

# LowLevelFEM – API logical structure (draft, function-level)

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⚠ Working document. This is NOT documentation, but a planning map for later API restructuring.

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## Core

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Fundamental data structures and concepts.

## Problem and materials

- Problem
- Material
- material
- elastic\_constants
- elasticSupport
- elasticSupportMatrix
- printElasticConstantsTable

## Fields

- ScalarField
- VectorField
- TensorField
- scalarField
- vectorField
- tensorField
- field
- mergeFields
- projectScalarField
- fieldError
- loadField
- saveField
- isNodal

- isElementwise
- isSaved

## Mesh and geometry

- Geometry
- CoordinateSystem
- generateMesh
- rotateNodes
- projectTo2D
- expandTo3D
- getDimForPhysicalName
- getTagForPhysicalName

## Mapping and integration

- nodesToElements
- elementsToNodes
- integrate
- normalVector
- normalVector1D
- tangentVector

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## Preprocessing

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Preparation of FEM problems.

## Boundary conditions

- BoundaryCondition
- BoundaryConditionFields
- displacementConstraint
- temperatureConstraint
- pressureConstraint
- elasticSupport
- applyBoundaryConditions

- applyBoundaryConditions!
- applyElasticSupport!
- suppressDeformationAtBoundaries
- suppressDeformationAtBoundaries!

## Initial conditions

- initialDisplacement
- initialDisplacement!
- initialVelocity
- initialVelocity!
- initialTemperature
- initialTemperature!

## Loads and sources

- loadVector
- loadVectorOld
- loadVectorNew
- nonFollowerLoadVector
- equivalentNodalForce
- thermalLoadVector
- thermalLoadVectorAXI
- thermalLoadVectorSolid
- heatSource
- heatSourceVector
- heatFlux
- heatFluxVector
- heatConvection
- heatConvectionVector

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## Operators

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Weak-form building blocks, physics-independent.

### Scalar field operators (Poisson / Laplace)

- poissonMatrix
- poissonMatrixVector
- poissonMatrixSymGradF
- stiffnessMatrixPoissonAllInOne
- traceLaplaceMatrix
- tensorLaplaceMatrix
- reactionMatrix
- sourceVector
- solveField

## Vector field operators

- gradMatrix
- gradDivMatrix
- gradDivMatrixF
- curlCurlMatrix
- symmetricGradientMatrix
- tensorDivDivMatrix
- beltramiMichellMatrix

## Advection and flow-related operators

- advectionMatrix
- navierStokesAdvectionMatrix

## Mass and auxiliary operators

- massMatrix
- mapScalarField
- unitTensor
- estimateLengthOfIJV

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## Mechanics

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### Linear mechanics

Small-deformation solid mechanics.

## Stiffness and mass

- stiffnessMatrix
- stiffnessMatrixSolid
- stiffnessMatrixSolidParallel
- stiffnessMatrixSolidParallelNew
- stiffnessMatrixAXI
- stiffnessMatrixTruss
- massMatrixSolid
- massMatrixSolidParallel
- massMatrixTruss
- dampingMatrix

## Constitutive relations

- constitutive\_matrix
- constitutive\_matrix\_stress

## Solvers

- solveDisplacement
- solveStress
- solveStressSlow
- solveStrain
- solveStrainNew
- solveAxialForce

## Eigenvalue and stability

- solveEigenModes
- solveModalAnalysis
- solveBuckling
- solveBucklingModes
- largestEigenValue
- smallestEigenValue
- largestPeriodTime

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- smallestPeriodTime

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## Nonlinear mechanics

Large deformation and energy-based formulations.

### Kinematics

- deformationGradient
- nodePositionVector
- grad
- grad\_xy
- div
- curl
- rot

### Internal forces and stresses

- internalForceVector
- internalForceTL
- stress\_from\_energy
- IIPiolaKirchhoff

### Tangent operators

- materialTangentMatrix
- tangentMatrixConstitutive
- tangentMatrixInitialStress
- geometricTangentMatrix
- tangent\_from\_energy
- externalTangentFollower
- externalTangentFollowerTL

### Solvers and postprocessing

- solveDeformation
  - showDeformationResults
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## Structural dynamics

Mechanical systems with inertia.

- massMatrix
  - dynamicResidual
  - dynamicTangent
  - HHT
  - CDM
  - initialStressMatrix
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## Heat transfer

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### Steady-state heat conduction

- heatConductionMatrix
- heatCondMatrixSolid
- heatCondMatrixAXI
- heatFluxVector
- solveHeatFlux

### Transient heat conduction

- heatCapacityMatrix
  - latentHeatMatrix
  - solveTemperature
  - q\_free
  - q\_theta
  - FDM
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## Postprocessing

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Evaluation and visualization of results.

### Field visualization

- showScalarResults
- showStressResults
- showStrainResults
- showHeatFluxResults
- showModalResults
- showBucklingResults
- showElementResults
- showOnSurface
- plotOnPath
- probe

## Resultants and derived values

- resultant
  - resultant2
  - flowRate
  - fieldsToVolume
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## Utilities

Internal helpers, debugging, and infrastructure.

- debugMatrix
- debugVector
- checkConsistency
- make\_workspace
- make\_ws
- make\_ws\_axi
- inv2x2\_fast
- inv3x3
- inv3x3\_fast
- openPreProcessor
- openPostProcessor
- showGapThickness