalpy.

This member function is to be called in any equation class that needs phase change laws.

Parameters

in	*H*	Enthalpy value
out	*T*	Calculated temperature value
out	*gamma*	Maximal slope of the curve `H -> T`

virtual int EnthalpyToTemperature (real_t & *H*, real_t & *T*, real_t & *gamma*) `[virtual]`

Virtual function to calculate temperature from enthalpy.

This member function must be implemented in any derived class in order to define user's own material laws.

Parameters

in	*H*	Enthalpy value
out	*T*	Calculated temperature value
out	*gamma*	Maximal slope of the curve `H -> T`

7.82 Point< T_ > Class Template Reference

Defines a point with arbitrary type coordinates.

Public Member Functions

- Point ()

  Default constructor.
- Point (T_ a, T_ b=T_(0), T_ c=T_(0))

  Constructor that assigns `a`, `b` *to* `x`-, `y`- *and* `z`*-coordinates respectively.*
- Point (const Point< T_ > &p)

  Copy constructor.
- T_ & operator() (size_t i)

  Operator (): Non constant version.
- const T_ & operator() (size_t i) const

  Operator (): Constant version.
- T_ & operator[ ] (size_t i)

  Operator []: Non constant version.
- const T_ & operator[ ] (size_t i) const

  Operator []: Constant version.
- Point< T_ > & operator+= (const Point< T_ > &p)

  Operator +=
- Point< T_ > & operator-= (const Point< T_ > &p)

  Operator -=
- Point< T_ > & operator= (const T_ &a)

  Operator =
- Point< T_ > & operator+= (const T_ &a)

  Operator +=
- Point< T_ > & operator-= (const T_ &a)

  Operator -=
- Point< T_ > & operator*= (const T_ &a)

  *Operator *=*
- Point< T_ > & operator/= (const T_ &a)

  Operator /=
- bool operator== (const Point< T_ > &p)

  Operator ==
- bool operator!= (const Point< T_ > &p)

Operator `!=`
- double NNorm () const

  Return squared euclidean norm of vector.
- double Norm () const

  Return norm (length) of vector.
- void Normalize ()

  Normalize vector.
- Point< double > Director (const Point< double > &p) const

  Return Director (Normalized vector)
- bool isCloseTo (const Point< double > &a, double toler=OFELI_TOLERANCE) const

  Return `true` *if current point is close to instance* `a` *(up to tolerance* `toler`*)*
- T_ operator, (const Point< T_ > &p) const

  Return Dot (scalar) product of two vectors.

Public Attributes

- T_ x

  First coordinate.
- T_ y

  Second coordinate.
- T_ z

  Third coordinate.

7.82.1 Detailed Description

template<class T_>
class OFELI::Point< T_ >

Defines a point with arbitrary type coordinates.
Operators = and `()` are overloaded.

Template Parameters

*T_*	Data type (double, float, complex<double>, ...)

7.82.2 Constructor & Destructor Documentation

Point (T_ *a*, T_ *b* = *T_(0)*, T_ *c* = *T_(0)*)

Constructor that assigns `a`, `b` to `x`-, `y`- and `z`-coordinates respectively.
Default values for `b` and `c` are `0`

7.82.3 Member Function Documentation

T_& operator() (size_t *i*)

Operator `()`: Non constant version.
Values `i = 1, 2, 3` correspond to `x`, `y` and `z` respectively

const T_& operator() (size_t *i*) const

Operator `()`: Constant version.
Values `i = 1, 2, 3` correspond to `x`, `y` and `z` respectively

T_& operator[ ] (size_t *i*)

Operator `[]`: Non constant version.
Values `i = 0, 1, 2` correspond to `x`, `y` and `z` respectively

const T_& operator[ ] (size_t *i*) const

Operator `[]`: Constant version.
Values `i = 0, 1, 2` correspond to `x`, `y` and `z` respectively

Point<T_>& operator+= (const Point< T_ > & *p*)

Operator `+=`
Add point `p` to current instance

Point<T_>& operator-= (const Point< T_ > & *p*)

Operator `-=`
Subtract point `p` from current instance

Point<T_>& operator= (const T_ & *a*)

Operator `=`
Assign constant `a` to current instance coordinates

Point<T_>& operator+= (const T_ & *a*)

Operator `+=`
Add constant `a` to current instance coordinates

Point<T_>& operator-= (const T_ & *a*)

Operator `-=`
Subtract constant `a` from current instance coordinates

Point<T_>& operator*= (const T_ & *a*)

Operator `*=`
Multiply constant `a` by current instance coordinates

Point<T_>& operator/= (const T_ & *a*)

Operator `/=`
Divide current instance coordinates by `a`

bool operator== (const Point< T_ > & *p*)

Operator `==`
Return `true` if current instance is equal to `p`, `false` otherwise.

bool operator!= (const Point< T_ > & *p*)

Operator `!=`
Return `false` if current instance is equal to `p`, `true` otherwise.

void Normalize ( )

Normalize vector.
Divide vector components by its 2-norm

bool isCloseTo (const Point< double > & *a*, double *toler* = OFELI_TOLERANCE) const

Return `true` if current point is close to instance `a` (up to tolerance `toler`)
Default value for `toler` is the `OFELI_TOLERANCE` constant.

T_ operator, (const Point< T_ > & *p*) const

Return Dot (scalar) product of two vectors.
A typical use of this operator is `double a = (p,q)` where `p` and `q` are 2 instances of `Point<double>`

Parameters

in	*p*	Point instance by which the current instance is multiplied

7.83 Point2D< T_ > Class Template Reference

Defines a 2-D point with arbitrary type coordinates.

Public Member Functions

- Point2D ()
  Default constructor.
- Point2D (T_ a, T_ b=T_(0))
  Constructor that assigns `a`, `b` to x-, y- and y-coordinates respectively.
- Point2D (T_ *a)
  Initialize point coordinates with C-array a.
- Point2D (const Point2D< T_ > &pt)
  Copy constructor.
- Point2D (const Point< T_ > &pt)
  Copy constructor from class Point.
- T_ & operator() (size_t i)
  Operator() : Non constant version.
- const T_ & operator() (size_t i) const
  Operator() : Constant version.
- T_ & operator[ ] (size_t i)
  Operator []: Non constant version.
- const T_ & operator[ ] (size_t i) const
  Operator [] Constant version.
- Point2D< T_ > & operator= (const Point2D< T_ > &p)

Operator =
- Point2D< T_ > & operator+= (const Point2D< T_ > &p)

    Operator +=
- Point2D< T_ > & operator-= (const Point2D< T_ > &p)

    Operator -=
- Point2D< T_ > & operator= (const T_ &a)

    Operator =
- Point2D< T_ > & operator+= (const T_ &a)

    Operator +=
- Point2D< T_ > & operator-= (const T_ &a)

    Operator -=
- Point2D< T_ > & operator*= (const T_ &a)

    *Operator *=*
- Point2D< T_ > & operator/= (const T_ &a)

    Operator /=
- bool operator== (const Point2D< T_ > &p)

    Operator ==
- bool operator!= (const Point2D< T_ > &p)

    Operator !=
- real_t CrossProduct (const Point2D< real_t > &lp, const Point2D< real_t > &rp)

    Return Cross product of two vectors `lp` and `rp`
- real_t NNorm () const

    Return squared norm (length) of vector.
- real_t Norm () const

    Return norm (length) of vector.
- Point2D< real_t > Director (const Point2D< real_t > &p) const

    Return Director (Normalized vector)
- bool isCloseTo (const Point2D< real_t > &a, real_t toler=OFELI_TOLERANCE) const

    Return `true` if current point is close to instance `a` (up to tolerance `toler`)

Public Attributes

- T_ x

    First coordinate of point.
- T_ y

    Second coordinate of point.

7.83.1 Detailed Description

template<class T_>
class OFELI::Point2D< T_ >

Defines a 2-D point with arbitrary type coordinates.

Operators = and () are overloaded. The actual

Template Parameters

*T_*	Data type (double, float, complex<double>, ...)

7.83.2 Constructor & Destructor Documentation

Point2D (T_ *a*, T_ *b* = *T_(0)*)

Constructor that assigns `a`, `b` to `x`-, `y`- and `y`-coordinates respectively.
Default value for *b* is 0

7.83.3 Member Function Documentation

T_& operator() (size_t *i*)

Operator() : Non constant version.
Values `i = 1,2` correspond to `x` and `y` respectively

const T_& operator() (size_t *i*) const

Operator() : Constant version.
Values `i=1,2` correspond to `x` and `y` respectively

T_& operator[ ] (size_t *i*)

Operator `[]`: Non constant version.
Values `i=0,1` correspond to `x` and `y` respectively

const T_& operator[ ] (size_t *i*) const

Operator `[]` Constant version.
Values `i=0,1` correspond to `x` and `y` respectively

Point2D<T_>& operator= (const Point2D< T_ > & *p*)

Operator =
Assign point `p` to current instance

Point2D<T_>& operator+= (const Point2D< T_ > & *p*)

Operator +=
Add point `p` to current instance

Point2D<T_>& operator-= (const Point2D< T_ > & *p*)

Operator `-=`
Subtract point `p` from current instance

Point2D<T_>& operator= (const T_ & *a*)

Operator =
Assign constant `a` to current instance coordinates

Point2D<T_>& operator+= (const T_ & *a*)

Operator +=
Add constant a to current instance coordinates

Point2D<T_>& operator-= (const T_ & *a*)

Operator -=
Subtract constant a from current instance coordinates

Point2D<T_>& operator*= (const T_ & *a*)

Operator *=
Multiply constant a by current instance coordinates

Point2D<T_>& operator/= (const T_ & *a*)

Operator /=
Divide current instance coordinates by a

bool operator== (const Point2D< T_ > & *p*)

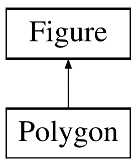
Operator ==
Return `true` if current instance is equal to `p`, `false` otherwise.

bool operator!= (const Point2D< T_ > & *p*)

Operator `!=`
Return `false` if current instance is equal to `p`, `true` otherwise.

7.84 Polygon Class Reference

To store and treat a polygonal figure.
Inheritance diagram for Polygon:



Public Member Functions

- polygon ()
  Default constructor.
- Polygon (const Vect< Point< real_t > > &v, int code=1)
  Constructor.
- void setVertices (const Vect< Point< real_t > > &v)
  Assign vertices of polygon.
- real_t getSignedDistance (const Point< real_t > &p) const
  Return signed distance of a given point from the current polygon.
- Polygon & operator+= (Point< real_t > a)

Operator +=.
- Polygon & operator+= (real_t a)

  *Operator *=.*
- void setCode (int code)

  Choose a code for the domain defined by the figure.
- void getSignedDistance (const Grid &g, Vect< real_t > &d) const

  Calculate signed distance to current figure with respect to grid points.
- real_t dLine (const Point< real_t > &p, const Point< real_t > &a, const Point< real_t > &b) const

  Compute signed distance from a line.

7.84.1 Detailed Description

To store and treat a polygonal figure.

7.84.2 Constructor & Destructor Documentation

Polygon (const Vect< Point< real_t > > & *v*, int *code* = *1*)

Constructor.

Parameters

in	*v*	Vect instance containing list of coordinates of polygon vertices
in	*code*	Code to assign to the generated domain (Default value = 1)

7.84.3 Member Function Documentation

void setVertices (const Vect< Point< real_t > > & *v*)

Assign vertices of polygon.

Parameters

in	*v*	Vector containing vertices coordinates in counter clockwise order

real_t getSignedDistance (const Point< real_t > & *p*) const [virtual]

Return signed distance of a given point from the current polygon.
The computed distance is negative if p lies in the polygon, negative if it is outside, and 0 on its boundary

Parameters

in	*p*	Point<double> instance

Reimplemented from Figure.

Polygon& operator+= (Point< real_t > *a*)

Operator +=.
Translate polygon by a vector a

Polygon& operator+= (real_t *a*)

Operator ∗=.
Scale polygon by a factor a

void getSignedDistance (const Grid & *g*, Vect< real_t > & *d*) const [inherited]

Calculate signed distance to current figure with respect to grid points.

Parameters

in	*g*	Grid instance
in	*d*	Vect instance containing calculated distance from each grid index to Figure

Remarks

Vector d doesn't need to be sized before invoking this function

real_t dLine (const Point< real_t > & *p*, const Point< real_t > & *a*, const Point< real_t > & *b*) const [inherited]

Compute signed distance from a line.

Parameters

in	*p*	Point for which distance is computed
in	*a*	First vertex of line
in	*b*	Second vertex of line

Returns

Signed distance

7.85 Prec< T_ > Class Template Reference

To set a preconditioner.

Public Member Functions

- Prec ()

  Default constructor.
- Prec (int type)

  Constructor that chooses preconditioner.
- Prec (const SpMatrix< T_ > &A, int type=DIAG_PREC)

  Constructor using matrix of the linear system to precondition.

- Prec (const Matrix< T_ > *A, int type=DIAG_PREC)

  Constructor using matrix of the linear system to precondition.
- ~Prec ()

  Destructor.
- void setType (int type)

  Define preconditioner type.
- void setMatrix (const Matrix< T_ > *A)

  Define pointer to matrix for preconditioning (if this one is abstract)
- void setMatrix (const SpMatrix< T_ > &A)

  Define the matrix for preconditioning.
- void solve (Vect< T_ > &x) const

  Solve a linear system with preconditioning matrix.
- void solve (const Vect< T_ > &b, Vect< T_ > &x) const

  Solve a linear system with preconditioning matrix.
- void TransSolve (Vect< T_ > &x) const

  Solve a linear system with transposed preconditioning matrix.
- void TransSolve (const Vect< T_ > &b, Vect< T_ > &x) const

  Solve a linear system with transposed preconditioning matrix.
- T_ & getPivot (size_t i) const

  Return i-th pivot of preconditioning matrix.

7.85.1 Detailed Description

template<class T_>
class OFELI::Prec< T_ >

To set a preconditioner.
The preconditioner type is chosen in the constructor

Template Parameters

<T_>	Data type (real_t, float, complex<real_t>, ...)

7.85.2 Constructor & Destructor Documentation

Prec (int *type*)

Constructor that chooses preconditioner.

Parameters

in	*type*	Preconditioner type: • `IDENT_PREC`: Identity preconditioner (No preconditioning) • `DIAG_PREC`: Diagonal preconditioner • `DILU_PREC`: Diagonal Incomplete factorization preconditioner • `ILU_PREC`: Incomplete factorization preconditioner • `SSOR_PREC`: SSOR preconditioner

Prec (const SpMatrix< T_ > & *A*, int *type* = DIAG_PREC)

Constructor using matrix of the linear system to precondition.

Parameters

in	*A*	Matrix to precondition
in	*type*	Preconditioner type: • `IDENT_PREC`: Identity preconditioner (No preconditioning) • `DIAG_PREC`: Diagonal preconditioner • `DILU_PREC`: Diagonal Incomplete factorization preconditioner • `ILU_PREC`: Incomplete factorization preconditioner • `SSOR_PREC`: SSOR preconditioner

Prec (const Matrix< T_ > ∗ *A*, int *type* = DIAG_PREC)

Constructor using matrix of the linear system to precondition.

Parameters

in	*A*	Pointer to abstract Matrix class to precondition
in	*type*	Preconditioner type: • `IDENT_PREC`: Identity preconditioner (No preconditioning) • `DIAG_PREC`: Diagonal preconditioner • `DILU_PREC`: Diagonal Incomplete factorization preconditioner • `ILU_PREC`: Incomplete factorization preconditioner • `SSOR_PREC`: SSOR preconditioner

7.85.3 Member Function Documentation

void setType (int *type*)

Define preconditioner type.

Parameters

in	*type*	Preconditioner type: • `IDENT_PREC`: Identity preconditioner (No preconditioning) • `DIAG_PREC`: Diagonal preconditioner • `DILU_PREC`: Diagonal Incomplete factorization preconditioner • `ILU_PREC`: Incomplete factorization preconditioner • `SSOR_PREC`: SSOR preconditioner

void setMatrix (const Matrix< T_ > * *A*)

Define pointer to matrix for preconditioning (if this one is abstract)

Parameters

in	*A*	Matrix to precondition

void setMatrix (const SpMatrix< T_ > & *A*)

Define the matrix for preconditioning.

Parameters

in	*A*	Matrix to precondition (instance of class SpMatrix)

void solve (Vect< T_ > & *x*) const

Solve a linear system with preconditioning matrix.

Parameters

in,out	*x*	Right-hand side on input and solution on output.

void solve (const Vect< T_ > & *b*, Vect< T_ > & *x*) const

Solve a linear system with preconditioning matrix.

Parameters

in	b	Right-hand side
out	x	Solution vector

void TransSolve (Vect< T_ > & x) const

Solve a linear system with transposed preconditioning matrix.

Parameters

in,out	x	Right-hand side in input and solution in output.

void TransSolve (const Vect< T_ > & b, Vect< T_ > & x) const

Solve a linear system with transposed preconditioning matrix.

Parameters

in	b	Right-hand side vector
out	x	Solution vector

7.86 Prescription Class Reference

To prescribe various types of data by an algebraic expression. Data may consist in boundary conditions, forces, tractions, fluxes, initial condition. All these data types can be defined through an enumerated variable.

Public Member Functions

- Prescription ()

  Default constructor.
- Prescription (Mesh &mesh, const string &file)

  Constructor that gives an instance of class Mesh and the data file name.
- ∼Prescription ()

  Destructor.
- int get (int type, Vect< real_t > &v, real_t time=0, size_t dof=0)

7.86.1 Detailed Description

To prescribe various types of data by an algebraic expression. Data may consist in boundary conditions, forces, tractions, fluxes, initial condition. All these data types can be defined through an enumerated variable.

7.86.2 Constructor & Destructor Documentation

Prescription (Mesh & *mesh*, const string & *file*)

Constructor that gives an instance of class Mesh and the data file name.
It reads parameters in Prescription Format from this file.

Parameters

in	*mesh*	Mesh instance
in	*file*	Name of Prescription file

7.86.3 Member Function Documentation

int get (int *type*, Vect< real_t > & *v*, real_t *time* = 0, size_t *dof* = 0)

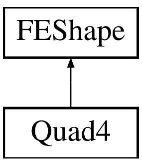
Read data in the given file and stores in a Vect instance for a chosen DOF. The input value type determines the type of data to read.

Parameters

in	*type*	Type of data to seek. To choose among the enumerated values: • `BOUNDARY_CONDITION`: Read values for (Dirichlet) boundary conditions • `BOUNDARY_FORCE`: Read values for boundary force (Neumann boundary condition). The values `TRACTION` and `FLUX` have the same effect. • `BODY_FORCE`: Read values for body (or volume) forces. The value `SOURCE` has the same effect. • `POINT_FORCE`: Read values for pointwise forces • `INITIAL_FIELD`: Read values for initial solution
in,out	*v*	Vect instance that is instantiatd on input and filled on output
in	*time*	Value of time for which data is read [Default: `0`].
in	*dof*	DOF to store (Default is `0`: All DOFs are chosen).

7.87 Quad4 Class Reference

Defines a 4-node quadrilateral finite element using $\mathtt{Q}_1$ isoparametric interpolation.
Inheritance diagram for Quad4:



Public Member Functions

- Quad4 ()
  Default Constructor.
- Quad4 (const Element *element)
  Constructor when data of Element `el` are given.
- Quad4 (const Side *side)
  Constructor when data of Side `sd` are given.
- ∼Quad4 ()
  Destructor.
- void set (const Element *el)
  Choose element by giving its pointer.
- void set (const Side *sd)
  Choose side by giving its pointer.
- void setLocal (const Point< real_t > &s)
  Initialize local point coordinates in element.
- Point< real_t > DSh (size_t i) const
  Return derivatives of shape function of node `i` at a given point.
- Point< real_t > Grad (const LocalVect< real_t, 4 > &u, const Point< real_t > &s)
  Return gradient of a function defined at element nodes.
- real_t getMaxEdgeLength () const
  Return maximal edge length of quadrilateral.
- real_t getMinEdgeLength () const
  Return minimal edge length of quadrilateral.
- real_t Sh (size_t i) const
  Return shape function of node `i` at given point.
- real_t Sh (size_t i, Point< real_t > s) const
  Calculate shape function of node `i` at a given point `s`.
- real_t getDet () const
  Return determinant of jacobian.
- Point< real_t > getCenter () const
  Return coordinates of center of element.
- Point< real_t > getLocalPoint () const
  Localize a point in the element.
- Point< real_t > getLocalPoint (const Point< real_t > &s) const
  Localize a point in the element.

7.87.1 Detailed Description

Defines a 4-node quadrilateral finite element using `Q1` isoparametric interpolation.

The reference element is the square `[-1,1]x[-1,1]`. The user must take care to the fact that determinant of jacobian and other quantities depend on the point in the reference element where they are calculated. For this, before any utilization of shape functions or jacobian, function **set↩ Local()** must be invoked.

7.87.2 Constructor & Destructor Documentation

Quad4 (const Element * *element*)

Constructor when data of Element `el` are given.

Parameters

in	*element*	Pointer to Element

Quad4 (const Side ∗ *side*)

Constructor when data of Side sd are given.

Parameters

in	*side*	Pointer to Side

7.87.3 Member Function Documentation

void setLocal (const Point< real_t > & *s*)

Initialize local point coordinates in element.

Parameters

in	*s*	Point in the reference element This function computes jacobian, shape functions and their partial derivatives at s. Other member functions only return these values.

Point<real_t> DSh (size_t *i*) const

Return derivatives of shape function of node i at a given point.

Member function **setLocal()** must have been called before in order to calculate relevant quantities.

Point<real_t> Grad (const LocalVect< real_t, 4 > & *u*, const Point< real_t > & *s*)

Return gradient of a function defined at element nodes.

Parameters

in	*u*	Vector of values at nodes
in	*s*	Local coordinates (in `[-1,1]`) of point where the gradient is evaluated

Returns

Value of gradient

Note

If the derivatives of shape functions were not computed before calling this function (by calling setLocal), this function will compute them

real_t Sh (size_t *i*, Point< real_t > *s*) const `[inherited]`

Calculate shape function of node i at a given point s.

Parameters

in	*i*	Local node label
in	*s*	Point in the reference triangle where the shape function is evaluated

real_t getDet ( ) const [inherited]

Return determinant of jacobian.

If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint ( ) const [inherited]

Localize a point in the element.

Return actual coordinates in the reference element. If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point< real_t> getLocalPoint (const Point< real_t > & *s*) const [inherited]

Localize a point in the element.

Return actual coordinates where s are coordinates in the reference element.

7.88 Reconstruction Class Reference

To perform various reconstruction operations.

Public Member Functions

- Reconstruction ()

  Default constructor.
- Reconstruction (const Mesh &ms)

  Constructor using a refrence to a Mesh instance.
- ∼Reconstruction ()

  Destructor.
- void setMesh (Mesh &ms)

  Provide Mesh instance.
- void P0toP1 (const Vect< real_t > &u, Vect< real_t > &v)

  Smooth an elementwise field to obtain a nodewise field by L^2 projection.
- void DP1toP1 (const Vect< real_t > &u, Vect< real_t > &v)

  Smooth an Discontinuous P1 field to obtain a nodewise (Continuous P_1) field by L^2 projection.

7.88.1 Detailed Description

To perform various reconstruction operations.

This class enables various reconstruction operations like smoothing, projections, ...

