Lab 21 03(1D FEM f=1)

Report date	Mar 22, 2024, 9:13:38 AM

Contents

1 Global Definitions

Date	Mar 21, 2024, 4:23:56 PM

GLOBAL SETTINGS

Name	Lab 21 03(1D FEM f=1).mph
Path	C:\Users\stell\Desktop\TU Delft\lab_21\lab_21_03(1D_FEM_f=1).mph
Version	COMSOL Multiphysics 6.2 (Build: 339)
Unit system	SI

USED PRODUCTS

COMSOL Multiphysics

COMPUTER INFORMATION

CPU	Intel64 Family 6 Model 158 Stepping 10, 6 cores, 15.85 GB RAM
Operating system	Windows 11

1.1 PARAMETERS

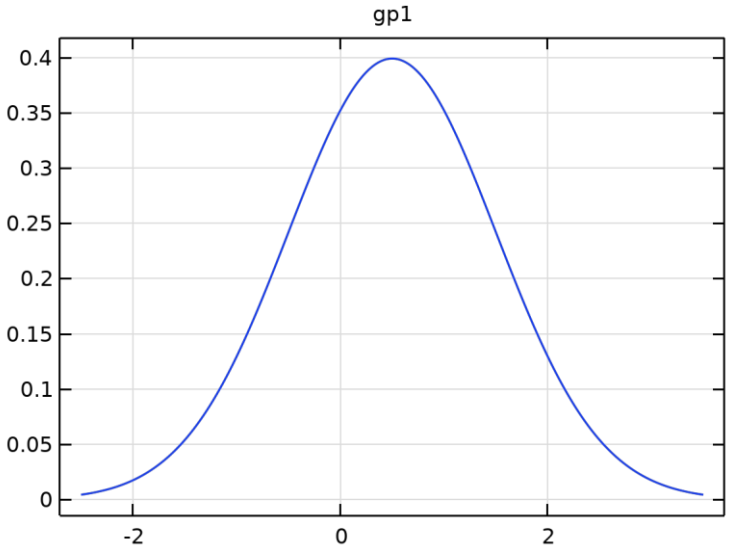
PARAMETERS 1

Name	Expression	Value	Description
width	0.05	0.05	
heigth	0.05	0.05	
A	width*heigth	0.0025	

1.2 FUNCTIONS

1.2.1 Gaussian Pulse 1

Function name	gp1
Function type	Gaussian pulse



Gaussian Pulse 1

PARAMETERS

Description	Value
Location	0.5
Standard deviation	1

2 Component 1

Date	Mar 20, 2024, 9:21:42 AM

SETTINGS

Description	Value
Unit system	Same as global system (SI)
Geometry shape function	Automatic

