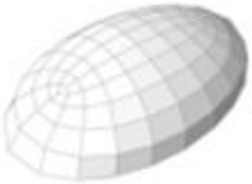






ME 760 – Microfluidics for Graduate Students

How to use
COMSOL Multiphysics 3.5

Finite Element Based software

By: Yasaman Daghighi

Department of Mechanical and Mechatronics Engineering
University of Waterloo
Winter 2012

Problem Definition

The physics of problem

- Straight Microchannel
- Two big reservoirs
- Voltage applies to the system

The physics of problem

- Straight Microchannel ➡ continues flow
- Two big reservoirs
- Voltage applies to the system

The physics of problem

- Straight Microchannel
- Two big reservoirs ⇨ Act like Well
- Voltage applies to the system

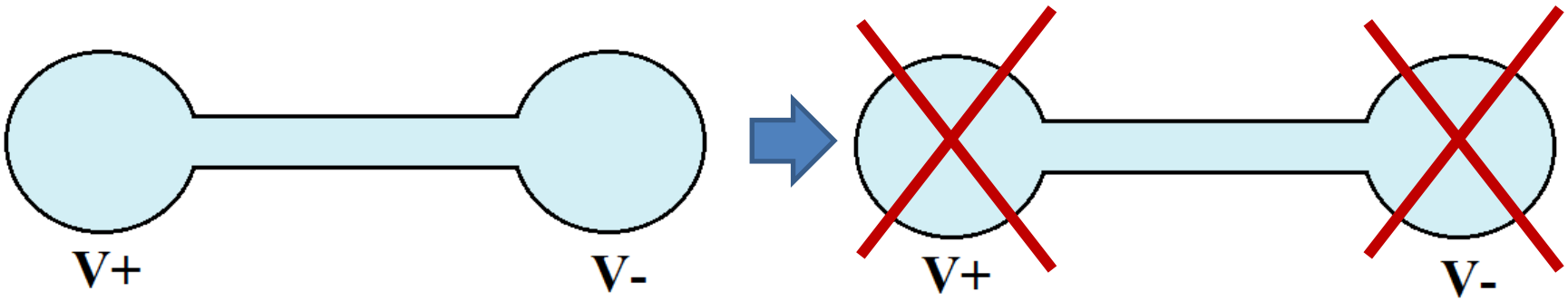
The physics of problem

- Straight Microchannel

- Two big reservoirs ⇨ Act like Well

  changes in the microchannel will not affect the liquid in the well

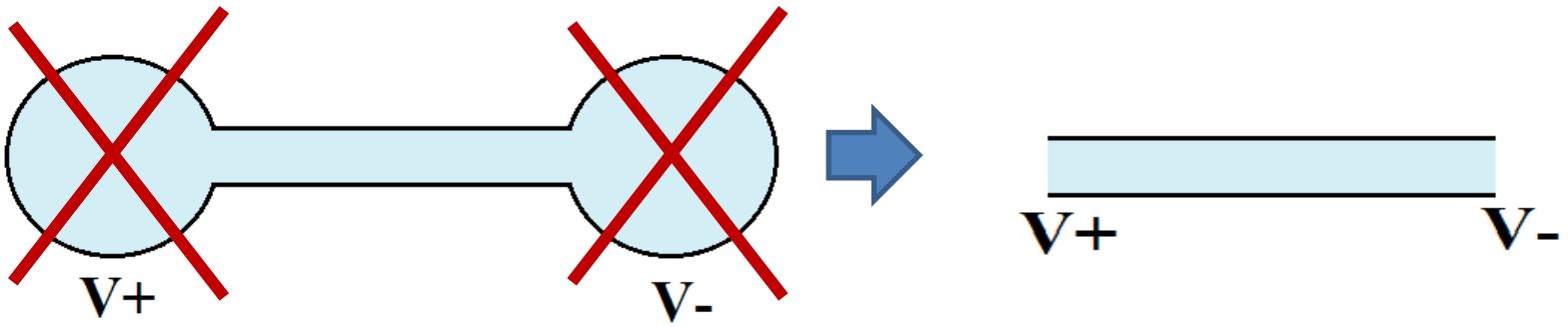
- Voltage applies to the system



The physics of problem

- Straight Microchannel

- Two big reservoirs ⇨ Act like Well
  - * **changes in the microchannel will not affect the liquid in the well**
  - * **Assuming open boundaries at two ends (instead of close system)**
- Voltage applies to the system



The physics of problem

- Straight Microchannel

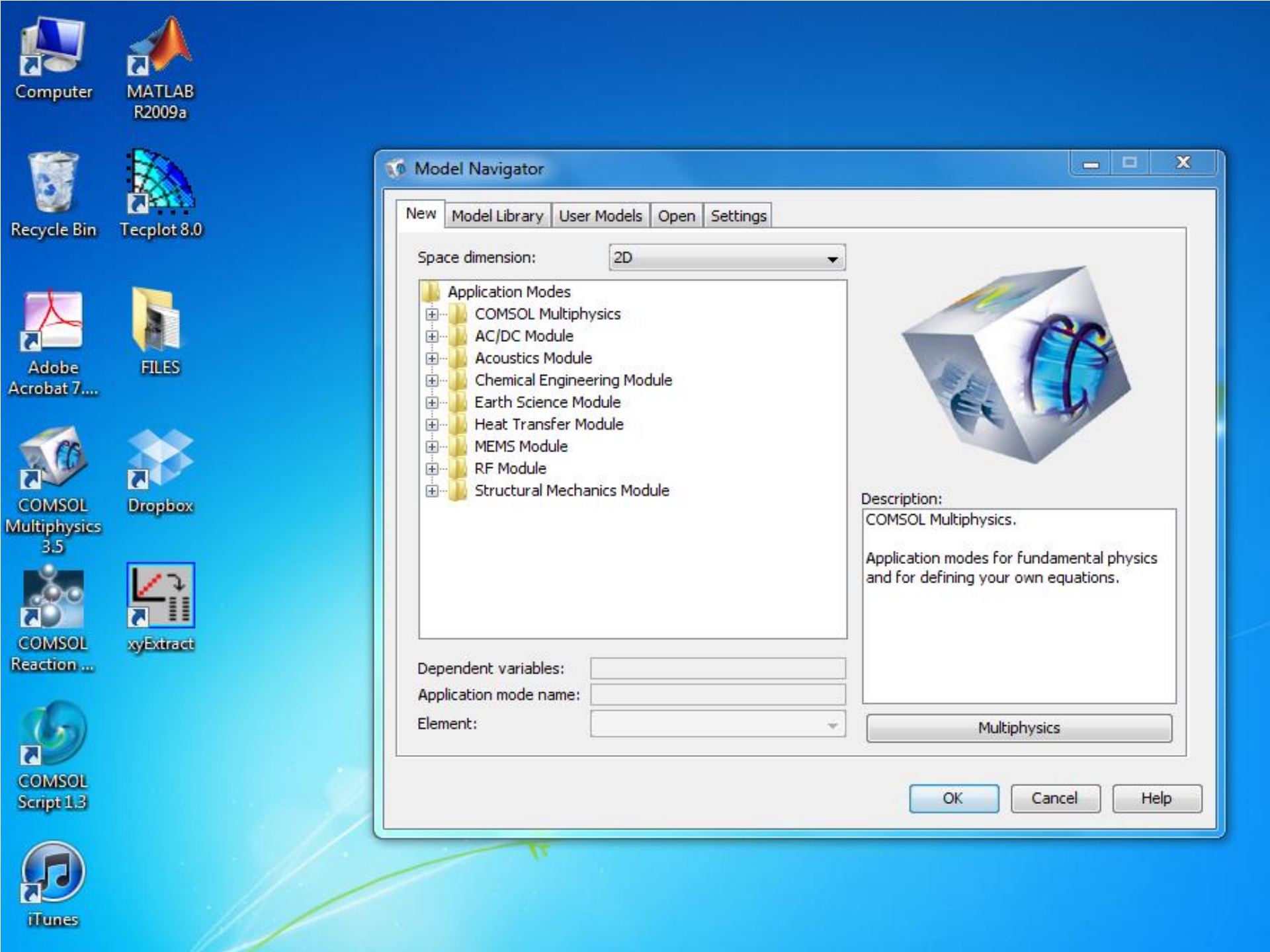
- Two big reservoirs ⇨ Act like Well
  * **changes in the microchannel will not affect the liquid in the well**
  * **Assuming open boundaries at two ends (instead of close system)**
- Voltage applies to the system
  * **the voltage gradient direction: from left to right**

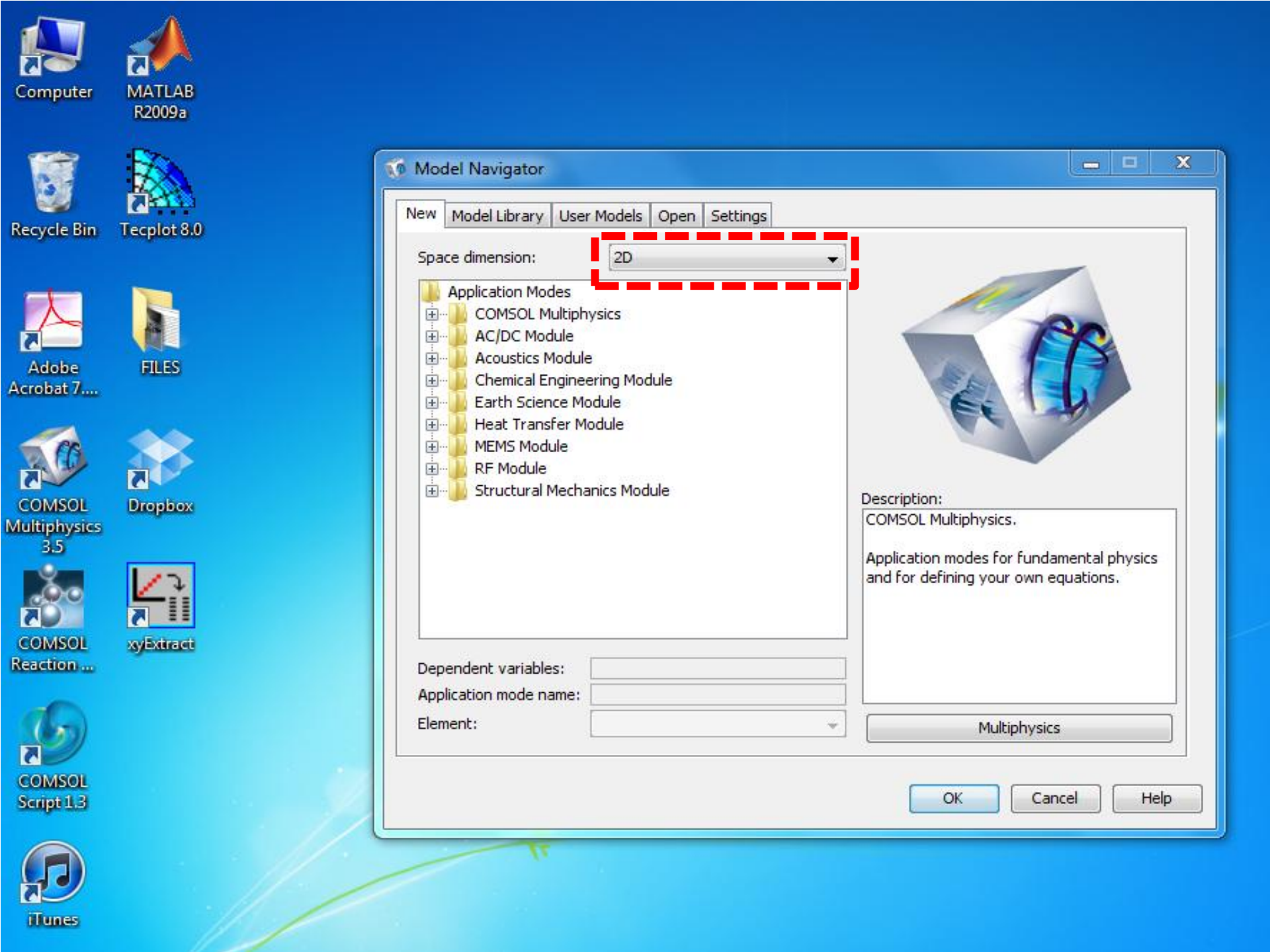
Step 1:

Open the Software


Computer
MATLAB R2009a
Recycle Bin
Tecplot 8.0
Adobe Acrobat 7....
FILES
COMSOL Multiphysics 3.5
Dropbox
COMSOL Reaction ...
xyExtract
COMSOL Script 1.3
iTunes


Computer
MATLAB R2009a
Recycle Bin
Tecplot 8.0
Adobe Acrobat 7....
FILES
COMSOL Multiphysics 3.5
Dropbox
COMSOL Reaction ...
xyExtract
COMSOL Script 1.3
iTunes
COMSOL
MULTIPHYSICS®
COMSOL
Patent pending. Copyright ©1994-2008 COMSOL AB. All rights reserved.


Computer
MATLAB R2009a
Recycle Bin
Tecplot 8.0
Adobe Acrobat 7....
FILES
COMSOL Multiphysics 3.5
Dropbox
COMSOL Reaction ...
xyExtract
COMSOL Script 1.3
iTunes
Model Navigator
New
Model Library
User Models
Open
Settings
Space dimension:
2D
Application Modes
COMSOL Multiphysics
AC/DC Module
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
RF Module
Structural Mechanics Module
Description:
COMSOL Multiphysics.
Application modes for fundamental physics and for defining your own equations.
Dependent variables:
Application mode name:
Element:
Multiphysics
OK
Cancel
Help