7.88.2 Member Function Documentation

void P0toP1 (const Vect< real_t > & *u*, Vect< real_t > & *v*)

Smooth an elementwise field to obtain a nodewise field by L^2 projection.

Parameters

in	u	Vect instance that contains field to smooth
out	v	Vect instance that contains on output smoothed field

void DP1toP1 (const Vect< real_t > & u, Vect< real_t > & v)

Smooth an Discontinuous P1 field to obtain a nodewise (Continuous P_1) field by L^2 projection.

Parameters

in	u	Vect instance that contains field to smooth
out	v	Vect instance that contains on output smoothed field

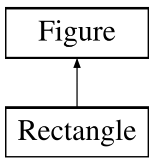
Warning

This function is valid for P_1 triangles (2-D) only.

7.89 Rectangle Class Reference

To store and treat a rectangular figure.

Inheritance diagram for Rectangle:



Public Member Functions

- Rectangle ()

  Default constructor.
- Rectangle (const Point< real_t > &bbm, const Point< real_t > &bbM, int code=1)

  Constructor.
- void setBoundingBox (const Point< real_t > &bbm, const Point< real_t > &bbM)

  Assign bounding box of the rectangle.
- Point< real_t > getBoundingBox1 () const

  Return first point of bounding box.
- Point< real_t > getBoundingBox2 () const

  Return second point of bounding box.
- real_t getSignedDistance (const Point< real_t > &p) const

  Return signed distance of a given point from the current rectangle.
- Rectangle & operator+= (Point< real_t > a)

  Operator +=.
- Rectangle & operator+= (real_t a)

  Operator ∗=.

- void setCode (int code)

  Choose a code for the domain defined by the figure.
- void getSignedDistance (const Grid &g, Vect< real_t > &d) const

  Calculate signed distance to current figure with respect to grid points.
- real_t dLine (const Point< real_t > &p, const Point< real_t > &a, const Point< real_t > &b) const

  Compute signed distance from a line.

7.89.1 Detailed Description

To store and treat a rectangular figure.

7.89.2 Constructor & Destructor Documentation

Rectangle (const Point< real_t > & ***bbm*****, const Point< real_t > &** ***bbM*****, int** ***code*** **=** *1* **)**

Constructor.

Parameters

in	*bbm*	Left Bottom point of rectangle
in	*bbM*	Right Top point of rectangle
in	*code*	Code to assign to rectangle

7.89.3 Member Function Documentation

void setBoundingBox (const Point< real_t > & ***bbm*****, const Point< real_t > &** ***bbM*** **)**

Assign bounding box of the rectangle.

Parameters

in	*bbm*	Left Bottom point
in	*bbM*	Right Top point

real_t getSignedDistance (const Point< real_t > & ***p*** **) const** `[virtual]`

Return signed distance of a given point from the current rectangle.

The computed distance is negative if `p` lies in the rectangle, negative if it is outside, and `0` on its boundary

Parameters

in	*p*	Point<double> instance

Reimplemented from Figure.

Rectangle& operator+= (Point< real_t > *a*)

Operator +=.
Translate rectangle by a vector `a`

Rectangle& operator+= (real_t *a*)

Operator ∗=.
Scale rectangle by a factor `a`

void getSignedDistance (const Grid & *g*, Vect< real_t > & *d*) const `[inherited]`

Calculate signed distance to current figure with respect to grid points.

Parameters

in	*g*	Grid instance
in	*d*	Vect instance containing calculated distance from each grid index to Figure

Remarks

Vector `d` doesn't need to be sized before invoking this function

real_t dLine (const Point< real_t > & *p*, const Point< real_t > & *a*, const Point< real_t > & *b*) const `[inherited]`

Compute signed distance from a line.

Parameters

in	*p*	Point for which distance is computed
in	*a*	First vertex of line
in	*b*	Second vertex of line

Returns

Signed distance

7.90 Side Class Reference

To store and treat finite element sides (edges in 2-D or faces in 3-D)

Public Types

Public Member Functions

- Side ()

  Default Constructor.
- Side (size_t label, const string &shape)

  Constructor initializing side label and shape.
- Side (size_t label, int shape)

Constructor initializing side label and shape.

- Side (const Side &sd)

  Copy constructor.
- ∼Side ()

  Destructor.
- void Add (Node ∗node)

  Insert a node at end of list of nodes of side.
- void Add (Edge ∗edge)

  Insert an edge at end of list of edges of side.
- void setLabel (size_t i)

  Define label of side.
- void setFirstDOF (size_t n)

  Define First DOF.
- void setNbDOF (size_t nb_dof)

  Set number of degrees of freedom (DOF).
- void DOF (size_t i, size_t dof)

  Define label of DOF.
- void setDOF (size_t &first_dof, size_t nb_dof)

  Define number of DOF.
- void setCode (size_t dof, int code)

  Assign code to a DOF.
- void setCode (const string &exp, int code, size_t dof=1)

  Define code by a boolean algebraic expression invoking coordinates of side nodes.
- void Replace (size_t label, Node ∗node)

  Replace a node at a given local label.
- void Add (Element ∗el)

  Set pointer to neighbor element.
- void set (Element ∗el, size_t i)

  Set pointer to neighbor element.
- void setNode (size_t i, Node ∗node)

  Assign a node given by its pointer as the `i`-th node of side.
- int getShape () const

  Return side's shape.
- size_t getLabel () const

  Return label of side.
- size_t n () const

  Return label of side.
- size_t getNbNodes () const

  Return number of side nodes.
- size_t getNbVertices () const

  Return number of side vertices.
- size_t getNbEq () const

  Return number of side equations.
- size_t getNbDOF () const

  Return number of DOF.
- int getCode (size_t dof=1) const

Return code for a given DOF of node.
- size_t getDOF (size_t i) const

  Return label of `i`*-th dof.*
- size_t getFirstDOF () const

  Return label of first dof of node.
- Node * getPtrNode (size_t i) const

  Return pointer to node of local label `i`*.*
- Node * operator() (size_t i) const

  Operator ().
- size_t getNodeLabel (size_t i) const

  Return global label of node with given local label.
- Element * getNeighborElement (size_t i) const

  Return pointer to i-th side neighboring element.
- Element * getOtherNeighborElement (Element *el) const

  Return pointer to other neighboring element than given one.
- Point< real_t > getNormal () const

  Return normal vector to side.
- Point< real_t > getUnitNormal () const

  Return unit normal vector to side.
- int isOnBoundary () const

  Boundary side or not.
- void setOnBoundary ()

  Say that the side is on the boundary.
- real_t getMeasure () const

  Return measure of side.
- size_t Contains (const Node *nd) const

  Say if a given node belongs to current side.
- void setActive (bool opt=true)

  Set side is active (default) or not if argument is `false`
- bool isActive () const

  Return `true` *or* `false` *whether side is active or not.*
- int getLevel () const

  Return side level Side level increases when side is refined (starting from `0`*). If the level is* `0`*, then the element has no father.*
- void setChild (Side *sd)

  Assign side as child of current one and assign current side as father.
- Side * getParent () const

  Return pointer to parent side Return null if no parent.
- Side * getChild (size_t i) const

  Return pointer to `i`*-th child side Returns null pointer is no childs.*
- size_t getNbChilds () const

  Return number of children of side.

7.90.1 Detailed Description

To store and treat finite element sides (edges in 2-D or faces in 3-D)

Defines a side of a finite element mesh. The sides are given in particular by their shapes and a list of nodes. Each node can be accessed by the member function **getPtrNode()**. The string defining the element shape must be chosen according to the following list:

7.90.2 Member Enumeration Documentation

enum SideType

To select side type (boundary side or not).

Enumerator

INTERNAL_SIDE Internal side

EXTERNAL_BOUNDARY Side on external boundary

INTERNAL_BOUNDARY Side on internal boundary

7.90.3 Constructor & Destructor Documentation

Side (size_t *label*, const string & *shape*)

Constructor initializing side label and shape.

Parameters

`in`	*label*	Label to assign to side.
`in`	*shape*	Shape of side (See class description).

Side (size_t *label*, int *shape*)

Constructor initializing side label and shape.

Parameters

`in`	*label*	to assign to side.
`in`	*shape*	of side (See enum ElementShape in Mesh).

7.90.4 Member Function Documentation

void DOF (size_t *i*, size_t *dof*)

Define label of DOF.

Parameters

`in`	*i*	DOF index
`in`	*dof*	Its label

void setDOF (size_t & *first_dof*, size_t *nb_dof*)

Define number of DOF.

Parameters

`in,out`	*first_dof*	Label of the first DOF in input that is actualized
`in`	*nb_dof*	Number of DOF

void setCode (size_t *dof*, int *code*)

Assign code to a DOF.

Parameters

in	*dof*	DOF to which code is assigned
in	*code*	Code to assign

void setCode (const string & *exp*, int *code*, size_t *dof* = `1`)

Define code by a boolean algebraic expression invoking coordinates of side nodes.

Parameters

in	*exp*	Boolean algebraic expression as required by `fparser`
in	*code*	Code to assign to node if the algebraic expression is true
in	*dof*	Degree of Freedom for which code is assigned [Default: 1]

void Add (Element ∗ *el*)

Set pointer to neighbor element.

Parameters

in	*el*	Pointer to element to add as a neigbor element

Remarks

This function adds the pointer `el` only if this one is not a null pointer

void set (Element ∗ *el*, size_t *i*)

Set pointer to neighbor element.

Parameters

in	*el*	Pointer to element to set as a neighbor element
in	*i*	Local number of neighbor element

Remarks

This function differs from the Add by the fact that the local label of neighbor element is given

int getCode (size_t *dof* = `1`) const

Return code for a given DOF of node.

Parameters

in	*dof*	Local label of degree of freedom. [Default: 1]

Node* operator() (size_t *i*) const

Operator ().
Return pointer to node of local label i.

Element* getNeighborElement (size_t *i*) const

Return pointer to i-th side neighboring element.

Parameters

in	*i*	Local label of neighbor element (must be equal to 1 or 2).

Element* getOtherNeighborElement (Element * *el*) const

Return pointer to other neighboring element than given one.

Parameters

in	*el*	Pointer to a given neighbor element

Remarks

If the side is on the boundary this function returns null pointer

Point<real_t> getNormal ( ) const

Return normal vector to side.
The normal vector is oriented from the first neighbor element to the second one.

Warning

The norm of this vector is equal to the measure of the side (length of the edge in 2-D and area of the face in 3-D), and To get the unit normal, use rather the member function get↩UnitNormal.

Point<real_t> getUnitNormal ( ) const

Return unit normal vector to side.
The unit normal vector is oriented from the first neighbor element to the second one.

Remarks

The norm of this vector is equal to one.

int isOnBoundary ( ) const

Boundary side or not.

Returns `1` or `-1` if side is on boundary Depending on whether the first or the second neighbor element is defined Returns `0` if side is an inner one

Remarks

> This member function is valid only if member function **Mesh::getAllSides()** or **Mesh::get←BoundarySides()** has been called before.

real_t getMeasure ( ) const

Return measure of side.

This member function returns length or area of side. In case of quadrilaterals it returns determinant of Jacobian of mapping between reference and actual side

size_t Contains (const Node * *nd*) const

Say if a given node belongs to current side.

Parameters

in	*nd*	Pointer to searched node

Returns

> index (local label) of node if found, `0` if not

void setChild (Side * *sd*)

Assign side as child of current one and assign current side as father.

This function is principally used when refining is invoked (*e.g.* for mesh adaption)

Parameters

in	*sd*	Pointer to side to assign

7.91 SideList Class Reference

Class to construct a list of sides having some common properties.

Public Member Functions

- SideList (Mesh &ms)

  Constructor using a Mesh instance.
- ∼SideList ()

  Destructor.
- void selectCode (int code, int dof=1)

  Select sides having a given code for a given degree of freedom.

- void unselectCode (int code, int dof=1)

  Unselect sides having a given code for a given degree of freedom.
- size_t getNbSides () const

  Return number of selected sides.
- void top ()

  Reset list of sides at its top position (Non constant version)
- void top () const

  Reset list of sides at its top position (Constant version)
- Side ∗ get ()

  Return pointer to current side and move to next one (Non constant version)
- Side ∗ get () const

  Return pointer to current side and move to next one (Constant version)

7.91.1 Detailed Description

Class to construct a list of sides having some common properties.

This class enables choosing multiple selection criteria by using function `select...` However, the intersection of these properties must be empty.

7.91.2 Member Function Documentation

void selectCode (int *code*, int *dof* = *1*)

Select sides having a given code for a given degree of freedom.

Parameters

`in`	*code*	Code that sides share
`in`	*dof*	Degree of Freedom label [Default: 1]

void unselectCode (int *code*, int *dof* = *1*)

Unselect sides having a given code for a given degree of freedom.

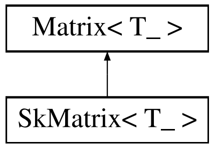
Parameters

`in`	*code*	Code of sides to exclude
`in`	*dof*	Degree of Freedom label [Default: 1]

7.92 SkMatrix< T_ > Class Template Reference

To handle square matrices in skyline storage format.

Inheritance diagram for SkMatrix< T_ >:



Public Member Functions

- SkMatrix ()

  Default constructor.
- SkMatrix (size_t size, int is_diagonal=false)

  Constructor that initializes a dense symmetric matrix.
- SkMatrix (Mesh &mesh, size_t dof=0, int is_diagonal=false)

  Constructor using mesh to initialize skyline structure of matrix.
- SkMatrix (const Vect< size_t > &ColHt)

  Constructor that initializes skyline structure of matrix using vector of column heights.
- SkMatrix (const SkMatrix< T_ > &m)

  Copy Constructor.
- ∼SkMatrix ()

  Destructor.
- void setMesh (Mesh &mesh, size_t dof=0)

  Determine mesh graph and initialize matrix.
- void setSkyline (Mesh &mesh)

  Determine matrix structure.
- void setDiag ()

  Store diagonal entries in a separate internal vector.
- void setDOF (size_t i)

  Choose DOF to activate.
- void set (size_t i, size_t j, const T_ &val)

  Assign a value to an entry ofthe matrix.
- void Axpy (T_ a, const SkMatrix< T_ > &m)

  Add to matrix the product of a matrix by a scalar.
- void Axpy (T_ a, const Matrix< T_ > ∗m)

  Add to matrix the product of a matrix by a scalar.
- void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector x and add to y.
- void TMultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector x and add to y.
- void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by a vector and add to another one.
- void Mult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector x and save in y.
- void TMult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector x and save in y.
- void add (size_t i, size_t j, const T_ &val)

  Add a constant value to an entry ofthe matrix.
- size_t getColHeight (size_t i) const

Return column height.

- T_ operator() (size_t i, size_t j) const

  Operator () (Constant version).

- T_ & operator() (size_t i, size_t j)

  Operator () (Non constant version).

- void DiagPrescribe (Mesh &mesh, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose an essential boundary condition.

- void DiagPrescribe (Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose an essential boundary condition using the Mesh instance provided by the constructor.

- SkMatrix< T_ > & operator= (const SkMatrix< T_ > &m)

  Operator =.

- SkMatrix< T_ > & operator= (const T_ &x)

  Operator =.

- SkMatrix< T_ > & operator+= (const SkMatrix< T_ > &m)

  Operator +=.

- SkMatrix< T_ > & operator+= (const T_ &x)

  Operator +=.

- SkMatrix< T_ > & operator*= (const T_ &x)

  *Operator *=.*

- int setLU ()

  Factorize the matrix (LU factorization)

- int solve (Vect< T_ > &b)

  Solve linear system.

- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve linear system.

- T_ * get () const

  Return C-Array.

- T_ get (size_t i, size_t j) const

  Return entry `(i,j)` of matrix if this one is stored, 0 else.

- size_t getNbRows () const

  Return number of rows.

- size_t getNbColumns () const

  Return number of columns.

- void setPenal (real_t p)

  Set Penalty Parameter (For boundary condition prescription).

- void setDiagonal ()

  Set the matrix as diagonal.

- void setDiagonal (Mesh &mesh)

  Initialize matrix storage in the case where only diagonal terms are stored.

- T_ getDiag (size_t k) const

  Return `k`-th diagonal entry of matrix.

- size_t size () const

  Return matrix dimension (Number of rows and columns).

- void Assembly (const Element &el, T_ *a)

  Assembly of element matrix into global matrix.

- void Assembly (const Element &el, const DMatrix< T_ > &a)

Assembly of element matrix into global matrix.

- void Assembly (const Side &sd, T_ *a)

  Assembly of side matrix into global matrix.
- void Assembly (const Side &sd, const DMatrix< T_ > &a)

  Assembly of side matrix into global matrix.
- void Prescribe (Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.
- void Prescribe (int dof, int code, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.
- void Prescribe (Vect< T_ > &b, int flag=0)

  Impose by a penalty method a homegeneous (=0) essential boundary condition.
- void Prescribe (size_t dof, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition when only one DOF is treated.
- void PrescribeSide ()

  Impose by a penalty method an essential boundary condition when DOFs are supported by sides.
- virtual int Factor ()=0

  Factorize matrix. Available only if the storage class enables it.
- int FactorAndSolve (Vect< T_ > &b)

  Factorize matrix and solve the linear system.
- int FactorAndSolve (const Vect< T_ > &b, Vect< T_ > &x)

  Factorize matrix and solve the linear system.
- size_t getLength () const

  Return number of stored terms in matrix.
- int isDiagonal () const

  Say if matrix is diagonal or not.
- int isFactorized () const

  Say if matrix is factorized or not.
- virtual size_t getColInd (size_t i) const

  Return Column index for column i (See the description for class SpMatrix).
- virtual size_t getRowPtr (size_t i) const

  Return Row pointer for row i (See the description for class SpMatrix).
- T_ operator() (size_t i) const

  Operator () with one argument (Constant version).
- T_ & operator() (size_t i)

  Operator () with one argument (Non Constant version).
- T_ & operator[ ] (size_t k)

  Operator [] (Non constant version).
- T_ operator[ ] (size_t k) const

  Operator [] (Constant version).
- Matrix & operator+= (const Matrix< T_ > &m)

  Operator +=.
- Matrix & operator-= (const Matrix< T_ > &m)

  Operator -=.
- Matrix & operator-= (const T_ &x)

  Operator -=.

7.92.1 Detailed Description

template<class T_>
class OFELI::SkMatrix< T_ >

To handle square matrices in skyline storage format.

This template class allows storing and manipulating a matrix in skyline storage format.

The matrix entries are stored in 2 vectors column by column as in the following example:

```
/                   \         /                      \
| l0              .  |         | u0   u1    0    0    u7 |
| l1  l2          .  |         |      u2   u3    0    u8 |
|  0  l3  l4      .  |         | ...       u4   u5    u9 |
|  0   0  l5  l6     |         |                u6   u10 |
| l7  l8  l9 l10 l11 |         |                     u11 |
\                   /         \                      /
```

Template Parameters

*T_*	Data type (double, float, complex<double>, ...)

7.92.2 Constructor & Destructor Documentation

SkMatrix ( )

Default constructor.

Initializes a zero-dimension matrix

SkMatrix (size_t *size*, int *is_diagonal* = `false`)

Constructor that initializes a dense symmetric matrix.

Normally, for a dense matrix this is not the right class.

Parameters

in	*size*	Number of matrix rows (and columns).
in	*is_diagonal*	Boolean to select if the matrix is diagonal or not [Default: false]

SkMatrix (Mesh & *mesh*, size_t *dof* = `0`, int *is_diagonal* = `false`)

Constructor using mesh to initialize skyline structure of matrix.

Parameters

in	*mesh*	Mesh instance for which matrix graph is determined.
in	*dof*	Option parameter, with default value `0`. `dof=1` means that only one degree of freedom for each node (or element or side) is taken to determine matrix structure. The value `dof=0` means that matrix structure is determined using all DOFs.
in	*is_diagonal*	Boolean argument to say is the matrix is actually a diagonal matrix or not.

SkMatrix (const Vect< size_t > & *ColHt*)

Constructor that initializes skyline structure of matrix using vector of column heights.

Parameters

in	*ColHt*	Vect instance that contains rows lengths of matrix.

7.92.3 Member Function Documentation

void setMesh (Mesh & *mesh*, size_t *dof* = `0`)

Determine mesh graph and initialize matrix.
This member function is called by constructor with the same arguments

Parameters

in	*mesh*	Mesh instance for which matrix graph is determined.
in	*dof*	Option parameter, with default value `0`. `dof=1` means that only one degree of freedom for each node (or element or side) is taken to determine matrix structure. The value `dof=0` means that matrix structure is determined using all DOFs.

void setSkyline (Mesh & *mesh*)

Determine matrix structure.
This member function calculates matrix structure using a Mesh instance.

Parameters

in	*mesh*	Mesh instance

void setDOF (size_t *i*)

Choose DOF to activate.
This function is available only if variable `dof` is equal to 1 in the constructor

Parameters

in	*i*	Index of the DOF

void set (size_t *i*, size_t *j*, const T_ & *val*) `[virtual]`

Assign a value to an entry ofthe matrix.

Parameters

in	*i*	Row index (starting at `i=1`)

Parameters

in	*j*	Column index (starting at `i=1`)
in	*val*	Value to assign to entry `a(i,j)`

Implements Matrix< T_ >.

void Axpy (T_ *a*, const SkMatrix< T_ > & *m*)

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*m*	Matrix by which `a` is multiplied. The result is added to current instance

void Axpy (T_ *a*, const Matrix< T_ > * *m*) `[virtual]`

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*m*	Matrix by which `a` is multiplied. The result is added to current instance

Implements Matrix< T_ >.

void MultAdd (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by vector `x` and add to `y`.

Parameters

in	*x*	Vector to multiply by matrix
in,out	*y*	Vector to add to the result. `y` contains on output the result.

Implements Matrix< T_ >.

void TMultAdd (const Vect< T_ > & *x*, Vect< T_ > & *y*) const

Multiply transpose of matrix by vector `x` and add to `y`.

Parameters

in	*x*	Vector to multiply by matrix
in,out	*y*	Vector to add to the result. `y` contains on output the result.

void MultAdd (T_ *a*, const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by a vector and add to another one.

Parameters

`in`	a	Constant to multiply by matrix
`in`	x	Vector to multiply by matrix
`in,out`	y	Vector to add to the result. `y` contains on output the result.

Implements Matrix< T_ >.

void Mult (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by vector `x` and save in `y`.

Parameters

`in`	x	Vector to multiply by matrix
`out`	y	Vector that contains on output the result.

Implements Matrix< T_ >.

void TMult (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply transpose of matrix by vector `x` and save in `y`.

Parameters

`in`	x	Vector to multiply by matrix
`out`	y	Vector that contains on output the result.

Implements Matrix< T_ >.

void add (size_t *i*, size_t *j*, const T_ & *val*) `[virtual]`

Add a constant value to an entry ofthe matrix.

Parameters

`in`	i	Row index
`in`	j	Column index
`in`	*val*	Constant value to add to `a(i,j)`

Implements Matrix< T_ >.

size_t getColHeight (size_t *i*) const

Return column height.

Column height at entry `i` is returned.

T_ operator() (size_t *i*, size_t *j*) const `[virtual]`

Operator () (Constant version).

Parameters

`in`	*i*	Row index
`in`	*j*	Column index

Implements Matrix< T_ >.

T_& operator() (size_t *i*, size_t *j*) `[virtual]`

Operator () (Non constant version).

