[](http://www.comsol.com/)

Ex3 8 heat 2d BC zdi

|  |  |
| --- | --- |
| Date | Dec 7, 2013 4:21:28 PM |

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1. Global

|  |  |
| --- | --- |
| Date | Dec 6, 2013 11:23:39 AM |

Global settings

|  |  |
| --- | --- |
| Name | Ex3 8 heat 2d BC zdi.mph |
| Path | /Users/gilliam/Desktop/collect\_15/research\_15/geo\_reg\_mono\_eugenio/Mono\_1\_15/Comsol\_EX\_GitHub/Chapter3/Chap3Ex8\_9\_2D\_ZDI\_Control/Ex3\_8\_BC\_zdi/Ex3\_8\_heat\_2d\_BC\_zdi.mph |
| Program | COMSOL 4.4 (Build: 150) |

Used products

|  |
| --- |
| COMSOL Multiphysics |

* 1. Definitions
     1. Parameters 1

Parameters

| **Name** | **Expression** | **Value** | **Description** |
| --- | --- | --- | --- |
| L | 2 | 2.0000 |  |
| H | 1 | 1.0000 |  |
| c | 0.1 | 0.10000 |  |
| Mr1 | 1 | 1.0000 |  |
| Mr2 | 2 | 2.0000 |  |
| Ar1 | 1 | 1.0000 |  |
| Ar2 | 2 | 2.0000 |  |
| K1 | 2 | 2.0000 |  |
| K2 | 5 | 5.0000 |  |
| Kd | 1 | 1.0000 |  |

1. Component 1

Component settings

|  |  |
| --- | --- |
| Unit system | None |

* 1. Definitions
     1. Variables

#### Variables 1

Selection

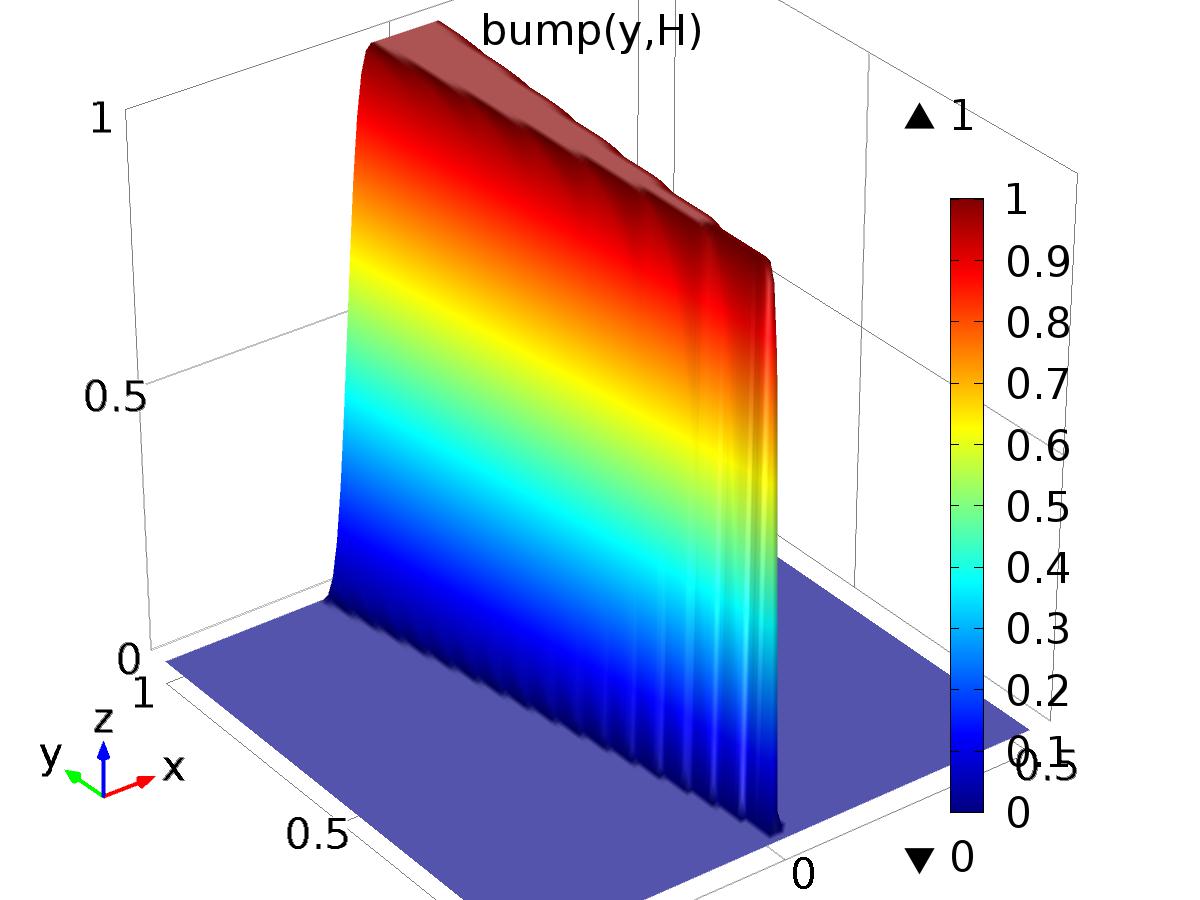
|  |  |
| --- | --- |
| Geometric entity level | Entire model |

| **Name** | **Expression** | **Description** |
| --- | --- | --- |
| yr1 | Ar1 + Mr1\*cos(1/4\* (x - t) ) |  |
| yr2 | Ar2 + Mr2\*sin( .75\*(x + t) ) |  |
| d | bump(y, H)\*sin(t) |  |
| e1 | C1((yr1 - z)^2) |  |
| e2 | C2((yr2 - z)^2) |  |

* + 1. Functions

#### Analytic 1

|  |  |
| --- | --- |
| Function name | bump |
| Function type | Analytic |



Analytic 1

Definition

| **Description** | **Value** |
| --- | --- |
| Expression | flc2hs(-y + H/8, H/16)\*flc2hs(y + H/8, H/16) |
| Arguments | {y, H} |

* + 1. Component Couplings

#### Integration 1

|  |  |
| --- | --- |
| Coupling type | Integration |
| Operator name | C1 |

Source selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Boundary 2 |

#### Integration 2

|  |  |
| --- | --- |
| Coupling type | Integration |
| Operator name | C2 |

Source selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Boundary 3 |

* + 1. Coordinate Systems

#### Boundary System 1

|  |  |
| --- | --- |
| Coordinate system type | Boundary system |
| Tag | sys1 |

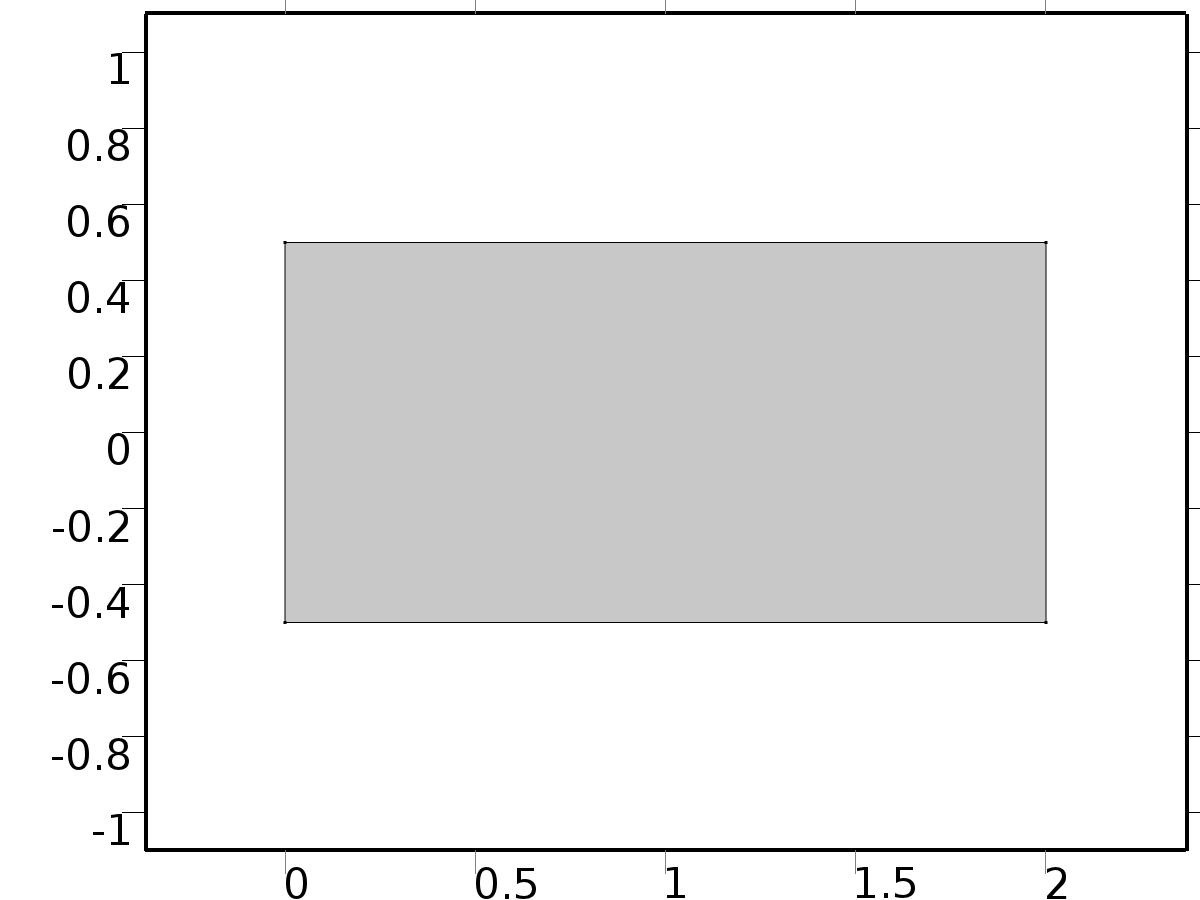
Coordinate names

| **First (t1)** | **Second (n)** | **Third (to)** |
| --- | --- | --- |
| t1 | n | to |

Settings

| **Description** | **Value** |
| --- | --- |
| Create first tangent direction from | Global Cartesian |

* 1. Geometry 1



Geometry 1

Units

|  |  |
| --- | --- |
| Length unit | m |
| Angular unit | deg |

Geometry statistics

| **Description** | **Value** |
| --- | --- |
| Space dimension | 2 |
| Number of domains | 1 |
| Number of boundaries | 4 |
| Number of vertices | 4 |

* + 1. Rectangle 1 (r1)