Computer
MATLAB R2009a
Recycle Bin
Tecplot 8.0
Adobe Acrobat 7....
FILES
COMSOL Multiphysics 3.5
Dropbox
COMSOL Reaction ...
xyExtract
COMSOL Script 1.3
iTunes
Model Navigator
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Model Library
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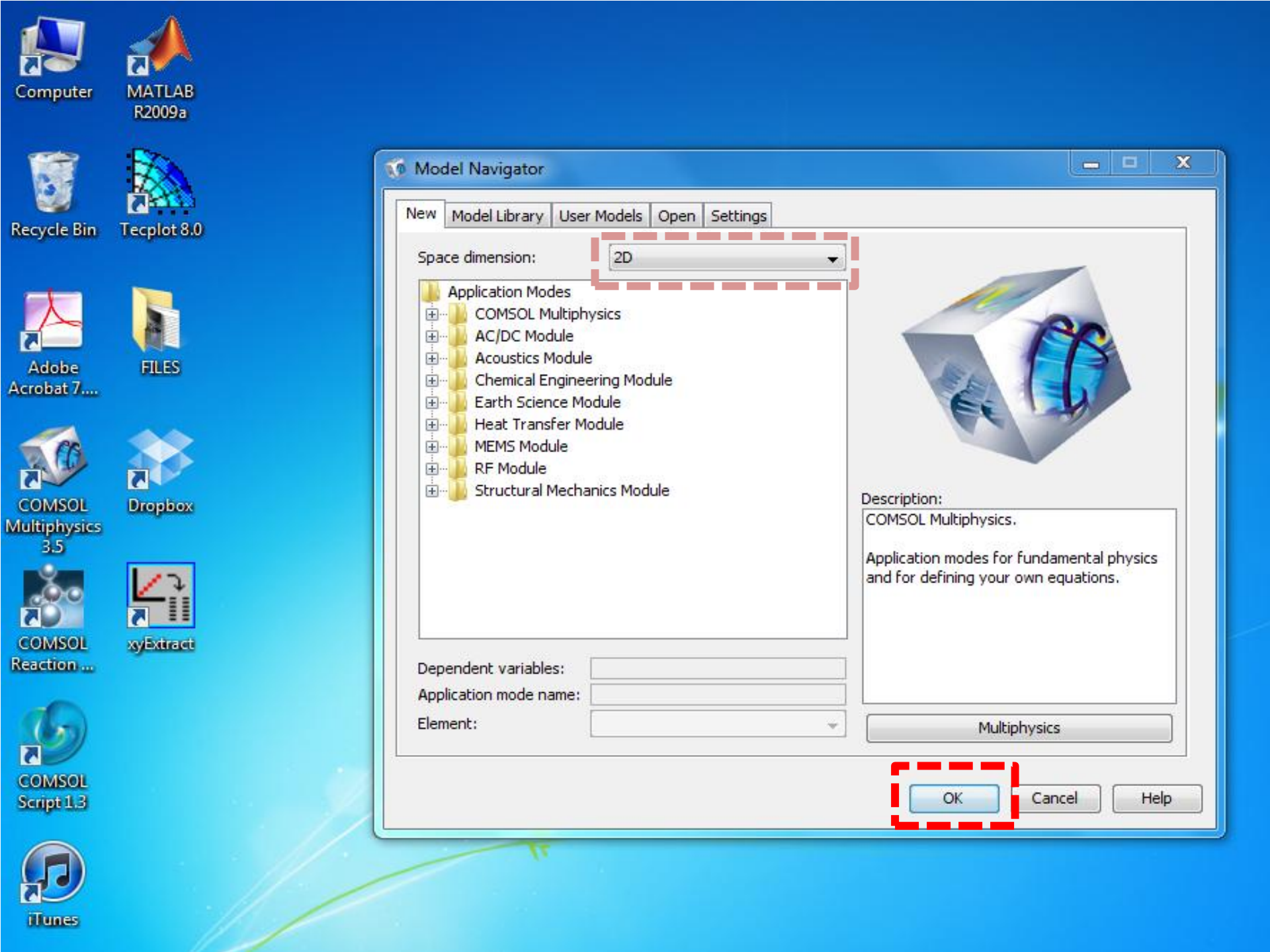
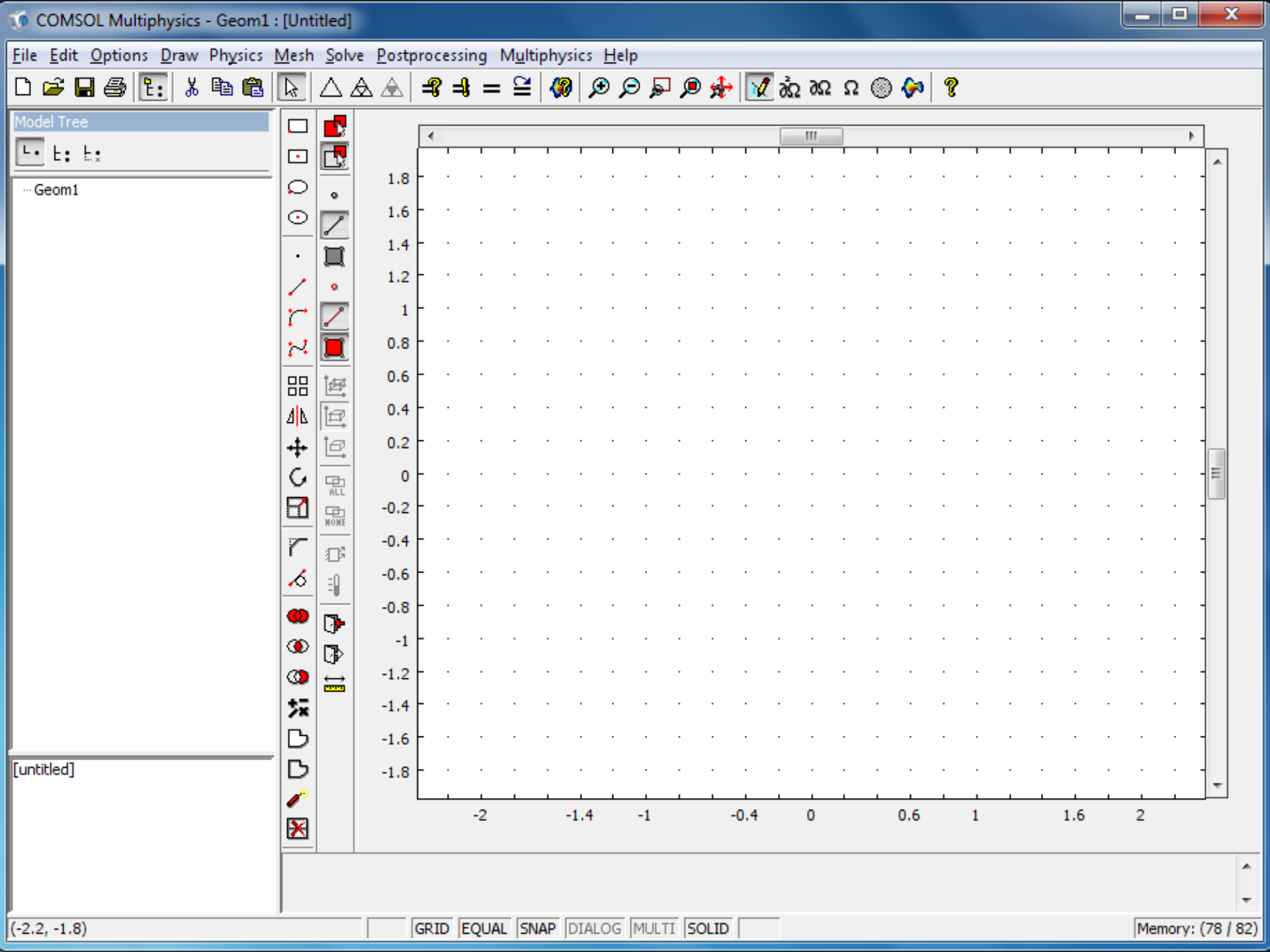
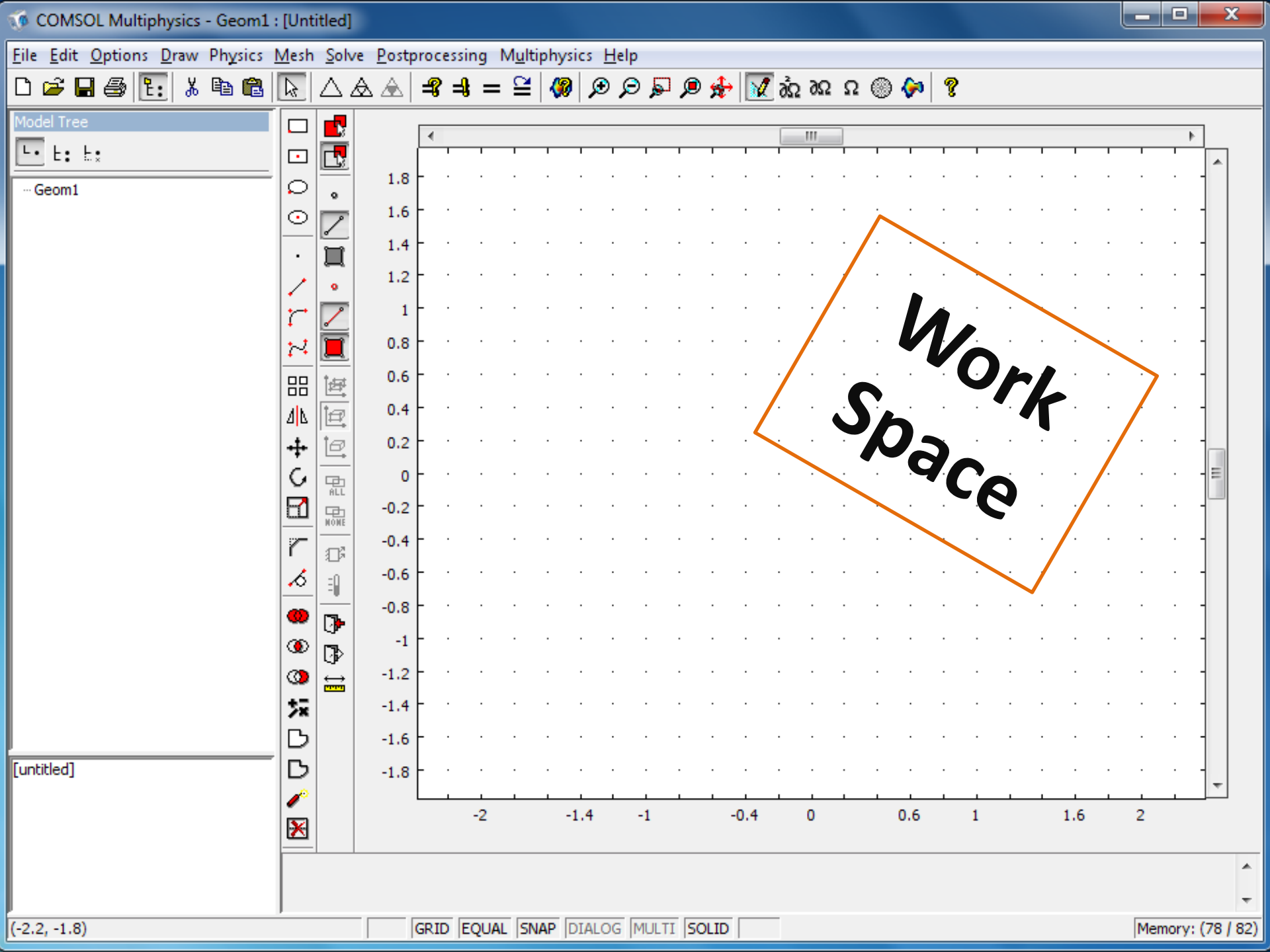
Open
Settings
Space dimension:
2D
Application Modes
COMSOL Multiphysics
AC/DC Module
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
RF Module
Structural Mechanics Module
Description:
COMSOL Multiphysics.
Application modes for fundamental physics and for defining your own equations.
Dependent variables:
Application mode name:
Element:
Multiphysics
OK
Cancel
Help

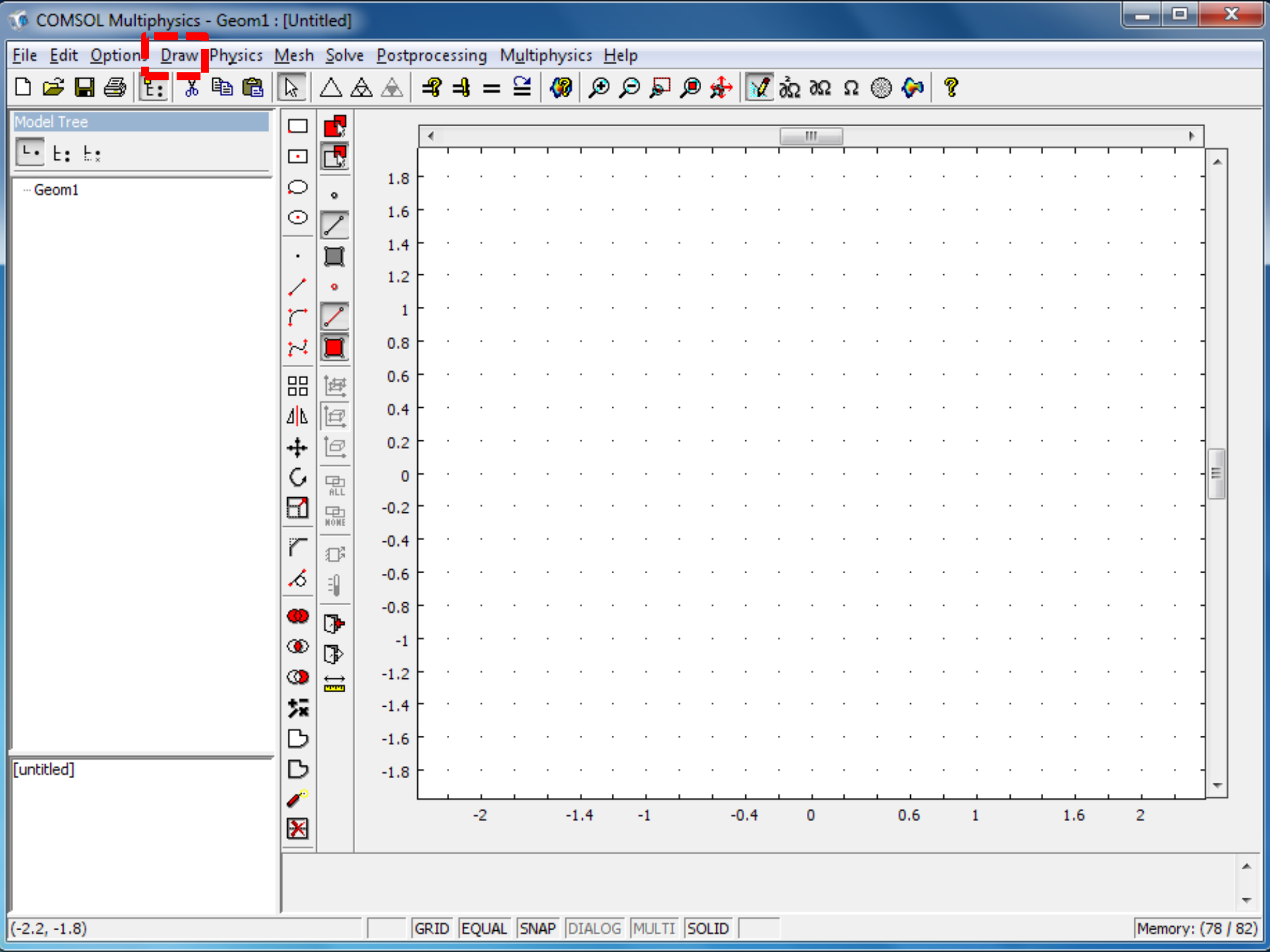

Computer
MATLAB R2009a
Recycle Bin
Tecplot 8.0
Adobe Acrobat 7....
FILES
COMSOL Multiphysics 3.5
Dropbox
COMSOL Reaction ...
xyExtract
COMSOL Script 1.3
iTunes
Model Navigator
New
Model Library
User Models
Open
Settings
Space dimension:
2D
Application Modes
COMSOL Multiphysics
AC/DC Module
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
RF Module
Structural Mechanics Module
Description:
COMSOL Multiphysics.
Application modes for fundamental physics and for defining your own equations.
Dependent variables:
Application mode name:
Element:
Multiphysics
OK
Cancel
Help