Parameters

`in`	*i*	Row index
`in`	*j*	Column index

Implements Matrix< T_ >.

void DiagPrescribe (Mesh & *mesh*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*)

Impose an essential boundary condition.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. It can be modified by member function **setPenal**(..).

Parameters

`in`	*mesh*	Mesh instance from which information is extracted.
`in`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void DiagPrescribe (Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*)

Impose an essential boundary condition using the Mesh instance provided by the constructor.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. It can be modified by member function **setPenal**(..).

Parameters

`in`	*b*	Vect instance that contains right-hand side.

Parameters

in	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

SkMatrix<T_>& operator= (const SkMatrix< T_ > & *m*)

Operator =.
Copy matrix `m` to current matrix instance.

SkMatrix<T_>& operator= (const T_ & *x*)

Operator =.
define the matrix as a diagonal one with all diagonal entries equal to `x`.

SkMatrix<T_>& operator+= (const SkMatrix< T_ > & *m*)

Operator +=.
Add matrix `m` to current matrix instance.

SkMatrix<T_>& operator+= (const T_ & *x*)

Operator +=.
Add constant value `x` to matrix entries.

SkMatrix<T_>& operator*= (const T_ & *x*)

Operator *=.
Premultiply matrix entries by constant value `x`.

int setLU ( )

Factorize the matrix (LU factorization)
LU factorization of the matrix is realized. Note that since this is an in place factorization, the contents of the matrix are modified.

Returns

- `0` if factorization was normally performed,
- `n` if the `n`-th pivot is null.

Remarks

A flag in this class indicates after factorization that this one has been realized, so that, if the member function solve is called after this no further factorization is done.

int solve (Vect< T_ > & *b*) `[virtual]`

Solve linear system.

The linear system having the current instance as a matrix is solved by using the LU decomposition. Solution is thus realized after a factorization step and a forward/backward substitution step. The factorization step is realized only if this was not already done.
Note that this function modifies the matrix contents is a factorization is performed. Naturally, if the the matrix has been modified after using this function, the user has to refactorize it using the function setLU. This is because the class has no non-expensive way to detect if the matrix has been modified. The function setLU realizes the factorization step only.

Parameters

`in,out`	*b*	Vect instance that contains right-hand side on input and solution on output.

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

Implements Matrix< T_ >.

int solve (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve linear system.

The linear system having the current instance as a matrix is solved by using the LU decomposition. Solution is thus realized after a factorization step and a forward/backward substitution step. The factorization step is realized only if this was not already done.
Note that this function modifies the matrix contents is a factorization is performed. Naturally, if the the matrix has been modified after using this function, the user has to refactorize it using the function setLU. This is because the class has no non-expensive way to detect if the matrix has been modified. The function setLU realizes the factorization step only.

Parameters

`in`	*b*	Vect instance that contains right-hand side.
`out`	*x*	Vect instance that contains solution

Returns

- `0` if solution was normally performed,
- `n` if the `n`-th pivot is null.

T_∗ get ( ) const

Return C-Array.

Skyline of matrix is stored row by row.

void setDiagonal (Mesh & *mesh*) `[inherited]`

Initialize matrix storage in the case where only diagonal terms are stored.

This member function is to be used for explicit time integration schemes

T_ getDiag (size_t *k*) const `[inherited]`

Return `k`-th diagonal entry of matrix.
First entry is given by **getDiag(1)**.

void Assembly (const Element & *el*, T_ * *a*) `[inherited]`

Assembly of element matrix into global matrix.
Case where element matrix is given by a C-array.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a C-array

void Assembly (const Element & *el*, const DMatrix< T_ > & *a*) `[inherited]`

Assembly of element matrix into global matrix.
Case where element matrix is given by a DMatrix instance.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a DMatrix instance

void Assembly (const Side & *sd*, T_ * *a*) `[inherited]`

Assembly of side matrix into global matrix.
Case where side matrix is given by a C-array.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a C-array instance

void Assembly (const Side & *sd*, const DMatrix< T_ > & *a*) `[inherited]`

Assembly of side matrix into global matrix.
Case where side matrix is given by a DMatrix instance.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a DMatrix instance

void Prescribe (Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

Parameters

`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (int *dof*, int *code*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

Parameters

`in`	*dof*	Degree of freedom for which a boundary condition is to be enforced
`in`	*code*	Code for which a boundary condition is to be enforced
`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (Vect< T_ > & *b*, int *flag* = *0*) `[inherited]`

Impose by a penalty method a homegeneous (=0) essential boundary condition.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

Parameters

`in,out`	*b*	Vect instance that contains right-hand side.

Parameters

in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (size_t *dof*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition when only one DOF is treated.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. This gunction is to be used if only one DOF per node is treated in the linear system. The penalty parameter is by default equal to 1.e20. It can be modified by member function setPenal.

Parameters

in	*dof*	Label of the concerned degree of freedom (DOF).
in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void PrescribeSide ( ) `[inherited]`

Impose by a penalty method an essential boundary condition when DOFs are supported by sides.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set↩ Penal**(..).

int FactorAndSolve (Vect< T_ > & *b*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage cass enables it.

Parameters

in,out	*b*	Vect instance that contains right-hand side on input and solution on output

int FactorAndSolve (const Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage class enables it.

Parameters

in	*b*	Vect instance that contains right-hand side

Parameters

out	x	Vect instance that contains solution

Returns

- 0 if solution was normally performed
- n if the n-th pivot is nul

int isFactorized ( ) const [inherited]

Say if matrix is factorized or not.
If the matrix was not factorized, the class does not allow solving by a direct solver.

T_ operator() (size_t *i*) const [inherited]

Operator () with one argument (Constant version).
Returns i-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	i	entry index

T_& operator() (size_t *i*) [inherited]

Operator () with one argument (Non Constant version).
Returns i-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	i	entry index

T_& operator[ ] (size_t *k*) [inherited]

Operator [] (Non constant version).
Returns k-th stored element in matrix Index k starts at 0.

T_ operator[ ] (size_t *k*) const [inherited]

Operator [] (Constant version).
Returns k-th stored element in matrix Index k starts at 0.

Matrix& operator+= (const Matrix< T_ > & *m*) [inherited]

Operator +=.
Add matrix m to current matrix instance.

Matrix& operator-= (const Matrix< T_ > & *m*) `[inherited]`

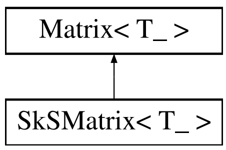
Operator -=.
Subtract matrix `m` from current matrix instance.

Matrix& operator-= (const T_ & *x*) `[inherited]`

Operator -=.
Subtract constant value `x` from all matrix entries.

7.93 SkSMatrix< T_ > Class Template Reference

To handle symmetric matrices in skyline storage format.
Inheritance diagram for SkSMatrix< T_ >:



Public Member Functions

- SkSMatrix ()
  Default constructor.
- SkSMatrix (size_t size, int is_diagonal=false)
  Constructor that initializes a dense symmetric matrix.
- SkSMatrix (Mesh &mesh, size_t dof=0, int is_diagonal=false)
  Constructor using mesh to initialize skyline structure of matrix.
- SkSMatrix (const Vect< size_t > &ColHt)
  Constructor that initializes skyline structure of matrix using vector of column height.
- SkSMatrix (const Vect< size_t > &I, const Vect< size_t > &J, int opt=1)
  Constructor for a square matrix using non zero row and column indices.
- SkSMatrix (const Vect< size_t > &I, const Vect< size_t > &J, const Vect< T_ > &a, int opt=1)
  Constructor for a square matrix using non zero row and column indices.
- SkSMatrix (const SkSMatrix< T_ > &m)
  Copy Constructor.
- ~SkSMatrix ()
  Destructor.
- void setMesh (Mesh &mesh, size_t dof=0)
  Determine mesh graph and initialize matrix.
- void setSkyline (Mesh &mesh)
  Determine matrix structure.
- void setDiag ()
  Store diagonal entries in a separate internal vector.
- void set (size_t i, size_t j, const T_ &val)
  Assign a value to an entry ofthe matrix.
- void Axpy (T_ a, const SkSMatrix< T_ > &m)
  Add to matrix the product of a matrix by a scalar.

- void Axpy (T_ a, const Matrix< T_ > *m)

  Add to matrix the product of a matrix by a scalar.
- void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `x` and add to `y`.
- void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `a*x` and add to `y`.
- void Mult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `x` and save in `y`
- void TMult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector x and save in y.
- void add (size_t i, size_t j, const T_ &val)

  Add a constant to an entry of the matrix.
- size_t getColHeight (size_t i) const

  Return column height.
- Vect< T_ > getColumn (size_t j) const

  Get `j`-th column vector.
- Vect< T_ > getRow (size_t i) const

  Get `i`-th row vector.
- T_ & operator() (size_t i, size_t j)

  Operator () (Non constant version).
- T_ operator() (size_t i, size_t j) const

  Operator () (Constant version).
- SkSMatrix< T_ > & operator= (const SkSMatrix< T_ > &m)

  Operator =.
- SkSMatrix< T_ > & operator= (const T_ &x)

  Operator =.
- SkSMatrix< T_ > & operator+= (const SkSMatrix< T_ > &m)

  Operator +=.
- SkSMatrix< T_ > & operator*= (const T_ &x)

  *Operator *=.*
- int setLDLt ()

  Factorize matrix (LDLt (Crout) factorization).
- int solveLDLt (const Vect< T_ > &b, Vect< T_ > &x)

  Solve a linear system using the LDLt (Crout) factorization.
- int solve (Vect< T_ > &b)

  Solve linear system.
- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve linear system.
- T_ * get () const

  Return C-Array.
- void set (size_t i, T_ x)

  Assign a value to the i-th entry of C-array containing matrix.
- T_ get (size_t i, size_t j) const

  Return entry `(i,j)` of matrix if this one is stored, `0` else.
- size_t getNbRows () const

  Return number of rows.

- size_t getNbColumns () const

  Return number of columns.
- void setPenal (real_t p)

  Set Penalty Parameter (For boundary condition prescription).
- void setDiagonal ()

  Set the matrix as diagonal.
- void setDiagonal (Mesh &mesh)

  Initialize matrix storage in the case where only diagonal terms are stored.
- T_ getDiag (size_t k) const

  Return k-th diagonal entry of matrix.
- size_t size () const

  Return matrix dimension (Number of rows and columns).
- void Assembly (const Element &el, T_ *a)

  Assembly of element matrix into global matrix.
- void Assembly (const Element &el, const DMatrix< T_ > &a)

  Assembly of element matrix into global matrix.
- void Assembly (const Side &sd, T_ *a)

  Assembly of side matrix into global matrix.
- void Assembly (const Side &sd, const DMatrix< T_ > &a)

  Assembly of side matrix into global matrix.
- void Prescribe (Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.
- void Prescribe (int dof, int code, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.
- void Prescribe (Vect< T_ > &b, int flag=0)

  Impose by a penalty method a homegeneous (=0) essential boundary condition.
- void Prescribe (size_t dof, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition when only one DOF is treated.
- void PrescribeSide ()

  Impose by a penalty method an essential boundary condition when DOFs are supported by sides.
- virtual int Factor ()=0

  Factorize matrix. Available only if the storage class enables it.
- int FactorAndSolve (Vect< T_ > &b)

  Factorize matrix and solve the linear system.
- int FactorAndSolve (const Vect< T_ > &b, Vect< T_ > &x)

  Factorize matrix and solve the linear system.
- size_t getLength () const

  Return number of stored terms in matrix.
- int isDiagonal () const

  Say if matrix is diagonal or not.
- int isFactorized () const

  Say if matrix is factorized or not.
- virtual size_t getColInd (size_t i) const

  Return Column index for column i (See the description for class SpMatrix).
- virtual size_t getRowPtr (size_t i) const

  Return Row pointer for row i (See the description for class SpMatrix).

- T_ operator() (size_t i) const

  Operator () with one argument (Constant version).
- T_ & operator() (size_t i)

  Operator () with one argument (Non Constant version).
- T_ & operator[ ] (size_t k)

  Operator [] (Non constant version).
- T_ operator[ ] (size_t k) const

  Operator [] (Constant version).
- Matrix & operator+= (const Matrix< T_ > &m)

  Operator +=.
- Matrix & operator+= (const T_ &x)

  Operator +=.
- Matrix & operator-= (const Matrix< T_ > &m)

  Operator -=.
- Matrix & operator-= (const T_ &x)

  Operator -=.

7.93.1 Detailed Description

template<class T_>
class OFELI::SkSMatrix< T_ >

To handle symmetric matrices in skyline storage format.

This template class allows storing and manipulating a symmetric matrix in skyline storage format.

The matrix entries are stored column by column as in the following example:

```
/                        \
| a0   a1    0    0   a7 |
|      a2   a3    0   a8 |
| ...       a4   a5   a9 |
|                a6  a10 |
|                    a11 |
\                        /
```

Template Parameters

*T_*	Data type (double, float, complex<double>, ...)

7.93.2 Member Function Documentation

T_* get ( ) const

Return C-Array.

Skyline of matrix is stored row by row.

void setDiagonal (Mesh & *mesh*) `[inherited]`

Initialize matrix storage in the case where only diagonal terms are stored.

This member function is to be used for explicit time integration schemes

T_ getDiag (size_t *k*) const [inherited]

Return k-th diagonal entry of matrix.
First entry is given by **getDiag(1)**.

void Assembly (const Element & *el*, T_ * *a*) [inherited]

Assembly of element matrix into global matrix.
Case where element matrix is given by a C-array.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a C-array

void Assembly (const Element & *el*, const DMatrix< T_ > & *a*) [inherited]

Assembly of element matrix into global matrix.
Case where element matrix is given by a DMatrix instance.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a DMatrix instance

void Assembly (const Side & *sd*, T_ * *a*) [inherited]

Assembly of side matrix into global matrix.
Case where side matrix is given by a C-array.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a C-array instance

void Assembly (const Side & *sd*, const DMatrix< T_ > & *a*) [inherited]

Assembly of side matrix into global matrix.
Case where side matrix is given by a DMatrix instance.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a DMatrix instance

void Prescribe (Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set**↩ **Penal**(..).

Parameters

`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (int *dof*, int *code*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set**↩ **Penal**(..).

Parameters

`in`	*dof*	Degree of freedom for which a boundary condition is to be enforced
`in`	*code*	Code for which a boundary condition is to be enforced
`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (Vect< T_ > & *b*, int *flag* = *0*) `[inherited]`

Impose by a penalty method a homegeneous (=0) essential boundary condition.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set**↩ **Penal**(..).

Parameters

`in,out`	*b*	Vect instance that contains right-hand side.

Parameters

`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (size_t *dof*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition when only one DOF is treated.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. This gunction is to be used if only one DOF per node is treated in the linear system. The penalty parameter is by default equal to 1.e20. It can be modified by member function setPenal.

Parameters

`in`	*dof*	Label of the concerned degree of freedom (DOF).
`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void PrescribeSide ( ) `[inherited]`

Impose by a penalty method an essential boundary condition when DOFs are supported by sides.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

int FactorAndSolve (Vect< T_ > & *b*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage cass enables it.

Parameters

`in,out`	*b*	Vect instance that contains right-hand side on input and solution on output

int FactorAndSolve (const Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage class enables it.

Parameters

`in`	*b*	Vect instance that contains right-hand side

Parameters

out	x	Vect instance that contains solution

Returns

- `0` if solution was normally performed
- `n` if the n-th pivot is nul

int isFactorized ( ) const `[inherited]`

Say if matrix is factorized or not.
If the matrix was not factorized, the class does not allow solving by a direct solver.

T_ operator() (size_t *i*) const `[inherited]`

Operator () with one argument (Constant version).
Returns `i`-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	i	entry index

T_& operator() (size_t *i*) `[inherited]`

Operator () with one argument (Non Constant version).
Returns `i`-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	i	entry index

T_& operator[ ] (size_t *k*) `[inherited]`

Operator [] (Non constant version).
Returns `k`-th stored element in matrix Index `k` starts at `0`.

T_ operator[ ] (size_t *k*) const `[inherited]`

Operator [] (Constant version).
Returns `k`-th stored element in matrix Index `k` starts at `0`.

Matrix& operator+= (const Matrix< T_ > & *m*) `[inherited]`

Operator +=.
Add matrix `m` to current matrix instance.

Matrix& operator+= (const T_ & *x*) `[inherited]`

Operator +=.
Add constant value `x` to all matrix entries.

Matrix& operator-= (const Matrix< T_ > & *m*) `[inherited]`

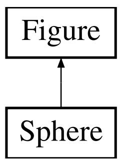
Operator -=.
Subtract matrix `m` from current matrix instance.

Matrix& operator-= (const T_ & *x*) `[inherited]`

Operator -=.
Subtract constant value `x` from all matrix entries.

7.94 Sphere Class Reference

To store and treat a sphere.
Inheritance diagram for Sphere:



Public Member Functions

- Sphere ()

  Default construcor.
- Sphere (const Point< real_t > &c, real_t r, int code=1)

  Constructor.
- void setRadius (real_t r)

  Assign radius of sphere.
- real_t getRadius () const

  Return radius of sphere.
- void setCenter (const Point< real_t > &c)

  Assign coordinates of center of sphere.
- Point< real_t > getCenter () const

  Return coordinates of center of sphere.
- real_t getSignedDistance (const Point< real_t > &p) const

  Return signed distance of a given point from the current sphere.
- Sphere & operator+= (Point< real_t > a)

  Operator +=.
- Sphere & operator+= (real_t a)

  Operator ∗=.
- void setCode (int code)

  Choose a code for the domain defined by the figure.
- void getSignedDistance (const Grid &g, Vect< real_t > &d) const

Calculate signed distance to current figure with respect to grid points.

- real_t dLine (const Point< real_t > &p, const Point< real_t > &a, const Point< real_t > &b) const

  Compute signed distance from a line.

7.94.1 Detailed Description

To store and treat a sphere.

7.94.2 Constructor & Destructor Documentation

Sphere (const Point< real_t > & *c*, real_t *r*, int *code* = *1*)

Constructor.

Parameters

in	*c*	Coordinates of center of sphere
in	*r*	Radius
in	*code*	Code to assign to the generated sphere [Default: 1]

7.94.3 Member Function Documentation

real_t getSignedDistance (const Point< real_t > & *p*) const `[virtual]`

Return signed distance of a given point from the current sphere.
The computed distance is negative if `p` lies in the ball, positive if it is outside, and 0 on the sphere

Parameters

in	*p*	Point<double> instance

Reimplemented from Figure.

Sphere& operator+= (Point< real_t > *a*)

Operator +=.
Translate sphere by a vector `a`

Sphere& operator+= (real_t *a*)

Operator ∗=.
Scale sphere by a factor `a`

void getSignedDistance (const Grid & *g*, Vect< real_t > & *d*) const `[inherited]`

Calculate signed distance to current figure with respect to grid points.

Parameters

in	*g*	Grid instance

Parameters

in	*d*	Vect instance containing calculated distance from each grid index to Figure

Remarks

Vector `d` doesn't need to be sized before invoking this function

real_t dLine (const Point< real_t > & *p*, const Point< real_t > & *a*, const Point< real_t > & *b*) const `[inherited]`

Compute signed distance from a line.

Parameters

in	*p*	Point for which distance is computed
in	*a*	First vertex of line
in	*b*	Second vertex of line

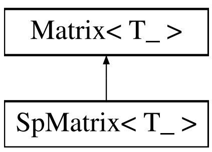
Returns

Signed distance

7.95 SpMatrix< T_ > Class Template Reference

To handle matrices in sparse storage format.

Inheritance diagram for SpMatrix< T_ >:



Public Member Functions

- SpMatrix ()

  Default constructor.
- SpMatrix (size_t nr, size_t nc)

  Constructor that initializes current instance as a dense matrix.
- SpMatrix (size_t size, int is_diagonal=false)

  Constructor that initializes current instance as a dense matrix.
- SpMatrix (Mesh &mesh, size_t dof=0, int is_diagonal=false)

  Constructor using a Mesh instance.
- SpMatrix (size_t nr, size_t nc, const vector< size_t > &row_ptr, const vector< size_t > &col↩ _ind, const vector< T_ > &a)

  Constructor for a rectangle matrix.
- SpMatrix (const SpMatrix &m)

Copy constructor.

- ~SpMatrix (void)

  Destructor.
- void Dense ()

  Define matrix as a dense one.
- void Identity ()

  Define matrix as identity matrix.
- void Diagonal ()

  Define matrix as a diagonal one.
- void Diagonal (const T_ &a)

  Define matrix as a diagonal one with diagonal entries equal to a
- void Laplace1D (size_t n, real_t h)

  Sets the matrix as the one for the Laplace equation in 1-D.
- void Laplace2D (size_t nx, size_t ny)

  Sets the matrix as the one for the Laplace equation in 2-D.
- void setMesh (Mesh &mesh, size_t dof=0)

  Determine mesh graph and initialize matrix.
- void setOneDOF ()

  Activate 1-DOF per node option.
- void setSides ()

  Activate Sides option.
- void setDiag ()

  Store diagonal entries in a separate internal vector.
- void DiagPrescribe (Mesh &mesh, Vect< T_ > &b, const Vect< T_ > &u)

  Impose by a diagonal method an essential boundary condition.
- void DiagPrescribe (Vect< T_ > &b, const Vect< T_ > &u)

  Impose by a diagonal method an essential boundary condition using the Mesh instance provided by the constructor.
- void setSize (size_t size)

  Set size of matrix (case where it's a square matrix).
- void setSize (size_t nr, size_t nc)

  Set size (number of rows) of matrix.
- void setGraph (const vector< RC > &I, int opt=1)

  Set graph of matrix by giving a vector of its nonzero entries.
- Vect< T_ > getRow (size_t i) const

  Get i*-th row vector.*
- Vect< T_ > getColumn (size_t j) const

  Get j*-th column vector.*
- T_ & operator() (size_t i, size_t j)

  Operator () (Non constant version)
- T_ operator() (size_t i, size_t j) const

  Operator () (Constant version)
- const T_ operator() (size_t i) const

  Operator () with one argument (Constant version)
- const T_ operator[ ] (size_t i) const

  Operator [] (Constant version).
- Vect< T_ > operator* (const Vect< T_ > &x) const

*Operator * to multiply matrix by a vector.*

- SpMatrix< T_ > & operator*= (const T_ &a)

  *Operator *= to premultiply matrix by a constant.*

- void getMesh (Mesh &mesh)

  Get mesh instance whose reference will be stored in current instance of SpMatrix.

- void Mult (const Vect< T_ > &v, Vect< T_ > &w) const

  Multiply matrix by vector and save in another one.

- void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `x` and add to `y`.

- void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `a*x` and add to `y`.

- void TMult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector `x` and save in `y`.

- void Axpy (T_ a, const SpMatrix< T_ > &m)

  Add to matrix the product of a matrix by a scalar.

- void Axpy (T_ a, const Matrix< T_ > *m)

  Add to matrix the product of a matrix by a scalar.

- void set (size_t i, size_t j, const T_ &val)

  Assign a value to an entry of the matrix.

- void add (size_t i, size_t j, const T_ &val)

  Add a value to an entry of the matrix.

- void operator= (const T_ &x)

  Operator =.

- size_t getColInd (size_t i) const

  Return storage information.

- size_t getRowPtr (size_t i) const

  Return Row pointer at position `i`.