SPATIAL FRAME COORDINATES

First	Second	Third
x	y	z

MATERIAL FRAME COORDINATES

First	Second	Third
X	Y	Z

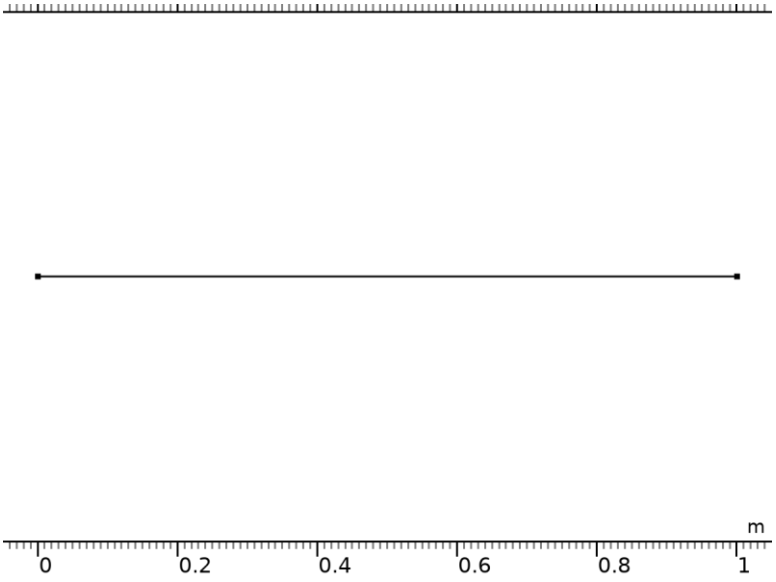
GEOMETRY FRAME COORDINATES

First	Second	Third
Xg	Yg	Zg

MESH FRAME COORDINATES

First	Second	Third
Xm	Ym	Zm

2.1 GEOMETRY 1



Geometry 1

UNITS

Length unit	m
Angular unit	deg

GEOMETRY STATISTICS

Description	Value
Space dimension	1
Number of domains	1
Number of boundaries	2

2.1.1 Interval 1 (i1)

INTERVAL

Coordinates (m)
0
1

INFORMATION

Description	Value
Last build time	< 1 second
Built with	COMSOL 6.2.0.339 (win64), Mar 20, 2024, 9:22:30 AM

2.1.2 Form Union (fin)

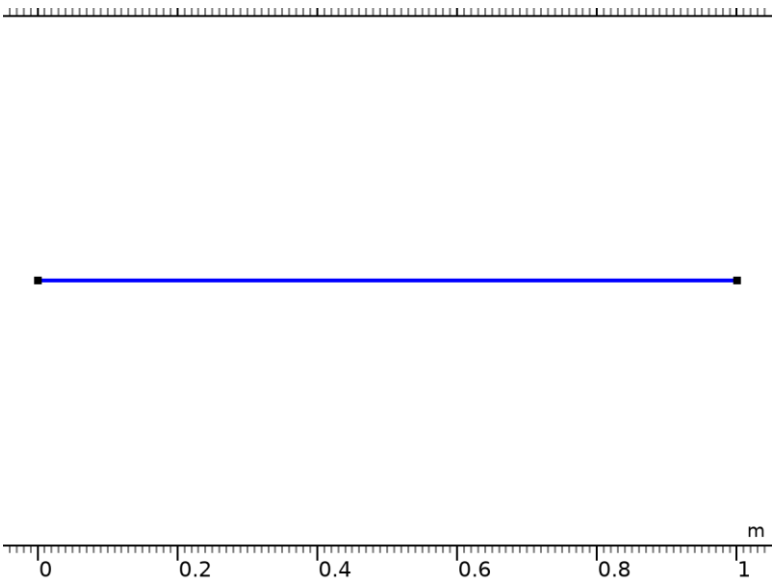
INFORMATION

Description	Value
Details	{Formed union of 1 solid object., Union has 1 domain and 2 boundaries.}
Last build time	< 1 second
Built with	COMSOL 6.2.0.339 (win64), Mar 20, 2024, 9:24:27 AM

2.2 GENERAL FORM PDE

USED PRODUCTS

COMSOL Multiphysics



General Form PDE

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 1: All domains

EQUATIONS

$$\nabla \cdot \Gamma = f$$
$$\mathbf{u} = [u1, u2]^T$$
$$\nabla = \frac{\partial}{\partial x}$$

2.2.1 Interface Settings

Discretization

SETTINGS

Description	Value
Shape function type	Lagrange
Element order	Quadratic
Frame	Spatial