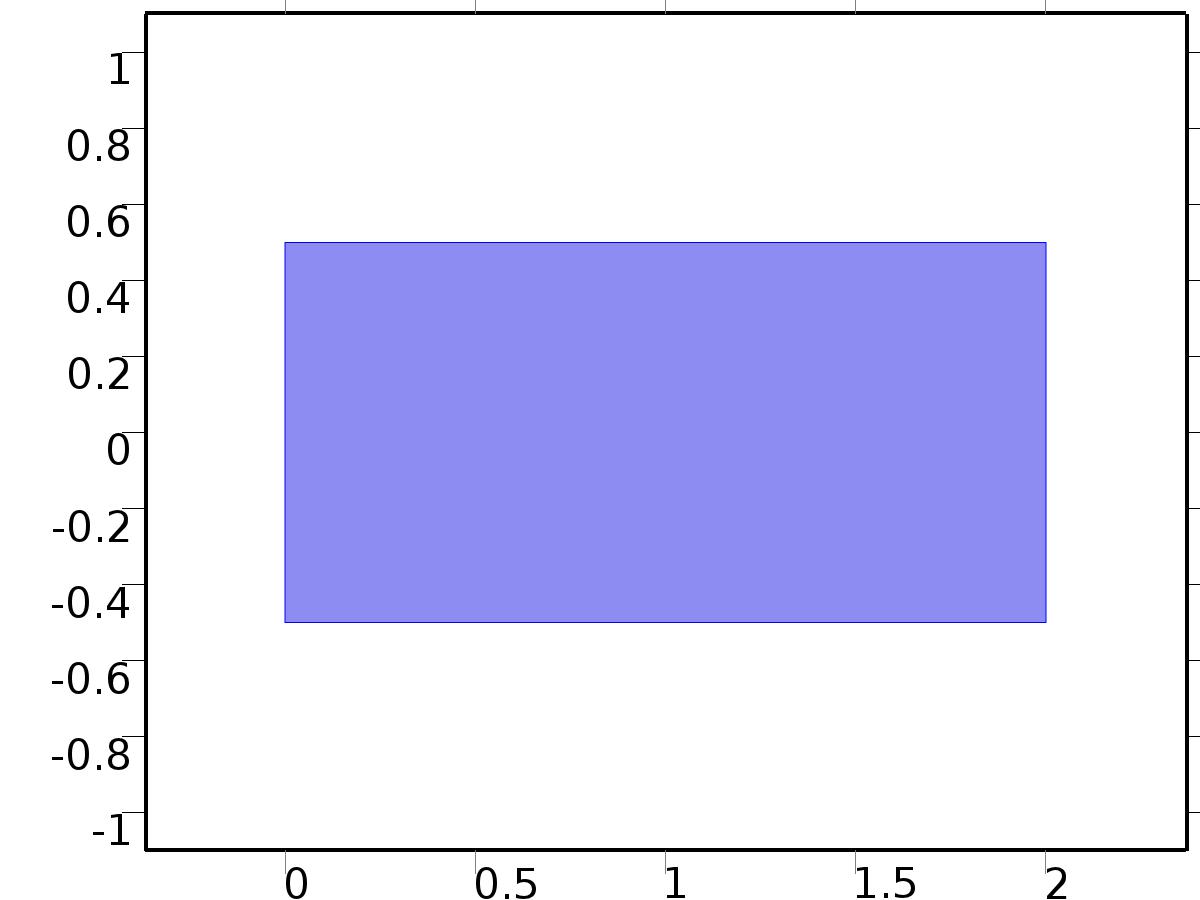
Position

| **Description** | **Value** |
| --- | --- |
| Position | {0, -H/2} |
| Layers |  |

Size

| **Description** | **Value** |
| --- | --- |
| Width | L |
| Height | H |

* 1. Coefficient Form PDE



Coefficient Form PDE

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Domain 1 |

Settings

| **Description** | **Value** |
| --- | --- |
| Shape function type | Lagrange |
| Element order | Quadratic |
| Compute boundary fluxes | On |
| Apply smoothing to boundary fluxes | On |
| Value type when using splitting of complex variables | Complex |
| Dependent variable quantity | Dimensionless (1) |
| Source term quantity | None |
| Unit | m^ - 2 |

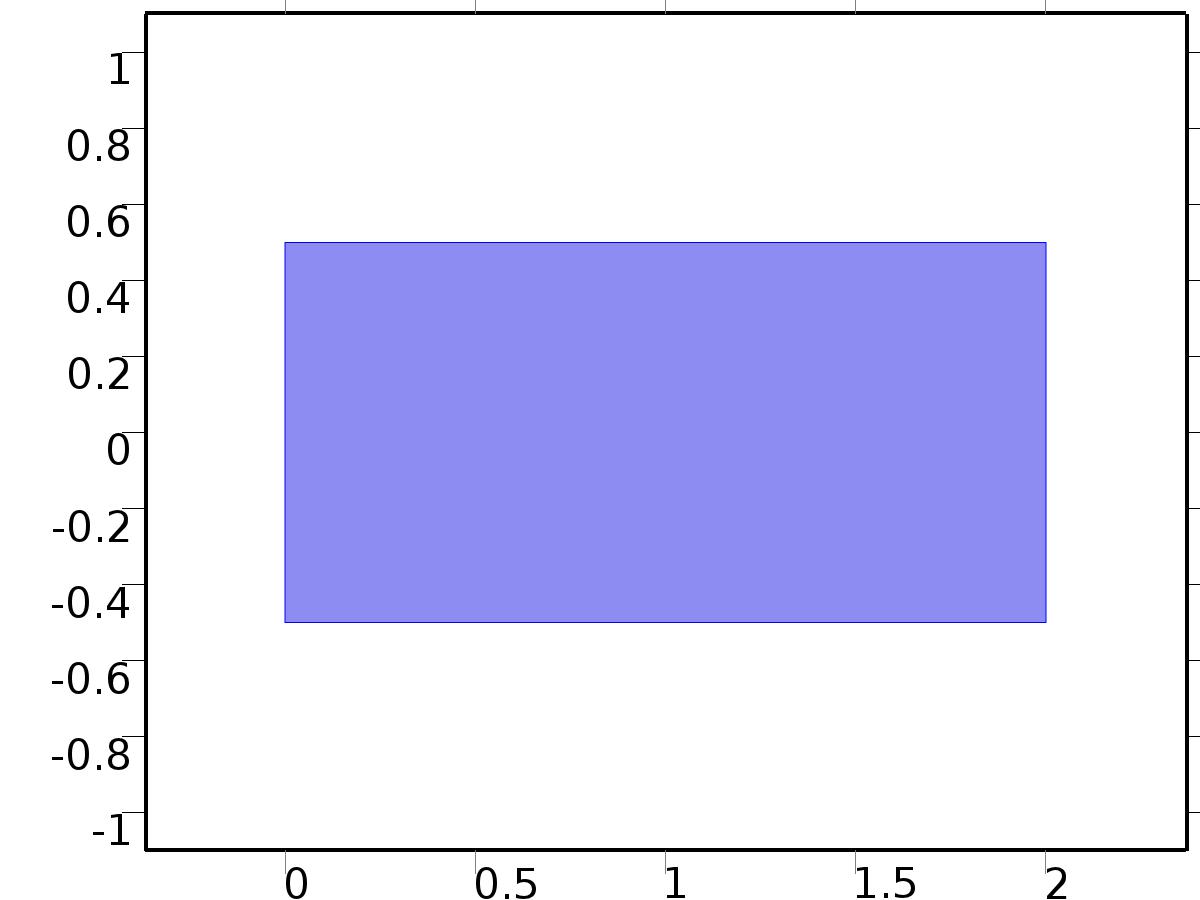
Used products

|  |
| --- |
| COMSOL Multiphysics |

Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| c.nx | nx |  | Normal vector, x component | Boundaries 1–4 |
| c.ny | ny |  | Normal vector, y component | Boundaries 1–4 |
| c.nz | root.nz |  | Normal vector, z component | Boundaries 1–4 |
| c.nxmesh | root.nxmesh |  | Normal vector (mesh), x component | Boundaries 1–4 |
| c.nymesh | root.nymesh |  | Normal vector (mesh), y component | Boundaries 1–4 |
| c.nzmesh | root.nzmesh |  | Normal vector (mesh), z component | Boundaries 1–4 |

* + 1. Coefficient Form PDE 1



Coefficient Form PDE 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Domain 1 |

Equations

Settings

| **Description** | **Value** |
| --- | --- |
| Diffusion coefficient | {{c, 0}, {0, c}} |
| Absorption coefficient | 0 |
| Source term | 0 |
| Mass coefficient | 0 |
| Damping or mass coefficient | 1 |
| Conservative flux convection coefficient | {0, 0} |
| Convection coefficient | {0, 0} |
| Conservative flux source | {0, 0} |

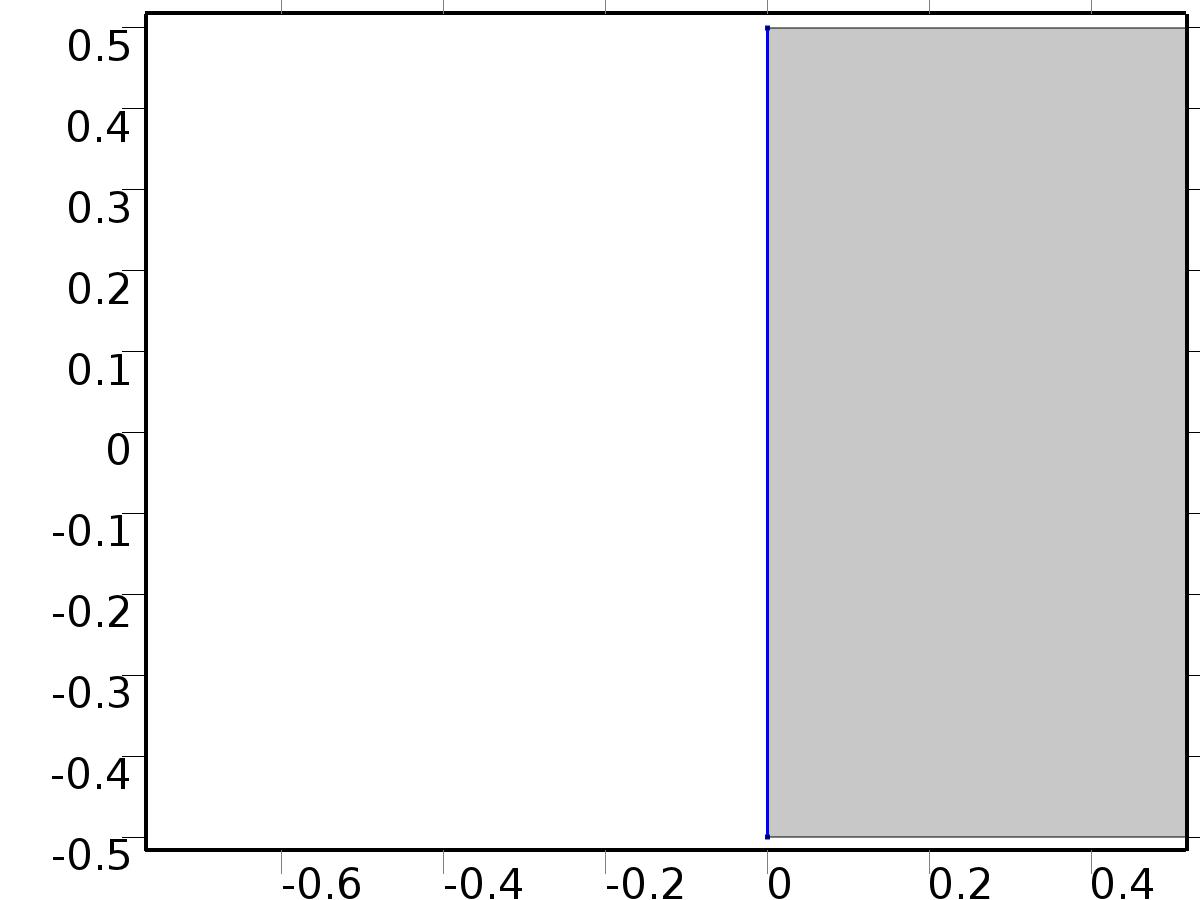
#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| domflux.Xx | -c\*d(X,x) |  | Domain flux, x component | Domain 1 |
| domflux.Xy | -c\*d(X,y) |  | Domain flux, y component | Domain 1 |