- int solve (Vect< T_ > &b)

  Solve the linear system of equations.

- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve the linear system of equations.

- void setSolver (Iteration solver=CG_SOLVER, Preconditioner prec=DIAG_PREC, int max↩ _it=1000, real_t toler=1.e-8)

  Choose solver and preconditioner for an iterative procedure.

- void clear ()

  brief Set all matrix entries to zero

- T_ * get () const

  Return C-Array.

- T_ get (size_t i, size_t j) const

  Return entry `(i,j)` of matrix if this one is stored, `0` otherwise.

- SpMat & getEigenMatrix ()

  Return reference to the matrix instance in Eigen library.

- size_t getNbRows () const

  Return number of rows.

- size_t getNbColumns () const

  Return number of columns.

- void setPenal (real_t p)

Set Penalty Parameter (For boundary condition prescription).

- void setDiagonal ()

  Set the matrix as diagonal.
- void setDiagonal (Mesh &mesh)

  Initialize matrix storage in the case where only diagonal terms are stored.
- T_ getDiag (size_t k) const

  Return k-th diagonal entry of matrix.
- size_t size () const

  Return matrix dimension (Number of rows and columns).
- void Assembly (const Element &el, T_ *a)

  Assembly of element matrix into global matrix.
- void Assembly (const Element &el, const DMatrix< T_ > &a)

  Assembly of element matrix into global matrix.
- void Assembly (const Side &sd, T_ *a)

  Assembly of side matrix into global matrix.
- void Assembly (const Side &sd, const DMatrix< T_ > &a)

  Assembly of side matrix into global matrix.
- void Prescribe (Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.
- void Prescribe (int dof, int code, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.
- void Prescribe (Vect< T_ > &b, int flag=0)

  Impose by a penalty method a homegeneous (=0) essential boundary condition.
- void Prescribe (size_t dof, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition when only one DOF is treated.
- void PrescribeSide ()

  Impose by a penalty method an essential boundary condition when DOFs are supported by sides.
- virtual int Factor ()=0

  Factorize matrix. Available only if the storage class enables it.
- int FactorAndSolve (Vect< T_ > &b)

  Factorize matrix and solve the linear system.
- int FactorAndSolve (const Vect< T_ > &b, Vect< T_ > &x)

  Factorize matrix and solve the linear system.
- size_t getLength () const

  Return number of stored terms in matrix.
- int isDiagonal () const

  Say if matrix is diagonal or not.
- int isFactorized () const

  Say if matrix is factorized or not.
- T_ & operator() (size_t i)

  Operator () with one argument (Non Constant version).
- T_ & operator[ ] (size_t k)

  Operator [] (Non constant version).
- Matrix & operator+= (const Matrix< T_ > &m)

  Operator +=.
- Matrix & operator+= (const T_ &x)

Operator +=.

- Matrix & operator-= (const Matrix< T_ > &m)

  Operator -=.
- Matrix & operator-= (const T_ &x)

  Operator -=.

Friends

- template<class TT_ >
  ostream & operator<< (ostream &s, const SpMatrix< TT_ > &A)

7.95.1 Detailed Description

template<class T_>
class OFELI::SpMatrix< T_ >

To handle matrices in sparse storage format.

This template class enables storing and manipulating a sparse matrix, i.e. only nonzero terms are stored. Internally, the matrix is stored as a vector instance and uses for the definition of its graph a `Vect<size_t>` instance row_ptr and a Vect<size_t> instance `col_ind` that contains respectively addresses of first element of each row and column indices.

To illustrate this, consider the matrix

```
1   2   0
3   4   0
0   5   0
```

Such a matrix is stored in the vector<real_t> instance {1,2,3,4,5}. The vectors `row_ptr` and `col_ind` are respectively: {`0,2,4,5`}, {`1,2,1,2,2`}

When the library `eigen` is used in conjunction with `OFELI`, the class uses the sparse matrix class of `eigen` and enables then access to specific solvers (see class LinearSolver)

Template Parameters

*T_*	Data type (double, float, complex<double>, ...)

7.95.2 Constructor & Destructor Documentation

SpMatrix ( )

Default constructor.

Initialize a zero-dimension matrix

SpMatrix (size_t *nr*, size_t *nc*)

Constructor that initializes current instance as a dense matrix.

Normally, for a dense matrix this is not the right class.

Parameters

in	*nr*	Number of matrix rows.
in	*nc*	Number of matrix columns.

SpMatrix (size_t *size*, int *is_diagonal* = `false`)

Constructor that initializes current instance as a dense matrix.
Normally, for a dense matrix this is not the right class.

Parameters

`in`	*size*	Number of matrix rows (and columns).
`in`	*is_diagonal*	Boolean argument to say is the matrix is actually a diagonal matrix or not.

SpMatrix (Mesh & *mesh*, size_t *dof* = `0`, int *is_diagonal* = `false`)

Constructor using a Mesh instance.

Parameters

`in`	*mesh*	Mesh instance from which matrix graph is extracted.
`in`	*dof*	Option parameter, with default value `0`. `dof=1` means that only one degree of freedom for each node (or element or side) is taken to determine matrix structure. The value `dof=0` means that matrix structure is determined using all DOFs.
`in`	*is_diagonal*	Boolean argument to say is the matrix is actually a diagonal matrix or not.

SpMatrix (size_t *nr*, size_t *nc*, const vector< size_t > & *row_ptr*, const vector< size_t > & *col_ind*, const vector< T_ > & *a*)

Constructor for a rectangle matrix.

Parameters

`in`	*nr*	Number of rows
`in`	*nc*	Number of columns
`in`	*row_ptr*	Vector of row pointers (See the above description of this class).
`in`	*col_ind*	Vector of column indices (See the above description of this class).
`in`	*a*	vector instance containing matrix entries stored columnwise

7.95.3 Member Function Documentation

void Laplace1D (size_t *n*, real_t *h*)

Sets the matrix as the one for the Laplace equation in 1-D.
The matrix is initialized as the one resulting from P_1 finite element discretization of the classical elliptic operator -u'' = f with homogeneous Dirichlet boundary conditions

Remarks

This function is available for real valued matrices only.

Parameters

in	*n*	Size of matrix (Number of rows)
in	*h*	Mesh size (assumed constant)

void Laplace2D (size_t *nx*, size_t *ny*)

Sets the matrix as the one for the Laplace equation in 2-D.

The matrix is initialized as the one resulting from P_1 finite element discretization of the classical elliptic operator -Delta u = f with homogeneous Dirichlet boundary conditions

Remarks

This function is available for real valued matrices only.

Parameters

in	*nx*	Number of unknowns in the x-direction
in	*ny*	Number of unknowns in the y-direction

Remarks

The number of rows is equal to `nx*ny`

void setMesh (Mesh & *mesh*, size_t *dof* = `0`)

Determine mesh graph and initialize matrix.

This member function is called by constructor with the same arguments

Parameters

in	*mesh*	Mesh instance for which matrix graph is determined.
in	*dof*	Option parameter, with default value `0`. `dof=1` means that only one degree of freedom for each node (or element or side) is taken to determine matrix structure. The value `dof=0` means that matrix structure is determined using all DOFs.

void DiagPrescribe (Mesh & *mesh*, Vect< T_ > & *b*, const Vect< T_ > & *u*)

Impose by a diagonal method an essential boundary condition.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set**↩ **Penal**(..).

Parameters

in	*mesh*	Mesh instance from which information is extracted.
in,out	*b*	Vect instance that contains right-hand side.

Parameters

in	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.

void DiagPrescribe (Vect< T_ > & *b*, const Vect< T_ > & *u*)

Impose by a diagonal method an essential boundary condition using the Mesh instance provided by the constructor.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **setPenal**(..).

Parameters

in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.

void setSize (size_t *size*)

Set size of matrix (case where it's a square matrix).

Parameters

in	*size*	Number of rows and columns.

void setSize (size_t *nr*, size_t *nc*)

Set size (number of rows) of matrix.

Parameters

in	*nr*	Number of rows
in	*nc*	Number of columns

void setGraph (const vector< RC > & *I*, int *opt* = *1*)

Set graph of matrix by giving a vector of its nonzero entries.

Parameters

in	*I*	Vector containing pairs of row and column indices
in	*opt*	Flag indicating if vector `I` is cleaned and ordered (`opt=1`: default) or not (`opt=0`). In the latter case, this vector can have the same contents more than once and are not necessarily ordered

T_& operator() (size_t *i*, size_t *j*) `[virtual]`

Operator () (Non constant version)

Parameters

`in`	*i*	Row index
`in`	*j*	Column index

Implements Matrix< T_ >.

T_ operator() (size_t *i*, size_t *j*) const `[virtual]`

Operator `()` (Constant version)

Parameters

`in`	*i*	Row index
`in`	*j*	Column index

Implements Matrix< T_ >.

const T_ operator() (size_t *i*) const

Operator `()` with one argument (Constant version)

Returns `i`-th position in the array storing matrix entries. The first entry is at location `1`. Entries are stored row by row.

const T_ operator[ ] (size_t *i*) const

Operator `[]` (Constant version).

Returns `i`-th position in the array storing matrix entries. The first entry is at location `0`. Entries are stored row by row.

Vect<T_> operator∗ (const Vect< T_ > & *x*) const

Operator ∗ to multiply matrix by a vector.

Parameters

`in`	*x*	Vect instance to multiply by

Returns

Vector product of matrix by `x`

SpMatrix<T_>& operator∗= (const T_ & *a*)

Operator ∗= to premultiply matrix by a constant.

Parameters

in	*a*	Constant to multiply matrix by

Returns

Resulting matrix

void Mult (const Vect< T_ > & *v*, Vect< T_ > & *w*) const `[virtual]`

Multiply matrix by vector and save in another one.

Parameters

in	*v*	Vector to multiply by matrix
out	*w*	Vector that contains on output the result.

Implements Matrix< T_ >.

void MultAdd (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by vector `x` and add to `y`.

Parameters

in	*x*	Vector to multiply by matrix
out	*y*	Vector to add to the result. `y` contains on output the result.

Implements Matrix< T_ >.

void MultAdd (T_ *a*, const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply matrix by vector `a*x` and add to `y`.

Parameters

in	*a*	Constant to multiply by matrix
in	*x*	Vector to multiply by matrix
out	*y*	Vector to add to the result. `y` contains on output the result.

Implements Matrix< T_ >.

void TMult (const Vect< T_ > & *x*, Vect< T_ > & *y*) const `[virtual]`

Multiply transpose of matrix by vector `x` and save in `y`.

Parameters

in	*x*	Vector to multiply by matrix
out	*y*	Vector that contains on output the result.

Implements Matrix< T_ >.

void Axpy (T_ *a*, const SpMatrix< T_ > & *m*)

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*m*	Matrix by which `a` is multiplied. The result is added to current instance

void Axpy (T_ *a*, const Matrix< T_ > * *m*) `[virtual]`

Add to matrix the product of a matrix by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*m*	Pointer to Matrix by which `a` is multiplied. The result is added to current instance

Implements Matrix< T_ >.

void set (size_t *i*, size_t *j*, const T_ & *val*) `[virtual]`

Assign a value to an entry of the matrix.

Parameters

in	*i*	Row index
in	*j*	Column index
in	*val*	Value to assign to `a(i,j)`

Implements Matrix< T_ >.

void add (size_t *i*, size_t *j*, const T_ & *val*) `[virtual]`

Add a value to an entry of the matrix.

Parameters

in	*i*	Row index
in	*j*	Column index
in	*val*	Constant value to add to `a(i,j)`

Implements Matrix< T_ >.

void operator= (const T_ & *x*)

Operator =.

Assign constant value x to all matrix entries.

size_t getColInd (size_t *i*) const [virtual]

Return storage information.

Returns

Column index of the i-th stored element in matrix

Reimplemented from Matrix< T_ >.

int solve (Vect< T_ > & *b*) [virtual]

Solve the linear system of equations.
The default parameters are:

- CG_SOLVER for solver
- DIAG_PREC for preconditioner
- Max. Number of iterations is 1000
- Tolerance is 1.e-8

To change these values, call function setSolver before this function

Parameters

in,out	*b*	Vector that contains right-hand side on input and solution on output

Returns

Number of actual performed iterations

Implements Matrix< T_ >.

int solve (const Vect< T_ > & *b*, Vect< T_ > & *x*)

Solve the linear system of equations.
The default parameters are:

- CG_SOLVER for solver
- DIAG_PREC for preconditioner
- Max. Number of iterations is 1000
- Tolerance is 1.e-8

To change these values, call function setSolver before this function

Parameters

in	*b*	Vector that contains right-hand side
out	*x*	Vector that contains the obtained solution

Returns

Number of actual performed iterations

void setSolver (Iteration *solver* = CG_SOLVER, Preconditioner *prec* = DIAG_PREC, int *max_it* = *1000*, real_t *toler* = *1.e-8*)

Choose solver and preconditioner for an iterative procedure.

Parameters

in	*solver*	Option to choose iterative solver in an enumerated variable • `CG_SOLVER`: Conjugate Gradient [default] • `CGS_SOLVER`: Squared conjugate gradient • `BICG_SOLVER`: Biconjugate gradient • `BICG_STAB_SOLVER`: Biconjugate gradient stabilized • `GMRES_SOLVER`: Generalized Minimal Residual Default value is `CG_SOLVER`
in	*prec*	Option to choose preconditioner in an enumerated variable • `IDENT_PREC`: Identity preconditioner (no preconditioning) • `DIAG_PREC`: Diagonal preconditioner [default] • `SSOR_PREC`: SSOR (Symmetric Successive Over Relaxation) preconditioner • `DILU_PREC`: ILU (Diagonal Incomplete factorization) preconditioner • `ILU_PREC`: ILU (Incomplete factorization) preconditioner Default value is `DIAG_PREC`
in	*max←_it*	Maximum number of allowed iterations. Default value is `1000`.
in	*toler*	Tolerance for convergence. Default value is `1.e-8`

T_* get ( ) const

Return C-Array.
Non zero terms of matrix is stored row by row.

T_ get (size_t *i*, size_t *j*) const `[virtual]`

Return entry `(i,j)` of matrix if this one is stored, `0` otherwise.

Parameters

in	*i*	Row index (Starting from 1)
in	*j*	Column index (Starting from 1)

Implements Matrix< T_ >.

void setDiagonal (Mesh & *mesh*) [inherited]

Initialize matrix storage in the case where only diagonal terms are stored.
This member function is to be used for explicit time integration schemes

T_ getDiag (size_t *k*) const [inherited]

Return k-th diagonal entry of matrix.
First entry is given by **getDiag(1)**.

void Assembly (const Element & *el*, T_ * *a*) [inherited]

Assembly of element matrix into global matrix.
Case where element matrix is given by a C-array.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a C-array

void Assembly (const Element & *el*, const DMatrix< T_ > & *a*) [inherited]

Assembly of element matrix into global matrix.
Case where element matrix is given by a DMatrix instance.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a DMatrix instance

void Assembly (const Side & *sd*, T_ * *a*) [inherited]

Assembly of side matrix into global matrix.
Case where side matrix is given by a C-array.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a C-array instance

void Assembly (const Side & *sd*, const DMatrix< T_ > & *a*) [inherited]

Assembly of side matrix into global matrix.
Case where side matrix is given by a DMatrix instance.

Parameters

in	*sd*	Pointer to side instance

Parameters

in	*a*	Side matrix as a DMatrix instance

void Prescribe (Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0* **)** `[inherited]`

Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set**↩ **Penal**(..).

Parameters

in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (int *dof*, int *code*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0* **)** `[inherited]`

Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set**↩ **Penal**(..).

Parameters

in	*dof*	Degree of freedom for which a boundary condition is to be enforced
in	*code*	Code for which a boundary condition is to be enforced
in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (Vect< T_ > & *b*, int *flag* = *0* **)** `[inherited]`

Impose by a penalty method a homegeneous (=0) essential boundary condition.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty

parameter is defined by default equal to 1.e20. It can be modified by member function **set↩ Penal**(..).

Parameters

in,out	*b*	Vect instance that contains right-hand side.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (size_t *dof*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition when only one DOF is treated.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. This gunction is to be used if only one DOF per node is treated in the linear system. The penalty parameter is by default equal to 1.e20. It can be modified by member function setPenal.

Parameters

in	*dof*	Label of the concerned degree of freedom (DOF).
in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void PrescribeSide ( ) `[inherited]`

Impose by a penalty method an essential boundary condition when DOFs are supported by sides.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set↩ Penal**(..).

int FactorAndSolve (Vect< T_ > & *b*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage cass enables it.

Parameters

in,out	*b*	Vect instance that contains right-hand side on input and solution on output

int FactorAndSolve (const Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage class enables it.

Parameters

in	*b*	Vect instance that contains right-hand side
out	*x*	Vect instance that contains solution

Returns

- `0` if solution was normally performed
- `n` if the n-th pivot is nul

int isFactorized ( ) const `[inherited]`

Say if matrix is factorized or not.
If the matrix was not factorized, the class does not allow solving by a direct solver.

T_& operator() (size_t *i*) `[inherited]`

Operator () with one argument (Non Constant version).
Returns `i`-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	*i*	entry index

T_& operator[ ] (size_t *k*) `[inherited]`

Operator [] (Non constant version).
Returns `k`-th stored element in matrix Index `k` starts at `0`.

Matrix& operator+= (const Matrix< T_ > & *m*) `[inherited]`

Operator +=.
Add matrix `m` to current matrix instance.

Matrix& operator+= (const T_ & *x*) `[inherited]`

Operator +=.
Add constant value `x` to all matrix entries.

Matrix& operator-= (const Matrix< T_ > & *m*) `[inherited]`

Operator -=.
Subtract matrix `m` from current matrix instance.

Matrix& operator-= (const T_ & *x*) `[inherited]`

Operator -=.
Subtract constant value `x` from all matrix entries.

7.96 SteklovPoincare2DBE Class Reference

Solver of the Steklov Poincare problem in 2-D geometries using piecewie constant boundary elemen.

Public Member Functions

- SteklovPoincare2DBE (bool ext=false)

  Default Constructor.
- SteklovPoincare2DBE (const Mesh &mesh, bool ext=false)

  Constructor using mesh data.
- SteklovPoincare2DBE (const Mesh &mesh, const Vect< real_t > &g, Vect< real_t > &b, bool ext=false)

  Constructor that solves the Steklov Poincare problem.
- ∼SteklovPoincare2DBE ()

  Destructor.
- void setMesh (const Mesh &mesh, bool ext=false)

  set Mesh instance
- void Solve ()

  Build equation left and right-hand sides for P_0 (piecewise constant) approximation.
- int Solve (Vect< real_t > &b, const Vect< real_t > &g)

  Build equation left and right-hand sides for P_0 (piecewise constant) approximation.

7.96.1 Detailed Description

Solver of the Steklov Poincare problem in 2-D geometries using piecewie constant boundary elemen.

SteklovPoincare2DBE solves the Steklov Poincare problem in 2-D: Given the trace of a harmonic function on the boundary of a given (inner or outer) domain, this class computes the normal derivative of the function. The normal is considered as oriented out of the bounded (inner) domain in both inner and outer configurations. The numerical approximation uses piecewise constant (P_0) approximation on edges of the boundary. Solution is obtained from the GMRES iterative solver without preconditioning. The given data is the vector (instance of class Vect) of piecewise constant values of the harmonic function on the boundary and the returned solution is piecewise constant value of the normal derivative considered either as a Vect instance.

Note

> Although the mesh of the inner domain is not necessary to solve the problem, this one must be provided in order to calculate the outward normal.

7.96.2 Constructor & Destructor Documentation

SteklovPoincare2DBE (bool *ext* = `false`)

Default Constructor.

Parameters

in	*ext*	Boolean variable to say if the domain is external (true) or internal (false: Default value).

SteklovPoincare2DBE (const Mesh & *mesh*, bool *ext* = `false`)

Constructor using mesh data.
This constructor calls member function setMesh.

Parameters

in	*mesh*	Reference to mesh instance.
in	*ext*	Boolean variable to say if the domain is external (true) or internal (false: Default value).

SteklovPoincare2DBE (const Mesh & *mesh*, const Vect< real_t > & *g*, Vect< real_t > & *b*, bool *ext* = `false`)

Constructor that solves the Steklov Poincare problem.
This constructor calls member function setMesh and Solve.

Parameters

in	*mesh*	Reference to mesh instance.
in	*g*	Vect instance that contains imposed solution on the boundary
in	*b*	Vect instance that contains the left hand side in input and the solution in output
in	*ext*	Boolean variable to say if the domain is external (true) or internal (false: Default value).

7.96.3 Member Function Documentation

void setMesh (const Mesh & *mesh*, bool *ext* = `false`)

set Mesh instance

Parameters

in	*mesh*	Mesh instance
in	*ext*	Boolean variable to say if the domain is external (true) or internal (false: Default value).

void Solve ( )

Build equation left and right-hand sides for P_0 (piecewise constant) approximation.
This member function is to be used if the constructor using `mesh`, `b` and `g` has been used.

int Solve (Vect< real_t > & *b*, const Vect< real_t > & *g*)

Build equation left and right-hand sides for P_0 (piecewise constant) approximation.
This member function is to be used if the constructor using `mesh` has been used. It concerns cases where the imposed boundary condition is given by sides

Parameters

in	*g*	Vector that contains imposed solution on the boundary
in	*b*	Vector that contains the left hand side in input and the solution in output

7.97 Tabulation Class Reference

To read and manipulate tabulated functions.

Public Member Functions

- Tabulation ()
  Default constructor.
- Tabulation (string file)
  Constructor using file name.
- ~Tabulation ()
  Destructor.
- void setFile (string file)
  Set file name.
- real_t getValue (string funct, real_t v)
  Return the calculated value of the function.
- real_t getDerivative (string funct, real_t v)
  Return the derivative of the function at a given point.
- real_t getValue (string funct, real_t v1, real_t v2)
  Return the calculated value of the function.
- real_t getValue (string funct, real_t v1, real_t v2, real_t v3)
  Return the calculated value of the function.

7.97.1 Detailed Description

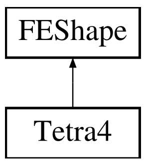
To read and manipulate tabulated functions.

This class enables reading a tabulated function of one to three variables and calculating the value of the function using piecewise multilinear interpolation.
The file defining the function is an XML file where any function is introduced via the tag "↩
Function".

7.98 Tetra4 Class Reference

Defines a three-dimensional 4-node tetrahedral finite element using $\mathtt{P}_1$ interpolation.

Inheritance diagram for Tetra4:



Public Member Functions

- Tetra4 ()

  Default Constructor.
- Tetra4 (const Element ∗el)

  Constructor when data of Element `el` are given.
- ∼Tetra4 ()

  Destructor.
- void set (const Element ∗el)

  Choose element by giving its pointer.
- real_t Sh (size_t i, Point< real_t > s) const

  Calculate shape function of node `i` at a given point `s`.
- Point< real_t > DSh (size_t i) const

  Return `x`, `y` and `z` partial derivatives of shape function associated to node `i`.
- real_t getVolume () const

  Return volume of element.
- Point< real_t > getRefCoord (const Point< real_t > &x) const

  Return reference coordinates of a point `x` in element.
- bool isIn (const Point< real_t > &x)

  Check whether point `x` is in current tetrahedron or not.
- real_t getInterpolate (const Point< real_t > &x, const LocalVect< real_t, 4 > &v)

  Return interpolated value at point of coordinate `x`
- Point< real_t > EdgeSh (size_t k, Point< real_t > s)

  Return edge shape function.
- Point< real_t > CurlEdgeSh (size_t k)

  Return curl of edge shape function.
- real_t getMaxEdgeLength () const

  Return maximal edge length of tetrahedron.
- real_t getMinEdgeLength () const

  Return minimal edge length of tetrahedron.
- real_t Sh (size_t i) const

  Return shape function of node `i` at given point.
- real_t getDet () const

  Return determinant of jacobian.
- Point< real_t > getCenter () const

  Return coordinates of center of element.
- Point< real_t > getLocalPoint () const

  Localize a point in the element.
- Point< real_t > getLocalPoint (const Point< real_t > &s) const

  Localize a point in the element.