SETTINGS

Description	Value
Equation form	Study controlled

Units

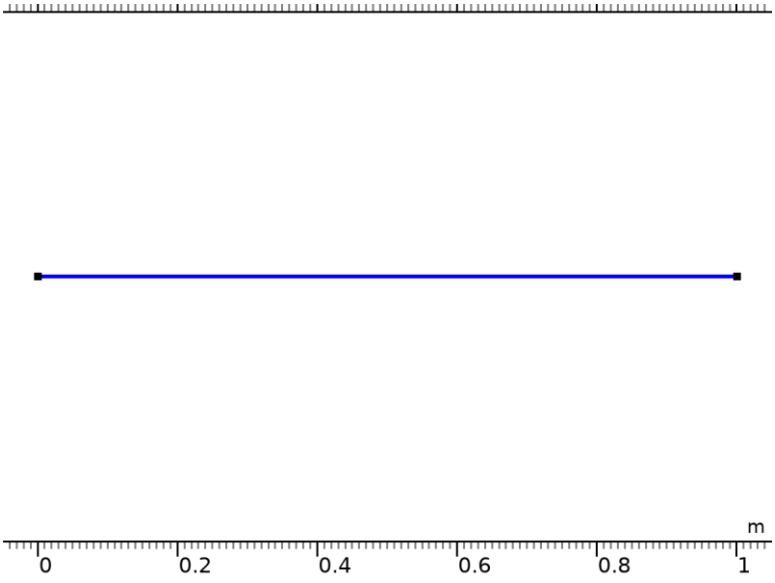
Dependent variable quantity	Unit
none	

Source term quantity	Unit
none	

2.2.2 Variables

Name	Expression	Unit	Description	Selection	Details
g.nx	nx		Normal vector, x-component	Boundaries 1–2	Meta
g.ny	root.ny		Normal vector, y-component	Boundaries 1–2	Meta
g.nz	root.nz		Normal vector, z-component	Boundaries 1–2	Meta
g.nxmesh	nxmesh		Normal vector (mesh), x-component	Boundaries 1–2	Meta
g.nymesh	root.nymesh		Normal vector (mesh), y-component	Boundaries 1–2	Meta
g.nzmesh	root.nzmesh		Normal vector (mesh), z-component	Boundaries 1–2	Meta
g.omega	2*pi*g.freq	rad/s	Angular frequency	Global	
g.freq	freq	Hz	Frequency	Global	
g.iomega	g.omega*i	rad/s	Complex angular frequency	Global	

2.2.3 General Form PDE 1



General Form PDE 1

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 1: All domains

EQUATIONS

$$e_a\frac{\partial^2\mathbf{u}}{\partial t^2}+d_a\frac{\partial\mathbf{u}}{\partial t}+\nabla\cdot\Gamma=f$$
$$\mathbf{u}=[u1,u2]^T$$
$$\nabla=\frac{\partial}{\partial x}$$

SETTINGS

Description	Value	Unit
Source term	{u2, 1}	1/m²
Conservative flux	{-u1x, -u2x}	1/m
Mass coefficient	0	s²/m²
Damping or mass coefficient	100	s/m²

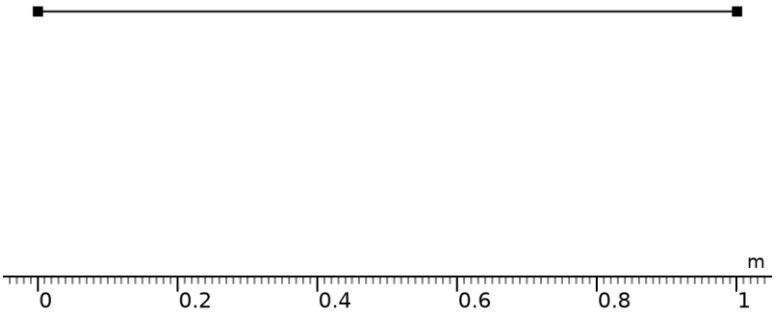
Variables

Name	Expression	Unit	Description	Selection
domflux.u1x	-u1x	1/m	Domain flux, x-component	Domain 1
domflux.u2x	-u2x	1/m	Domain flux, x-component	Domain 1

Shape functions

Name	Shape function	Unit	Description	Shape frame	Selection
u1	Lagrange (Quadratic)	1	Dependent variable u1	Spatial	Domain 1
u2	Lagrange (Quadratic)	1	Dependent variable u2	Spatial	Domain 1

2.2.4 Zero Flux 1



Zero Flux 1

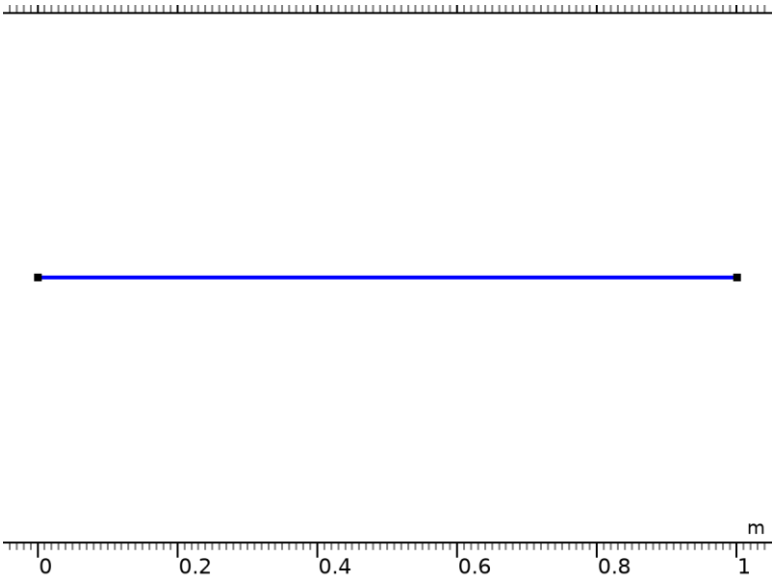
SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 0: All boundaries