#### Shape functions

| **Name** | **Shape function** | **Unit** | **Description** | **Shape frame** | **Selection** |
| --- | --- | --- | --- | --- | --- |
| X | Lagrange (Quadratic) |  | Dependent variable X | Material | Domain 1 |

* + 1. Zero Flux 1



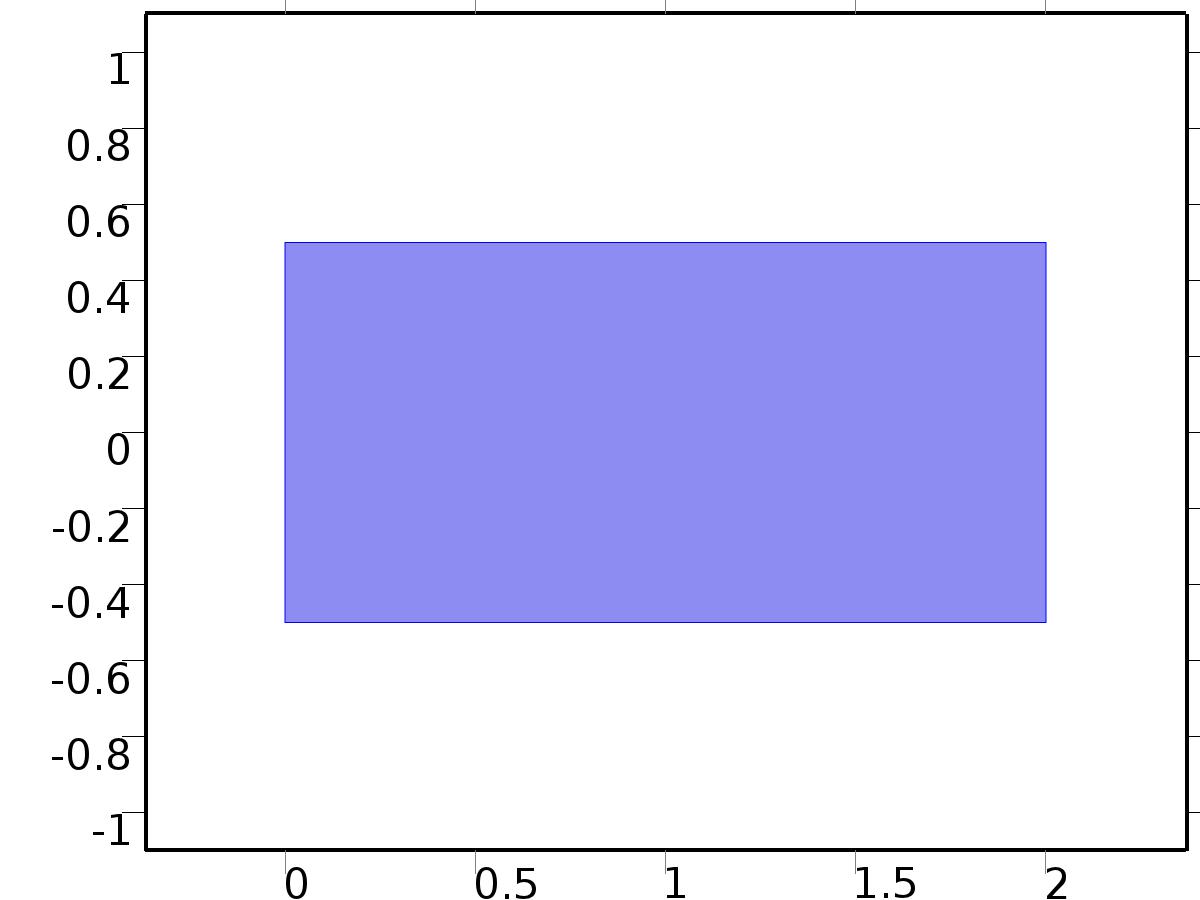
Zero Flux 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Boundary 1 |

Equations

* + 1. Initial Values 1



Initial Values 1

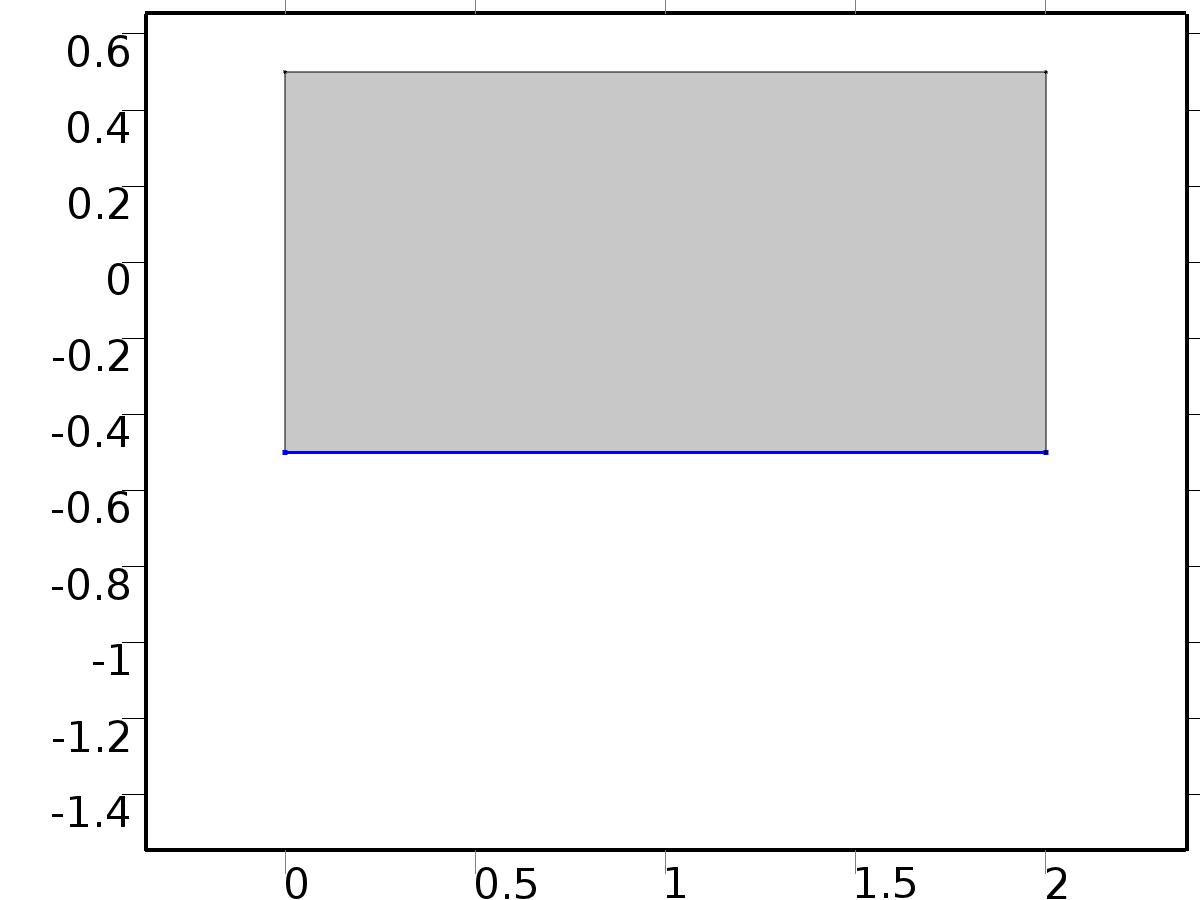
Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Domain 1 |

Settings

| **Description** | **Value** |
| --- | --- |
| Initial value for X | 0 |
| Initial time derivative of X | 0 |

* + 1. Constraint 1



Constraint 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Boundary 2 |

Equations

Settings

| **Description** | **Value** |
| --- | --- |
| Bidirectional constraint, R = 0 | X - yr1 |
| Apply reaction terms on | Individual dependent variables |
| Use weak constraints | On |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| c.R\_X | X-yr1 |  | Bidirectional constraint, R = 0 | Boundary 2 |