7.98.1 Detailed Description

Defines a three-dimensional 4-node tetrahedral finite element using P_1 interpolation.

The reference element is the right tetrahedron with four unit edges interpolation.

7.98.2 Member Function Documentation

real_t Sh (size_t *i*, Point< real_t > *s*) const

Calculate shape function of node `i` at a given point `s`.
`s` is a point in the reference tetrahedron.

Point<real_t> DSh (size_t *i*) const

Return `x`, `y` and `z` partial derivatives of shape function associated to node `i`.
Note that these are constant in element.

Point<real_t> EdgeSh (size_t *k*, Point< real_t > *s*)

Return edge shape function.

Parameters

in	*k*	Local edge number for which the edge shape function is computed
in	*s*	Local coordinates in element

Remarks

Element edges are ordered as follows: Edge `k` has end vertices `k` and `k+1`

Point<real_t> CurlEdgeSh (size_t *k*)

Return curl of edge shape function.

Parameters

in	*k*	Local edge number for which the curl of the edge shape function is computed

Remarks

Element edges are ordered as follows: Edge `k` has end vertices `k` and `k+1`

real_t getDet ( ) const `[inherited]`

Return determinant of jacobian.
If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint ( ) const `[inherited]`

Localize a point in the element.
Return actual coordinates in the reference element. If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint (const Point< real_t > & *s*) const `[inherited]`

Localize a point in the element.

Return actual coordinates where `s` are coordinates in the reference element.

7.99 Timer Class Reference

To handle elapsed time counting.

Public Member Functions

- Timer ()

  Default constructor.
- ~Timer ()

  Destructor.
- bool Started () const

  Say if time counter has started.
- void Start ()

  Start (or resume) time counting.
- void Stop ()

  Stop time counting.
- void Clear ()

  Clear time value (Set to zero)
- real_t get () const

  Return elapsed time (in seconds)
- real_t getTime () const

  Return elapsed time (in seconds)

7.99.1 Detailed Description

To handle elapsed time counting.

This class is to be used when testing program performances. A normal usage of the class is, once an instance is constructed, to use alternatively, Start, Stop and Resume. Elapsed time can be obtained once the member function Stop is called.

7.99.2 Member Function Documentation

bool Started ( ) const

Say if time counter has started.

Return true if time has started, false if not

void Start ( )

Start (or resume) time counting.

This member function is to be used to start or resume time counting

void Stop ( )

Stop time counting.

This function interrupts time counting. This one can be resumed by the function Start

real_t getTime ( ) const

Return elapsed time (in seconds)
Identical to get

7.100 TimeStepping Class Reference

To solve time stepping problems, i.e. systems of linear ordinary differential equations of the form [A2]{y"} + [A1]{y'} + [A0]{y} = {b}.

Public Member Functions

- TimeStepping ()
  Default constructor.
- TimeStepping (TimeScheme s, real_t time_step=theTimeStep, real_t final_time=theFinal↩ Time)
  Constructor using time discretization data.
- ∼TimeStepping ()
  Destructor.
- void set (TimeScheme s, real_t time_step=theTimeStep, real_t final_time=theFinalTime)
  Define data of the differential equation or system.
- void setPDE (AbsEqua< real_t > &eq)
  Define partial differential equation to solve.
- void setRK4RHS (Vect< real_t > &f)
  Set intermediate right-hand side vector for the Runge-Kutta method.
- void setInitial (Vect< real_t > &u)
  Set initial condition for the system of differential equations.
- void setInitial (Vect< real_t > &u, Vect< real_t > &v)
  Set initial condition for a system of differential equations.
- void setInitialRHS (Vect< real_t > &f)
  Set initial RHS for a system of differential equations when the used scheme requires it.
- void setRHS (Vect< real_t > &b)
  Set right-hand side vector.
- void setBC (Vect< real_t > &u)
  Set vector containing boundary condition to enforce.
- void setNewmarkParameters (real_t beta, real_t gamma)
  Define parameters for the Newmark scheme.
- void setConstantMatrix ()
  Say that matrix problem is constant.
- void setNonConstantMatrix ()
  Say that matrix problem is variable.
- void setLinearSolver (Iteration s=DIRECT_SOLVER, Preconditioner p=DIAG_PREC)
  Set linear solver data.
- void setVerbose (int v=0)
  Set verbosity parameter:
- real_t runOneTimeStep ()
  Run one time step.
- void run (bool opt=false)

Run the time stepping procedure.

- void Assembly (const Element &el, real_t *b, real_t *A0, real_t *A1, real_t *A2=NULL)

  Assemble element arrays into global matrix and right-hand side.
- void SAssembly (const Side &sd, real_t *b, real_t *A=NULL)

  Assemble side arrays into global matrix and right-hand side.
- LinearSolver< real_t > & getLSolver ()

  Return LinearSolver instance.

7.100.1 Detailed Description

To solve time stepping problems, i.e. systems of linear ordinary differential equations of the form [A2]{y''} + [A1]{y'} + [A0]{y} = {b}.

Features:

- The system may be first or second order (first and/or second order time derivatives
- The following time integration schemes can be used:
  - For first order systems: The following schemes are implemented Forward Euler (value↩ : *FORWARD_EULER*)
    Backward Euler (value: *BACKWARD_EULER*)
    Crank-Nicolson (value: *CRANK_NICOLSON*)
    Heun (value: *HEUN*)
    2nd Order Adams-Bashforth (value: *AB2*)
    4-th order Runge-Kutta (value: *RK4*)
    2nd order Backward Differentiation Formula (value: *BDF2*)
  - For second order systems: The following schemes are implemented Newmark (value↩ : *NEWMARK*)

7.100.2 Constructor & Destructor Documentation

TimeStepping (TimeScheme *s*, real_t *time_step* = theTimeStep, real_t *final_time* = theFinalTime)

Constructor using time discretization data.

Parameters

in	*s*	Choice of the scheme: To be chosen in the enumerated variable *TimeScheme* (see the presentation of the class)
in	*time_step*	Value of the time step. This value will be modified if an adaptive method is used. The default value for this parameter if the value given by the global variable `theTimeStep`
in	*final_time*	Value of the final time (time starts at 0). The default value for this parameter is the value given by the global variable `theFinalTime`

7.100.3 Member Function Documentation

void set (TimeScheme *s*, real_t *time_step* = theTimeStep, real_t *final_time* = theFinalTime)

Define data of the differential equation or system.

Parameters

in	*s*	Choice of the scheme: To be chosen in the enumerated variable *TimeScheme* (see the presentation of the class)
in	*time_step*	Value of the time step. This value will be modified if an adaptive method is used. The default value for this parameter if the value given by the global variable `theTimeStep`
in	*final_time*	Value of the final time (time starts at 0). The default value for this parameter is the value given by the global variable `theFinalTime`

void setPDE (AbsEqua< real_t > & *eq*)

Define partial differential equation to solve.
The used equation class must have been constructed using the Mesh instance

Parameters

in	*eq*	Reference to equation instance

void setRK4RHS (Vect< real_t > & *f*)

Set intermediate right-hand side vector for the Runge-Kutta method.

Parameters

in	*f*	Vector containing the RHS

void setInitial (Vect< real_t > & *u*)

Set initial condition for the system of differential equations.

Parameters

in	*u*	Vector containing initial condition for the unknown

Remarks

If a second-order differential equation is to be solved, use the the same function with two initial vectors (one for the unknown, the second for its time derivative)

void setInitial (Vect< real_t > & *u*, Vect< real_t > & *v*)

Set initial condition for a system of differential equations.

Parameters

in	*u*	Vector containing initial condition for the unknown
in	*v*	Vector containing initial condition for the time derivative of the unknown

Note

> This function can be used to provide solution at previous time step if a restarting procedure is used.
> This member function is to be used only in the case of a second order system

void setInitialRHS (Vect< real_t > & *f*)

Set initial RHS for a system of differential equations when the used scheme requires it.
Giving the right-hand side at initial time is somtimes required for high order methods like Runge-Kutta

Parameters

in	*f*	Vector containing right-hand side at initial time. This vector is helpful for high order methods

Note

> This function can be used to provide solution at previous time step if a restarting procedure is used.

void setNewmarkParameters (real_t *beta*, real_t *gamma*)

Define parameters for the Newmark scheme.

Parameters

in	*beta*	Parameter beta [Default: `0.25`]
in	*gamma*	Parameter gamma [Default: `0.5`]

void setConstantMatrix ( )

Say that matrix problem is constant.
This is useful if the linear system is solved by a factorization method but has no effect otherwise

void setNonConstantMatrix ( )

Say that matrix problem is variable.
This is useful if the linear system is solved by a factorization method but has no effect otherwise

void setLinearSolver (Iteration *s* = DIRECT_SOLVER, Preconditioner *p* = DIAG_PREC)

Set linear solver data.

Parameters

in	*s*	Solver identification parameter. To be chosen in the enumeration variable Iteration: DIRECT_SOLVER, CG_SOLVER, CGS_SOLVER, BICG_SOLVER, BICG_STAB_SOLVER, GMRES_SOLVER, QMR_SOLVER [Default: `DIRECT_SOLVER`]

Parameters

in	*p*	Preconditioner identification parameter. To be chosen in the enumeration variable Preconditioner: IDENT_PREC, DIAG_PREC, ILU_PREC [Default: `DIAG_PREC`]

Note

The argument *p* has no effect if the solver is DIRECT_SOLVER

void setVerbose (int *v* = `0` **)**

Set verbosity parameter:

- = 0, No output
- = 1, Print step label and time value
- = 2, Print step label, time value, time step and integration scheme

real_t runOneTimeStep ( )

Run one time step.

Returns

Value of new time step if this one is updated

void run (bool *opt* = `false` **)**

Run the time stepping procedure.

Parameters

in	*opt*	Flag to say if problem matrix is constant while time stepping (true) or not (Default value is false)

Note

This argument is not used if the time stepping scheme is explicit

void Assembly (const Element & *el*, real_t $*$ *b*, real_t $*$ *A0*, real_t $*$ *A1*, real_t $*$ *A2* = `NULL` **)**

Assemble element arrays into global matrix and right-hand side.
This member function is to be called from finite element equation classes

Parameters

in	*el*	Reference to Element class
in	*b*	Pointer to element right-hand side
in	*A0*	Pointer to matrix of 0-th order term (involving no time derivative)

Parameters

in	*A1*	Pointer to matrix of first order term (involving time first derivative)
in	*A2*	Pointer to matrix of second order term (involving time second derivative) [Default: `NULL`]

void SAssembly (const Side & *sd*, real_t ∗ *b*, real_t ∗ *A* = `NULL` **)**

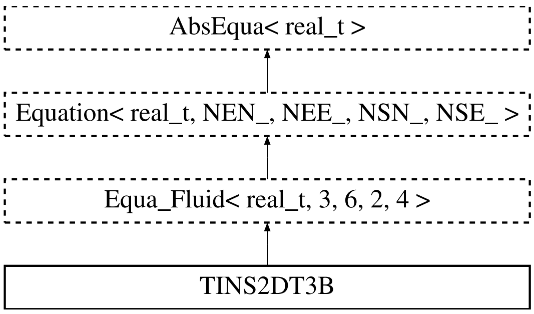
Assemble side arrays into global matrix and right-hand side.
This member function is to be called from finite element equation classes

Parameters

in	*sd*	Reference to Side class
in	*b*	Pointer to side right-hand side
in	*A*	Pointer to matrix e) [Default: `NULL`]

7.101 TINS2DT3B Class Reference

Builds finite element arrays for thermal diffusion and convection in 2-D domains using 3-Node triangles.
Inheritance diagram for TINS2DT3B:



Public Member Functions

- TINS2DT3B ()

  Default Constructor.
- TINS2DT3B (Mesh &mesh, Vect< real_t > &u, Vect< real_t > &p, real_t &ts, real_t Re=0.)

  Constructor using mesh.
- ∼TINS2DT3B ()

  Destructor.
- void setInput (EqDataType opt, Vect< real_t > &u)

  Set equation input data.
- int runOneTimeStep ()

  Run one time step.
- int run ()

Run (in the case of one step run)

- void updateBC (const Element &el, const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void updateBC (const Vect< real_t > &bc)

  Update Right-Hand side by taking into account essential boundary conditions.
- void DiagBC (int dof_type=NODE_DOF, int dof=0)

  Update element matrix to impose bc by diagonalization technique.
- void LocalNodeVector (Vect< real_t > &b)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementNodeVector (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be, int dof)

  Localize Element Vector from a Vect instance.
- void ElementNodeVectorSingleDOF (const Vect< real_t > &b, LocalVect< real_t, NEN_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementSideVector (const Vect< real_t > &b, LocalVect< real_t, NSE_ > &be)

  Localize Element Vector from a Vect instance.
- void ElementVector (const Vect< real_t > &b, int dof_type=NODE_FIELD, int flag=0)

  Localize Element Vector.
- void SideVector (const Vect< real_t > &b)

  Localize Side Vector.
- void ElementNodeCoordinates ()

  Localize coordinates of element nodes.
- void SideNodeCoordinates ()

  Localize coordinates of side nodes.
- void ElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (PETScVect< real_t > &b)

  Assemble element right-hand side vector into global one.
- void ElementAssembly (BMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one.
- void ElementAssembly (Vect< real_t > &v)

  Assemble element vector into global one.
- void SideAssembly (PETScMatrix< real_t > &A)

  Assemble side matrix into global one.
- void SideAssembly (PETScVect< real_t > &b)

Assemble side right-hand side vector into global one.

- void SideAssembly (Matrix< real_t > *A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkSMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SkMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (SpMatrix< real_t > &A)

  Assemble side (edge or face) matrix into global one.
- void SideAssembly (Vect< real_t > &v)

  Assemble side (edge or face) vector into global one.
- void DGElementAssembly (Matrix< real_t > *A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkSMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SkMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (SpMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void DGElementAssembly (TrMatrix< real_t > &A)

  Assemble element matrix into global one for the Discontinuous Galerkin approximation.
- void AxbAssembly (const Element &el, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of element matrix by element vector into global vector.
- void AxbAssembly (const Side &sd, const Vect< real_t > &x, Vect< real_t > &b)

  Assemble product of side matrix by side vector into global vector.
- size_t getNbNodes () const

  Return number of element nodes.
- size_t getNbEq () const

  Return number of element equations.
- void setInitialSolution (const Vect< real_t > &u)

  Set initial solution (previous time step)
- real_t setMaterialProperty (const string &exp, const string &prop)

  Define a material property by an algebraic expression.
- void setMesh (Mesh &m)

  Define mesh and renumber DOFs after removing imposed ones.
- Mesh & getMesh () const

  Return reference to Mesh instance.
- LinearSolver< real_t > & getLinearSolver ()

  Return reference to linear solver instance.
- void setSolver (Iteration ls, Preconditioner pc=IDENT_PREC)

  Choose solver for the linear system.
- int SolveLinearSystem (Matrix< real_t > *A, Vect< real_t > &b, Vect< real_t > &x)

  Solve the linear system.

Public Attributes

- LocalMatrix< real_t, NEE_, NEE_ > eMat

  LocalMatrix instance containing local matrix associated to current element.
- LocalMatrix< real_t, NSE_, NSE_ > sMat

  LocalMatrix instance containing local matrix associated to current side.
- LocalVect< real_t, NEE_ > ePrev

  LocalVect instance containing local vector associated to current element.
- LocalVect< real_t, NEE_ > eRHS

  LocalVect instance containing local right-hand side vector associated to current element.
- LocalVect< real_t, NEE_ > eRes

  LocalVect instance containing local residual vector associated to current element.
- LocalVect< real_t, NSE_ > sRHS

  LocalVect instance containing local right-hand side vector associated to current side.

Protected Member Functions

- void Viscosity (const real_t &visc)

  Set (constant) Viscosity.
- void Viscosity (const string &exp)

  Set viscosity given by an algebraic expression.
- void Density (const real_t &dens)

  Set (constant) Viscosity.
- void Density (const string &exp)

  Set Density given by an algebraic expression.
- void ThermalExpansion (const real_t *e)

  Set (constant) thermal expansion coefficient.
- void ThermalExpansion (const string &exp)

  Set thermal expansion coefficient given by an algebraic expression.
- void setMaterial ()

  Set material properties.
- void Init (const Element *el)

  Set element arrays to zero.
- void Init (const Side *sd)

  Set side arrays to zero.

7.101.1 Detailed Description

Builds finite element arrays for thermal diffusion and convection in 2-D domains using 3-Node triangles.

Note that members calculating element arrays have as an argument a double `coef` that will be multiplied by the contribution of the current element. This makes possible testing different algorithms.

7.101.2 Constructor & Destructor Documentation

TINS2DT3B (Mesh & *mesh*, Vect< real_t > & *u*, Vect< real_t > & *p*, real_t & *ts*, real_t *Re* = `0.` **)**

Constructor using mesh.

Parameters

in	*mesh*	Mesh instance
in,out	*u*	Vect instance containing initial velocity. This vector is updated during computations and will therefore contain velocity at each time step
out	*p*	Vect instance that will contain pressure at nodes. This vector is updated during computations and will therefore contain pressure at each time step
in	*ts*	Time step
in	*Re*	Reynolds number. The default value (0) means that no Reynolds number is given and problem data are supplied by material properties. If Re has any other value, then nondimensional form of the equations is assumed and material properties are ignored.

7.101.3 Member Function Documentation

void setInput (EqDataType *opt*, Vect< real_t > & *u*)

Set equation input data.

Parameters

in	*opt*	Parameter to select type of input (enumerated values) • `INITIAL_FIELD`: Initial temperature • `BOUNDARY_CONDITION_DATA`: Boundary condition (Dirichlet) • `SOURCE_DATA`: Heat source • `FLUX_DATA`: Heat flux (Neumann boundary condition) • `VELOCITY_FIELD`: Velocity vector (for the convection term)
in	*u*	Vector containing input data (Vect instance)

void updateBC (const Element & *el*, const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

in	*el*	Reference to current element instance
in	*bc*	Vector that contains imposed values at all DOFs

void updateBC (const Vect< real_t > & *bc*) `[inherited]`

Update Right-Hand side by taking into account essential boundary conditions.

Parameters

Parameters

in	*bc*	Vector that contains imposed values at all DOFs

Remarks

The current element is pointed by `_theElement`

void DiagBC (int *dof_type* = *NODE_DOF*, int *dof* = *0*) `[inherited]`

Update element matrix to impose bc by diagonalization technique.

Parameters

in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*dof*	DOF setting: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF No. `dof` is handled in the system

void LocalNodeVector (Vect< real_t > & *b*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Reference to global vector to be localized. The resulting local vector can be accessed by attribute ePrev. This member function is to be used if a constructor with Element was invoked.

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

in	*b*	Global vector to be localized.
out	*be*	Local vector, the length of which is the total number of element equations.

Remarks

All degrees of freedom are transferred to the local vector

void ElementNodeVector (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*, int *dof*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.
`in`	*dof*	Degree of freedom to transfer to the local vector

Remarks

Only yhe dega dof is transferred to the local vector

void ElementNodeVectorSingleDOF (const Vect< real_t > & *b*, LocalVect< real_t , NEN_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is the total number of element equations.

Remarks

Vector `b` is assumed to contain only one degree of freedom by node.

void ElementSideVector (const Vect< real_t > & *b*, LocalVect< real_t , NSE_ > & *be*) `[inherited]`

Localize Element Vector from a Vect instance.

Parameters

`in`	*b*	Global vector to be localized.
`out`	*be*	Local vector, the length of which is

void ElementVector (const Vect< real_t > & *b*, int *dof_type* = `NODE_FIELD`, int *flag* = `0`) `[inherited]`

Localize Element Vector.

Parameters

in	*b*	Global vector to be localized
in	*dof_type*	DOF type option. To choose among the enumerated values: • `NODE_FIELD`, DOFs are supported by nodes [Default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides
in	*flag*	Option to set: • `= 0`, All DOFs are taken into account [Default] • `!= 0`, Only DOF number `dof` is handled in the system The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Element was invoked. It uses the Element pointer `_theElement`

void SideVector (const Vect< real_t > & *b*) `[inherited]`

Localize Side Vector.

Parameters

in	*b*	Global vector to be localized • `NODE_FIELD`, DOFs are supported by nodes [default] • `ELEMENT_FIELD`, DOFs are supported by elements • `SIDE_FIELD`, DOFs are supported by sides The resulting local vector can be accessed by attribute `ePrev`.

Remarks

This member function is to be used if a constructor with Side was invoked. It uses the Side pointer `_theSide`

void ElementNodeCoordinates ( ) `[inherited]`

Localize coordinates of element nodes.

Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Side pointer `_theSide`

void SideNodeCoordinates ( ) `[inherited]`

Localize coordinates of side nodes.
Coordinates are stored in array `_x[0], _x[1], ...` which are instances of class Point<real_t>

Remarks

This member function uses the Element pointer `_theElement`

void ElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Reference to global matrix

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (PETScVect< real_t > & *b*) `[inherited]`

Assemble element right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (BMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as a BMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one.

Parameters

in	A	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void ElementAssembly (Vect$<$ **real_t** $>$ **&** v **)** `[inherited]`

Assemble element vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The element pointer is given by the global variable `theElement`

void SideAssembly (PETScMatrix$<$ **real_t** $>$ **&** A **)** `[inherited]`

Assemble side matrix into global one.

Parameters

A	Reference to global matrix

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (PETScVect$<$ **real_t** $>$ **&** b **)** `[inherited]`

Assemble side right-hand side vector into global one.

Parameters

b	Reference to global right-hand side vector

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Matrix$<$ **real_t** $>$ $*$ A **)** `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkSMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SkMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble side (edge or face) matrix into global one.

Parameters

`in`	*A*	Global matrix stored as an SpMatrix instance

Warning

The side pointer is given by the global variable `theSide`

void SideAssembly (Vect< real_t > & *v*) `[inherited]`

Assemble side (edge or face) vector into global one.

Parameters

in	v	Global vector (Vect instance)

Warning

The side pointer is given by the global variable `theSide`

void DGElementAssembly (Matrix< real_t > * *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Pointer to global matrix (abstract class: can be any of classes SkSMatrix, SkMatrix, SpMatrix)

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkSMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

A	Global matrix stored as an SkSMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SkMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	A	Global matrix stored as an SkMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (SpMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an SpMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void DGElementAssembly (TrMatrix< real_t > & *A*) `[inherited]`

Assemble element matrix into global one for the Discontinuous Galerkin approximation.

Parameters

in	*A*	Global matrix stored as an TrMatrix instance

Warning

The element pointer is given by the global variable `theElement`

void AxbAssembly (const Element & *el*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of element matrix by element vector into global vector.