EQUATIONS

$$-\mathbf{n}\cdot\Gamma = 0$$

2.2.5 Initial Values 1



Initial Values 1

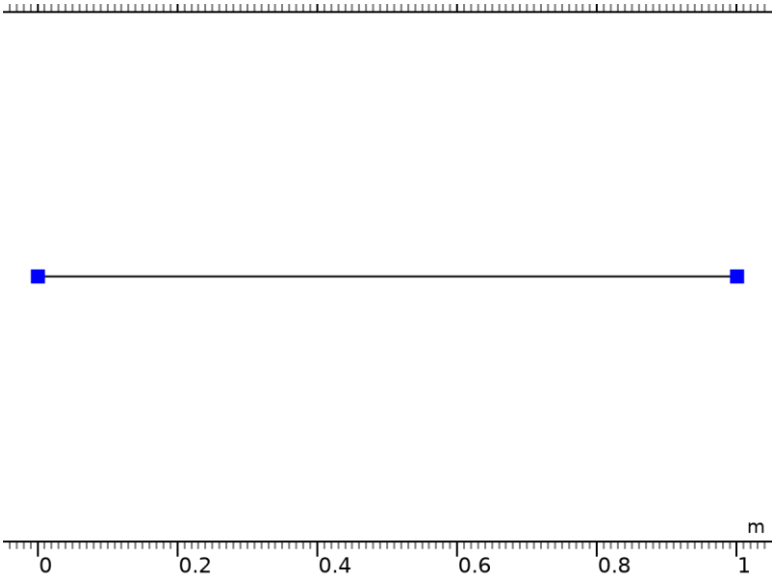
SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 1: All domains

SETTINGS

Description	Value	Unit
Initial time derivative of u2	0	1/s
Initial time derivative of u1	0	1/s
Initial value for u1	0	1
Initial value for u2	0	1

2.2.6 Dirichlet Boundary Condition 1



Dirichlet Boundary Condition 1

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 0: Boundaries 1–2

EQUATIONS

$$\mathbf{u} = r$$
$$\mathbf{u} = [u1, u2]^T$$
$$g_{\text{reaction}} = -\mu$$
$$\mu = [\mu_1, \mu_2]^T$$

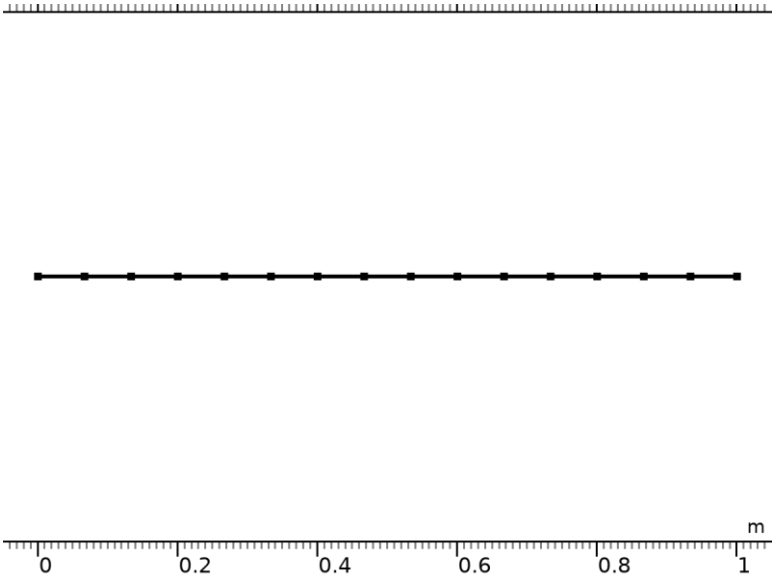
SETTINGS

Description	Value
Value on boundary	{0, 0}
Prescribed value of u1	On
Prescribed value of u2	On