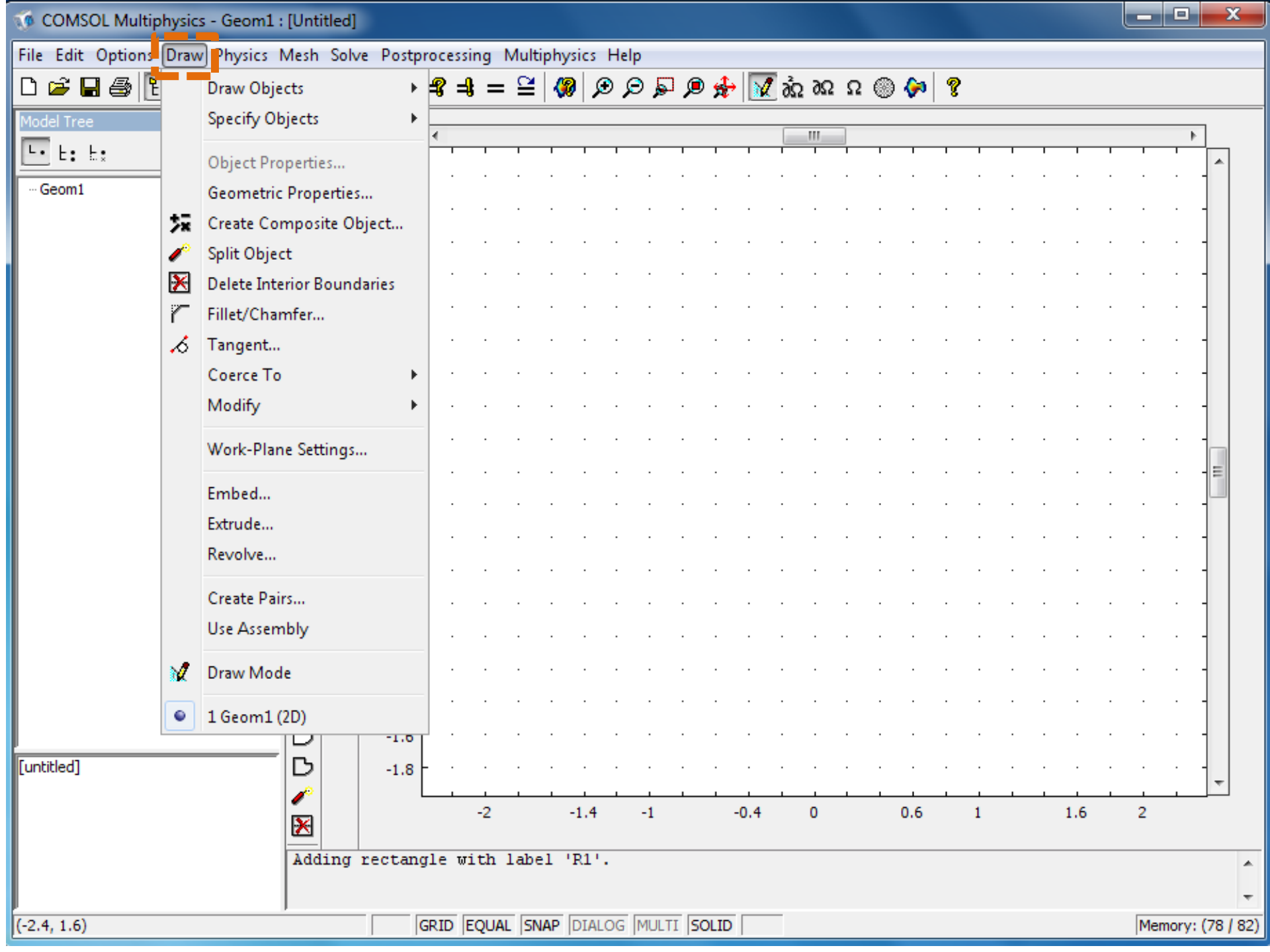

COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-2
-1.4
-1
-0.4
0
0.6
1
1.6
2
(-2.2, -1.8)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (78 / 82)

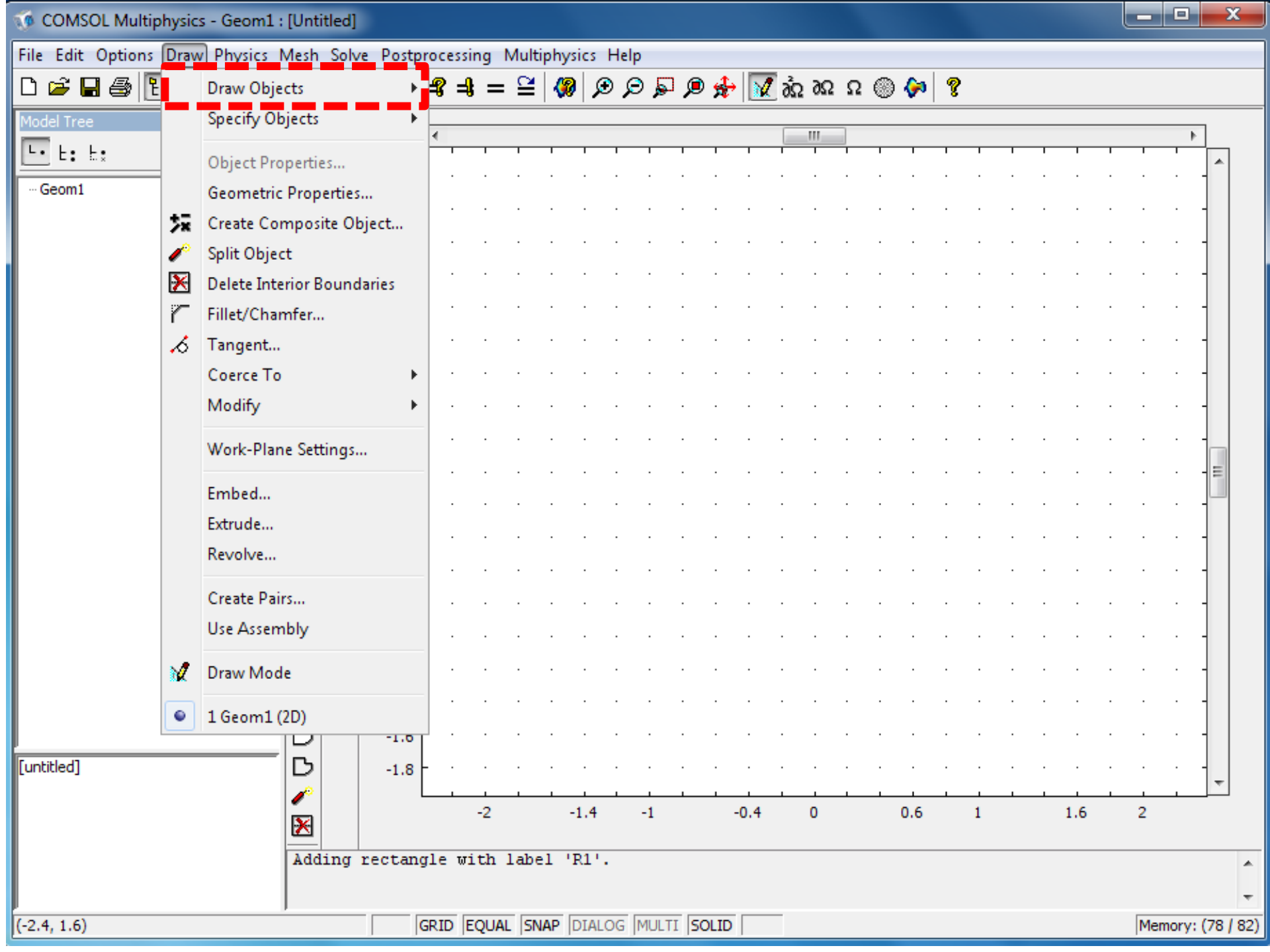

COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Work Space
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-2
-1.4
-1
-0.4
0
0.6
1
1.6
2
(-2.2, -1.8)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (78 / 82)

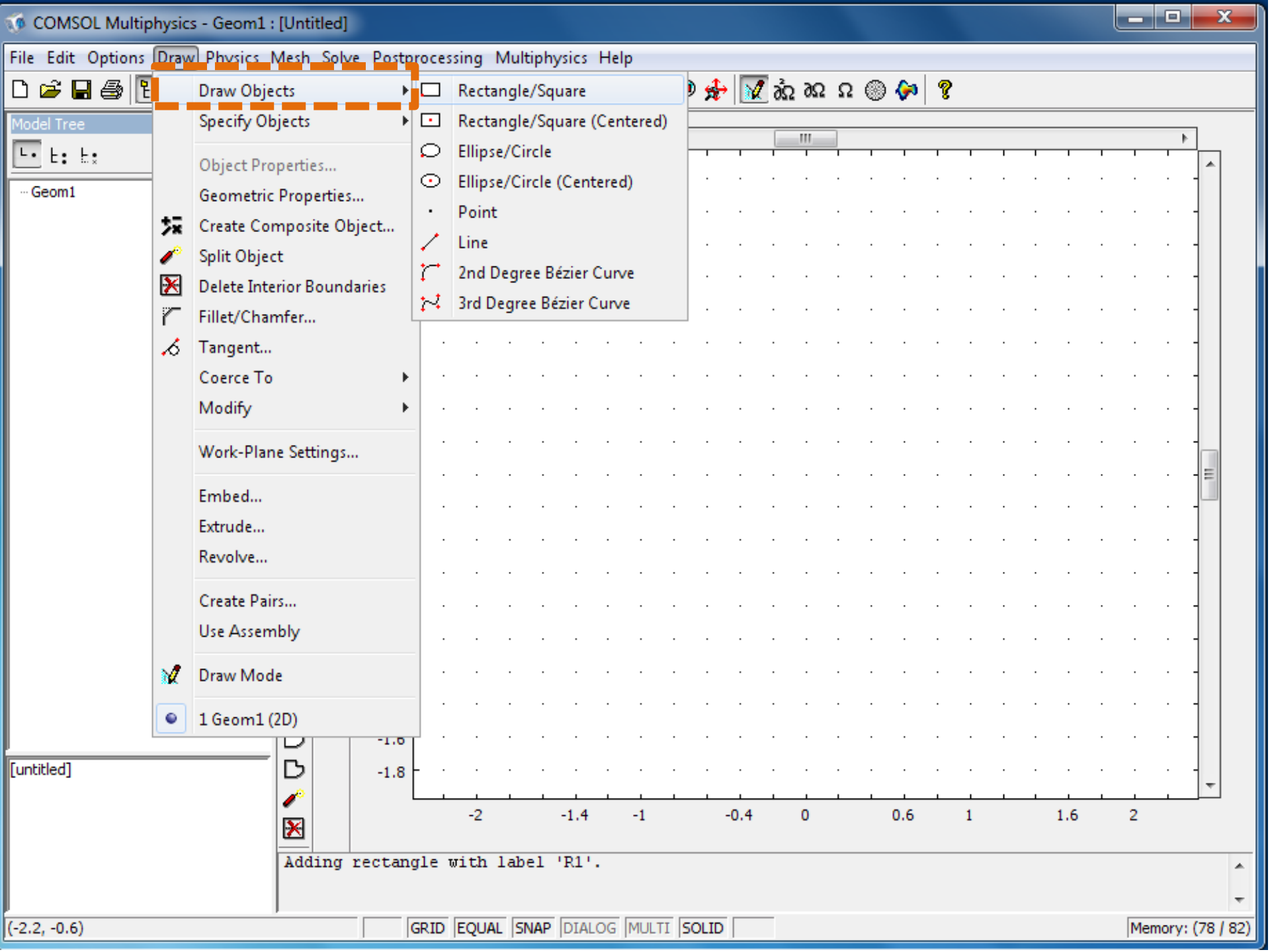
Step 2:

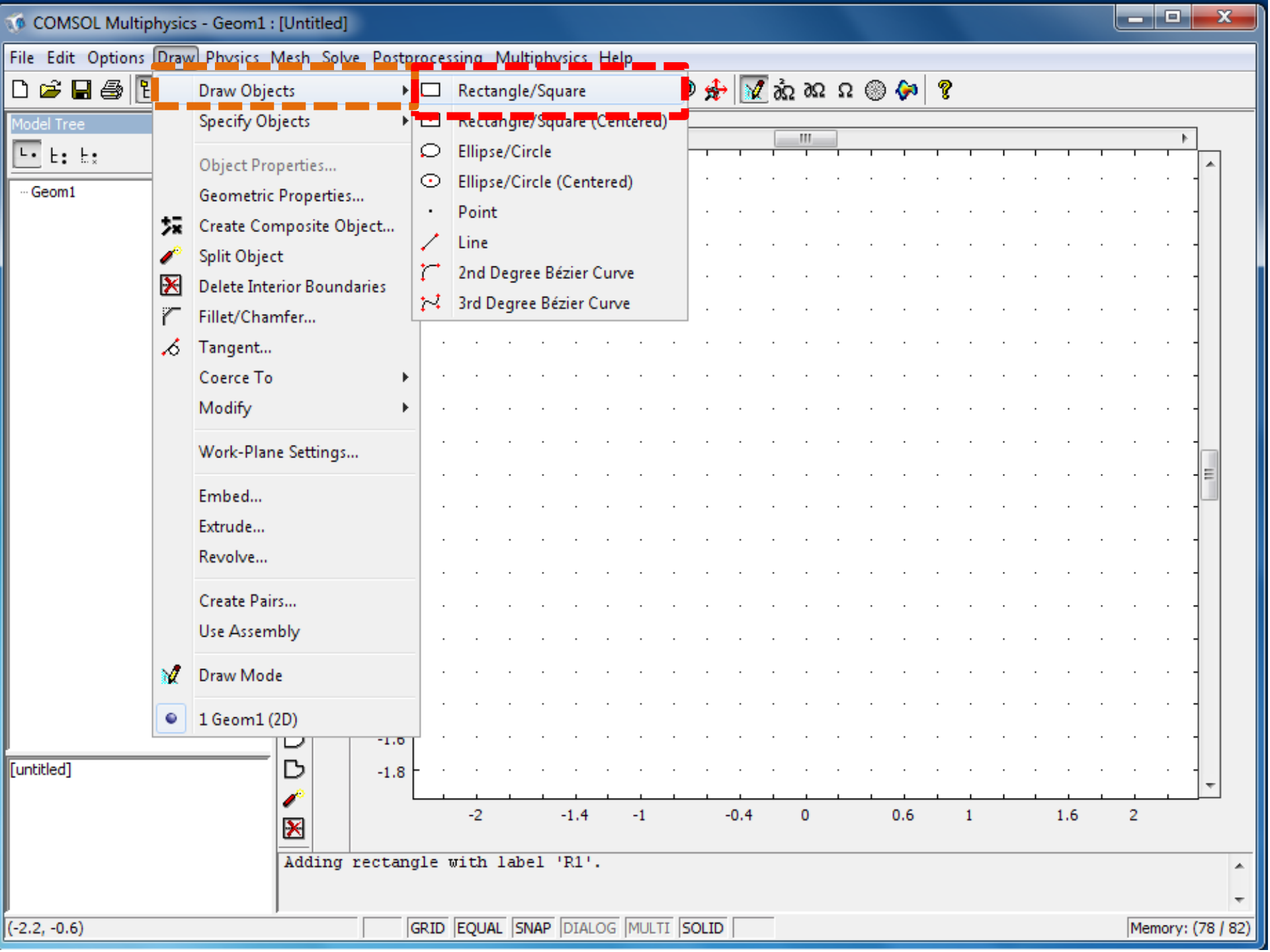
Draw your geometry

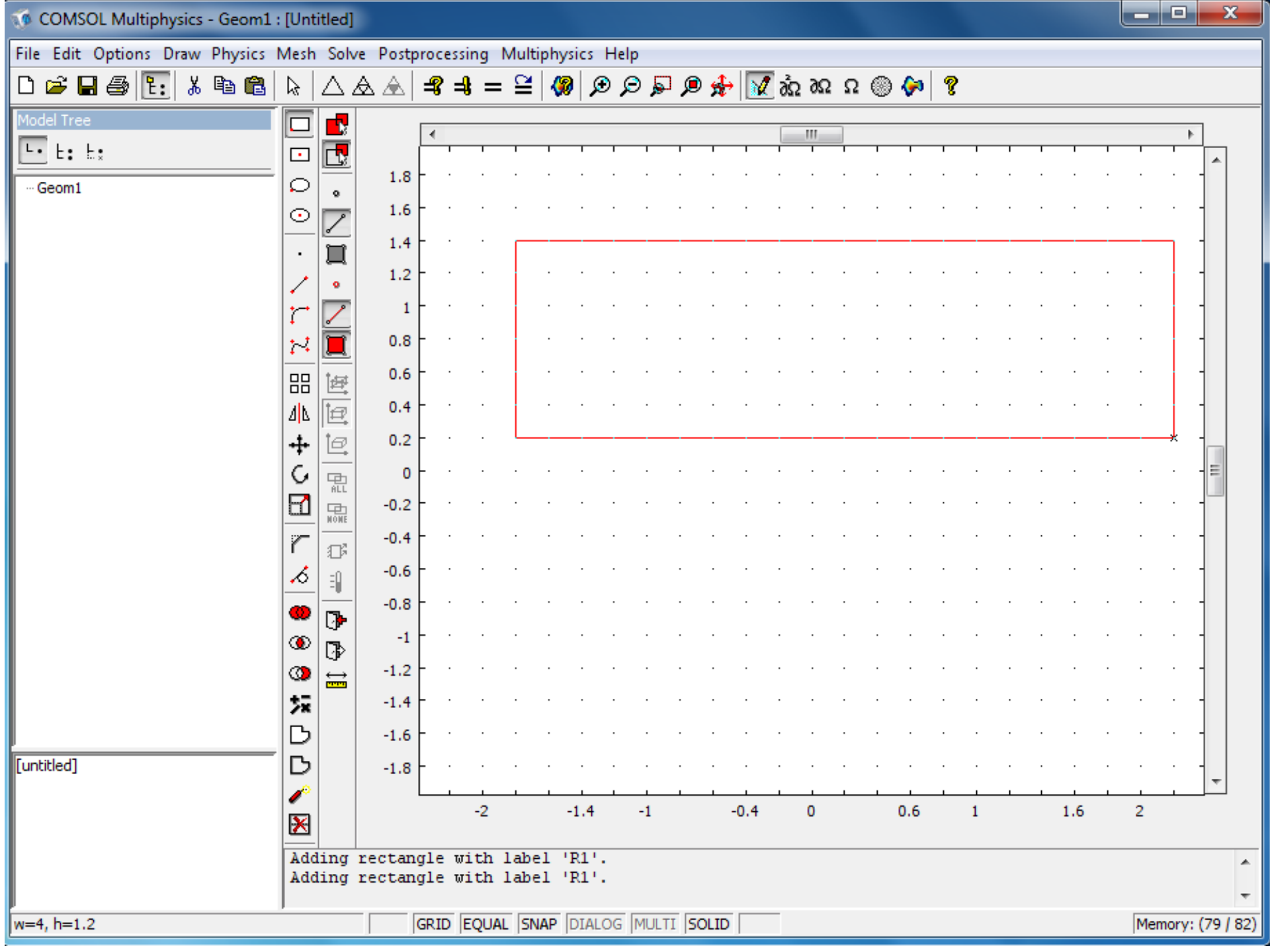

COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
1.8 1.6 1.4 1.2 1 0.8 0.6 0.4 0.2 0 -0.2 -0.4 -0.6 -0.8 -1 -1.2 -1.4 -1.6 -1.8
-2 -1.4 -1 -0.4 0 0.6 1 1.6 2
(-2.2, -1.8)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (78 / 82)


COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Draw Objects
Specify Objects
Object Properties...
Geometric Properties...
Create Composite Object...
Split Object
Delete Interior Boundaries
Fillet/Chamfer...
Tangent...
Coerce To
Modify
Work-Plane Settings...
Embed...
Extrude...
Revolve...
Create Pairs...
Use Assembly
Draw Mode
1 Geom1 (2D)
Model Tree
Geom1
[untitled]
-1.8
-2
-1.4
-1
-0.4
0
0.6
1
1.6
2
Adding rectangle with label 'R1'.
(-2.4, 1.6)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (78 / 82)


COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Draw Objects
Specify Objects
Object Properties...
Geometric Properties...
Create Composite Object...
Split Object
Delete Interior Boundaries
Fillet/Chamfer...
Tangent...
Coerce To
Modify
Work-Plane Settings...
Embed...
Extrude...
Revolve...
Create Pairs...
Use Assembly
Draw Mode
1 Geom1 (2D)
Model Tree
Geom1
[untitled]
-1.8
-2
-1.4
-1
-0.4
0
0.6
1
1.6
2
Adding rectangle with label 'R1'.
(-2.4, 1.6)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (78 / 82)


COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Draw Objects
Specify Objects
Object Properties...
Geometric Properties...
Create Composite Object...
Split Object
Delete Interior Boundaries
Fillet/Chamfer...
Tangent...
Coerce To
Modify
Work-Plane Settings...
Embed...
Extrude...
Revolve...
Create Pairs...
Use Assembly
Draw Mode
1 Geom1 (2D)
Rectangle/Square
Rectangle/Square (Centered)
Ellipse/Circle
Ellipse/Circle (Centered)
Point
Line
2nd Degree Bézier Curve
3rd Degree Bézier Curve
Model Tree
Geom1
[untitled]
-1.6
-1.8
-2
-1.4
-1
-0.4
0
0.6
1
1.6
2
Adding rectangle with label 'R1'.
(-2.2, -0.6)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (78 / 82)


COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Draw Objects
Specify Objects
Object Properties...
Geometric Properties...
Create Composite Object...
Split Object
Delete Interior Boundaries
Fillet/Chamfer...
Tangent...
Coerce To
Modify
Work-Plane Settings...
Embed...
Extrude...
Revolve...
Create Pairs...
Use Assembly
Draw Mode
1 Geom1 (2D)
Rectangle/Square
Rectangle/Square (Centered)
Ellipse/Circle
Ellipse/Circle (Centered)
Point
Line
2nd Degree Bézier Curve
3rd Degree Bézier Curve
Model Tree
Geom1
[untitled]
-1.6
-1.8
-2
-1.4
-1
-0.4
0
0.6
1
1.6
2
Adding rectangle with label 'R1'.
(-2.2, -0.6)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (78 / 82)


COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-2
-1.4
-1
-0.4
0
0.6
1
1.6
2
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
w=4, h=1.2
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (79 / 82)

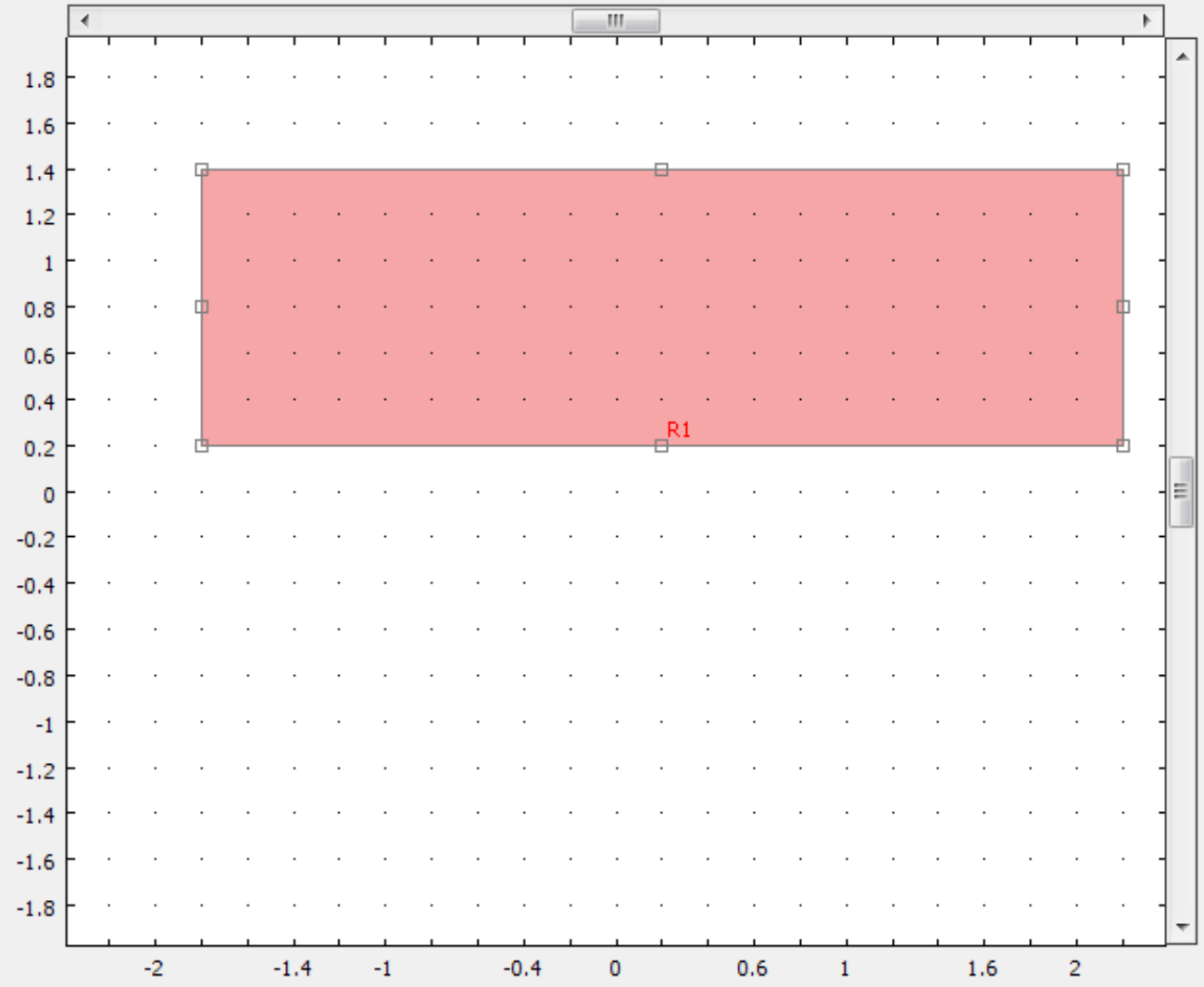
COMSOL Multiphysics - Geom1 : [Untitled]

File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help

Model Tree

Geom1

[untitled]




```
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
```

(0.4, -1) GRID EQUAL SNAP DIALOG MULTI SOLID Memory: (79 / 82)

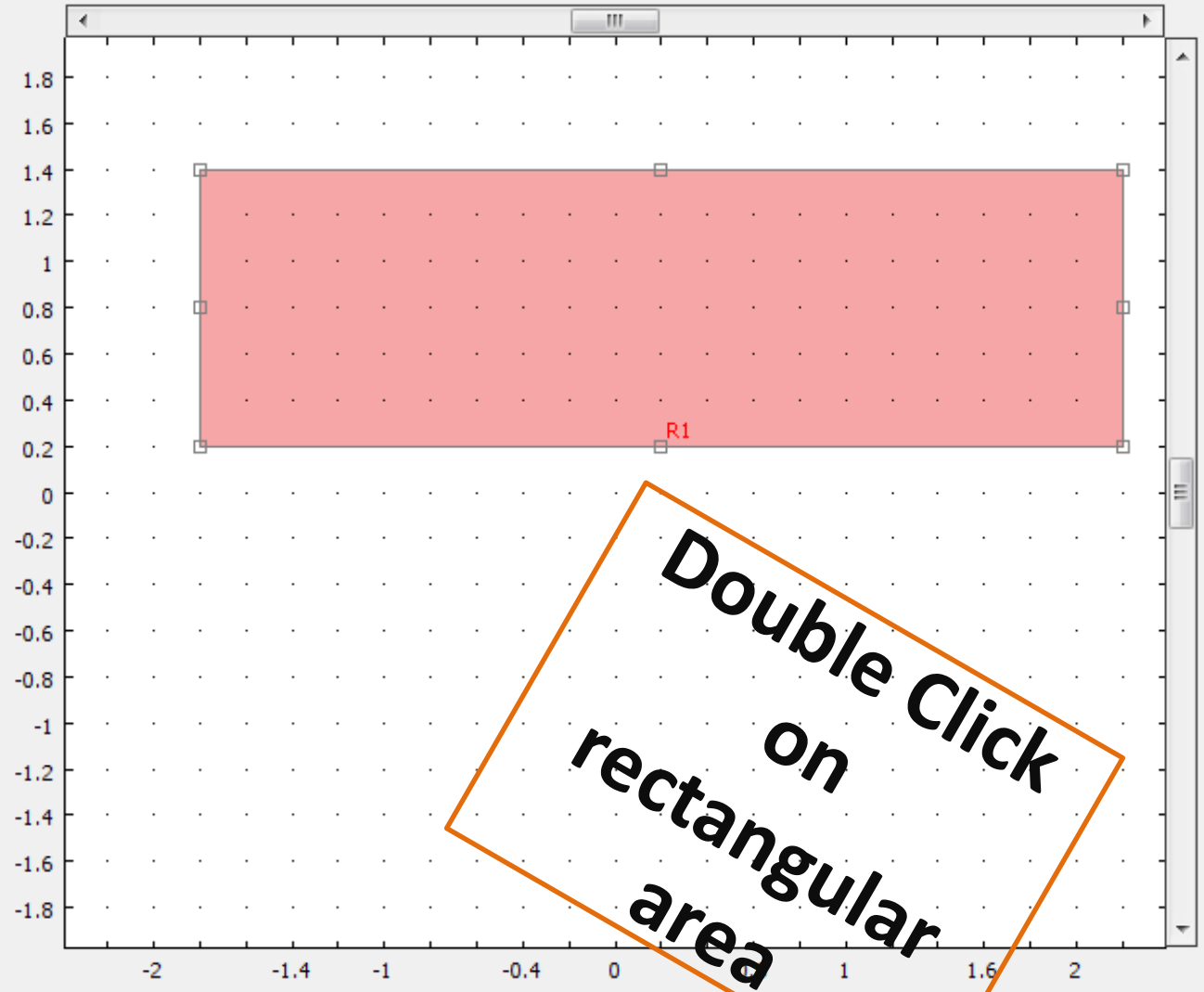
COMSOL Multiphysics - Geom1 : [Untitled]