Parameters

in	*el*	Reference to Element instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector to add (Vect instance)

void AxbAssembly (const Side & *sd*, const Vect< real_t > & *x*, Vect< real_t > & *b*) `[inherited]`

Assemble product of side matrix by side vector into global vector.

Parameters

in	*sd*	Reference to Side instance
in	*x*	Global vector to multiply by (Vect instance)
out	*b*	Global vector (Vect instance)

real_t setMaterialProperty (const string & *exp*, const string & *prop*) `[inherited]`

Define a material property by an algebraic expression.

Parameters

in	*exp*	Algebraic expression
in	*prop*	Property name

Returns

Return value in expression evaluation:

- `=0`, Normal evaluation
- `!=0`, An error message is displayed

Mesh& getMesh ( ) const `[inherited]`

Return reference to Mesh instance.

Returns

Reference to Mesh instance

void setSolver (Iteration *ls*, **Preconditioner** *pc* **=** *`IDENT_PREC`* **)** `[inherited]`

Choose solver for the linear system.

Parameters

in	*ls*	Solver of the linear system. To choose among the enumerated values: `DIRECT_SOLVER`, `CG_SOLVER`, `GMRES_SOLVER` • `DIRECT_SOLVER`, Use a facorization solver [default] • `CG_SOLVER`, Conjugate Gradient iterative solver • `CGS_SOLVER`, Squared Conjugate Gradient iterative solver • `BICG_SOLVER`, BiConjugate Gradient iterative solver • `BICG_STAB_SOLVER`, BiConjugate Gradient Stabilized iterative solver • `GMRES_SOLVER`, GMRES iterative solver • `QMR_SOLVER`, QMR iterative solver
in	*pc*	Preconditioner to associate to the iterative solver. If the direct solver was chosen for the first argument this argument is not used. Otherwise choose among the enumerated values: • `IDENT_PREC`, Identity preconditioner (no preconditioning [default]) • `DIAG_PREC`, Diagonal preconditioner • `ILU_PREC`, Incomplete LU factorization preconditioner

int SolveLinearSystem (Matrix< real_t > * *A*, Vect< real_t > & *b*, Vect< real_t > & *x*) `[inherited]`

Solve the linear system.

Parameters

`in`	*A*	Pointer to matrix of the system (Instance of class SpMatrix)
`in`	*b*	Vector containing right-hand side
`in,out`	*x*	Vector containing initial guess of solution on input, actual solution on output

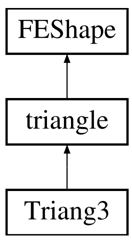
7.101.4 Member Data Documentation

LocalVect<real_t ,NEE_> ePrev `[inherited]`

LocalVect instance containing local vector associated to current element.
This vector has been stored as the one at previous iteration or previous time step

7.102 Triang3 Class Reference

Defines a 3-Node (P_1) triangle.
Inheritance diagram for Triang3:



Public Member Functions

- Triang3 ()

    Default Constructor.
- Triang3 (const Element *el)

    Constructor for an element.
- Triang3 (const Side *sd)

    Constructor for a side.
- ~Triang3 ()

    Destructor.
- void set (const Element *el)

    Choose element by giving its pointer.
- void set (const Side *sd)

    Choose side by giving its pointer.
- real_t Sh (size_t i, Point< real_t > s) const

    Calculate shape function of node at a given point.
- Point< real_t > DSh (size_t i) const

Calculate derivatives of shape function of node i

- real_t getInterpolate (const Point< real_t > &x, const LocalVect< real_t, 3 > &v)

  Return interpolated value at point of coordinate x
- real_t check () const

  Check element area and number of nodes.
- Point< real_t > Grad (const LocalVect< real_t, 3 > &u) const

  Return constant gradient vector in triangle.
- real_t getMaxEdgeLength () const

  Return maximal edge length of triangle.
- real_t getMinEdgeLength () const

  Return minimal edge length of triangle.
- real_t getArea ()

  Return element area.
- Point< real_t > getCenter () const

  Return coordinates of center of element.
- Point< real_t > getCircumcenter () const

  Return coordinates of circumcenter of element.
- real_t getCircumRadius () const

  Return radius of circumscribed circle of triangle.
- real_t getInRadius () const

  Return radius of inscribed circle of triangle.
- Point< real_t > getRefCoord (const Point< real_t > &x) const

  Return reference coordinates of a point x in element.
- bool isIn (const Point< real_t > &x) const

  Check whether point x is in current triangle or not.
- bool isStrictlyIn (const Point< real_t > &x) const

  Check whether point x is strictly in current triangle (not on the boundary) or not.
- real_t Sh (size_t i) const

  Return shape function of node i at given point.
- real_t getDet () const

  Return determinant of jacobian.
- Point< real_t > getLocalPoint () const

  Localize a point in the element.
- Point< real_t > getLocalPoint (const Point< real_t > &s) const

  Localize a point in the element.

7.102.1 Detailed Description

Defines a 3-Node (P_1) triangle.

The reference element is the rectangle triangle with two unit edges.

7.102.2 Constructor & Destructor Documentation

Triang3 (const Element ∗ *el*)

Constructor for an element.

The constructed triangle is an element in a 2-D mesh.

Triang3 (const Side ∗ *sd*)

Constructor for a side.
The constructed triangle is a side in a 3-D mesh.

7.102.3 Member Function Documentation

real_t Sh (size_t *i*, Point< real_t > *s*) const

Calculate shape function of node at a given point.

Parameters

in	*i*	Label (local) of node
in	*s*	Natural coordinates of node where to evaluate

real_t check ( ) const

Check element area and number of nodes.

Returns

- > 0: *m* is the length
- = 0: zero length (=> Error)

Point<real_t> Grad (const LocalVect< real_t, 3 > & *u*) const

Return constant gradient vector in triangle.

Parameters

in	*u*	Local vector for which the gradient is evaluated

real_t getDet ( ) const `[inherited]`

Return determinant of jacobian.
If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint ( ) const `[inherited]`

Localize a point in the element.
Return actual coordinates in the reference element. If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

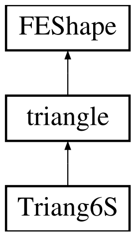
Point<real_t> getLocalPoint (const Point< real_t > & *s*) const `[inherited]`

Localize a point in the element.
Return actual coordinates where `s` are coordinates in the reference element.

7.103 Triang6S Class Reference

Defines a 6-Node straight triangular finite element using P_2 interpolation.

Inheritance diagram for Triang6S:



Public Member Functions

- Triang6S ()

  Default Constructor.
- Triang6S (const Element *el)

  Constructor for an element.
- ~Triang6S ()

  Destructor.
- real_t Sh (size_t i, const Point< real_t > &s) const

  Calculate shape function of a node.
- Point< real_t > DSh (size_t i, const Point< real_t > &s) const

  Calculate derivatives of shape function of a node.
- Point< real_t > getCenter () const

  Return coordinates of center of element.
- Point< real_t > Grad (const LocalVect< real_t, 6 > &u, const Point< real_t > &s) const

  Return gradient vector in triangle at a given point.
- real_t getMaxEdgeLength () const

  Return maximal edge length of triangle.
- real_t getMinEdgeLength () const

  Return minimal edge length of triangle.
- real_t getArea ()

  Return element area.
- Point< real_t > getCircumcenter () const

  Return coordinates of circumcenter of element.
- real_t getCircumRadius () const

  Return radius of circumscribed circle of triangle.
- real_t getInRadius () const

  Return radius of inscribed circle of triangle.
- Point< real_t > getRefCoord (const Point< real_t > &x) const

  Return reference coordinates of a point x in element.
- bool isIn (const Point< real_t > &x) const

  Check whether point x is in current triangle or not.
- bool isStrictlyIn (const Point< real_t > &x) const

  Check whether point x is strictly in current triangle (not on the boundary) or not.

- real_t Sh (size_t i) const

  Return shape function of node `i` *at given point.*
- real_t Sh (size_t i, Point< real_t > s) const

  Calculate shape function of node `i` *at a given point* `s`*.*
- Point< real_t > DSh (size_t i) const

  Return derivatives of shape function of node `i` *at a given point.*
- real_t getDet () const

  Return determinant of jacobian.
- Point< real_t > getLocalPoint () const

  Localize a point in the element.
- Point< real_t > getLocalPoint (const Point< real_t > &s) const

  Localize a point in the element.

7.103.1 Detailed Description

Defines a 6-Node straight triangular finite element using P_2 interpolation.
The reference element is the rectangle triangle with two unit edges.

7.103.2 Constructor & Destructor Documentation

Triang6S (const Element ∗ *el*)

Constructor for an element.
The constructed triangle is an element in a 2-D mesh.

Parameters

in	*el*	Pointer to Element instance

7.103.3 Member Function Documentation

real_t Sh (size_t *i*, const Point< real_t > & *s*) const

Calculate shape function of a node.

Parameters

in	*i*	Local label of the node $1 \leq i \leq 6$
in	*s*	Local coordinates of the point where the shape function is evaluated

Point<real_t> DSh (size_t *i*, const Point< real_t > & *s*) const

Calculate derivatives of shape function of a node.

Parameters

in	*i*	Local label of node
in	*s*	Local coordinates of the point where the gradient of the shape function is evaluated

Point<real_t> Grad (const LocalVect< real_t, 6 > & *u*, const Point< real_t > & *s*) const

Return gradient vector in triangle at a given point.

Parameters

in	*s*	Local coordinates of the point where the gradient of the shape function is evaluated
in	*u*	Local vector for which the gradient is evaluated

real_t Sh (size_t *i*, Point< real_t > *s*) const `[inherited]`

Calculate shape function of node `i` at a given point `s`.

Parameters

in	*i*	Local node label
in	*s*	Point in the reference triangle where the shape function is evaluated

Point<real_t> DSh (size_t *i*) const `[inherited]`

Return derivatives of shape function of node `i` at a given point.

If the transformation (Reference element -> Actual element) is not affine, member function `setLocal()` must have been called before in order to calcuate relevant quantities.

Parameters

in	*i*	Partial derivative index (1, 2 or 3)

real_t getDet ( ) const `[inherited]`

Return determinant of jacobian.

If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint ( ) const `[inherited]`

Localize a point in the element.

Return actual coordinates in the reference element. If the transformation (Reference element -> Actual element) is not affine, member function **setLocal()** must have been called before in order to calcuate relevant quantities.

Point<real_t> getLocalPoint (const Point< real_t > & *s*) const `[inherited]`

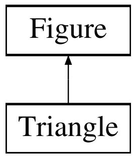
Localize a point in the element.

Return actual coordinates where `s` are coordinates in the reference element.

7.104 Triangle Class Reference

To store and treat a triangle.

Inheritance diagram for Triangle:



Public Member Functions

- Triangle ()
  Default constructor.
- Triangle (const Point< real_t > &v1, const Point< real_t > &v2, const Point< real_t > &v3, int code=1)
  Constructor with vertices and code.
- void setVertex1 (const Point< real_t > &v)
  Assign first vertex of triangle.
- void setVertex2 (const Point< real_t > &v)
  Assign second vertex of triangle.
- void setVertex3 (const Point< real_t > &v)
  Assign third vertex of triangle.
- real_t getSignedDistance (const Point< real_t > &p) const
  Return signed distance of a given point from the current triangle.
- Triangle & operator+= (Point< real_t > a)
  Operator +=.
- Triangle & operator+= (real_t a)
  Operator ∗=.
- void setCode (int code)
  Choose a code for the domain defined by the figure.
- void getSignedDistance (const Grid &g, Vect< real_t > &d) const
  Calculate signed distance to current figure with respect to grid points.
- real_t dLine (const Point< real_t > &p, const Point< real_t > &a, const Point< real_t > &b) const
  Compute signed distance from a line.

7.104.1 Detailed Description

To store and treat a triangle.

7.104.2 Constructor & Destructor Documentation

Triangle ( )

Default constructor.
Constructs a unit triangle with vertices `(0,0)`, `(1,0)` and `(0,1)`

Triangle (const Point< real_t > & *v1*, const Point< real_t > & *v2*, const Point< real_t > & *v3*, int *code* = *1*)

Constructor with vertices and code.

Parameters

in	*v1*	Coordinates of first vertex of triangle
in	*v2*	Coordinates of second vertex of triangle
in	*v3*	Coordinates of third vertex of triangle
in	*code*	Code to assign to the generated figure [Default: 1]

Remarks

Vertices must be given in couterclockwise order

7.104.3 Member Function Documentation

real_t getSignedDistance (const Point< real_t > & *p*) const `[virtual]`

Return signed distance of a given point from the current triangle.

The computed distance is negative if `p` lies in the triangle, positive if it is outside, and 0 on its boundary

Parameters

in	*p*	Point<double> instance

Reimplemented from Figure.

Triangle& operator+= (Point< real_t > *a*)

Operator +=.

Translate triangle by a vector `a`

Triangle& operator+= (real_t *a*)

Operator ∗=.

Scale triangle by a factor `a`

void getSignedDistance (const Grid & *g*, Vect< real_t > & *d*) const `[inherited]`

Calculate signed distance to current figure with respect to grid points.

Parameters

in	*g*	Grid instance
in	*d*	Vect instance containing calculated distance from each grid index to Figure

Remarks

Vector `d` doesn't need to be sized before invoking this function

real_t dLine (const Point< real_t > & *p*, const Point< real_t > & *a*, const Point< real_t > & *b*) const `[inherited]`

Compute signed distance from a line.

Parameters

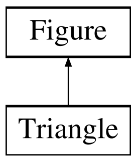
in	*p*	Point for which distance is computed
in	*a*	First vertex of line
in	*b*	Second vertex of line

Returns

Signed distance

7.105 Triangle Class Reference

To store and treat a triangle.
Inheritance diagram for Triangle:



Public Member Functions

- Triangle ()
  Default constructor.
- Triangle (const Point< real_t > &v1, const Point< real_t > &v2, const Point< real_t > &v3, int code=1)
  Constructor with vertices and code.
- void setVertex1 (const Point< real_t > &v)
  Assign first vertex of triangle.
- void setVertex2 (const Point< real_t > &v)
  Assign second vertex of triangle.
- void setVertex3 (const Point< real_t > &v)
  Assign third vertex of triangle.
- real_t getSignedDistance (const Point< real_t > &p) const
  Return signed distance of a given point from the current triangle.
- Triangle & operator+= (Point< real_t > a)
  Operator +=.
- Triangle & operator+= (real_t a)
  Operator ∗=.
- void setCode (int code)
  Choose a code for the domain defined by the figure.
- void getSignedDistance (const Grid &g, Vect< real_t > &d) const
  Calculate signed distance to current figure with respect to grid points.
- real_t dLine (const Point< real_t > &p, const Point< real_t > &a, const Point< real_t > &b) const
  Compute signed distance from a line.

7.105.1 Detailed Description

To store and treat a triangle.

7.105.2 Constructor & Destructor Documentation

Triangle ( )

Default constructor.
Constructs a unit triangle with vertices `(0,0)`, `(1,0)` and `(0,1)`

Triangle (const Point< real_t > & *v1*, const Point< real_t > & *v2*, const Point< real_t > & *v3*, int *code* = *1*)

Constructor with vertices and code.

Parameters

`in`	*v1*	Coordinates of first vertex of triangle
`in`	*v2*	Coordinates of second vertex of triangle
`in`	*v3*	Coordinates of third vertex of triangle
`in`	*code*	Code to assign to the generated figure [Default: 1]

Remarks

Vertices must be given in couterclockwise order

7.105.3 Member Function Documentation

real_t getSignedDistance (const Point< real_t > & *p*) const `[virtual]`

Return signed distance of a given point from the current triangle.
The computed distance is negative if `p` lies in the triangle, positive if it is outside, and 0 on its boundary

Parameters

`in`	*p*	Point<double> instance

Reimplemented from Figure.

Triangle& operator+= (Point< real_t > *a*)

Operator +=.
Translate triangle by a vector `a`

Triangle& operator+= (real_t *a*)

Operator $*=$.
Scale triangle by a factor `a`

void getSignedDistance (const Grid & *g*, Vect< real_t > & *d*) const `[inherited]`

Calculate signed distance to current figure with respect to grid points.

Parameters

in	*g*	Grid instance
in	*d*	Vect instance containing calculated distance from each grid index to Figure

Remarks

Vector `d` doesn't need to be sized before invoking this function

real_t dLine (const Point< real_t > & *p*, const Point< real_t > & *a*, const Point< real_t > & *b*) const `[inherited]`

Compute signed distance from a line.

Parameters

in	*p*	Point for which distance is computed
in	*a*	First vertex of line
in	*b*	Second vertex of line

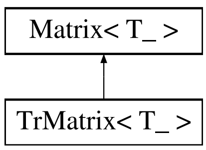
Returns

Signed distance

7.106 TrMatrix< T_ > Class Template Reference

To handle tridiagonal matrices.

Inheritance diagram for TrMatrix< T_ >:



Public Member Functions

- TrMatrix ()

  Default constructor.
- TrMatrix (size_t size)

  Constructor for a tridiagonal matrix with `size` *rows.*
- TrMatrix (const TrMatrix &m)

  Copy Constructor.
- ~TrMatrix ()

  Destructor.
- void Identity ()

  Define matrix as identity matrix.
- void Diagonal ()

Define matrix as a diagonal one.

- void Diagonal (const T_ &a)

  Define matrix as a diagonal one with diagonal entries equal to `a`
- void Laplace1D (real_t h)

  Sets the matrix as the one for the Laplace equation in 1-D.
- void setSize (size_t size)

  Set size (number of rows) of matrix.
- void MultAdd (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `x` *and add result to* `y`*.*
- void MultAdd (T_ a, const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `a*x` *and add result to* `y`*.*
- void Mult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply matrix by vector `x` *and save result in* `y`*.*
- void TMult (const Vect< T_ > &x, Vect< T_ > &y) const

  Multiply transpose of matrix by vector `x` *and save result in* `y`*.*
- void Axpy (T_ a, const TrMatrix< T_ > &m)

  Add to matrix the product of a matrix by a scalar.
- void Axpy (T_ a, const Matrix< T_ > *m)

  Add to matrix the product of a matrix by a scalar.
- void set (size_t i, size_t j, const T_ &val)

  Assign constant `val` *to an entry* `(i,j)` *of the matrix.*
- void add (size_t i, size_t j, const T_ &val)

  Add constant `val` *value to an entry* `(i,j)` *of the matrix.*
- T_ operator() (size_t i, size_t j) const

  Operator () (Constant version).
- T_ & operator() (size_t i, size_t j)

  Operator () (Non constant version).
- TrMatrix< T_ > & operator= (const TrMatrix< T_ > &m)

  Operator =.
- TrMatrix< T_ > & operator= (const T_ &x)

  Operator = Assign matrix to identity times `x`*.*
- TrMatrix< T_ > & operator*= (const T_ &x)

  *Operator *=.*
- int solve (Vect< T_ > &b)

  Solve a linear system with current matrix (forward and back substitution).
- int solve (const Vect< T_ > &b, Vect< T_ > &x)

  Solve a linear system with current matrix (forward and back substitution).
- T_ * get () const

  Return C-Array.
- T_ get (size_t i, size_t j) const

  Return entry `(i,j)` *of matrix.*
- size_t getNbRows () const

  Return number of rows.
- size_t getNbColumns () const

  Return number of columns.
- void setPenal (real_t p)

Set Penalty Parameter (For boundary condition prescription).

- void setDiagonal ()

  Set the matrix as diagonal.
- void setDiagonal (Mesh &mesh)

  Initialize matrix storage in the case where only diagonal terms are stored.
- T_ getDiag (size_t k) const

  Return k-th diagonal entry of matrix.
- size_t size () const

  Return matrix dimension (Number of rows and columns).
- void Assembly (const Element &el, T_ *a)

  Assembly of element matrix into global matrix.
- void Assembly (const Element &el, const DMatrix< T_ > &a)

  Assembly of element matrix into global matrix.
- void Assembly (const Side &sd, T_ *a)

  Assembly of side matrix into global matrix.
- void Assembly (const Side &sd, const DMatrix< T_ > &a)

  Assembly of side matrix into global matrix.
- void Prescribe (Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.
- void Prescribe (int dof, int code, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.
- void Prescribe (Vect< T_ > &b, int flag=0)

  Impose by a penalty method a homegeneous (=0) essential boundary condition.
- void Prescribe (size_t dof, Vect< T_ > &b, const Vect< T_ > &u, int flag=0)

  Impose by a penalty method an essential boundary condition when only one DOF is treated.
- void PrescribeSide ()

  Impose by a penalty method an essential boundary condition when DOFs are supported by sides.
- virtual int Factor ()=0

  Factorize matrix. Available only if the storage class enables it.
- int FactorAndSolve (Vect< T_ > &b)

  Factorize matrix and solve the linear system.
- int FactorAndSolve (const Vect< T_ > &b, Vect< T_ > &x)

  Factorize matrix and solve the linear system.
- size_t getLength () const

  Return number of stored terms in matrix.
- int isDiagonal () const

  Say if matrix is diagonal or not.
- int isFactorized () const

  Say if matrix is factorized or not.
- virtual size_t getColInd (size_t i) const

  Return Column index for column i (See the description for class SpMatrix).
- virtual size_t getRowPtr (size_t i) const

  Return Row pointer for row i (See the description for class SpMatrix).
- T_ operator() (size_t i) const

  Operator () with one argument (Constant version).
- T_ & operator() (size_t i)

Operator () with one argument (Non Constant version).

- T_ & operator[ ] (size_t k)

  Operator [] (Non constant version).

- T_ operator[ ] (size_t k) const

  Operator [] (Constant version).

- Matrix & operator+= (const Matrix< T_ > &m)

  Operator +=.

- Matrix & operator+= (const T_ &x)

  Operator +=.

- Matrix & operator-= (const Matrix< T_ > &m)

  Operator -=.

- Matrix & operator-= (const T_ &x)

  Operator -=.

7.106.1 Detailed Description

template<class T_>
class OFELI::TrMatrix< T_ >

To handle tridiagonal matrices.

This class enables storing and manipulating tridiagonal matrices. The template parameter is the type of matrix entries

Template Parameters

*T_*	Data type (double, float, complex<double>, ...)

7.106.2 Member Function Documentation

void Laplace1D (real_t *h*)

Sets the matrix as the one for the Laplace equation in 1-D.

The matrix is initialized as the one resulting from P_1 finite element discretization of the classical elliptic operator -u'' = f with homogeneous Dirichlet boundary conditions

Remarks

This function is available for real valued matrices only.

Parameters

in	*h*	Mesh size (assumed constant)

void setDiagonal (Mesh & *mesh*) `[inherited]`

Initialize matrix storage in the case where only diagonal terms are stored.

This member function is to be used for explicit time integration schemes

T_ getDiag (size_t *k*) const [inherited]

Return k-th diagonal entry of matrix.
First entry is given by **getDiag(1)**.

void Assembly (const Element & *el*, T_ * *a*) [inherited]

Assembly of element matrix into global matrix.
Case where element matrix is given by a C-array.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a C-array

void Assembly (const Element & *el*, const DMatrix< T_ > & *a*) [inherited]

Assembly of element matrix into global matrix.
Case where element matrix is given by a DMatrix instance.