Constraints

Constraint	Constraint force	Shape function	Selection	Details
-u1	-test(u1)	Lagrange (Quadratic)	Boundaries 1–2	Elemental
-u2	-test(u2)	Lagrange (Quadratic)	Boundaries 1–2	Elemental

2.3 MESH 1



Mesh 1

MESH STATISTICS

Description	Value
Status	Complete mesh
Mesh vertices	16
Edge elements	15
Vertex elements	2
Number of elements	15
Minimum element quality	1
Average element quality	1
Element length ratio	1
Mesh length	1 m

2.3.1 Size (size)

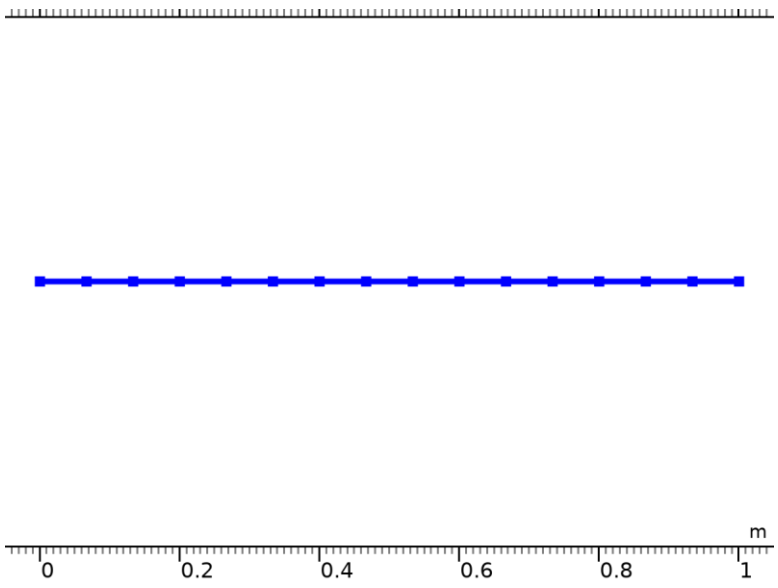
SETTINGS

Description	Value
Maximum element size	0.067
Minimum element size	3E-4
Curvature factor	0.3
Maximum element growth rate	1.3

2.3.2 Edge 1 (edg1)

SELECTION

Geometric entity level	Domain
Selection	Remaining



Edge 1

INFORMATION

Description	Value
Last build time	< 1 second
Built with	COMSOL 6.2.0.339 (win64), Mar 20, 2024, 9:25:53 AM

3 Study 1

COMPUTATION INFORMATION

Computation time	1 s

3.1 STATIONARY

STUDY SETTINGS

Description	Value
Include geometric nonlinearity	Off

PHYSICS AND VARIABLES SELECTION

Physics interface	Solve for	Equation form
General Form PDE (g)	On	Automatic (Stationary)

STORE IN OUTPUT

Interface	Output	Selection
General Form PDE (g)	Physics controlled	

MESH SELECTION

Component	Mesh
Component 1	Mesh 1

3.2 TIME DEPENDENT

Times	Unit
range(0,1,20)	s

STUDY SETTINGS

Description	Value
Include geometric nonlinearity	Off

STUDY SETTINGS

Description	Value
Output times	{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20}

PHYSICS AND VARIABLES SELECTION

Physics interface	Solve for	Equation form
General Form PDE (g)	On	Automatic (Time domain)

STORE IN OUTPUT

Interface	Output	Selection

Interface	Output	Selection
General Form PDE (g)	Physics controlled	

MESH SELECTION

Component	Mesh
Component 1	Mesh 1

3.3 SOLVER CONFIGURATIONS

3.3.1 Solution 1

Compile Equations: Time Dependent (st1)