File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help

Model Tree

Geom1

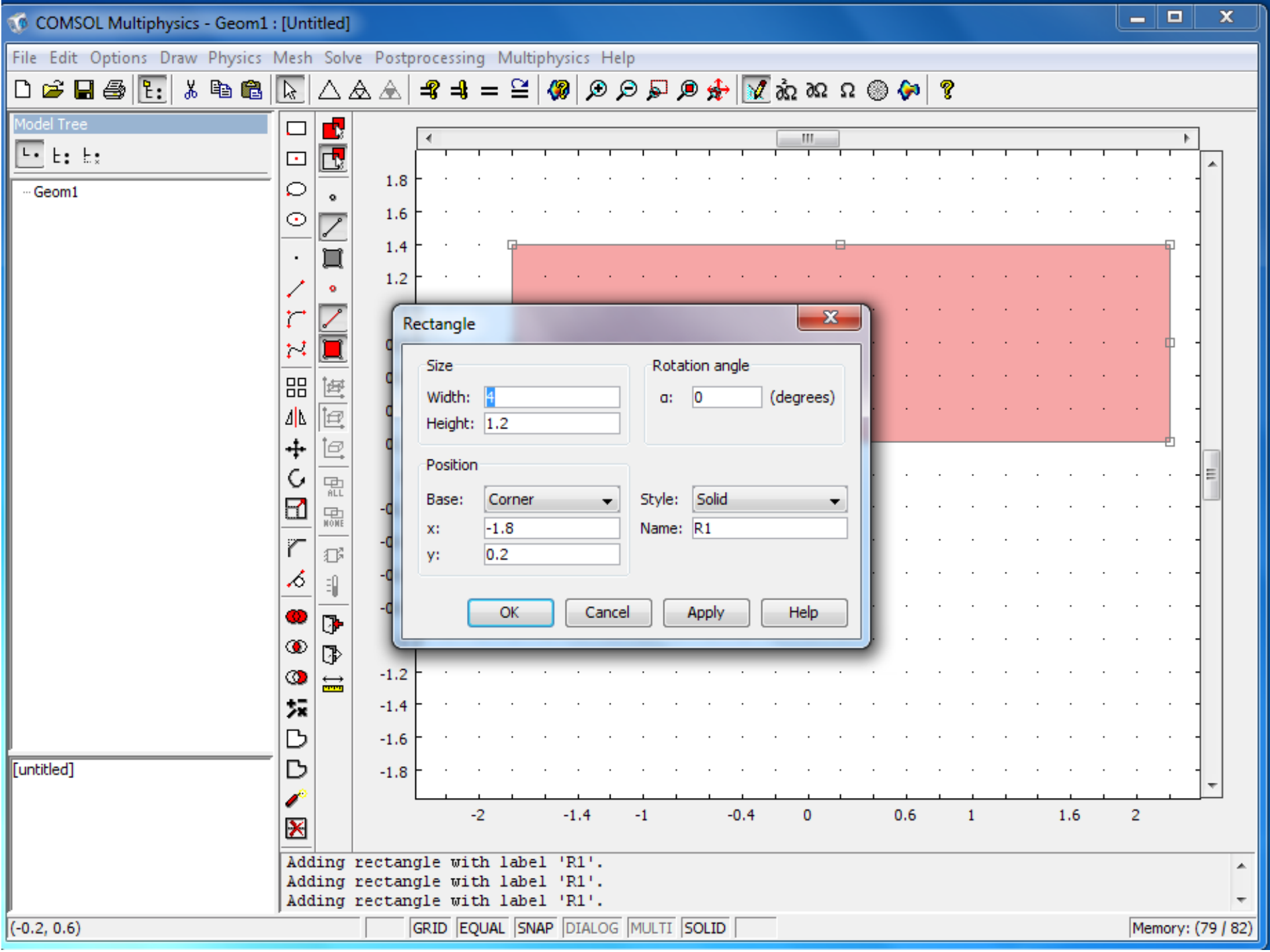
[untitled]

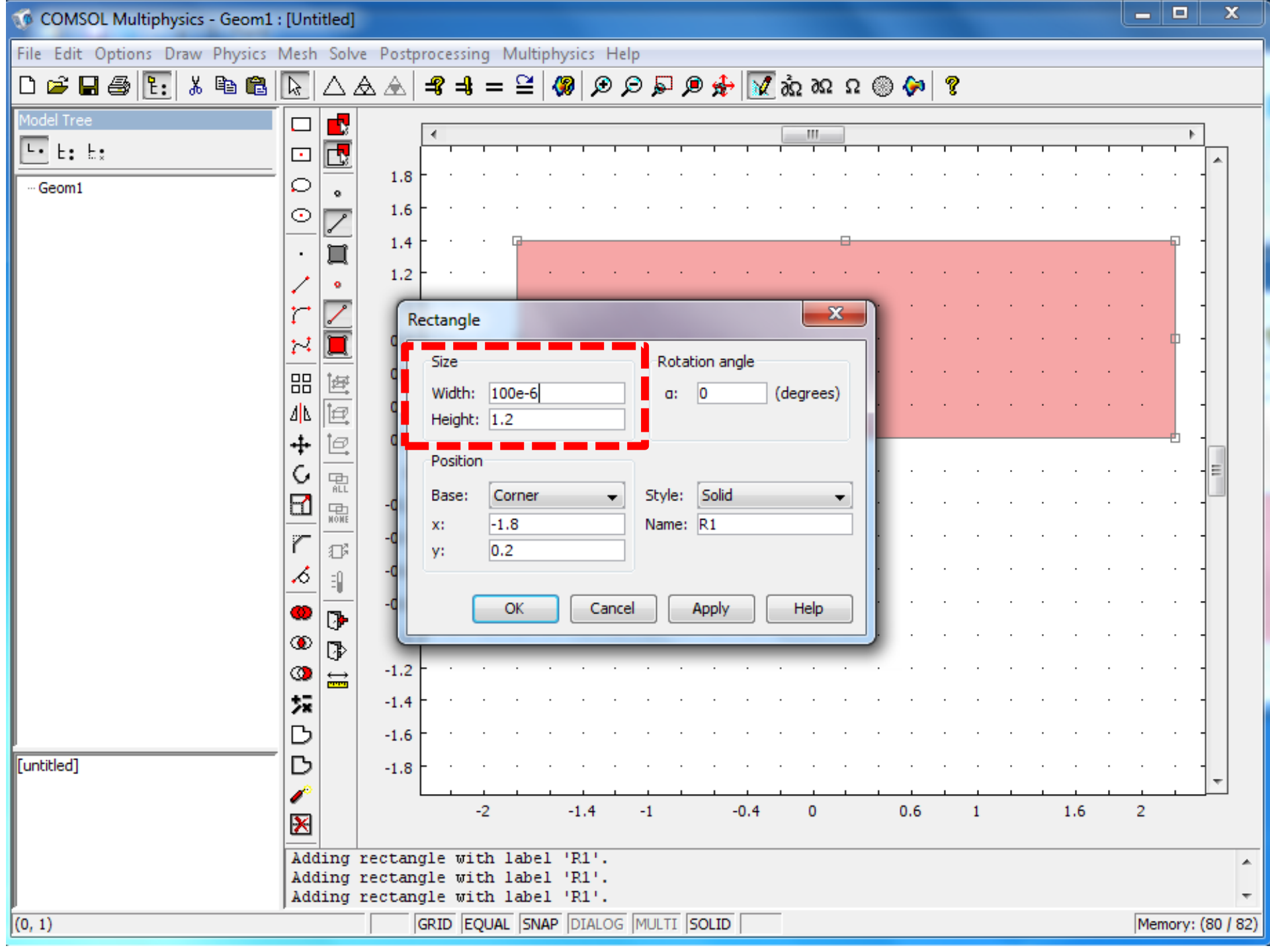


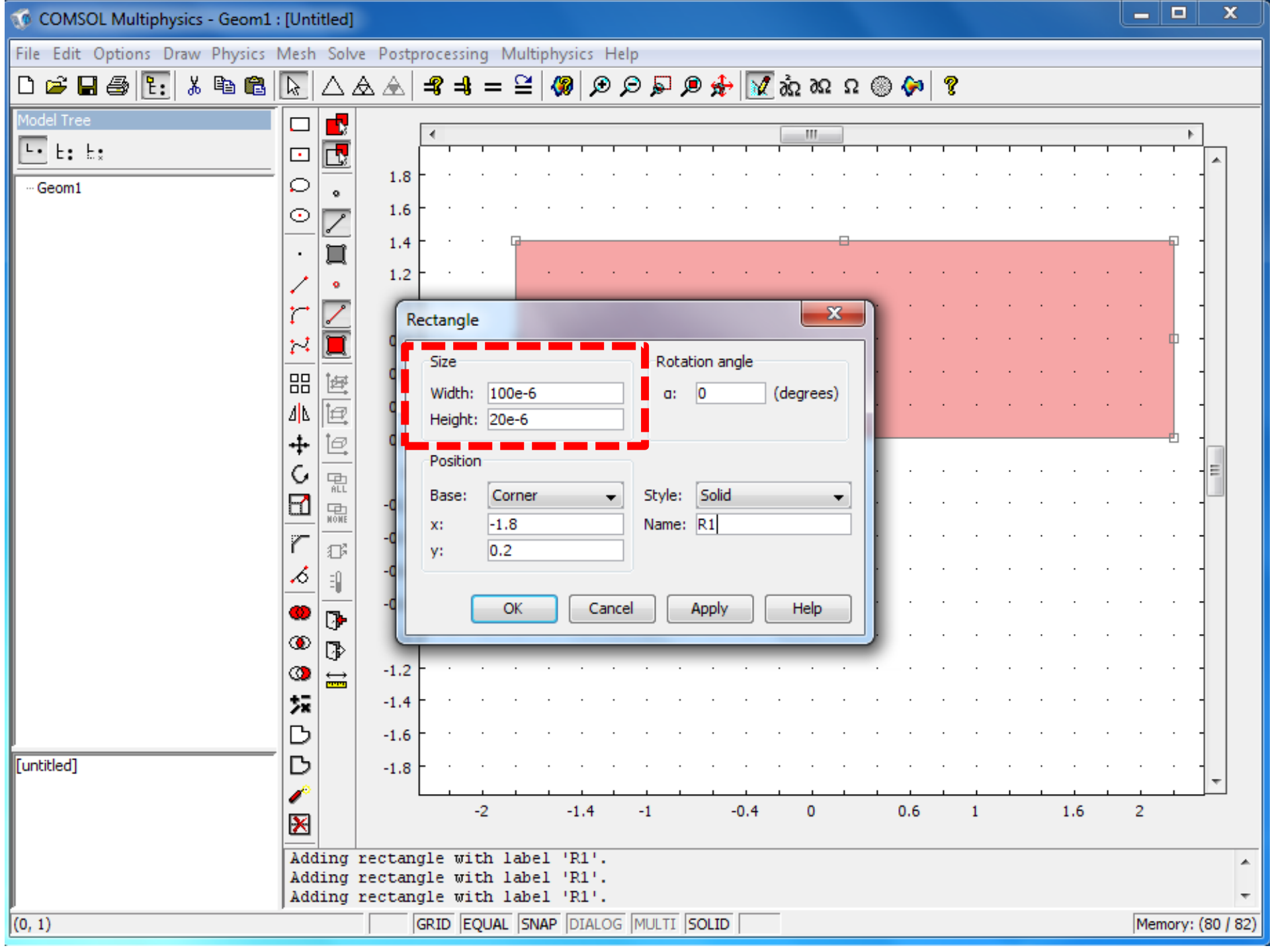
Double Click on rectangular area

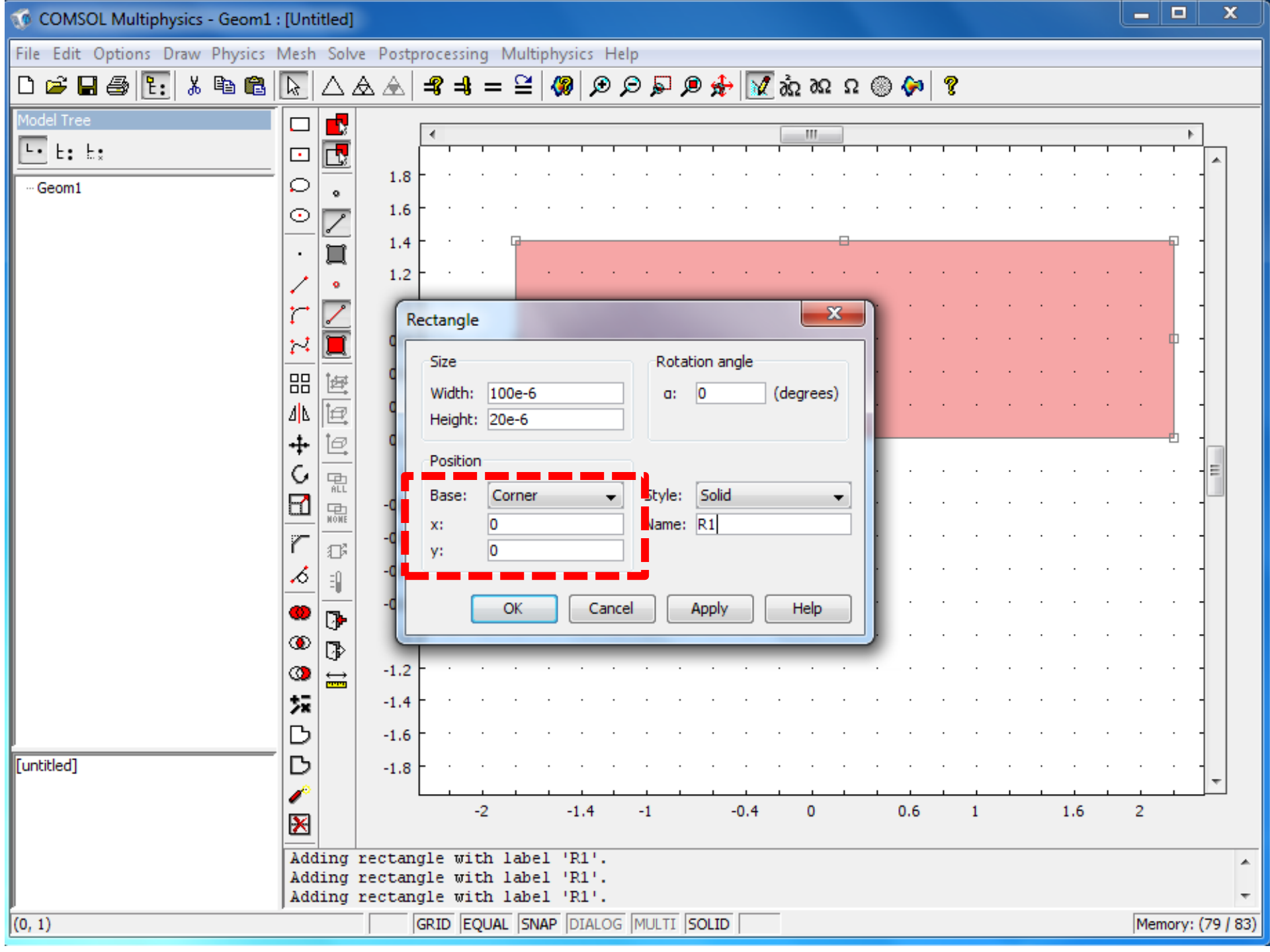
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.