Parameters

in	*el*	Pointer to element instance
in	*a*	Element matrix as a DMatrix instance

void Assembly (const Side & *sd*, T_ * *a*) [inherited]

Assembly of side matrix into global matrix.
Case where side matrix is given by a C-array.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a C-array instance

void Assembly (const Side & *sd*, const DMatrix< T_ > & *a*) [inherited]

Assembly of side matrix into global matrix.
Case where side matrix is given by a DMatrix instance.

Parameters

in	*sd*	Pointer to side instance
in	*a*	Side matrix as a DMatrix instance

void Prescribe (Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition, using the Mesh instance provided by the constructor.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

Parameters

`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (int *dof*, int *code*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition to a given degree of freedom for a given code.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

Parameters

`in`	*dof*	Degree of freedom for which a boundary condition is to be enforced
`in`	*code*	Code for which a boundary condition is to be enforced
`in,out`	*b*	Vect instance that contains right-hand side.
`in`	*u*	Vect instance that contains imposed valued at DOFs where they are to be imposed.
`in`	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof`>0) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (Vect< T_ > & *b*, int *flag* = *0*) `[inherited]`

Impose by a penalty method a homegeneous (=0) essential boundary condition.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set←Penal**(..).

Parameters

`in,out`	*b*	Vect instance that contains right-hand side.

Parameters

in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void Prescribe (size_t *dof*, Vect< T_ > & *b*, const Vect< T_ > & *u*, int *flag* = *0*) `[inherited]`

Impose by a penalty method an essential boundary condition when only one DOF is treated.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. This gunction is to be used if only one DOF per node is treated in the linear system. The penalty parameter is by default equal to 1.e20. It can be modified by member function setPenal.

Parameters

in	*dof*	Label of the concerned degree of freedom (DOF).
in,out	*b*	Vect instance that contains right-hand side.
in	*u*	Vect instance that conatins imposed valued at DOFs where they are to be imposed.
in	*flag*	Parameter to determine whether only the right-hand side is to be modified (`dof>0`) or both matrix and right-hand side (`dof=0`, default value).

void PrescribeSide ( ) `[inherited]`

Impose by a penalty method an essential boundary condition when DOFs are supported by sides.

This member function modifies diagonal terms in matrix and terms in vector that correspond to degrees of freedom with nonzero code in order to impose a boundary condition. The penalty parameter is defined by default equal to 1.e20. It can be modified by member function **set**↩
Penal(..).

int FactorAndSolve (Vect< T_ > & *b*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage cass enables it.

Parameters

in,out	*b*	Vect instance that contains right-hand side on input and solution on output

int FactorAndSolve (const Vect< T_ > & *b*, Vect< T_ > & *x*) `[inherited]`

Factorize matrix and solve the linear system.

This is available only if the storage class enables it.

Parameters

in	*b*	Vect instance that contains right-hand side

Parameters

out	x	Vect instance that contains solution

Returns

- 0 if solution was normally performed
- n if the n-th pivot is nul

int isFactorized ( ) const [inherited]

Say if matrix is factorized or not.
If the matrix was not factorized, the class does not allow solving by a direct solver.

T_ operator() (size_t *i*) const [inherited]

Operator () with one argument (Constant version).
Returns i-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	i	entry index

T_& operator() (size_t *i*) [inherited]

Operator () with one argument (Non Constant version).
Returns i-th position in the array storing matrix entries. The first entry is at location 1. Entries are stored row by row.

Parameters

in	i	entry index

T_& operator[ ] (size_t *k*) [inherited]

Operator [] (Non constant version).
Returns k-th stored element in matrix Index k starts at 0.

T_ operator[ ] (size_t *k*) const [inherited]

Operator [] (Constant version).
Returns k-th stored element in matrix Index k starts at 0.

Matrix& operator+= (const Matrix< T_ > & *m*) [inherited]

Operator +=.
Add matrix m to current matrix instance.

Matrix& operator+= (const T_ & *x*) `[inherited]`

Operator +=.
Add constant value `x` to all matrix entries.

Matrix& operator-= (const Matrix< T_ > & *m*) `[inherited]`

Operator -=.
Subtract matrix `m` from current matrix instance.

Matrix& operator-= (const T_ & *x*) `[inherited]`

Operator -=.
Subtract constant value `x` from all matrix entries.

7.107 UserData< T_ > Class Template Reference

Abstract class to define by user various problem data.

Public Member Functions

- UserData ()

  Default Constructor.
- UserData (const class Mesh &mesh)

  Constructor using mesh instance.
- virtual ~UserData ()

  Destructor.
- void setTime (real_t time)

  Set time value.
- void setDBC (Vect< T_ > &b)

  Set Dirichlet Boundary Conditions.
- void setInitialData (Vect< T_ > &b)

  Set initial data.
- void setBodyForce (Vect< T_ > &b)

  Set Nodewise Body Force using a Vect instance.
- void setSurfaceForce (Vect< T_ > &b)

  Set Surface Force.
- virtual T_ BoundaryCondition (Point< real_t > x, int code, real_t time=0., size_t dof=1)

  Define boundary condition to impose at point of coordinates `x`*, with code* `code` *at time* `time`*, for DOF* `dof`
- virtual T_ BodyForce (Point< real_t > x, real_t time=0., size_t dof=1)

  Define body force to impose at point of coordinates `x`*, with code* `code` *at time* `time`*, for DOF* `dof`
- virtual T_ SurfaceForce (Point< real_t > x, int code, real_t time=0., size_t dof=1)

  Define surface force to impose at point of coordinates `x`*, with code* `code` *at time* `time`*, for DOF* `dof`
- virtual T_ InitialData (Point< real_t > x, size_t dof=1)

  Define initial data to impose at point of coordinates `x`*, for DOF* `dof`

7.107.1 Detailed Description

template<class T_>
class OFELI::UserData< T_ >

Abstract class to define by user various problem data.

The user has to implement a class that derives from the present one where the virtual functions are implemented.

Template Parameters

<T_>	Data type (real_t, float, complex<real_t>, ...)

7.107.2 Constructor & Destructor Documentation

UserData (const class Mesh & *mesh*)

Constructor using mesh instance.

Parameters

mesh	Reference to Mesh instance

7.107.3 Member Function Documentation

void setDBC (Vect< T_ > & *b*)

Set Dirichlet Boundary Conditions.

This function loops over all nodes and calls for each node the member function BoundaryCondition to assign the value defined by it

Parameters

out	*b*	Vector that contains boundary conditions at nodes This vector must be sized before invoking this function

void setInitialData (Vect< T_ > & *b*)

Set initial data.

This function loops over all nodes and calls for each node the member function InitialData to assign the value defined by it

Parameters

out	*b*	Vector that contains initial data at nodes This vector must be sized before invoking this function

void setBodyForce (Vect< T_ > & *b*)

Set Nodewise Body Force using a Vect instance.

Parameters

in	*b*	Vector containing body forces at nodes to impose

This function loops over all nodes and calls for each node the member function BodyForce to assign the value defined by it

Parameters

out	*b*	Vector that contains body forces at nodes This vector must be sized before invoking this function

void setSurfaceForce (Vect< T_ > & *b*)

Set Surface Force.

Parameters

in	*b*	Vector containing surface forces at nodes to impose

This function loops over all nodes and calls for each node the member function SurfaceForce to assign the value defined by it

Parameters

out	*b*	Vector that contains body forces at nodes This vector must be sized before invoking this function

virtual T_ BoundaryCondition (Point< real_t > *x*, int *code*, real_t *time* = 0., size_t *dof* = 1) `[virtual]`

Define boundary condition to impose at point of coordinates `x`, with code `code` at time `time`, for DOF `dof`

Function to implement by user

Parameters

in	*x*	Coordinates of point at which the value is to be prescribed
in	*code*	Code of node for which the value is to be prescribed
in	*time*	Value of time [Default: `0.`]
in	*dof*	Corresponding degree of freedom [Default: `1`]

Returns

Value of boundary condition to prescribe corresponding to these parameters

virtual T_ BodyForce (Point< real_t > *x*, real_t *time* = *0.*, size_t *dof* = *1*) `[virtual]`

Define body force to impose at point of coordinates `x`, with code `code` at time `time`, for DOF `dof`
Function to implement by user

Parameters

in	*x*	Coordinates of point at which the body force is given
in	*time*	Value of time [Default: `0.`]
in	*dof*	Corresponding degree of freedom [Default: `1`]

Returns

Value of body force corresponding to these parameters

virtual T_ SurfaceForce (Point< real_t > *x*, int *code*, real_t *time* = *0.*, size_t *dof* = *1*) `[virtual]`

Define surface force to impose at point of coordinates `x`, with code `code` at time `time`, for DOF `dof`
Function to implement by user

Parameters

in	*x*	Coordinates of point at which the surface force is given
in	*code*	Code of node for which the surface force is given
in	*time*	Value of time [Default: `0.`]
in	*dof*	Corresponding degree of freedom [Default: `1`]

Returns

Value of surface force corresponding to these parameters

virtual T_ InitialData (Point< real_t > *x*, size_t *dof* = *1*) `[virtual]`

Define initial data to impose at point of coordinates `x`, for DOF `dof`
Function to implement by user

Parameters

in	*x*	Coordinates of point at which the surface force is given
in	*dof*	Corresponding degree of freedom [Default: `1`]

Returns

Value of initial data corresponding to these parameters

7.108 Vect< T_ > Class Template Reference

To handle general purpose vectors.

Public Types

- typedef Eigen::Matrix< T_, Eigen::Dynamic, 1 > VectorX
  This type is the vector type in the Eigen library.

Public Member Functions

- Vect ()
  Default Constructor. Initialize a zero-length vector.
- Vect (size_t n)
  Constructor setting vector size.
- Vect (size_t nx, size_t ny)
  Constructor of a 2-D index vector.
- Vect (size_t nx, size_t ny, size_t nz)
  Constructor of a 3-D index vector.
- Vect (size_t n, T_ *x)
  Create an instance of class Vect as an image of a C/C++ array.
- Vect (Mesh &m, int nb_dof=0, int dof_type=NODE_FIELD)
  Constructor with a mesh instance.
- Vect (Mesh &m, string name, real_t t=0.0, int nb_dof=0, int dof_type=NODE_FIELD)
  Constructor with a mesh instance giving name and time for vector.
- Vect (const Element *el, const Vect< T_ > &v)
  Constructor of an element vector.
- Vect (const Side *sd, const Vect< T_ > &v)
  Constructor of a side vector.
- Vect (const Vect< T_ > &v, const Vect< T_ > &bc)
  Constructor using boundary conditions.
- Vect (const Vect< T_ > &v, size_t nb_dof, size_t first_dof)
  Constructor to select some components of a given vector.
- Vect (const Vect< T_ > &v)
  Copy constructor.
- Vect (const Vect< T_ > &v, size_t n)
  Constructor to select one component from a given 2 or 3-component vector.
- Vect (size_t d, const Vect< T_ > &v, const string &name=" ")
  Constructor that extracts some degrees of freedom (components) from given instance of Vect.
- Vect (const VectorX &v)
  Constructor that copies the vector from a Eigen Vector instance.
- ~Vect ()
  Destructor.
- void set (const T_ *v, size_t n)

Initialize vector with a c-array.

- void select (const Vect< T_ > &v, size_t nb_dof=0, size_t first_dof=1)

  Initialize vector with another Vect instance.
- void set (const string &exp, size_t dof=1)

  Initialize vector with an algebraic expression.
- void set (const string &exp, const Vect< real_t > &x)

  Initialize vector with an algebraic expression.
- void set (Mesh &ms, const string &exp, size_t dof=1)

  Initialize vector with an algebraic expression with providing mesh data.
- void set (const Vect< real_t > &x, const string &exp)

  Initialize vector with an algebraic expression.
- void setMesh (Mesh &m, size_t nb_dof=0, size_t dof_type=NODE_FIELD)

  Define mesh class to size vector.
- size_t size () const

  Return vector (global) size.
- void setSize (size_t nx, size_t ny=1, size_t nz=1)

  Set vector size (for 1-D, 2-D or 3-D cases)
- void resize (size_t n)

  Set vector size.
- void resize (size_t n, T_ v)

  Set vector size and initialize to a constant value.
- void setDOFType (int dof_type)

  Set DOF type of vector.
- void setDG (int degree=1)

  Set Discontinuous Galerkin type vector.
- size_t getNbDOF () const

  Return vector number of degrees of freedom.
- size_t getNb () const

  Return vector number of entities (nodes, elements or sides)
- Mesh & getMesh () const

  Return Mesh instance.
- bool WithMesh () const

  Return `true` if vector contains a Mesh pointer, `false` if not.
- int getDOFType () const
- void setTime (real_t t)

  Set time value for vector.
- real_t getTime () const

  Get time value for vector.
- void setName (string name)

  Set name of vector.
- string getName () const

  Get name of vector.
- real_t getNorm1 () const

  Calculate 1-norm of vector.
- real_t getNorm2 () const

  Calculate 2-norm (Euclidean norm) of vector.
- real_t getNormMax () const

Calculate Max-norm (Infinite norm) of vector.

- real_t getWNorm1 () const

  Calculate weighted 1-norm of vector The wighted 1-norm is the 1-Norm of the vector divided by its size.
- real_t getWNorm2 () const

  Calculate weighted 2-norm of vector.
- T_ getMin () const

  Calculate Min value of vector entries.
- T_ getMax () const

  Calculate Max value of vector entries.
- size_t getNx () const

  Return number of grid points in the x-direction if grid indexing is set.
- size_t getNy () const

  Return number of grid points in the y-direction if grid indexing is set.
- size_t getNz () const

  Return number of grid points in the z-direction if grid indexing is set.
- void setNodeBC (Mesh &m, int code, T_ val, size_t dof=1)

  Assign a given value to components of vector with given code.
- void setSideBC (Mesh &m, int code, T_ val, size_t dof=1)

  Assign a given value to components of vector corresponding to sides with given code.
- void setNodeBC (Mesh &m, int code, const string &exp, size_t dof=1)

  Assign a given function (given by an interpretable algebraic expression) to components of vector with given code.
- void setSideBC (Mesh &m, int code, const string &exp, size_t dof=1)

  Assign a given function (given by an interpretable algebraic expression) to components of vector corresponding to sides with given code.
- void setNodeBC (int code, T_ val, size_t dof=1)

  Assign a given value to components of vector with given code.
- void setNodeBC (int code, const string &exp, size_t dof=1)

  Assign a given function (given by an interpretable algebraic expression) to components of vector with given code.
- void setSideBC (int code, const string &exp, size_t dof=1)

  Assign a given function (given by an interpretable algebraic expression) to components of vector with given code.
- void setSideBC (int code, T_ val, size_t dof=1)

  Assign a given value to components of vector with given code.
- void removeBC (const Mesh &ms, const Vect< T_ > &v, int dof=0)

  Remove boundary conditions.
- void removeBC (const Vect< T_ > &v, int dof=0)

  Remove boundary conditions.
- void transferBC (const Vect< T_ > &bc, int dof=0)

  Transfer boundary conditions to the vector.
- void insertBC (Mesh &m, const Vect< T_ > &v, const Vect< T_ > &bc, int dof=0)

  Insert boundary conditions.
- void insertBC (Mesh &m, const Vect< T_ > &v, int dof=0)

  Insert boundary conditions.
- void insertBC (const Vect< T_ > &v, const Vect< T_ > &bc, int dof=0)

  Insert boundary conditions.

- void insertBC (const Vect< T_ > &v, int dof=0)

  Insert boundary conditions.
- void Assembly (const Element &el, const Vect< T_ > &b)

  Assembly of element vector into current instance.
- void Assembly (const Element &el, const T_ *b)

  Assembly of element vector (as C-array) into Vect instance.
- void Assembly (const Side &sd, const Vect< T_ > &b)

  Assembly of side vector into Vect instance.
- void Assembly (const Side &sd, T_ *b)

  Assembly of side vector (as C-array) into Vect instance.
- void getGradient (class Vect< T_ > &v)

  Evaluate the discrete Gradient vector of the current vector.
- void getGradient (Vect< Point< T_ > > &v)

  Evaluate the discrete Gradient vector of the current vector.
- void getCurl (Vect< T_ > &v)

  Evaluate the discrete curl vector of the current vector.
- void getCurl (Vect< Point< T_ > > &v)

  Evaluate the discrete curl vector of the current vector.
- void getSCurl (Vect< T_ > &v)

  Evaluate the discrete scalar curl in 2-D of the current vector.
- void getDivergence (Vect< T_ > &v)

  Evaluate the discrete Divergence of the current vector.
- real_t getAverage (const Element &el, int type) const

  Return average value of vector in a given element.
- void save (string file, int opt)

  Save vector in a file according to a given format.
- Vect< T_ > & MultAdd (const Vect< T_ > &x, const T_ &a)

  Multiply by a constant then add to a vector.
- void Axpy (T_ a, const Vect< T_ > &x)

  Add to vector the product of a vector by a scalar.
- void set (size_t i, T_ val)

  Assign a value to an entry for a 1-D vector.
- void set (size_t i, size_t j, T_ val)

  Assign a value to an entry for a 2-D vector.
- void set (size_t i, size_t j, size_t k, T_ val)

  Assign a value to an entry for a 3-D vector.
- void add (size_t i, T_ val)

  Add a value to an entry for a 1-index vector.
- void add (size_t i, size_t j, T_ val)

  Add a value to an entry for a 2-index vector.
- void add (size_t i, size_t j, size_t k, T_ val)

  Assign a value to an entry for a 3-index vector.
- void clear ()

  Clear vector: Set all its elements to zero.
- T_ & operator[] (size_t i)

  Operator [] (Non constant version)

- T_ operator[ ] (size_t i) const

  Operator [] (Constant version)
- T_ & operator() (size_t i)

  Operator () (Non constant version)
- T_ operator() (size_t i) const

  Operator () (Constant version)
- T_ & operator() (size_t i, size_t j)

  Operator () with 2-D indexing (Non constant version, case of a grid vector).
- T_ operator() (size_t i, size_t j) const

  Operator () with 2-D indexing (Constant version).
- T_ & operator() (size_t i, size_t j, size_t k)

  Operator () with 3-D indexing (Non constant version).
- T_ operator() (size_t i, size_t j, size_t k) const

  Operator () with 3-D indexing (Constant version).
- Vect< T_ > & operator= (const Vect< T_ > &v)

  Operator = between vectors.
- Vect< T_ > & operator= (const VectorX &v)

  Operator = for an instance of `VectorX`
- void operator= (string s)

  Operator =
- void setUniform (T_ vmin, T_ delta, T_ vmax)

  Initialize vector entries by setting extremal values and interval.
- Vect< T_ > & operator= (const T_ &a)

  Operator =
- Vect< T_ > & operator+= (const Vect< T_ > &v)

  Operator +=
- Vect< T_ > & operator+= (const T_ &a)

  Operator +=
- Vect< T_ > & operator-= (const Vect< T_ > &v)

  Operator -=
- Vect< T_ > & operator-= (const T_ &a)

  Operator -=
- Vect< T_ > & operator*= (const T_ &a)

  *Operator *=*
- Vect< T_ > & operator/= (const T_ &a)

  Operator /=
- void push_back (const T_ &v)

  Add an entry to the vector.
- const Mesh & getMeshPtr () const

  Return reference to Mesh instance.
- T_ operator, (const Vect< T_ > &v) const

  Return Dot (scalar) product of two vectors.
- operator VectorX () const

  Casting operator.

7.108.1 Detailed Description

template<class T_>
class OFELI::Vect< T_ >

To handle general purpose vectors.

This template class enables defining and manipulating vectors of various data types. It inherits from the class std::vector An instance of class Vect can be:

- A simple vector of given size
- A vector with up to three indices, *i.e.*, an entry of the vector can be `a(i)`, `a(i,j)` or `a(i,j,k)`. This feature is useful, for instance, in the case of a structured grid
- A vector associate to a finite element mesh. In this case, a constructor uses a reference to the Mesh instance. The size of the vector is by default equal to the number of nodes `x` the number of degrees of freedom by node. If the degrees of freedom are supported by elements or sides, then the vector is sized accordingly

Operators =, [] and () are overloaded so that one can write for instance:

```
Vect<real_t> u(10), v(10);
v = -1.0;
u = v;
u(3) = -2.0;
```

to set vector **v** entries to **-1**, copy vector **v** into vector **u** and assign third entry of **v** to **-2**. Note that entries of **v** are here **v(1)**, **v(2)**, ..., **v(10)**, *i.e.* vector entries start at index **1**.

Template Parameters

*T_*	Data type (real_t, float, complex<real_t>, ...)

7.108.2 Constructor & Destructor Documentation

Vect (size_t *n*)

Constructor setting vector size.

Parameters

in	*n*	Size of vector

Vect (size_t *nx*, size_t *ny*)

Constructor of a 2-D index vector.

This constructor can be used for instance for a 2-D grid vector

Parameters

in	*nx*	Size for the first index
in	*ny*	Size for the second index

Remarks

The size of resulting vector is nx∗ny

Vect (size_t *nx*, size_t *ny*, size_t *nz*)

Constructor of a 3-D index vector.
This constructor can be used for instance for a 3-D grid vector

Parameters

in	*nx*	Size for the first index
in	*ny*	Size for the second index
in	*nz*	Size for the third index

Remarks

The size of resulting vector is nx∗ny∗nz

Vect (size_t *n*, T_ ∗ *x*)

Create an instance of class Vect as an image of a C/C++ array.

Parameters

in	*n*	Dimension of vector to construct
in	*x*	C-array to copy

Vect (Mesh & *m*, int *nb_dof* = `0`, int *dof_type* = `NODE_FIELD`)

Constructor with a mesh instance.

Parameters

in	*m*	Mesh instance
in	*nb_dof*	Number of degrees of freedom per node, element or side If `nb_dof` is set to `0` (default value) the constructor picks this number from the Mesh instance
in	*dof_type*	Type of degrees of freedom. To be given among the enumerated values: `NODE_FIELD`, `ELEMENT_FIELD`, `SIDE_FIELD` or `EDGE_FIELD` (Default: `NODE_FIELD`)

Vect (Mesh & *m*, string *name*, real_t *t* = `0.0`, int *nb_dof* = `0`, int *dof_type* = `NODE_FIELD`)

Constructor with a mesh instance giving name and time for vector.

Parameters

in	*m*	Mesh instance
in	*name*	Name of the vector
in	*t*	Time value for the vector

Parameters

in	*nb_dof*	Number of degrees of freedom per node, element or side If `nb_dof` is set to `0` the constructor picks this number from the Mesh instance
in	*dof_type*	Type of degrees of freedom. To be given among the enumerated values: `NODE_FIELD`, `ELEMENT_FIELD`, `SIDE_FIELD` or `EDGE_FIELD` (Default: `NODE_FIELD`)

Vect (const Element ∗ *el*, const Vect< T_ > & *v*)

Constructor of an element vector.
The constructed vector has local numbering of nodes

Parameters

in	*el*	Pointer to Element to localize
in	*v*	Global vector to localize

Vect (const Side ∗ *sd*, const Vect< T_ > & *v*)

Constructor of a side vector.
The constructed vector has local numbering of nodes

Parameters

in	*sd*	Pointer to Side to localize
in	*v*	Global vector to localize

Vect (const Vect< T_ > & *v*, const Vect< T_ > & *bc*)

Constructor using boundary conditions.
Boundary condition values contained in `bc` are reported to vector `v`

Parameters

in	*v*	Vect instance to update
in	*bc*	Vect instance containing imposed valued at desired DOF

Vect (const Vect< T_ > & *v*, size_t *nb_dof*, size_t *first_dof*)

Constructor to select some components of a given vector.