STUDY AND STEP

Description	Value
Use study	Study 1
Use study step	Time Dependent

LOG

```
<---- Compile Equations: Time Dependent in Study 1/Solution 1 (sol1) -----------
Started at Mar 22, 2024, 9:11:20 AM.
Geometry shape function: Quadratic Lagrange
Running on Intel64 Family 6 Model 158 Stepping 10, GenuineIntel.
Using 1 socket with 6 cores in total on LAPTOP-LVOJVEBN.
Available memory: 16.24 GB.
Time: 0 s.
Physical memory: 1.1 GB
Virtual memory: 1.2 GB
Ended at Mar 22, 2024, 9:11:20 AM.
----- Compile Equations: Time Dependent in Study 1/Solution 1 (sol1) ---------->
```

Dependent Variables 1 (v1)

GENERAL

Description	Value
Defined by study step	Step 2: Time Dependent

RESIDUAL SCALING

Description	Value
Method	Manual

INITIAL VALUE CALCULATION CONSTANTS

Constant name	Initial value source
t	{range(0,1,20)}[s]
timestep	0.02[s]

LOG

```
<---- Dependent Variables 1 in Study 1/Solution 1 (sol1) ----------------------
Started at Mar 22, 2024, 9:11:20 AM.
Solution time: 0 s.
Physical memory: 1.1 GB
Virtual memory: 1.2 GB
Ended at Mar 22, 2024, 9:11:20 AM.
----- Dependent Variables 1 in Study 1/Solution 1 (sol1) ---------------------->
```

Dependent Variable U1 (comp1.u1) (comp1_u1)

GENERAL

Description	Value
Field components	comp1.u1
Internal variables	{comp1.uflux.u1, comp1.dflux.u1}

Dependent Variable U2 (comp1.u2) (comp1_u2)

GENERAL

Description	Value
Field components	comp1.u2
Internal variables	{comp1.uflux.u2, comp1.dflux.u2}

Time-Dependent Solver 1 (t1)

GENERAL

Description	Value
Defined by study step	Step 2: Time Dependent
Output times	{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20}

ABSOLUTE TOLERANCE

Field	Method	Tolerance method	Tolerance factor	Derivative tolerance method	Time derivative factor	Tolerance	Tolerance for time derivatives
Dependent Variable U1 (comp1.u1)	Use global	Factor	0.1	Automatic	1	0.001	0.001
Dependent Variable U2 (comp1.u2)	Use global	Factor	0.1	Automatic	1	0.001	0.001

LOG

```
<---- Time-Dependent Solver 1 in Study 1/Solution 1 (sol1) ----------------------
Started at Mar 22, 2024, 9:11:20 AM.
Time-dependent solver (BDF)
Number of degrees of freedom solved for: 62 (plus 4 internal DOFs).
Nonsymmetric matrix found.
Scales for dependent variables:
Dependent Variable U1 (comp1.u1): 1
Dependent Variable U2 (comp1.u2): 1
Step        Time    Stepsize      Res  Jac  Sol Order Tfail NLfail   LinErr   LinRes
   0           0           - out    2    3    2                 0  2.3e-16  2.7e-16
   1     0.02004        0.02        3    4    3     1     0      0  1.1e-16    1e-16
   4     0.16004        0.08        8    5    8     3     0      0  2.1e-16    2e-16
   6     0.64004        0.32       12    7   12     1     0      0  3.4e-16    2e-16
   9        1.92        0.64       16    7   16     2     0      0  3.2e-16    1e-15
   -           3           - out
  11        3.84        1.28       19    8   19     2     0      0  8.2e-16  6.7e-16
   -           6           - out
  13         6.4        1.28       21    8   21     2     0      0  4.3e-16  1.3e-15
   -           9           - out
   -          10           - out
  16       10.96           2       26    8   26     3     0      0    4e-16  2.3e-15
   -          15           - out
   -          16           - out
  19       16.96           2       29    8   29     3     0      0  5.6e-16  1.8e-15
   -          19           - out
   -          20           - out
  21       20.96           2       32    8   32     4     0      0    4e-16  2.3e-15
Time-stepping completed.
Solution time: 1 s.
Physical memory: 1.1 GB
Virtual memory: 1.2 GB
Ended at Mar 22, 2024, 9:11:20 AM.
----- Time-Dependent Solver 1 in Study 1/Solution 1 (sol1) ---------------------->
```