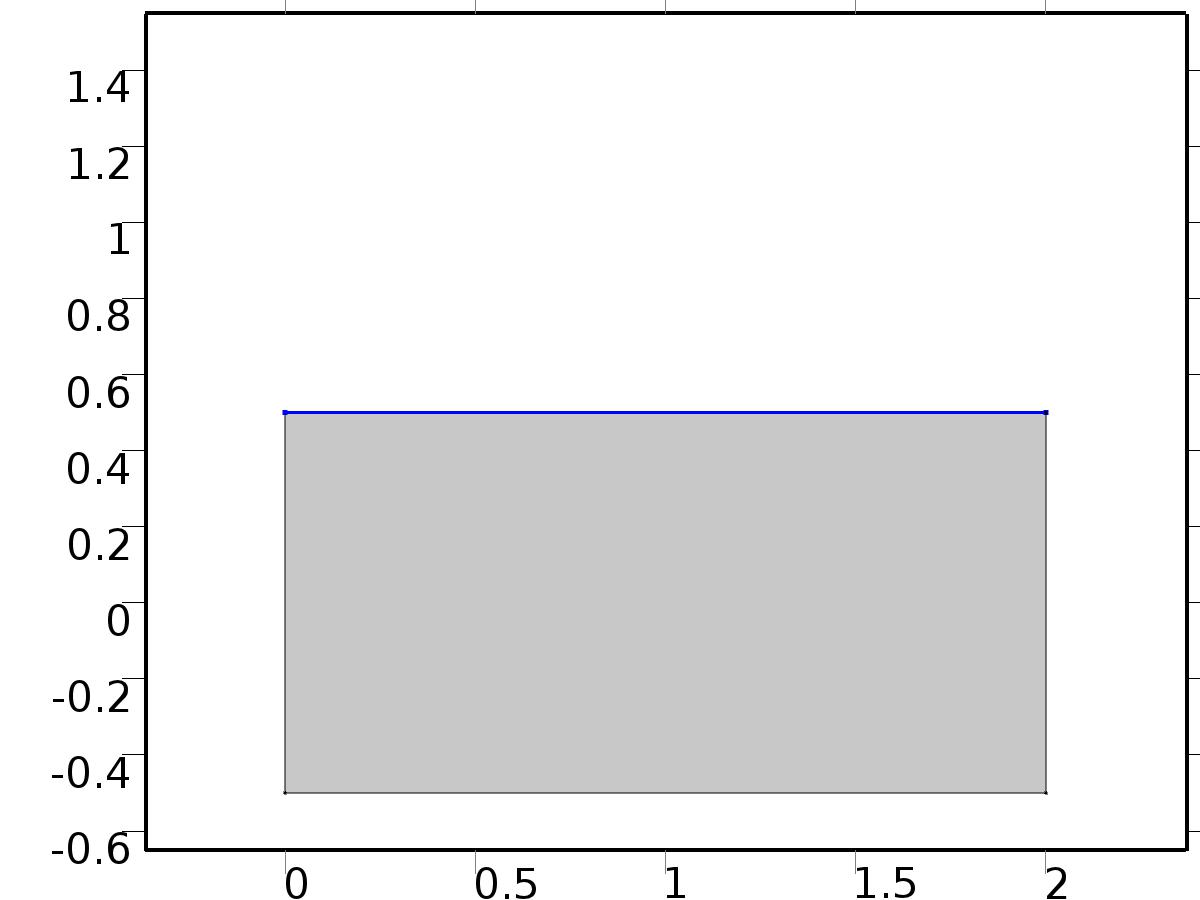
#### Shape functions

| **Name** | **Shape function** | **Unit** | **Description** | **Shape frame** | **Selection** |
| --- | --- | --- | --- | --- | --- |
| X\_lm | Lagrange (Quadratic) |  | Lagrange multiplier for dependent variable x | Material | Boundary 2 |

#### Weak expressions

| **Weak expression** | **Integration frame** | **Selection** |
| --- | --- | --- |
| (X-yr1)\*test(-X\_lm) | Material | Boundary 2 |
| test(X)\*X\_lm | Material | Boundary 2 |

* + 1. Constraint 2



Constraint 2

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Boundary 3 |

Equations

Settings

| **Description** | **Value** |
| --- | --- |
| Bidirectional constraint, R = 0 | X - yr2 |
| Apply reaction terms on | Individual dependent variables |
| Use weak constraints | On |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| c.R\_X | X-yr2 |  | Bidirectional constraint, R = 0 | Boundary 3 |

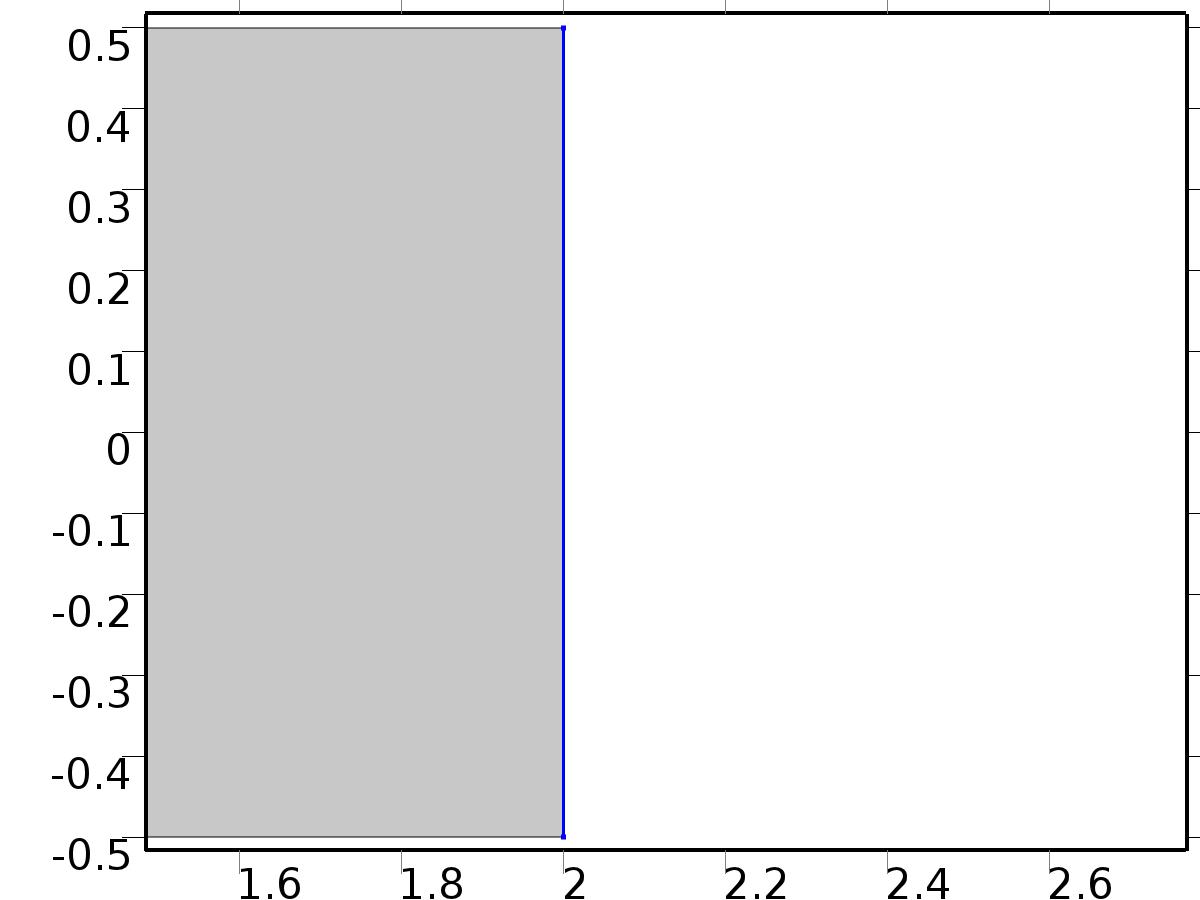
#### Shape functions

| **Name** | **Shape function** | **Unit** | **Description** | **Shape frame** | **Selection** |
| --- | --- | --- | --- | --- | --- |
| X\_lm | Lagrange (Quadratic) |  | Lagrange multiplier for dependent variable x | Material | Boundary 3 |

#### Weak expressions

| **Weak expression** | **Integration frame** | **Selection** |
| --- | --- | --- |
| (X-yr2)\*test(-X\_lm) | Material | Boundary 3 |
| test(X)\*X\_lm | Material | Boundary 3 |

* + 1. Flux/Source 1



Flux/Source 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Boundary 4 |

Equations

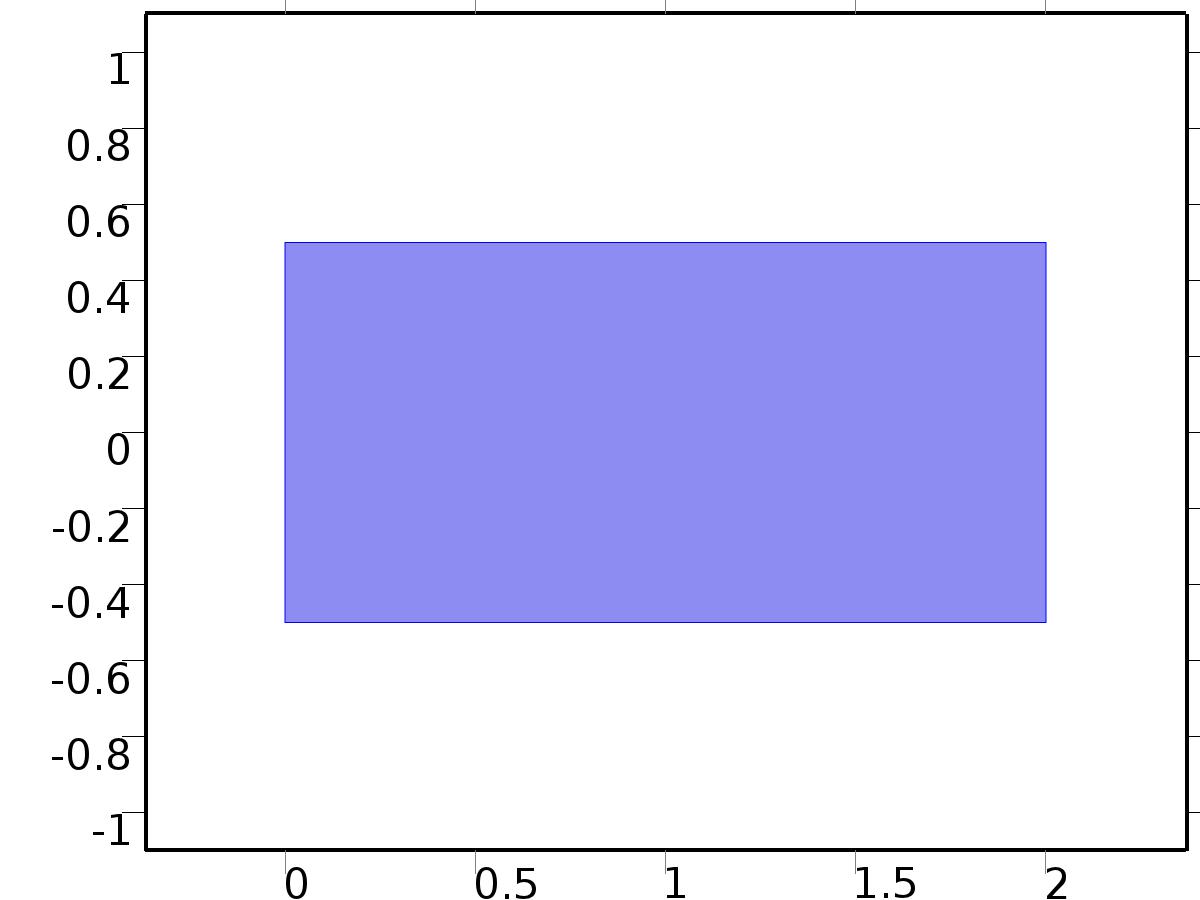
Settings

| **Description** | **Value** |
| --- | --- |
| Boundary flux/source | d |
| Boundary absorption/impedance term | Kd |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| c.g\_X | d-Kd\*X |  | Boundary flux/source | Boundary 4 |

* 1. Coefficient Form PDE 2



Coefficient Form PDE 2

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Domain 1 |

Settings

| **Description** | **Value** |
| --- | --- |
| Shape function type | Lagrange |
| Element order | Quadratic |
| Compute boundary fluxes | On |
| Apply smoothing to boundary fluxes | On |
| Value type when using splitting of complex variables | Complex |
| Dependent variable quantity | Dimensionless (1) |
| Source term quantity | None |
| Unit | m^ - 2 |