Parameters

in	*v*	Vect instance to extract from
in	*nb_dof*	Number of DOF to extract
in	*first_dof*	First DOF to extract For instance, a choice `first_dof=2` and `nb_dof=1` means that the second DOF of each node is copied in the vector

Vect (const Vect< T_ > & *v*, size_t *n*)

Constructor to select one component from a given 2 or 3-component vector.

Parameters

in	*v*	Vect instance to extract from
in	*n*	Component to extract (must be > 1 and < 4 or).

Vect (size_t *d*, const Vect< T_ > & *v*, const string & *name* = " ")

Constructor that extracts some degrees of freedom (components) from given instance of Vect.

This constructor enables constructing a subvector of a given Vect instance. It selects a given list of degrees of freedom and put it according to a given order in the instance to construct.

Parameters

in	*d*	Integer number giving the list of degrees of freedom. This number is made of `n` digits where `n` is the number of degrees of freedom. Let us give an example: Assume that the instance `v` has 3 DOF by entity (node, element or side). The choice `d=201` means that the constructed instance has 2 DOF where the first DOF is the third one of `v`, and the second DOF is the first one of f `v`. Consequently, no digit can be larger than the number of DOF the constructed instance. In this example, a choice `d=103` would produce an error message.
in	*v*	Vect instance from which extraction is performed.
in	*name*	Name to assign to vector instance (Default value is " ").

Warning

Don't give zeros as first digits for the argument `d`. The number is in this case interpreted as octal !!

Vect (const VectorX & *v*)

Constructor that copies the vector from a Eigen Vector instance.

Parameters

in	*v*	VectorX instance from which extraction is performed

Warning

This constructor is available only if the library `eigen` is used in conjunction with OFELI

Remarks

: This constructor is available only if the Eigen library was installed in conjunction with OFELI

7.108.3 Member Function Documentation

void set (const T_ ∗ *v*, size_t *n*)

Initialize vector with a c-array.

Parameters

in	*v*	c-array (pointer) to initialize Vect
in	*n*	size of array

void select (const Vect< T_ > & *v*, size_t *nb_dof* = 0, size_t *first_dof* = 1)

Initialize vector with another Vect instance.

Parameters

in	*v*	Vect instance to extract from
in	*nb_dof*	Number of DOF per node, element or side (By default, 0: Number of degrees of freedom extracted from the Mesh instance)
in	*first_dof*	First DOF to extract (Default: 1) For instance, a choice `first_dof=2` and `nb_dof=1` means that the second DOF of each node is copied in the vector

void set (const string & *exp*, size_t *dof* = 1)

Initialize vector with an algebraic expression.
This function is to be used is a Mesh instance is associated to the vector

Parameters

in	*exp*	Regular algebraic expression that defines a function of `x`, `y`, `z` which are coordinates of nodes and `t` which is the time value.
in	*dof*	Degree of freedom to which the value is assigned [Default: 1]

Warning

If the time variable `t` is involved in the expression, the time value associated to the vector instance must be defined (Default value is 0) either by using the appropriate constructor or by the member function setTime.

void set (const string & *exp*, const Vect< real_t > & *x*)

Initialize vector with an algebraic expression.
This function can be used for instance in 1-D

Parameters

in	*exp*	Regular algebraic expression that defines a function of `x` which are coordinates of nodes
in	*x*	Vector

void set (Mesh & *ms*, const string & *exp*, size_t *dof* = *1*)

Initialize vector with an algebraic expression with providing mesh data.

Parameters

in	*ms*	Mesh instance
in	*exp*	Regular algebraic expression that defines a function of x, y and z which are coordinates of nodes.
in	*dof*	Degree of freedom to which the value is assigned [Default: 1]

void set (const Vect< real_t > & *x*, const string & *exp*)

Initialize vector with an algebraic expression.

Parameters

in	*x*	Vect instance that contains coordinates of points
in	*exp*	Regular algebraic expression that defines a function of x and i which are coordinates of nodes and indices starting from `1`.

void setMesh (Mesh & *m*, size_t *nb_dof* = *0*, size_t *dof_type* = *NODE_FIELD*)

Define mesh class to size vector.

Parameters

in	*m*	Mesh instance
in	*nb_dof*	Number of degrees of freedom per node, element or side If `nb_dof` is set to `0` the constructor picks this number from the Mesh instance
in	*dof_type*	Parameter to precise the type of degrees of freedom. To be chosen among the enumerated values: `NODE_FIELD`, `ELEMENT_FIELD`, `SIDE_FIELD`, `EDGE_FIELD` [Default: `NODE_FIELD`]

size_t size ( ) const

Return vector (global) size.

Warning

This constructor is available only if the library `eigen` is used in conjunction with OFELI

void setSize (size_t *nx*, size_t *ny* = *1*, size_t *nz* = *1*)

Set vector size (for 1-D, 2-D or 3-D cases)
This function allocates memory for the vector but does not initialize its components

Parameters

in	*nx*	Number of grid points in x-direction
in	*ny*	Number of grid points in y-direction [Default: 1]
in	*nz*	Number of grid points in z-direction [Default: 1]

void resize (size_t *n*)

Set vector size.
This function allocates memory for the vector but does not initialize its components

Parameters

in	*n*	Size of vector

void resize (size_t *n*, T_ *v*)

Set vector size and initialize to a constant value.
This function allocates memory for the vector

Parameters

in	*n*	Size of vector
in	*v*	Value to assign to vector entries

void setDOFType (int *dof_type*)

Set DOF type of vector.
The DOF type combined with number of DOF per component enable determining the size of vector

Parameters

in	*dof_type*	Type of degrees of freedom. Value to be chosen among the enumerated values: `NODE_FIELD`, `ELEMENT_FIELD`, `SIDE_FIELD` or `EDGE_FIELD`

void setDG (int *degree* = *1*)

Set Discontinuous Galerkin type vector.
When the vector is associated to a mesh, this one is sized differently if the DG method is used.

Parameters

in	*degree*	Polynomial degree of the DG method [Default: 1]

bool WithMesh ( ) const

Return `true` if vector contains a Mesh pointer, `false` if not.
A Vect instance can be constructed using mesh information

int getDOFType ( ) const

Return DOF type of vector

Returns

dof_type Type of degrees of freedom. Value among the enumerated values: `NODE_FIELD`, `ELEMENT_FIELD`, `SIDE_FIELD` or `EDGE_FIELD`

real_t getNorm1 ( ) const

Calculate 1-norm of vector.

Remarks

This function is available only if the template parameter is `double` or `complex<double>`

real_t getNorm2 ( ) const

Calculate 2-norm (Euclidean norm) of vector.

Remarks

This function is available only if the template parameter is `double` or `complex<double>`

real_t getNormMax ( ) const

Calculate Max-norm (Infinite norm) of vector.

Remarks

This function is available only if the template parameter is `double` or `complex<double>`

real_t getWNorm2 ( ) const

Calculate weighted 2-norm of vector.
The weighted 2-norm is the 2-Norm of the vector divided by the square root of its size

void setNodeBC (Mesh & *m*, int *code*, T_ *val*, size_t *dof* = *1*)

Assign a given value to components of vector with given code.
Vector components are assumed nodewise

Parameters

in	*m*	Instance of mesh
in	*code*	Code for which nodes will be assigned prescribed value
in	*val*	Value to prescribe
in	*dof*	Degree of Freedom for which the value is assigned [default: 1]

void setSideBC (Mesh & *m*, int *code*, T_ *val*, size_t *dof* = 1)

Assign a given value to components of vector corresponding to sides with given code.
Vector components are assumed nodewise

Parameters

in	*m*	Instance of mesh
in	*code*	Code for which nodes will be assigned prescribed value
in	*val*	Value to prescribe
in	*dof*	Degree of Freedom for which the value is assigned [default: 1]

void setNodeBC (Mesh & *m*, int *code*, const string & *exp*, size_t *dof* = 1)

Assign a given function (given by an interpretable algebraic expression) to components of vector with given code.
Vector components are assumed nodewise

Parameters

in	*m*	Instance of mesh
in	*code*	Code for which nodes will be assigned prescribed value
in	*exp*	Regular algebraic expression to prescribe
in	*dof*	Degree of Freedom for which the value is assigned [default: 1]

void setSideBC (Mesh & *m*, int *code*, const string & *exp*, size_t *dof* = 1)

Assign a given function (given by an interpretable algebraic expression) to components of vector corresponding to sides with given code.
Vector components are assumed nodewise

Parameters

in	*m*	Instance of mesh
in	*code*	Code for which nodes will be assigned prescribed value
in	*exp*	Regular algebraic expression to prescribe
in	*dof*	Degree of Freedom for which the value is assigned [default: 1]

void setNodeBC (int *code*, T_ *val*, size_t *dof* = 1)

Assign a given value to components of vector with given code.
Vector components are assumed nodewise

Parameters

in	*code*	Code for which nodes will be assigned prescribed value
in	*val*	Value to prescribe

Parameters

in	*dof*	Degree of Freedom for which the value is assigned [default: 1]

void setNodeBC (int *code*, const string & *exp*, size_t *dof* = *1*)

Assign a given function (given by an interpretable algebraic expression) to components of vector with given code.
Vector components are assumed nodewise

Parameters

in	*code*	Code for which nodes will be assigned prescribed value
in	*exp*	Regular algebraic expression to prescribe
in	*dof*	Degree of Freedom for which the value is assigned [default: 1]

Warning

This member function is to be used in the case where a constructor with a Mesh has been used

void setSideBC (int *code*, const string & *exp*, size_t *dof* = *1*)

Assign a given function (given by an interpretable algebraic expression) to components of vector with given code.
Vector components are assumed nodewise

Parameters

in	*code*	Code for which nodes will be assigned prescribed value
in	*exp*	Regular algebraic expression to prescribe
in	*dof*	Degree of Freedom for which the value is assigned [default: 1]

Warning

This member function is to be used in the case where a constructor with a Mesh has been used

void setSideBC (int *code*, T_ *val*, size_t *dof* = *1*)

Assign a given value to components of vector with given code.
Vector components are assumed nodewise

Parameters

in	*code*	Code for which nodes will be assigned prescribed value
in	*val*	Value to prescribe
in	*dof*	Degree of Freedom for which the value is assigned [default: 1]

Warning

This member function is to be used in the case where a constructor with a Mesh has been used

void removeBC (const Mesh & *ms*, const Vect< T_ > & *v*, int *dof* = 0)

Remove boundary conditions.

This member function copies to current vector a vector where only non imposed DOF are retained.

Parameters

in	*ms*	Mesh instance
in	*v*	Vector (Vect instance to copy from)
in	*dof*	Parameter to say if all degrees of freedom are concerned (=0, Default) or if only one degree of freedom (dof) is inserted into vector v which has only one degree of freedom

void removeBC (const Vect< T_ > & *v*, int *dof* = 0)

Remove boundary conditions.

This member function copies to current vector a vector where only non imposed DOF are retained.

Parameters

in	*v*	Vector (Vect instance to copy from)
in	*dof*	Parameter to say if all degrees of freedom are concerned [Default: 0] or if only one degree of freedom (dof) is inserted into vector v which has only one degree of freedom.

Warning

This member function is to be used in the case where a constructor with a Mesh has been used

void transferBC (const Vect< T_ > & *bc*, int *dof* = 0)

Transfer boundary conditions to the vector.

Parameters

in	*bc*	Vect instance from which imposed degrees of freedom are copied to current instance
in	*dof*	Parameter to say if all degrees of freedom are concerned (=0, Default) or if only one degree of freedom (dof) is inserted into vector v which has only one degree of freedom.

void insertBC (Mesh & *m*, const Vect< T_ > & *v*, const Vect< T_ > & *bc*, int *dof* = 0)

Insert boundary conditions.

Parameters

in	*m*	Mesh instance.
in	*v*	Vect instance from which free degrees of freedom are copied to current instance.
in	*bc*	Vect instance from which imposed degrees of freedom are copied to current instance.
in	*dof*	Parameter to say if all degrees of freedom are concerned (=0, Default) or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom by node or side

void insertBC (Mesh & *m*, const Vect< T_ > & *v*, int *dof* = 0)

Insert boundary conditions.
DOF with imposed boundary conditions are set to zero.

Parameters

in	*m*	Mesh instance.
in	*v*	Vect instance from which free degrees of freedom are copied to current instance.
in	*dof*	Parameter to say if all degrees of freedom are concerned (=`0`, Default) or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom by node or side

void insertBC (const Vect< T_ > & *v*, const Vect< T_ > & *bc*, int *dof* = 0)

Insert boundary conditions.

Parameters

in	*v*	Vect instance from which free degrees of freedom are copied to current instance.
in	*bc*	Vect instance from which imposed degrees of freedom are copied to current instance.
in	*dof*	Parameter to say if all degrees of freedom are concerned (=0, Default) or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom by node or side

void insertBC (const Vect< T_ > & *v*, int *dof* = 0)

Insert boundary conditions.
DOF with imposed boundary conditions are set to zero.

Parameters

in	*v*	Vect instance from which free degrees of freedom are copied to current instance.

Parameters

in	*dof*	Parameter to say if all degrees of freedom are concerned (=0, Default) or if only one degree of freedom (`dof`) is inserted into vector `v` which has only one degree of freedom by node or side

Warning

This member function is to be used in the case where a constructor with a Mesh has been used

void Assembly (const Element & *el*, const Vect< T_ > & *b*)

Assembly of element vector into current instance.

Parameters

in	*el*	Reference to Element instance
in	*b*	Local vector to assemble (Instance of class Vect)

void Assembly (const Element & *el*, const T_ * *b*)

Assembly of element vector (as C-array) into Vect instance.

Parameters

in	*el*	Reference to Element instance
in	*b*	Local vector to assemble (C-Array)

void Assembly (const Side & *sd*, const Vect< T_ > & *b*)

Assembly of side vector into Vect instance.

Parameters

in	*sd*	Reference to Side instance
in	*b*	Local vector to assemble (Instance of class Vect)

void Assembly (const Side & *sd*, T_ * *b*)

Assembly of side vector (as C-array) into Vect instance.

Parameters

in	*sd*	Reference to Side instance
in	*b*	Local vector to assemble (C-Array)

void getGradient (class Vect< T_ > & *v*)

Evaluate the discrete Gradient vector of the current vector.

The resulting gradient is stored in a Vect instance. This function handles node vectors assuming P_1 approximation. The gradient is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the gradient, where `v(n,1)`, `v(n,2)` and `v(n,3)` are respectively the `x` and `y` and `z` derivatives at element `n`.

void getGradient (Vect< Point< T_ > > & *v*)

Evaluate the discrete Gradient vector of the current vector.

The resulting gradient is stored in an Vect instance. This function handles node vectors assuming P_1 approximation. The gradient is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the gradient, where `v(n,1).x`, `v(n,2).y` and `v(n,3).z` are respectively the `x` and `y` and `z` derivatives at element `n`.

void getCurl (Vect< T_ > & *v*)

Evaluate the discrete curl vector of the current vector.

The resulting curl is stored in a Vect instance. This function handles node vectors assuming P_1 approximation. The curl is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the curl, where `v(n,1)`, `v(n,2)` and `v(n,3)` are respectively the `x` and `y` and `z` `curl` components at element `n`.

void getCurl (Vect< Point< T_ > > & *v*)

Evaluate the discrete curl vector of the current vector.

The resulting curl is stored in a Vect instance. This function handles node vectors assuming P_1 approximation. The curl is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the curl, where `v(n,1).x`, `v(n,2).y` and `v(n,3).z` are respectively the `x` and `y` and `z` `curl` components at element `n`.

void getSCurl (Vect< T_ > & *v*)

Evaluate the discrete scalar curl in 2-D of the current vector.

The resulting curl is stored in a Vect instance. This function handles node vectors assuming

P_1 approximation. The curl is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the scalar curl.

void getDivergence (Vect< T_ > & *v*)

Evaluate the discrete Divergence of the current vector.

The resulting divergence is stored in a Vect instance. This function handles node vectors assuming P_1 approximation. The divergence is then a constant vector for each element.

Parameters

in	*v*	Vect instance that contains the divergence.

real_t getAverage (const Element & *el*, int *type*) const

Return average value of vector in a given element.

Parameters

in	*el*	Element instance
in	*type*	Type of element. This is to be chosen among enumerated values: `LINE2`, `TRIANG3`, `QUAD4` `TETRA4`, `HEXA8`, `PENTA6`

void save (string *file*, int *opt*)

Save vector in a file according to a given format.

Parameters

in	*file*	Output file where to save the vector
in	*opt*	Option to choose file format to save. This is to be chosen among enumerated values: `GMSH`, `GNUPLOT`, `MATLAB`, `TECPLOT` and `VTK`

Vect<T_>& MultAdd (const Vect< T_ > & *x*, const T_ & *a*)

Multiply by a constant then add to a vector.

Parameters

in	*x*	Vect instance to add
in	*a*	Constant to multiply before adding

void Axpy (T_ *a*, const Vect< T_ > & *x*)

Add to vector the product of a vector by a scalar.

Parameters

in	*a*	Scalar to premultiply
in	*x*	Vect instance by which a is multiplied. The result is added to current instance

void set (size_t *i*, T_ *val*)

Assign a value to an entry for a 1-D vector.

Parameters

in	*i*	Rank index in vector (starts at 1)
in	*val*	Value to assign

void set (size_t *i*, size_t *j*, T_ *val*)

Assign a value to an entry for a 2-D vector.

Parameters

in	*i*	First index in vector (starts at 1)
in	*j*	Second index in vector (starts at 1)
in	*val*	Value to assign

void set (size_t *i*, size_t *j*, size_t *k*, T_ *val*)

Assign a value to an entry for a 3-D vector.

Parameters

in	*i*	First index in vector (starts at 1)
in	*j*	Second index in vector (starts at 1)
in	*k*	Third index in vector (starts at 1)
in	*val*	Value to assign

void add (size_t *i*, T_ *val*)

Add a value to an entry for a 1-index vector.

Parameters

in	*i*	Rank index in vector (starts at 1)

Parameters

in	*val*	Value to assign

void add (size_t *i*, size_t *j*, T_ *val*)

Add a value to an entry for a 2-index vector.

Parameters

in	*i*	First index in vector (starts at 1)
in	*j*	Second index in vector (starts at 1)
in	*val*	Value to assign

void add (size_t *i*, size_t *j*, size_t *k*, T_ *val*)

Assign a value to an entry for a 3-index vector.

Parameters

in	*i*	First index in vector (starts at 1)
in	*j*	Second index in vector (starts at 1)
in	*k*	Third index in vector (starts at 1)
in	*val*	Value to assign

T_& operator[ ] (size_t *i*)

Operator `[]` (Non constant version)

Parameters

in	*i*	Rank index in vector (starts at 0)

T_ operator[ ] (size_t *i*) const

Operator `[]` (Constant version)

Parameters

in	*i*	Rank index in vector (starts at 0)

T_& operator() (size_t *i*)

Operator `()` (Non constant version)

Parameters

in	*i*	Rank index in vector (starts at 1) • `v(i)` starts at `v(1)` to `v(size())` • `v(i)` is the same element as `v[i-1]`

T_ operator() (size_t *i*) const

Operator `()` (Constant version)

Parameters

in	*i*	Rank index in vector (starts at 1) • `v(i)` starts at `v(1)` to `v(size())` • `v(i)` is the same element as `v[i-1]`

T_& operator() (size_t *i*, size_t *j*)

Operator `()` with 2-D indexing (Non constant version, case of a grid vector).

Parameters

in	*i*	first index in vector (Number of vector components in the x-grid)
in	*j*	second index in vector (Number of vector components in the y-grid) `v(i,j)` starts at `v(1,1)` to `v(getNx(),getNy())`

T_ operator() (size_t *i*, size_t *j*) const

Operator `()` with 2-D indexing (Constant version).

Parameters

in	*i*	first index in vector (Number of vector components in the x-grid)
in	*j*	second index in vector (Number of vector components in the y-grid) `v(i,j)` starts at `v(1,1)` to `v(getNx(),getNy())`

T_& operator() (size_t *i*, size_t *j*, size_t *k*)

Operator `()` with 3-D indexing (Non constant version).

Parameters

in	*i*	first index in vector (Number of vector components in the x-grid)

Parameters

in	*j*	second index in vector (Number of vector components in the y-grid)
in	*k*	third index in vector (Number of vector components in the z-grid) `v(i,j,k)` starts at `v(1,1,1)` to `v(getNx(),getNy(),getNz())`

T_ operator() (size_t *i*, size_t *j*, size_t *k*) const

Operator `()` with 3-D indexing (Constant version).

Parameters

in	*i*	first index in vector (Number of vector components in the x-grid)
in	*j*	second index in vector (Number of vector components in the y-grid)
in	*k*	third index in vector (Number of vector components in the z-grid) `v(i,j,k)` starts at `v(1,1,1)` to `v(getNx(),getNy(),getNz())`

Vect<T_>& operator= (const VectorX & *v*)

Operator = for an instance of `VectorX`

Parameters

in	*v*	Instance of vector class in library `Eigen`

Remarks

The Vect instance must have been sized before
This operator is available only if the Eigen library was installed in conjunction with OFELI

void operator= (string *s*)

Operator =
Assign an algebraic expression to vector entries. This operator has the same effect as the member function set(s)

Parameters

in	*s*	String defining the algebraic expression as a function of coordinates and time

Warning

A Mesh instance must has been introduced before (*e.g.* by a constructor)

void setUniform (T_ *vmin*, T_ *delta*, T_ *vmax*)

Initialize vector entries by setting extremal values and interval.

Parameters

in	*vmin*	Minimal value to assign to the first entry
in	*delta*	Interval
in	*vmax*	Maximal value to assign to the lase entry

Remarks

Vector's size is deduced from the arguments. The vector does not need to be sized before using this function

Vect<T_>& operator= (const T_ & *a*)

Operator =

Assign a constant to vector entries

Parameters

in	*a*	Value to set

Vect<T_>& operator+= (const Vect< T_ > & *v*)

Operator +=

Add vector x to current vector instance.

Parameters

in	*v*	Vect instance to add to instance

Vect<T_>& operator+= (const T_ & *a*)

Operator +=

Add a constant to current vector entries.

Parameters

in	*a*	Value to add to vector entries

Vect<T_>& operator-= (const Vect< T_ > & *v*)

Operator -=

Parameters

in	*v*	Vect instance to subtract from

Vect<T_>& operator-= (const T_ & *a*)

Operator -=
Subtract constant from vector entries.

Parameters

in	*a*	Value to subtract from

Vect<T_>& operator∗= (const T_ & *a*)

Operator ∗=

Parameters

in	*a*	Value to multiply by

Vect<T_>& operator/= (const T_ & *a*)

Operator /=

Parameters

in	*a*	Value to divide by

void push_back (const T_ & *v*)

Add an entry to the vector.
This function is an overload of the member function push_back of the parent class vector. It adjusts in addition some vector parameters

Parameters

in	*v*	Entry value to add

T_ operator, (const Vect< T_ > & *v*) const

Return Dot (scalar) product of two vectors.
A typical use of this operator is `double a = (v,w)` where `v` and `w` are 2 instances of `Vect<double>`

Parameters

in	*v*	Vect instance by which the current instance is multiplied

operator VectorX ( ) const

Casting operator.

Warning

This constructor is available only if the library `eigen` is used in conjunction with OFELI

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