Fully Coupled 1 (fc1)

GENERAL

Description	Value
Linear solver	Direct

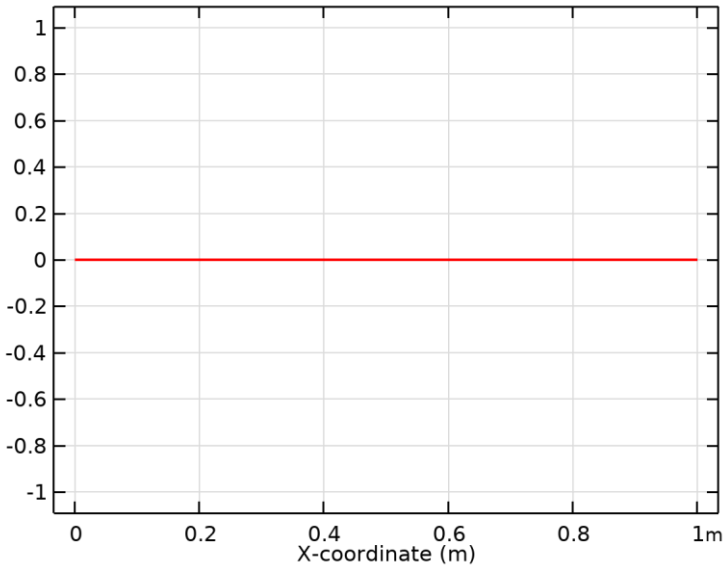
4 Results

4.1 DATASETS

4.1.1 Study 1/Solution 1

SOLUTION

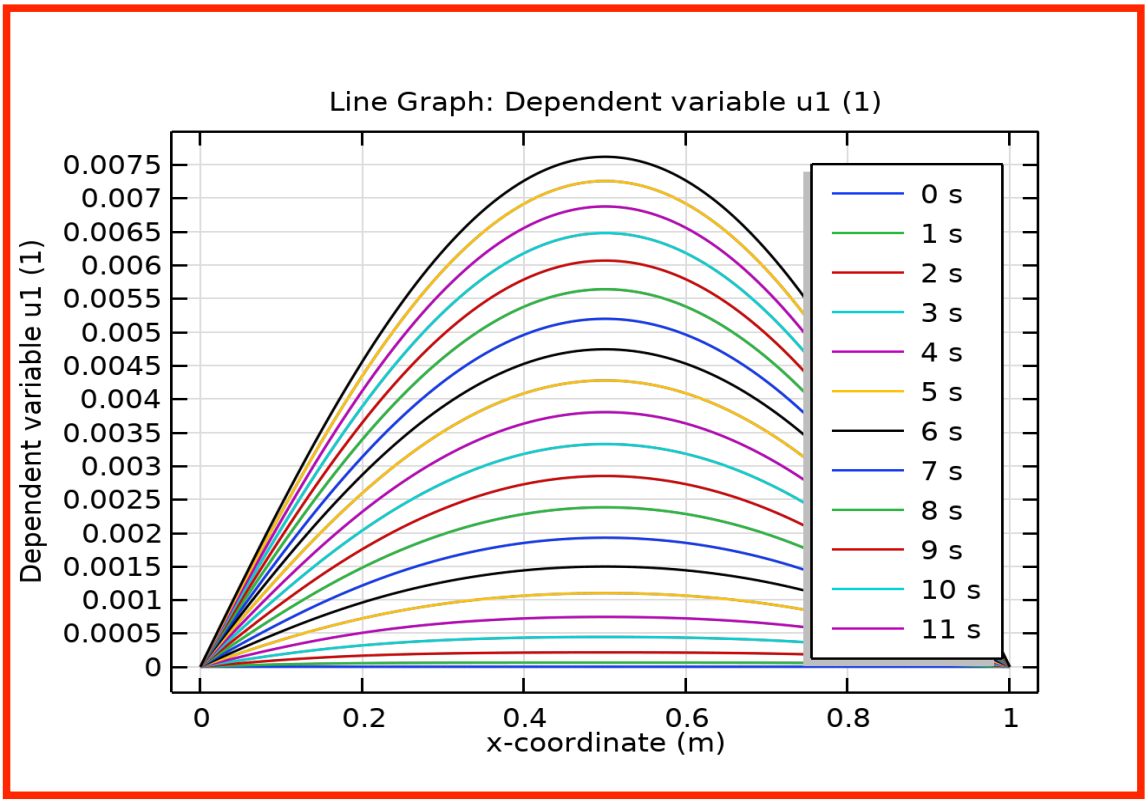
Description	Value
Solution	Solution 1 (sol1)
Component	Component 1 (comp1)