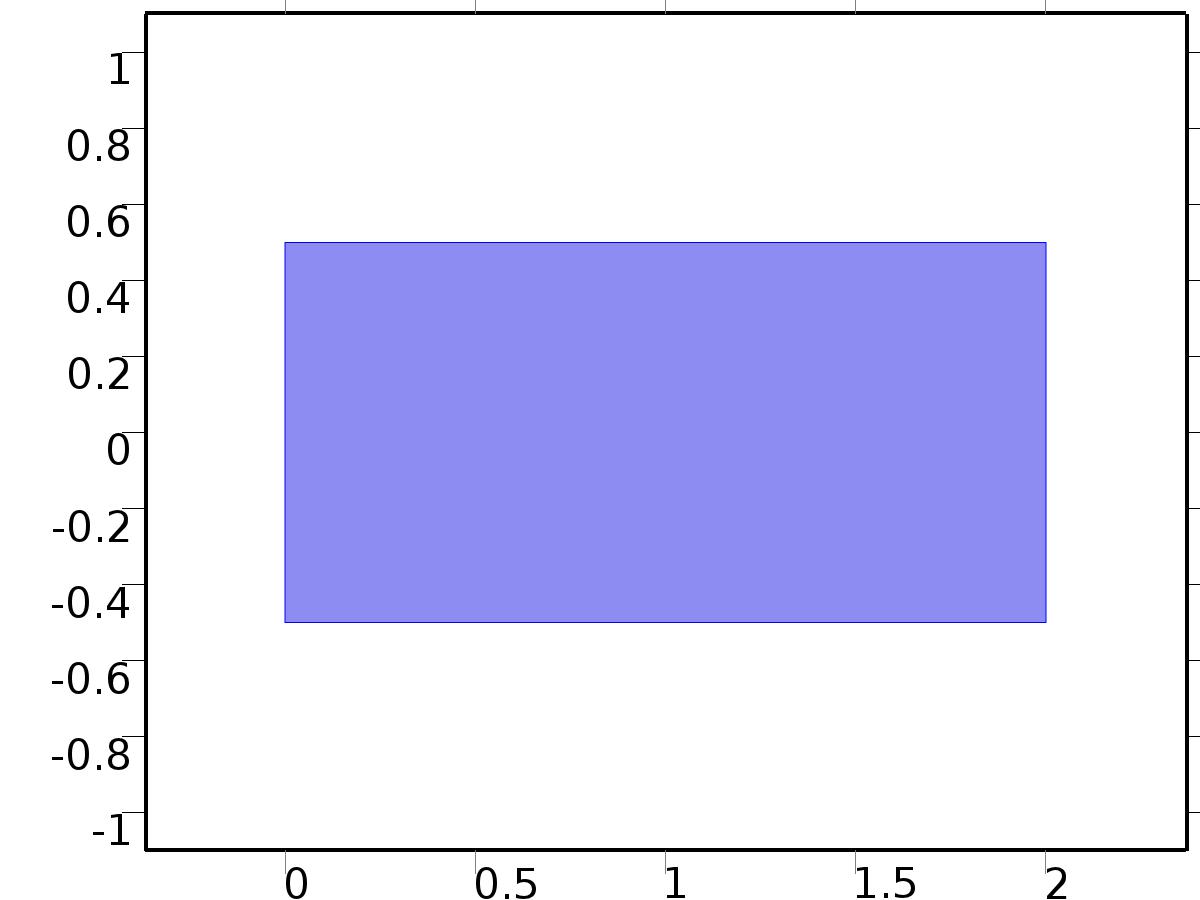
Used products

|  |
| --- |
| COMSOL Multiphysics |

Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| c2.nx | nx |  | Normal vector, x component | Boundaries 1–4 |
| c2.ny | ny |  | Normal vector, y component | Boundaries 1–4 |
| c2.nz | root.nz |  | Normal vector, z component | Boundaries 1–4 |
| c2.nxmesh | root.nxmesh |  | Normal vector (mesh), x component | Boundaries 1–4 |
| c2.nymesh | root.nymesh |  | Normal vector (mesh), y component | Boundaries 1–4 |
| c2.nzmesh | root.nzmesh |  | Normal vector (mesh), z component | Boundaries 1–4 |

* + 1. Coefficient Form PDE 1



Coefficient Form PDE 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Domain 1 |

Equations

Settings

| **Description** | **Value** |
| --- | --- |
| Diffusion coefficient | {{c, 0}, {0, c}} |
| Absorption coefficient | 0 |
| Source term | 0 |
| Mass coefficient | 0 |
| Damping or mass coefficient | 1 |
| Conservative flux convection coefficient | {0, 0} |
| Convection coefficient | {0, 0} |
| Conservative flux source | {0, 0} |

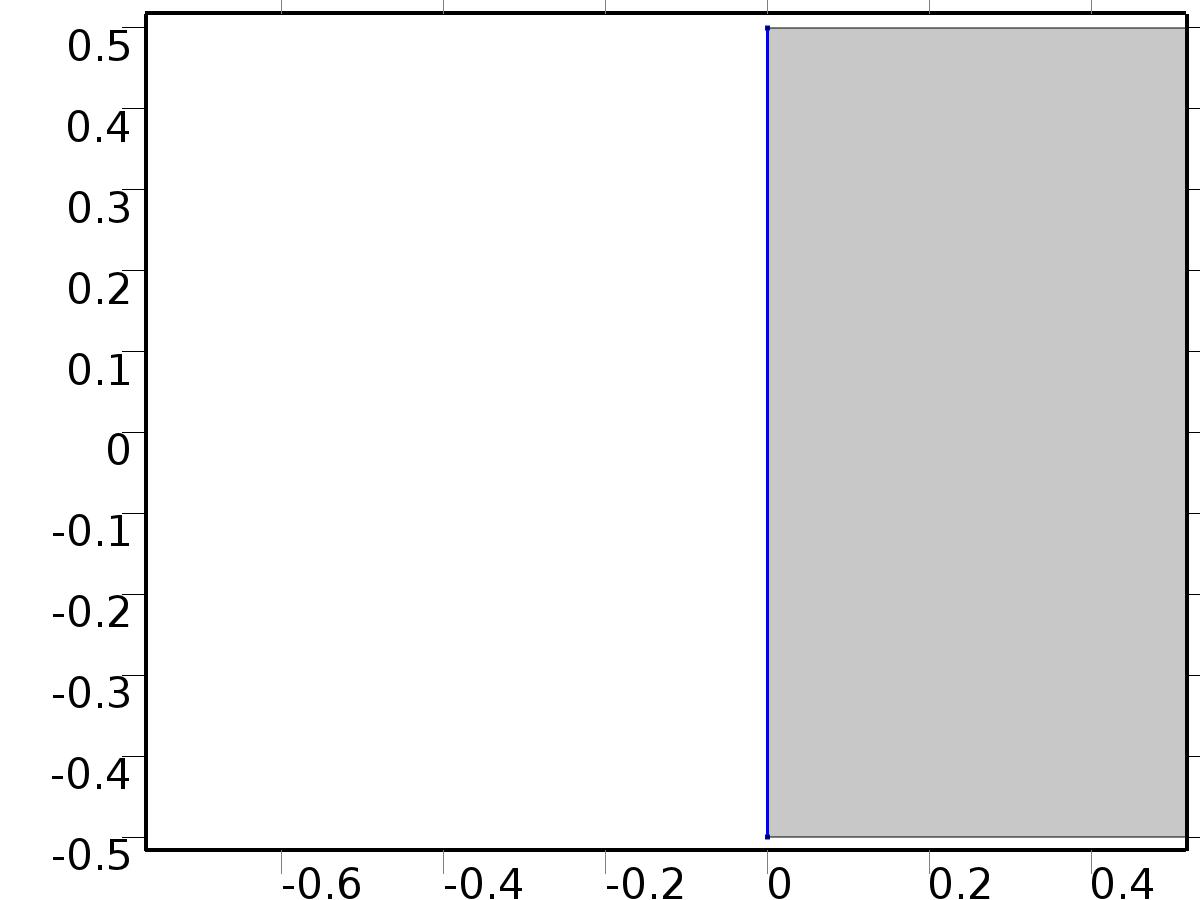
#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| domflux.zx | -c\*d(z,x) |  | Domain flux, x component | Domain 1 |
| domflux.zy | -c\*d(z,y) |  | Domain flux, y component | Domain 1 |

#### Shape functions

| **Name** | **Shape function** | **Unit** | **Description** | **Shape frame** | **Selection** |
| --- | --- | --- | --- | --- | --- |
| z | Lagrange (Quadratic) |  | Dependent variable z | Material | Domain 1 |

* + 1. Zero Flux 1



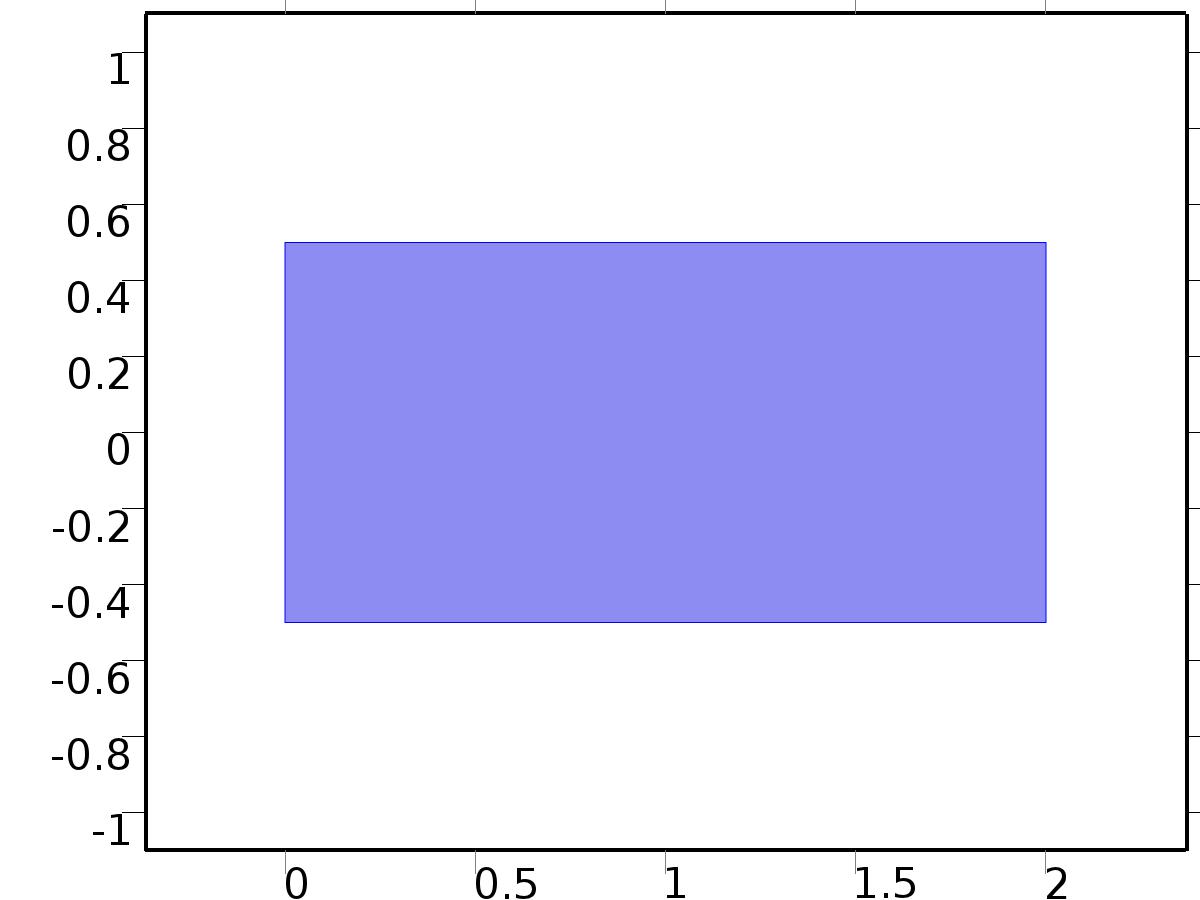
Zero Flux 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Boundary 1 |