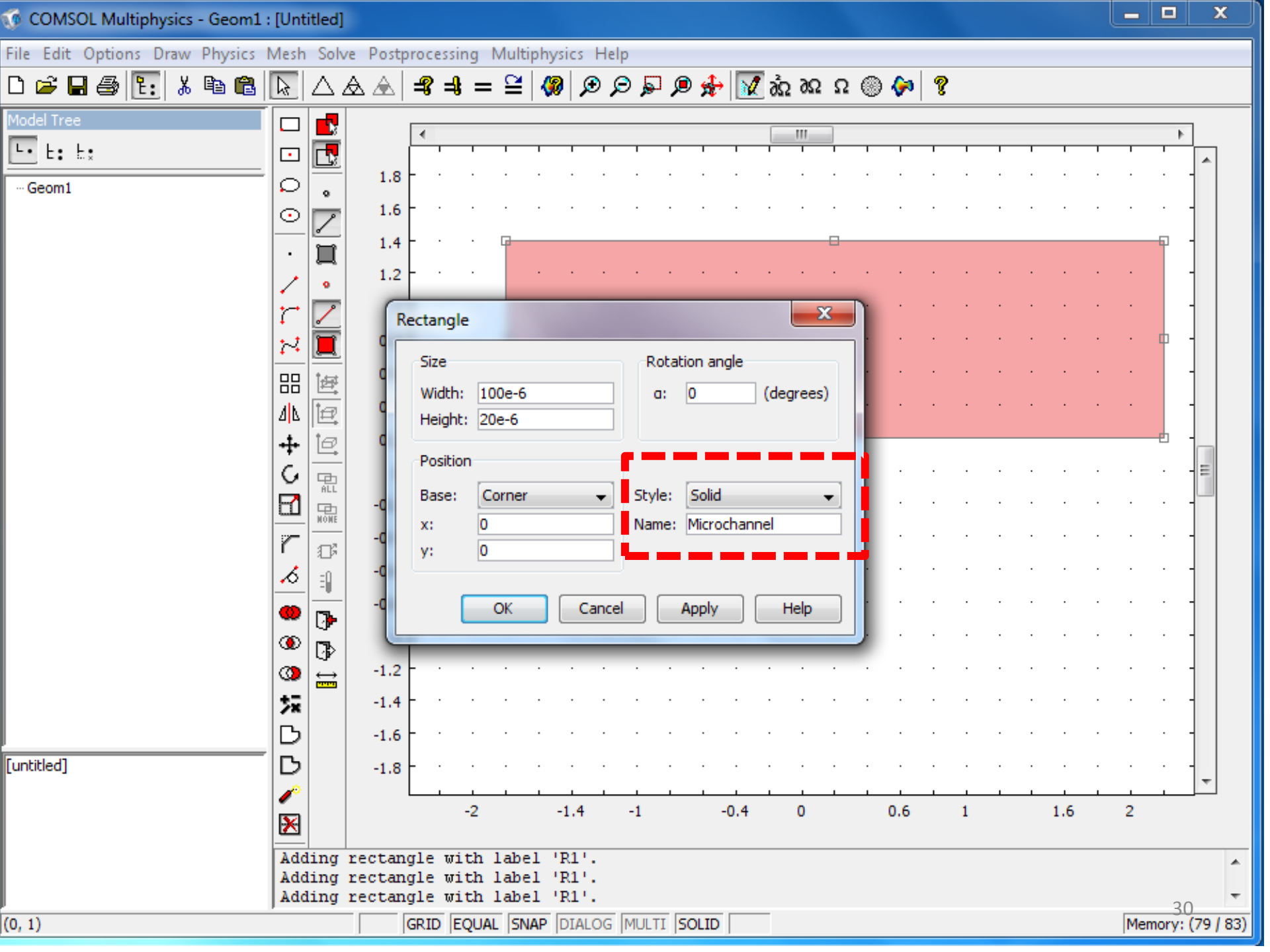
(0.4, -1) GRID EQUAL SNAP DIALOG MULTI SOLID Memory: (79 / 82)

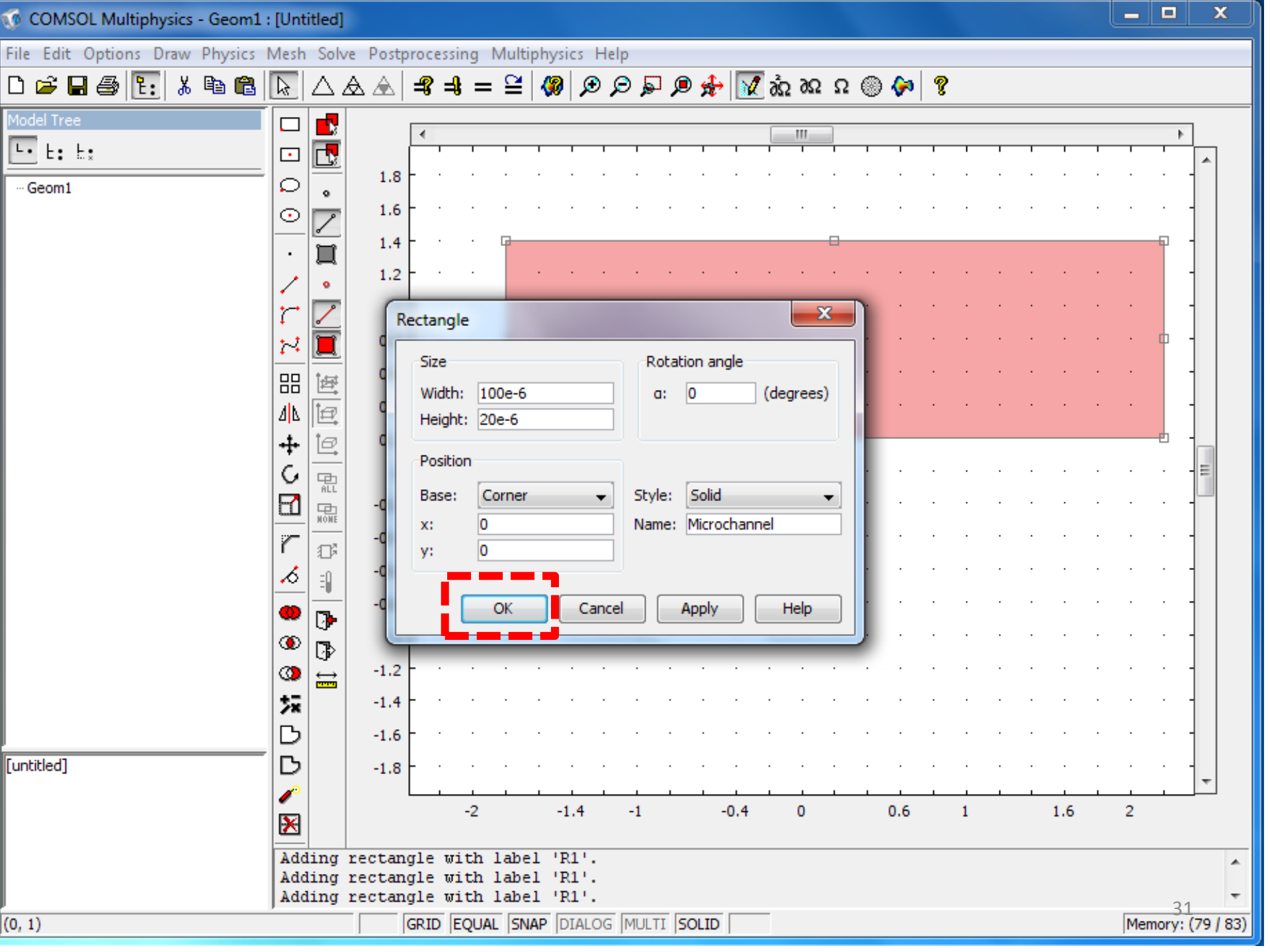

COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Rectangle
Size
Width: 4
Height: 1.2
Rotation angle
α: 0 (degrees)
Position
Base: Corner
x: -1.8
y: 0.2
Style: Solid
Name: R1
OK
Cancel
Apply
Help
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
(-0.2, 0.6)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (79 / 82)

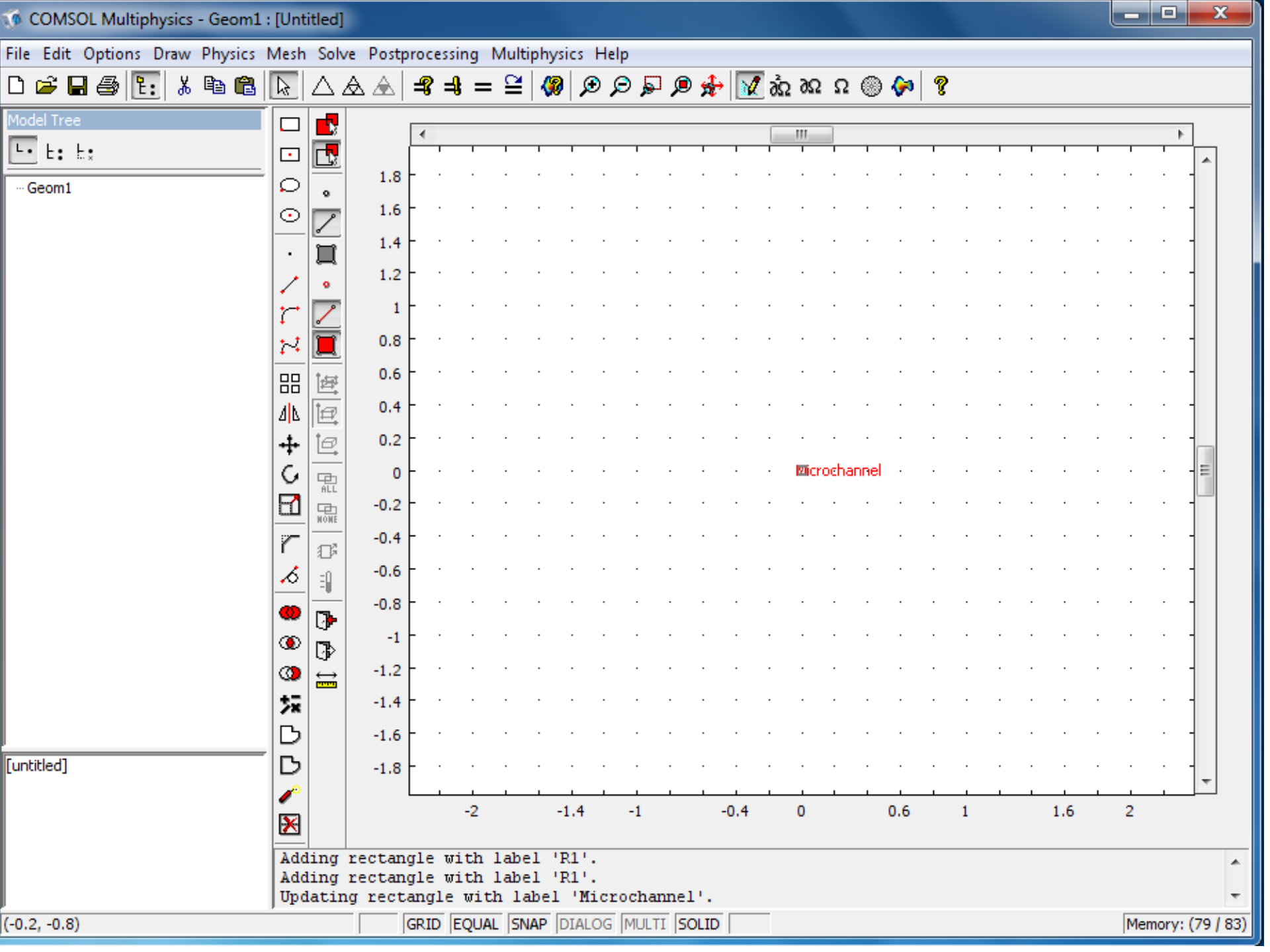

COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Rectangle
Size
Width: 100e-6
Height: 1.2
Rotation angle
α: 0 (degrees)
Position
Base: Corner
x: -1.8
y: 0.2
Style: Solid
Name: R1
OK
Cancel
Apply
Help
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
(0, 1)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (80 / 82)

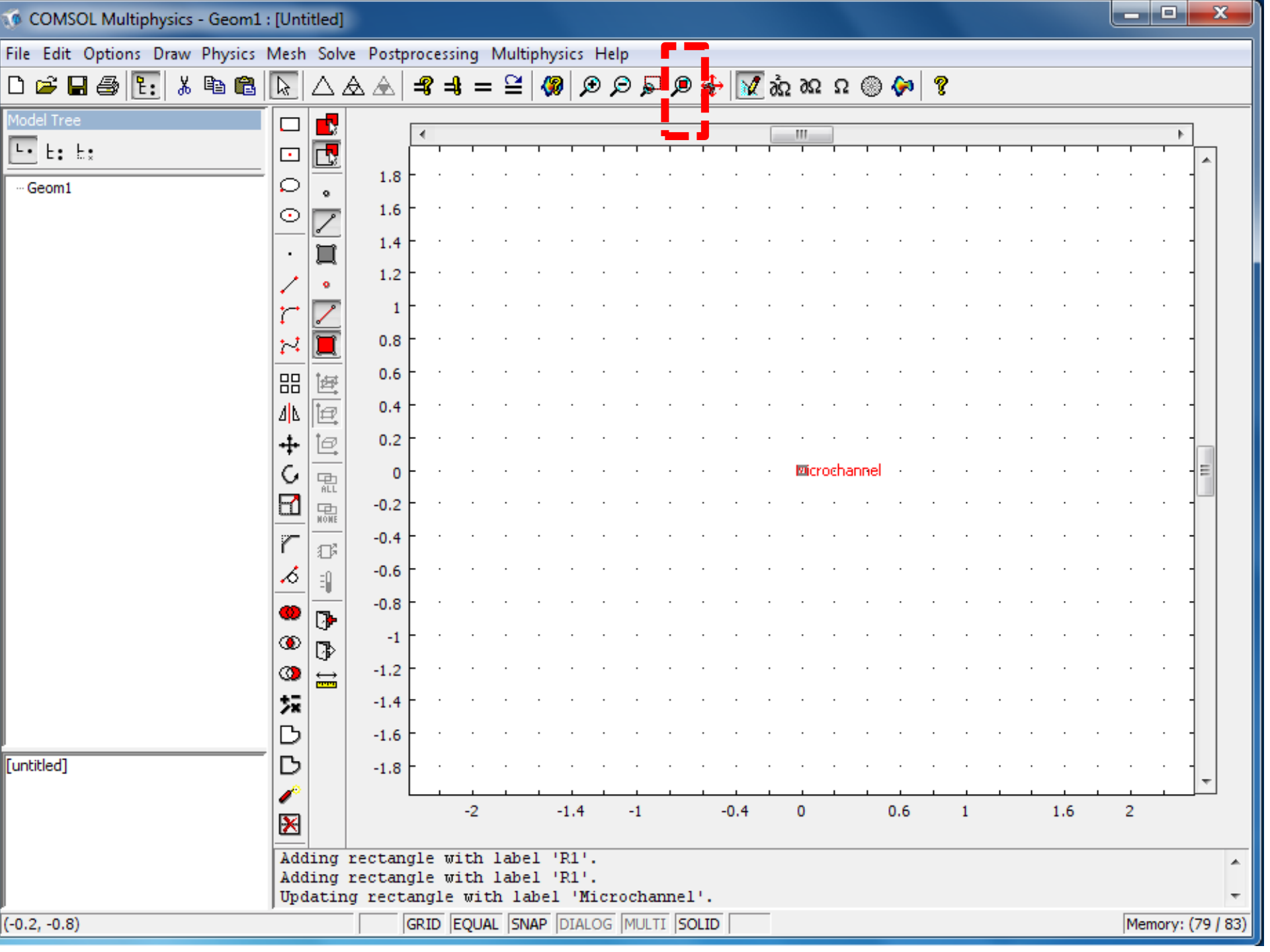

COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Rectangle
Size
Width: 100e-6
Height: 20e-6
Rotation angle
α: 0 (degrees)
Position
Base: Corner
x: -1.8
y: 0.2
Style: Solid
Name: R1
OK
Cancel
Apply
Help
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
(0, 1)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (80 / 82)


COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Rectangle
Size
Width: 100e-6
Height: 20e-6
Rotation angle
α: 0 (degrees)
Position
Base: Corner
x: 0
y: 0
Style: Solid
Name: R1
OK
Cancel
Apply
Help
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
(0, 1)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (79 / 83)


COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Rectangle
Size
Width: 100e-6
Height: 20e-6
Rotation angle
α: 0 (degrees)
Position
Base: Corner
x: 0
y: 0
Style: Solid
Name: Microchannel
OK
Cancel
Apply
Help
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
(0, 1)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (79 / 83)


COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Rectangle
Size
Width: 100e-6
Height: 20e-6
Rotation angle
α: 0 (degrees)
Position
Base: Corner
x: 0
y: 0
Style: Solid
Name: Microchannel
OK
Cancel
Apply
Help
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
(0, 1)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (79 / 83)


COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Microchannel
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-2
-1.4
-1
-0.4
0
0.6
1
1.6
2
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
Updating rectangle with label 'Microchannel'.
(-0.2, -0.8)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (79 / 83)


COMSOL Multiphysics - Geom1 : [Untitled]
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Microchannel
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-2
-1.4
-1
-0.4
0
0.6
1
1.6
2
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
Updating rectangle with label 'Microchannel'.
(-0.2, -0.8)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (79 / 83)

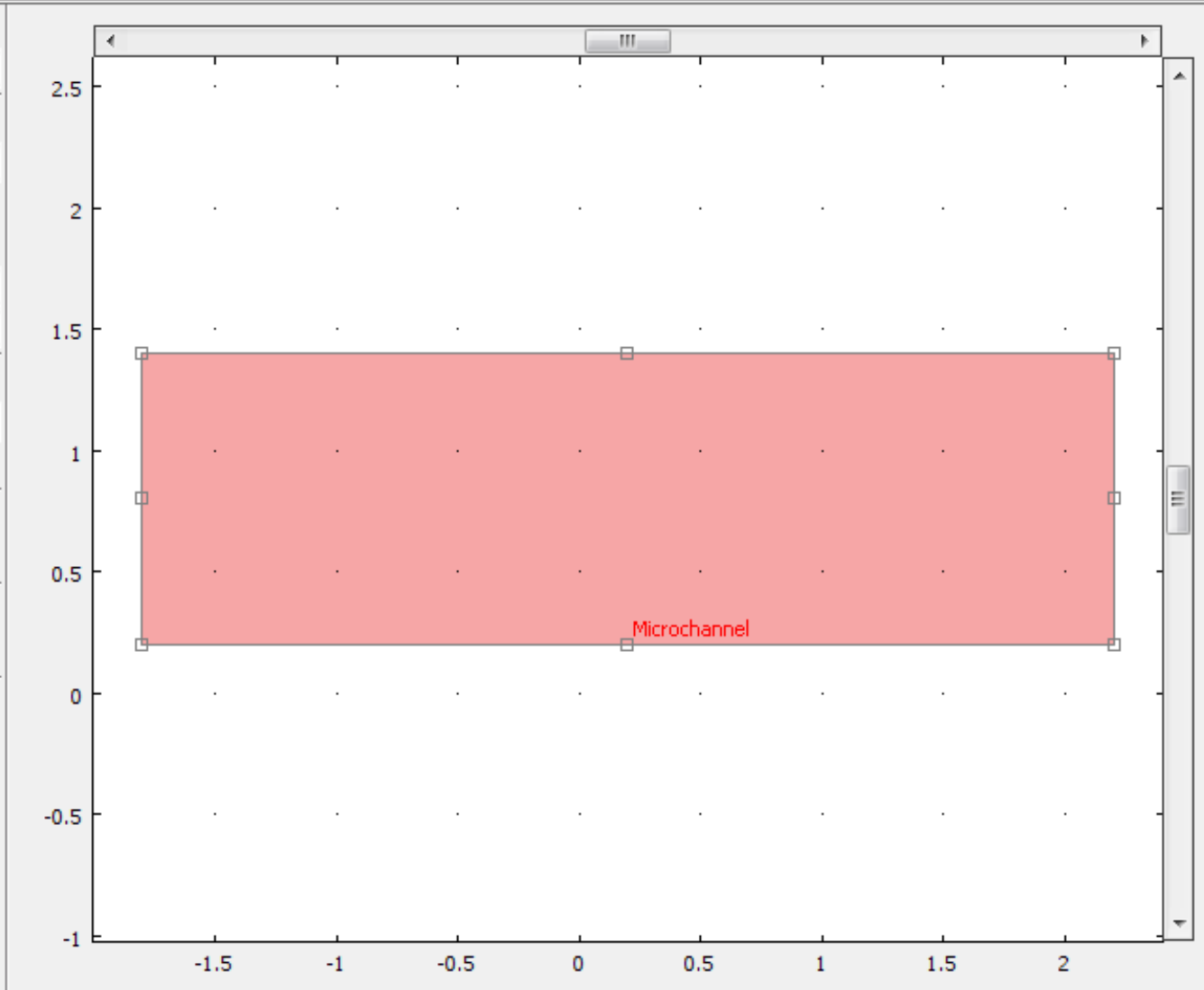
COMSOL Multiphysics - Geom1 : [Untitled]

File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help

Model Tree

Geom1

[untitled]

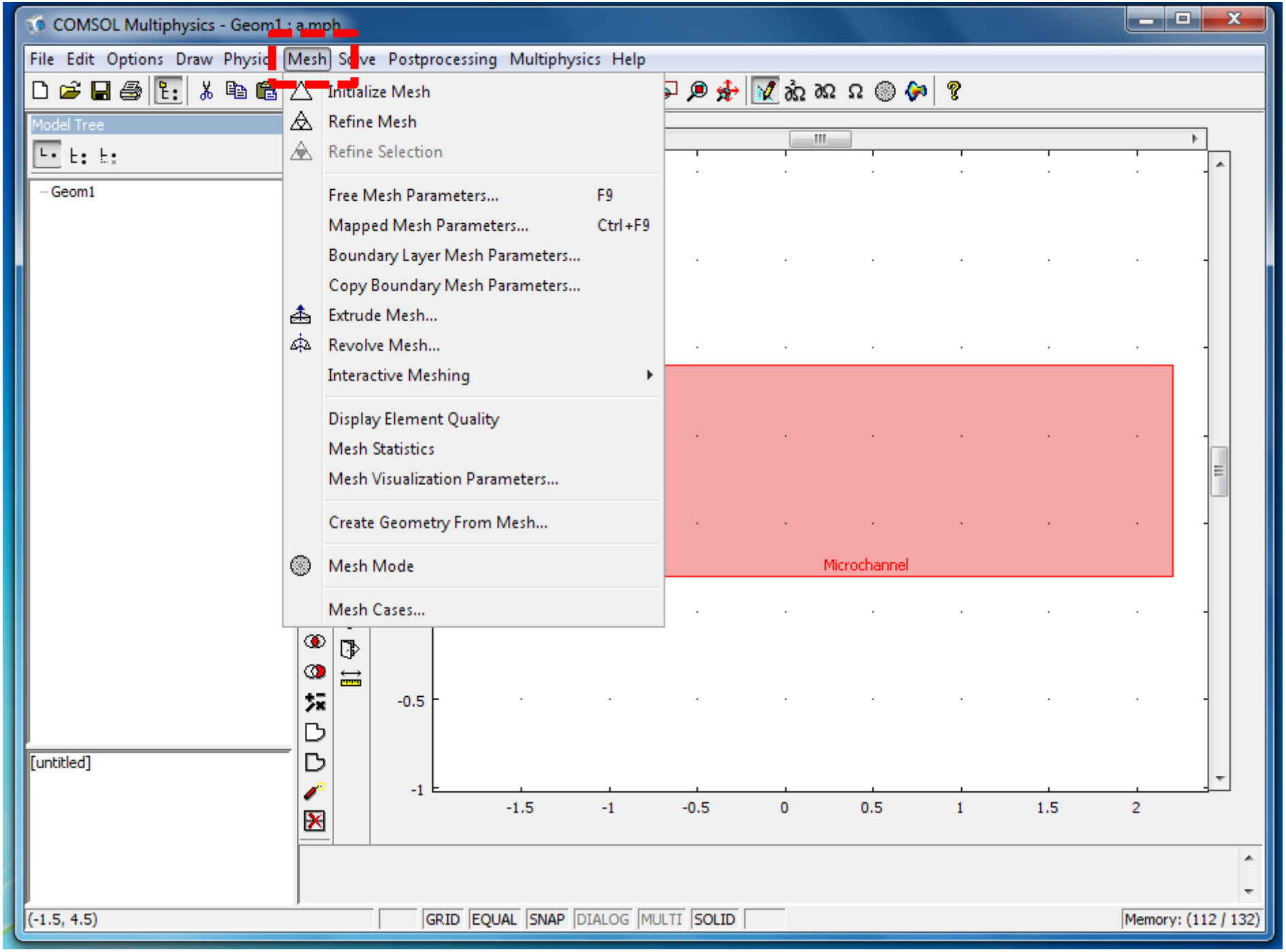


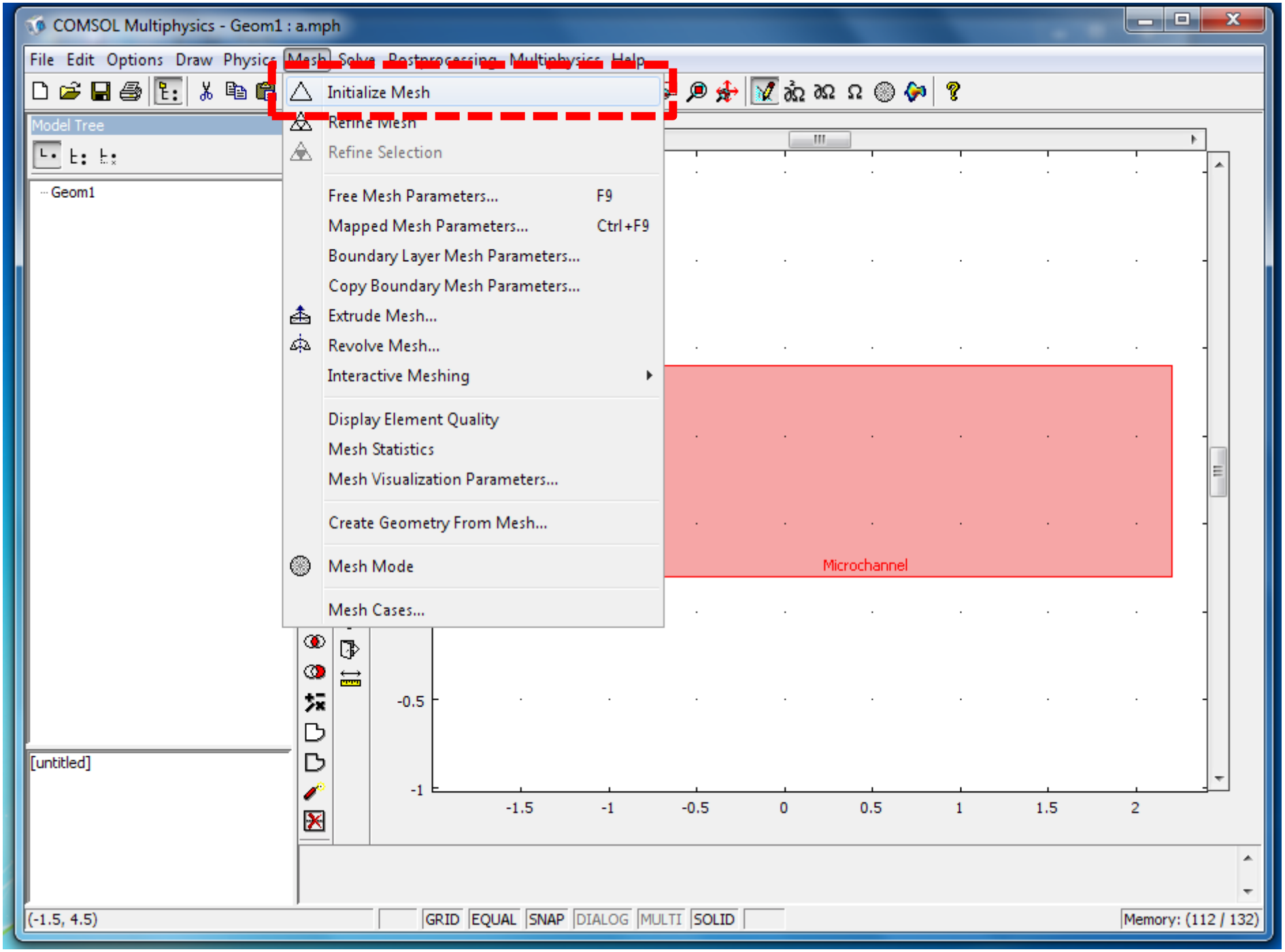
Adding rectangle with label 'R1'.
Adding rectangle with label 'R1'.
Updating rectangle with label 'Microchannel'.