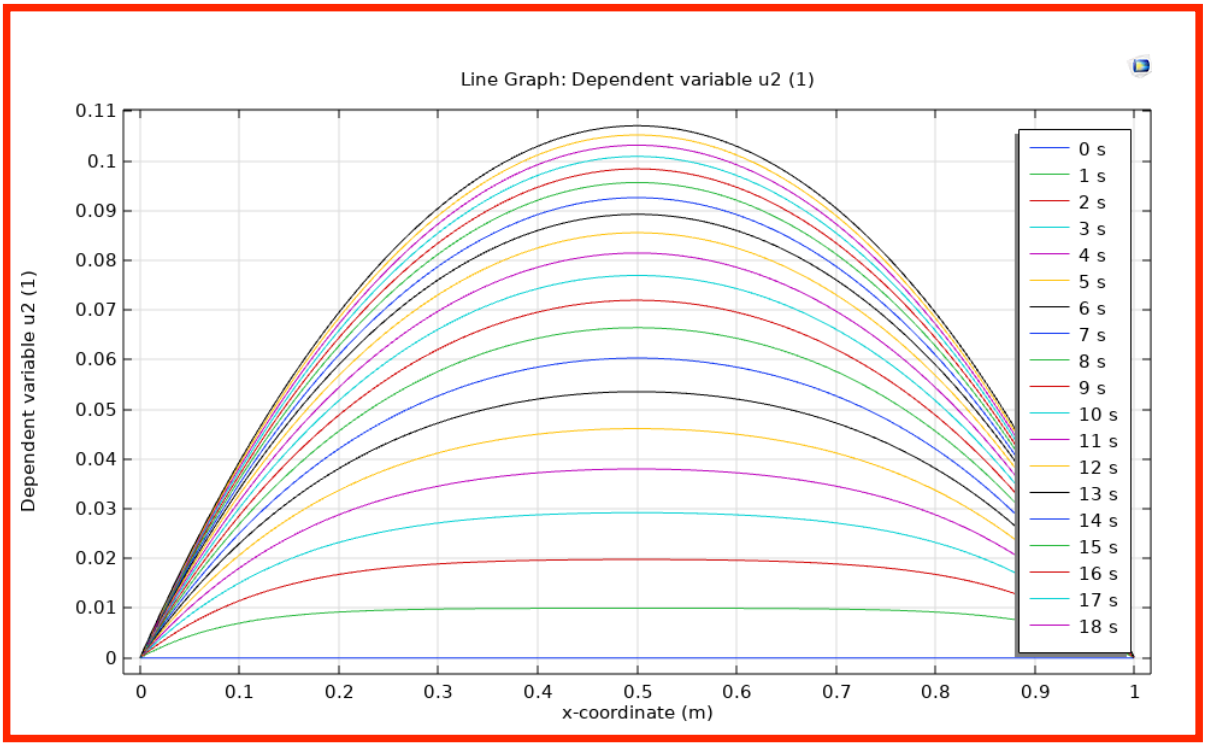


Dataset: Study 1/Solution 1

4.2 PLOT GROUPS

4.2.1 General Form PDE


Line Graph: Dependent variable u1 (1)
Dependent variable u1 (1)
0.0075
0.007
0.0065
0.006
0.0055
0.005
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
0
0.2
0.4
0.6
0.8
1
x-coordinate (m)
0 s
1 s
2 s
3 s
4 s
5 s
6 s
7 s
8 s
9 s
10 s
11 s


Line Graph: Dependent variable u2 (1)
Dependent variable u2 (1)
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
x-coordinate (m)
0 s
1 s
2 s
3 s
4 s
5 s
6 s
7 s
8 s
9 s
10 s
11 s
12 s
13 s
14 s
15 s
16 s
17 s
18 s