Equations

* + 1. Initial Values 1



Initial Values 1

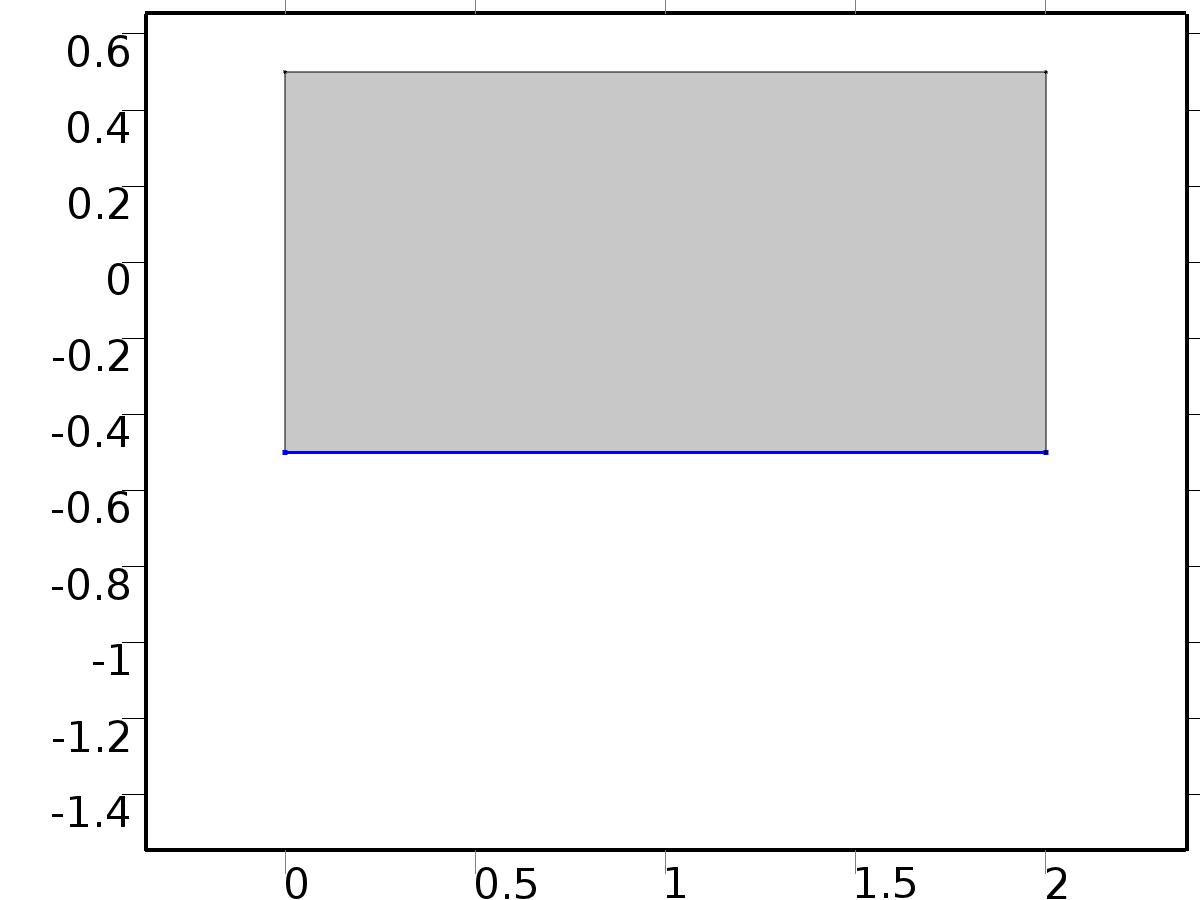
Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Domain 1 |

Settings

| **Description** | **Value** |
| --- | --- |
| Initial value for z | x\*y |
| Initial time derivative of z | 0 |

* + 1. Flux/Source 1



Flux/Source 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Boundary 2 |

Equations

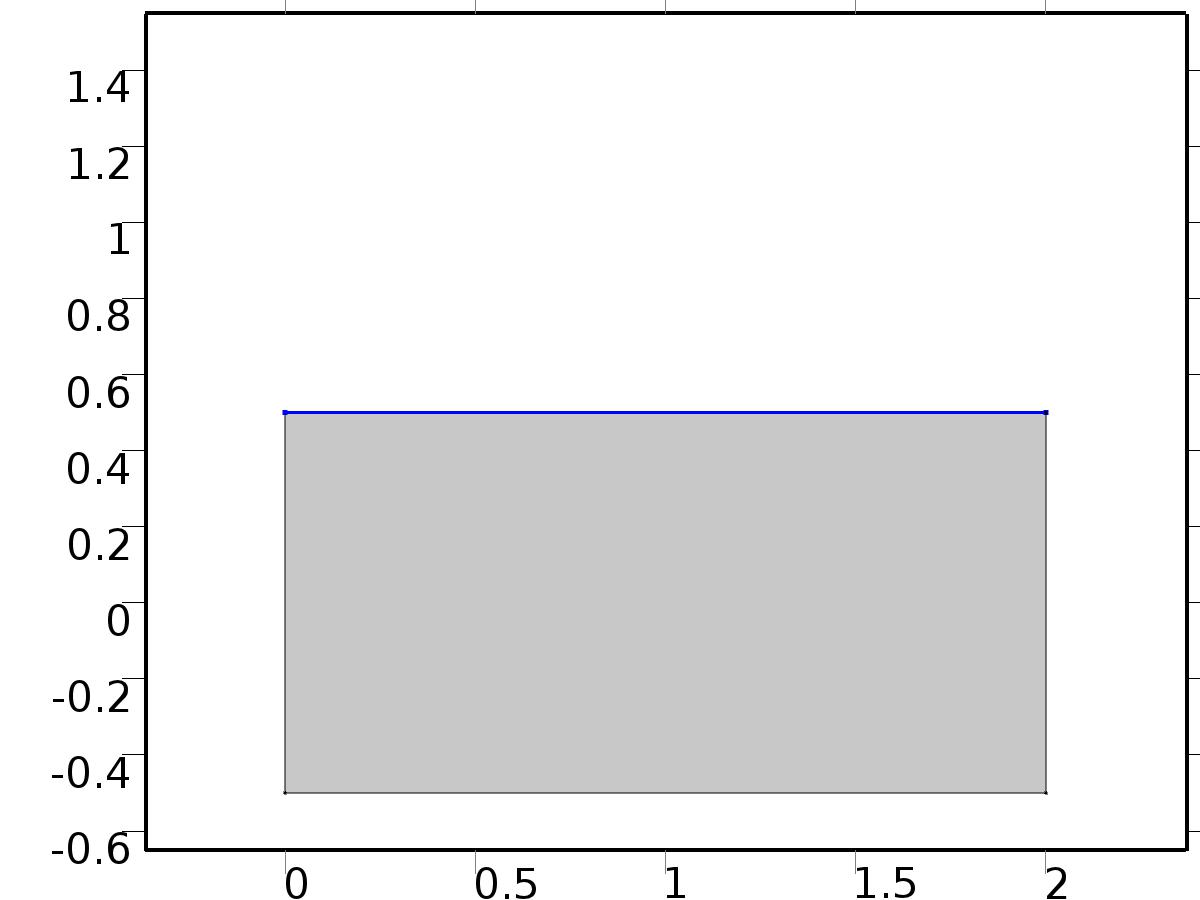
Settings

| **Description** | **Value** |
| --- | --- |
| Boundary flux/source | X\_lm\*flc2hs(t - 0.1, 0.1) |
| Boundary absorption/impedance term | 0 |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| c2.g\_z | X\_lm\*flc2hs(-0.1+t,0.1) |  | Boundary flux/source | Boundary 2 |

* + 1. Flux/Source 2



Flux/Source 2

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Boundary 3 |

Equations

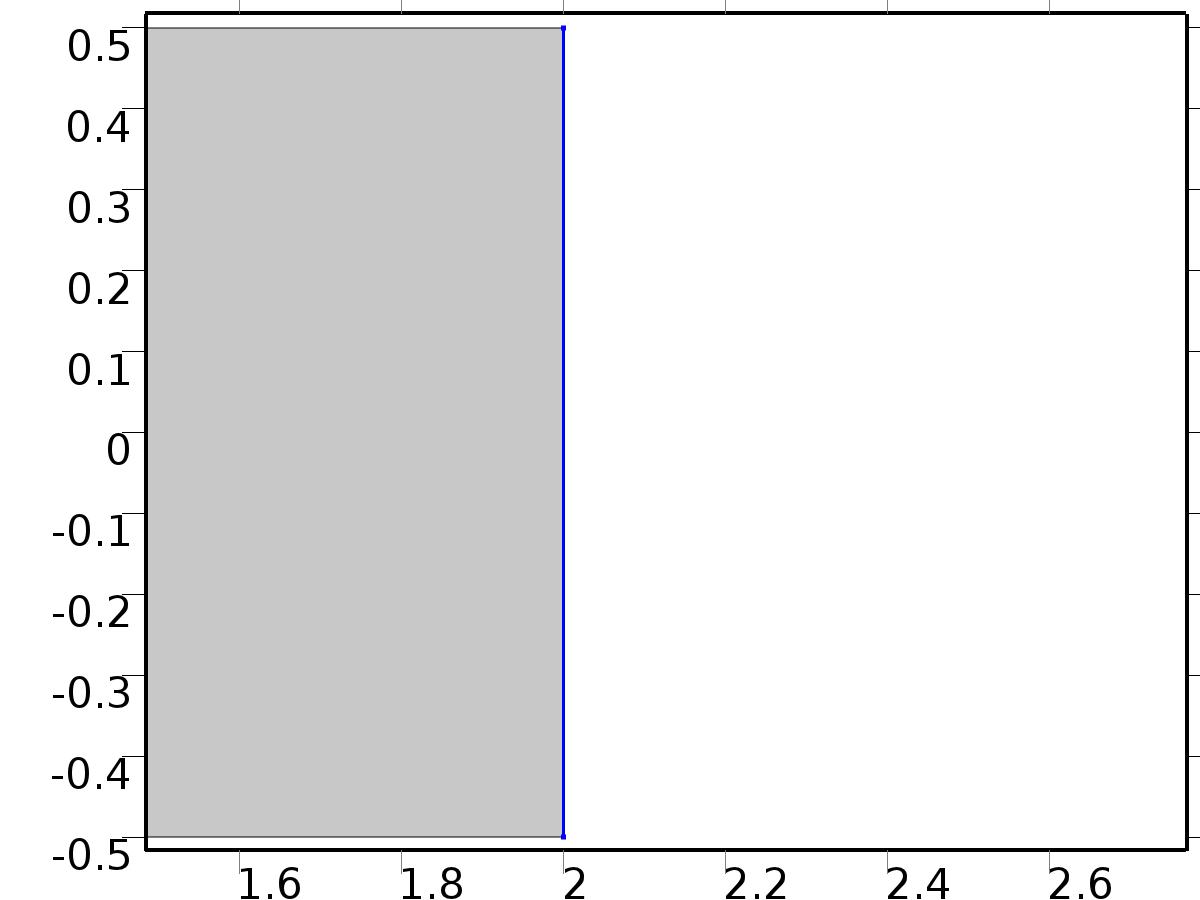
Settings

| **Description** | **Value** |
| --- | --- |
| Boundary flux/source | X\_lm\*flc2hs(t - 0.1, 0.1) |
| Boundary absorption/impedance term | 0 |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| c2.g\_z | X\_lm\*flc2hs(-0.1+t,0.1) |  | Boundary flux/source | Boundary 3 |

* + 1. Flux/Source 3



Flux/Source 3

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Boundary 4 |

Equations

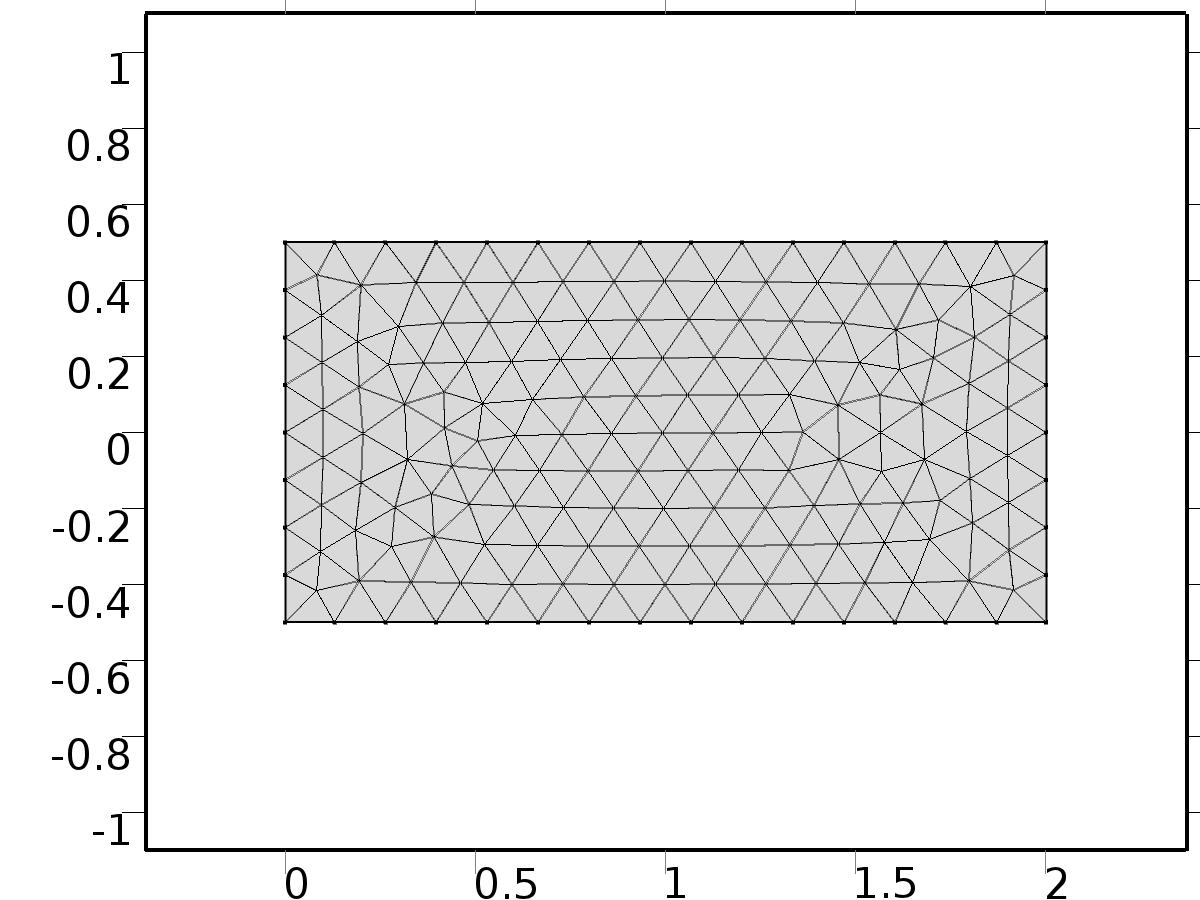
Settings

| **Description** | **Value** |
| --- | --- |
| Boundary flux/source | d\*flc2hs(t - 0.1, 0.1) |
| Boundary absorption/impedance term | Kd |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| c2.g\_z | d\*flc2hs(-0.1+t,0.1)-Kd\*z |  | Boundary flux/source | Boundary 4 |

* 1. Mesh 1



Mesh 1

* + 1. Size (size)

Settings

| **Description** | **Value** |
| --- | --- |
| Maximum element size | 0.134 |
| Minimum element size | 6.0E-4 |
| Curvature factor | 0.3 |
| Maximum element growth rate | 1.3 |

* + 1. Free Triangular 1 (ftri1)

Selection

|  |  |
| --- | --- |
| Geometric entity level | Remaining |

1. Study 1
   1. Time Dependent

Study settings

| **Description** | **Value** |
| --- | --- |
| Include geometric nonlinearity | Off |

| **Times** | **Unit** |
| --- | --- |
| range(-20,0.1,100) | s |

Physics and variables selection

| **Physics interface** | **Discretization** |
| --- | --- |
| Coefficient Form PDE (c) | physics |
| Coefficient Form PDE 2 (c2) | physics |

Mesh selection

| **Geometry** | **Mesh** |
| --- | --- |
| Geometry 1 (geom1) | mesh1 |

* 1. Solver Configurations
     1. Solver 1

#### Compile Equations: Time Dependent (st1)

Study and step

| **Description** | **Value** |
| --- | --- |
| Use study | Study 1 |
| Use study step | Time Dependent |

#### Dependent Variables 1 (v1)

General

| **Description** | **Value** |
| --- | --- |
| Defined by study step | Time Dependent |
| Constant |  |

Initial values of variables solved for

| **Description** | **Value** |
| --- | --- |
| Solution | Zero |

Values of variables not solved for

| **Description** | **Value** |
| --- | --- |
| Solution | Zero |

##### Lagrange multiplier for dependent variable x (comp1.X\_lm) (comp1\_X\_lm)

General

| **Description** | **Value** |
| --- | --- |
| Field components | comp1.X\_lm |

##### Dependent variable z (comp1.z) (comp1\_z)

General

| **Description** | **Value** |
| --- | --- |
| Field components | comp1.z |

##### Dependent variable X (comp1.X) (comp1\_X)

General

| **Description** | **Value** |
| --- | --- |
| Field components | comp1.X |

#### Time-Dependent Solver 1 (t1)

General

| **Description** | **Value** |
| --- | --- |
| Defined by study step | Time Dependent |
| Time | {-20, -19.9, -19.8, -19.7, -19.6, -19.5, -19.4, -19.3, -19.2, -19.1, -19, -18.9, -18.8, -18.7, -18.6, -18.5, -18.4, -18.3, -18.2, -18.1, -18, -17.9, -17.8, -17.7, -17.6, -17.5, -17.4, -17.3, -17.2, -17.1, -17, -16.9, -16.8, -16.7, -16.6, -16.5, -16.4, -16.3, -16.2, -16.1, -16, -15.899999999999999, -15.8, -15.7, -15.6, -15.5, -15.399999999999999, -15.3, -15.2, -15.1, -15, -14.899999999999999, -14.8, -14.7, -14.6, -14.5, -14.399999999999999, -14.3, -14.2, -14.1, -14, -13.899999999999999, -13.8, -13.7, -13.6, -13.5, -13.399999999999999, -13.3, -13.2, -13.1, -13, -12.899999999999999, -12.8, -12.7, -12.6, -12.5, -12.399999999999999, -12.3, -12.2, -12.1, -12, -11.9, -11.799999999999999, -11.7, -11.6, -11.5, -11.4, -11.299999999999999, -11.2, -11.1, -11, -10.9, -10.799999999999999, -10.7, -10.6, -10.5, -10.399999999999999, -10.299999999999999, -10.2, -10.1, -10, -9.899999999999999, -9.799999999999999, -9.7, -9.6, -9.5, -9.399999999999999, -9.299999999999999, -9.2, -9.1, -9, -8.899999999999999, -8.799999999999999, -8.7, -8.6, -8.5, -8.399999999999999, -8.299999999999999, -8.2, -8.1, -8, -7.899999999999999, -7.799999999999999, -7.699999999999999, -7.6, -7.5, -7.399999999999999, -7.299999999999999, -7.199999999999999, -7.1, -7, -6.899999999999999, -6.799999999999999, -6.699999999999999, -6.6, -6.5, -6.399999999999999, -6.299999999999999, -6.199999999999999, -6.1, -6, -5.899999999999999, -5.799999999999999, -5.699999999999999, -5.6, -5.5, -5.399999999999999, -5.299999999999999, -5.199999999999999, -5.1, -5, -4.899999999999999, -4.799999999999999, -4.699999999999999, -4.6, -4.5, -4.399999999999999, -4.299999999999999, -4.199999999999999, -4.1, -4, -3.8999999999999986, -3.8000000000000007, -3.6999999999999993, -3.599999999999998, -3.5, -3.3999999999999986, -3.3000000000000007, -3.1999999999999993, -3.099999999999998, -3, -2.8999999999999986, -2.8000000000000007, -2.6999999999999993, -2.599999999999998, -2.5, -2.3999999999999986, -2.3000000000000007, 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99.80000000000001, 99.9, 100} |
| Relative tolerance | 0.00001 |

Log

| **Description** | **Value** |
| --- | --- |
| Constant |  |

##### Fully Coupled 1 (fc1)

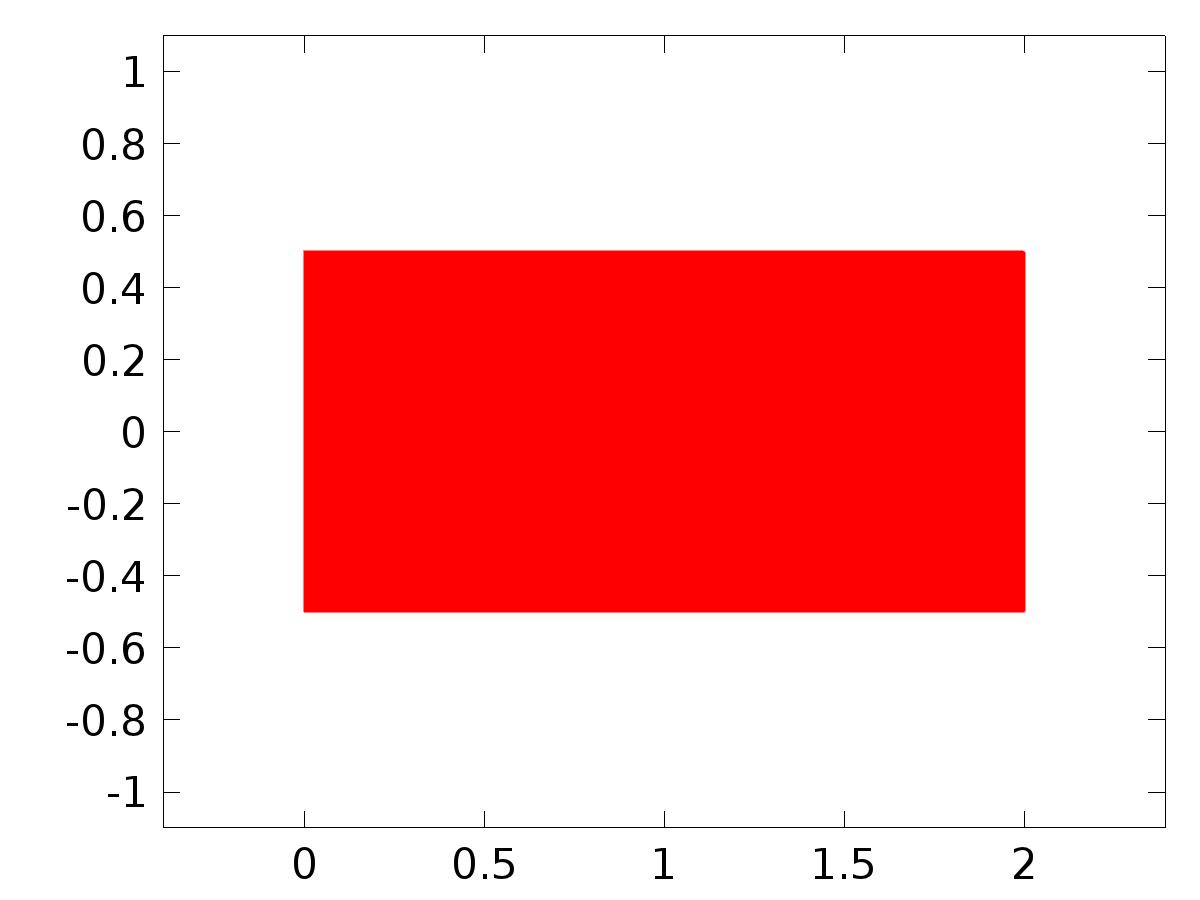
General

| **Description** | **Value** |
| --- | --- |
| Linear solver | Direct |

1. Results
   1. Data Sets
      1. Solution 1

Solution

| **Description** | **Value** |
| --- | --- |
| Solution | Solver 1 |
| Component | Save Point Geometry 1 |

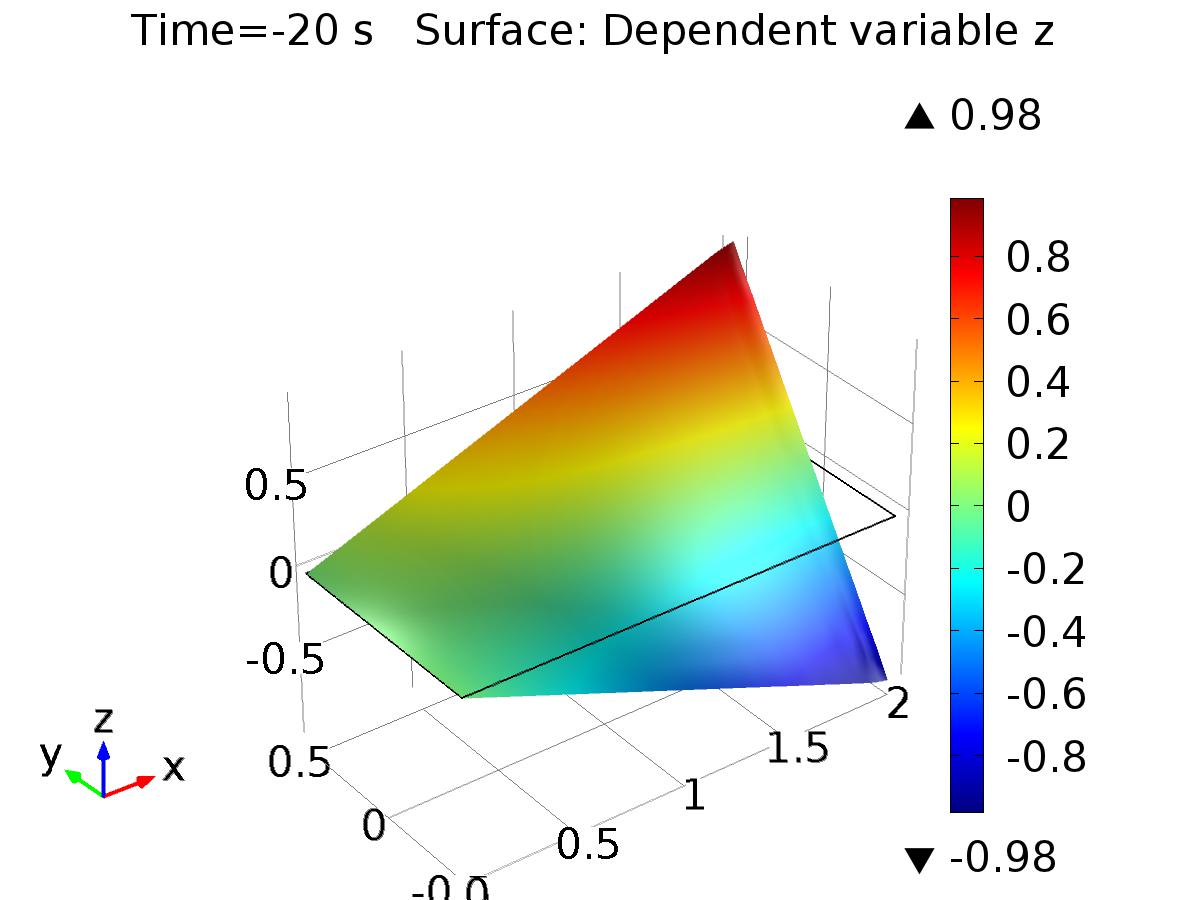


Data set: Solution 1

* 1. Tables
     1. Table 1

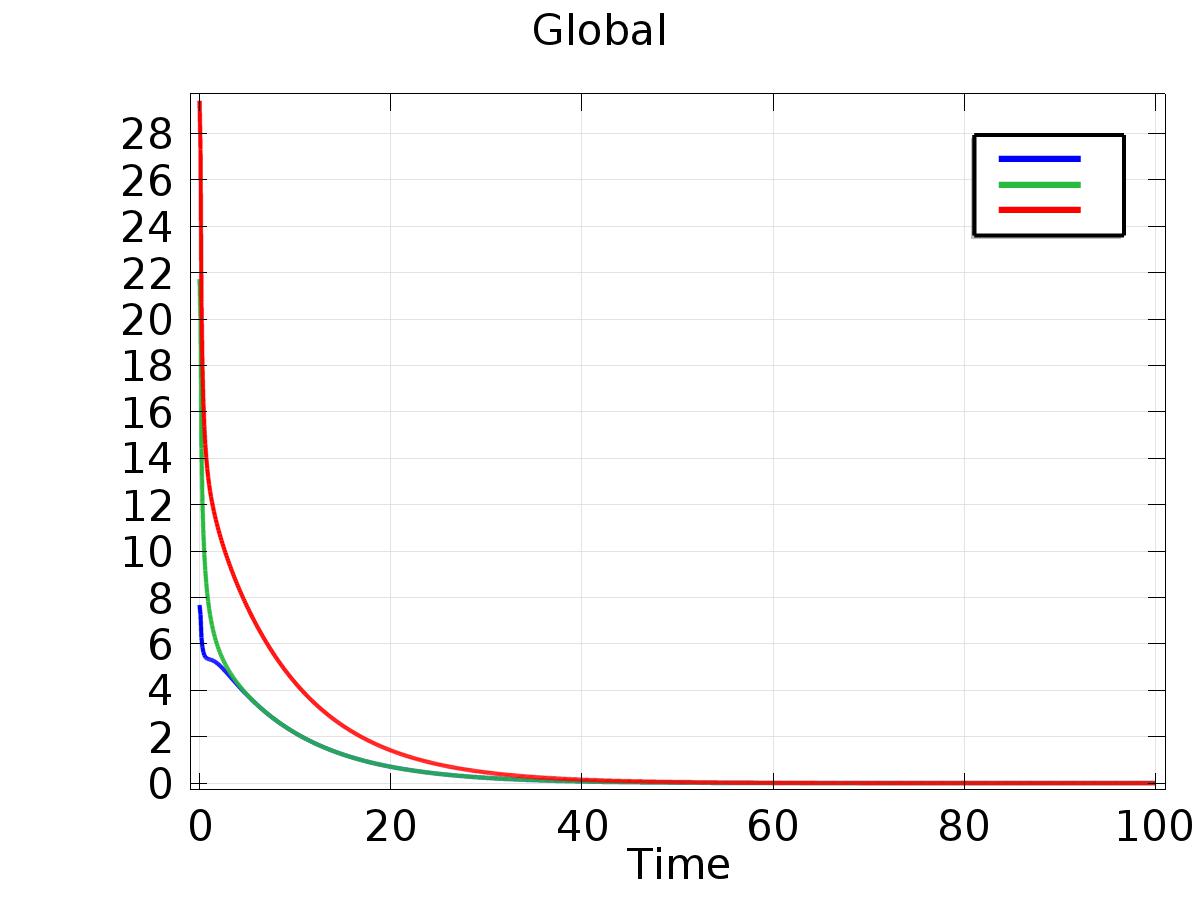
Global Evaluation 1 (z)

* 1. Plot Groups
     1. 2D Plot Group 1



Time=-20 s Surface: Dependent variable z

* + 1. 1D Plot Group 2



Global