(0, 2) GRID EQUAL SNAP DIALOG MULTI SOLID Memory: (79 / 83)

Step 3:

Mesh your domain


COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physic Mesh Solve Postprocessing Multiphysics Help
Initialize Mesh
Refine Mesh
Refine Selection
Free Mesh Parameters... F9
Mapped Mesh Parameters... Ctrl+F9
Boundary Layer Mesh Parameters...
Copy Boundary Mesh Parameters...
Extrude Mesh...
Revolve Mesh...
Interactive Meshing
Display Element Quality
Mesh Statistics
Mesh Visualization Parameters...
Create Geometry From Mesh...
Mesh Mode
Mesh Cases...
Model Tree
Geom1
[untitled]
Microchannel
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
1.5
2
(-1.5, 4.5)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (112 / 132)


COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Initialize Mesh
Refine Mesh
Refine Selection
Free Mesh Parameters... F9
Mapped Mesh Parameters... Ctrl+F9
Boundary Layer Mesh Parameters...
Copy Boundary Mesh Parameters...
Extrude Mesh...
Revolve Mesh...
Interactive Meshing
Display Element Quality
Mesh Statistics
Mesh Visualization Parameters...
Create Geometry From Mesh...
Mesh Mode
Mesh Cases...
Model Tree
Geom1
[untitled]
Microchannel
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
1.5
2
(-1.5, 4.5)
GRID EQUAL SNAP DIALOG MULTI SOLID
Memory: (112 / 132)

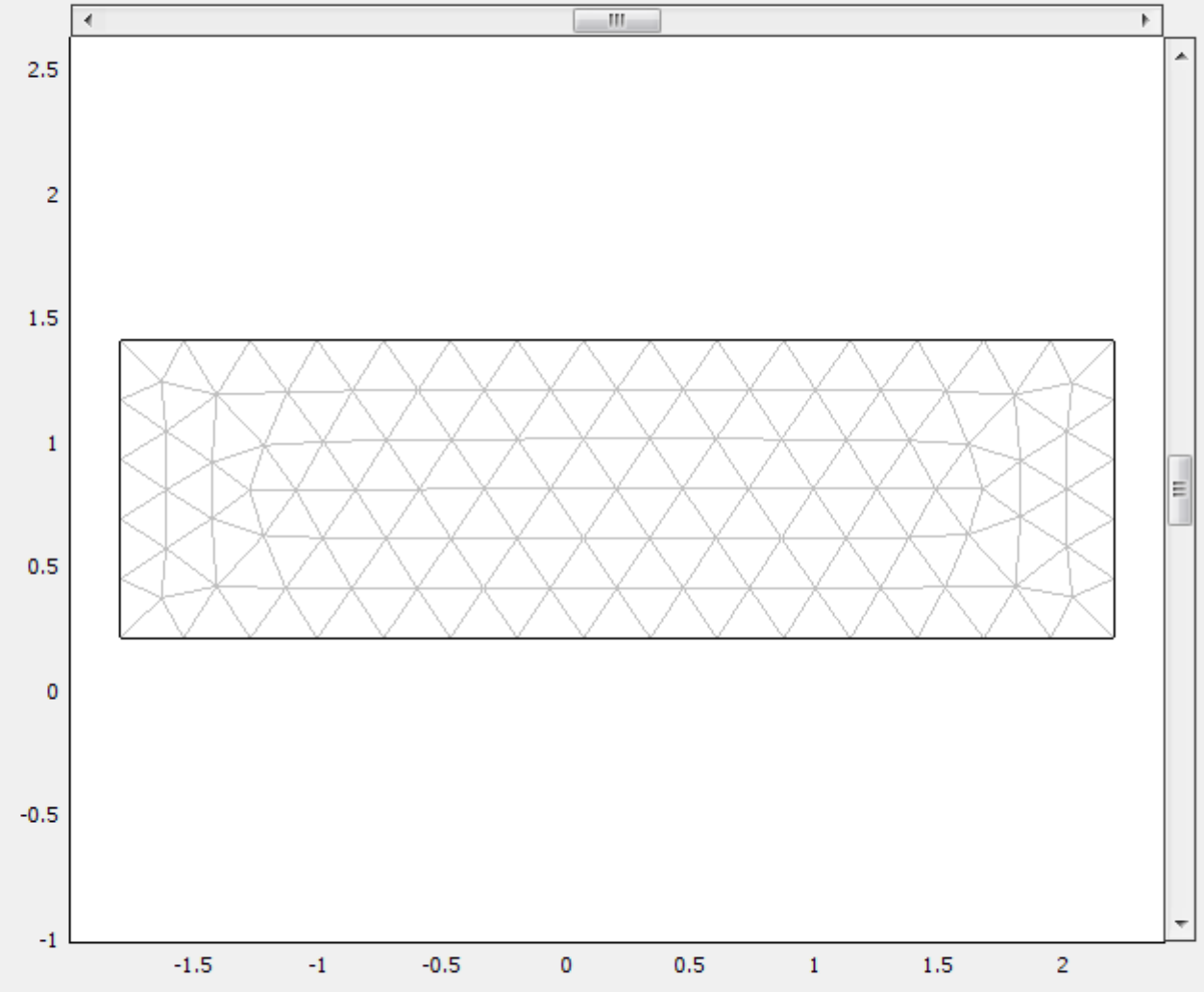
COMSOL Multiphysics - Geom1 : a.mph

File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help

Model Tree

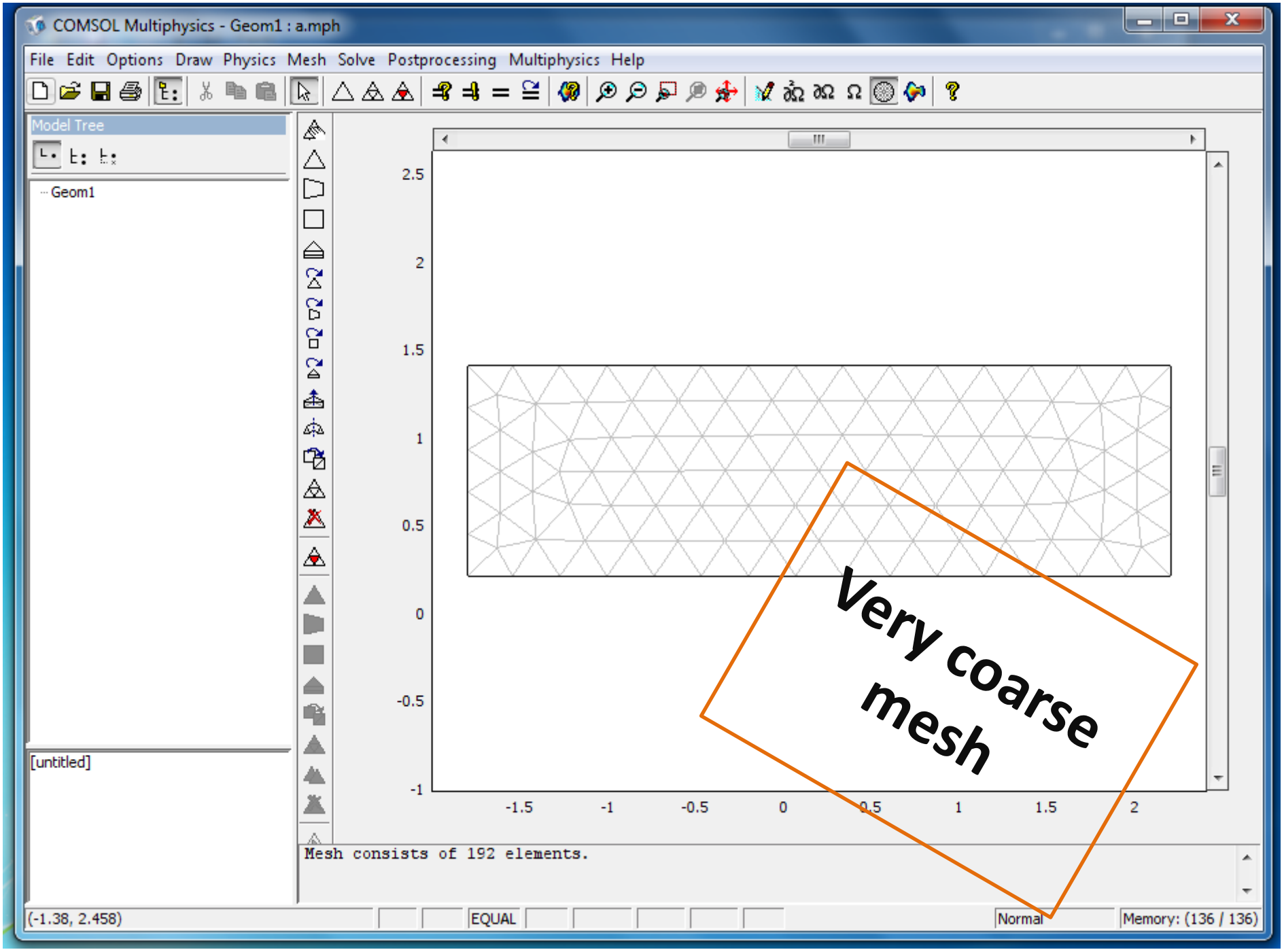
Geom1

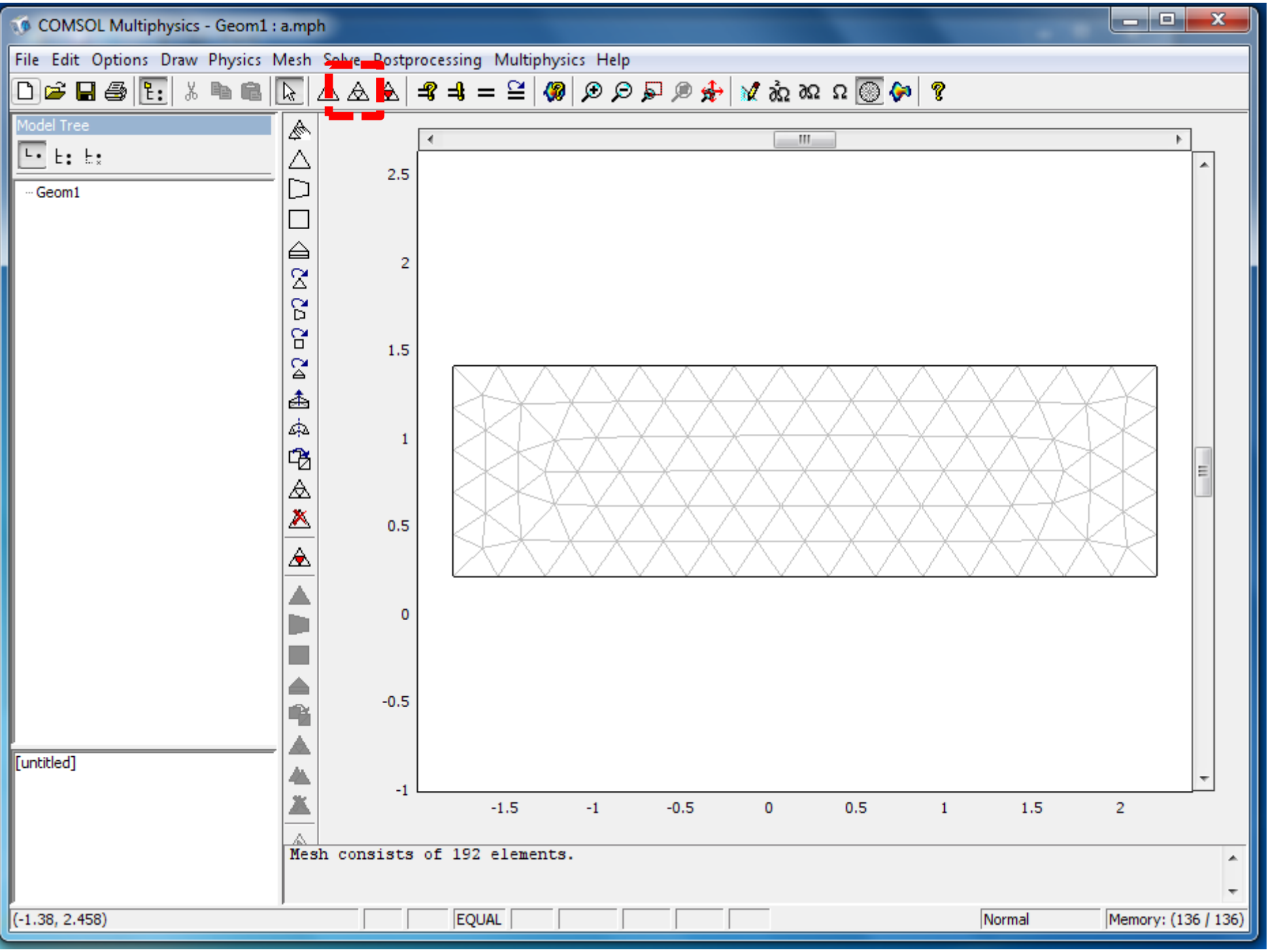
[untitled]

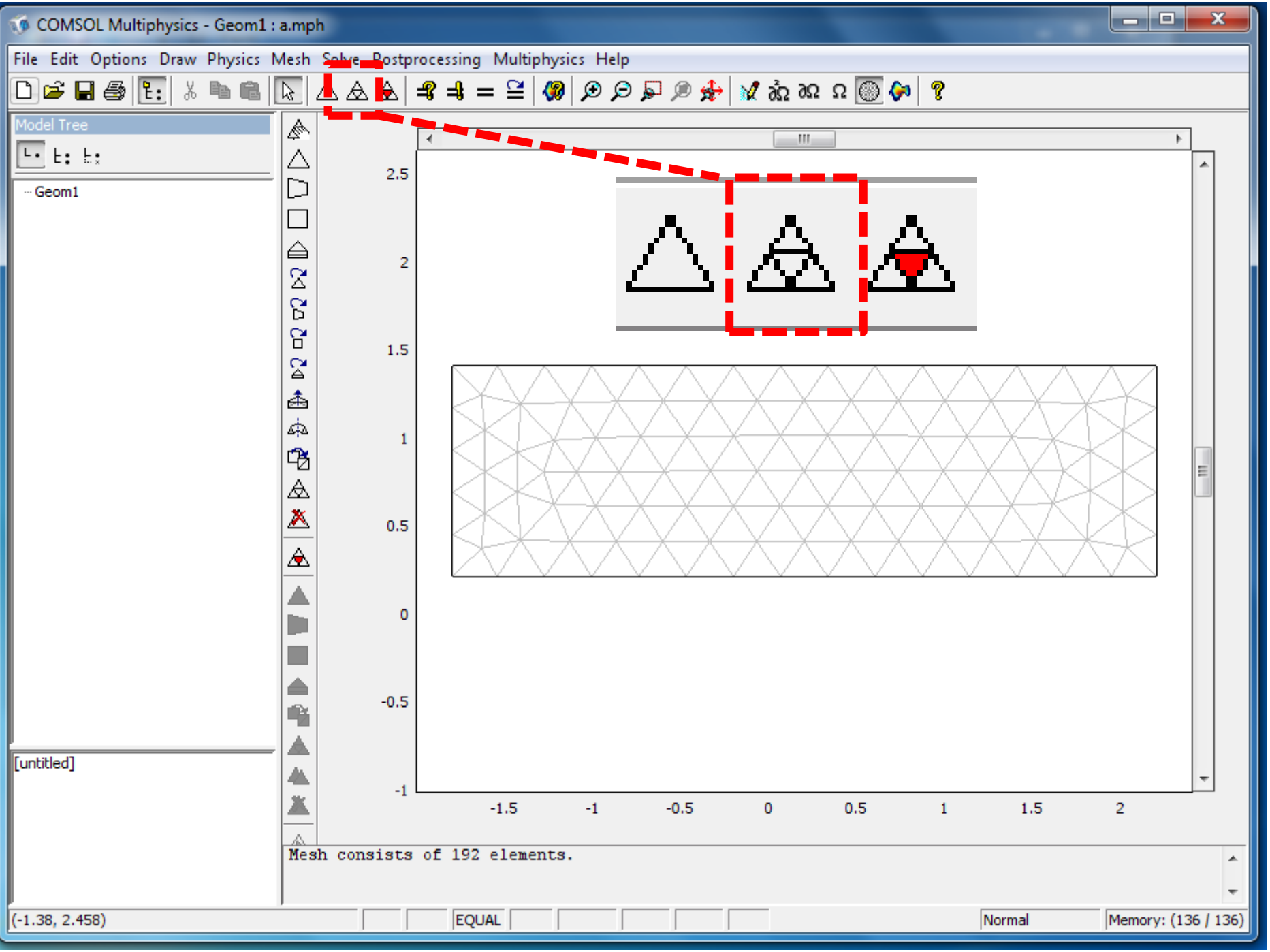


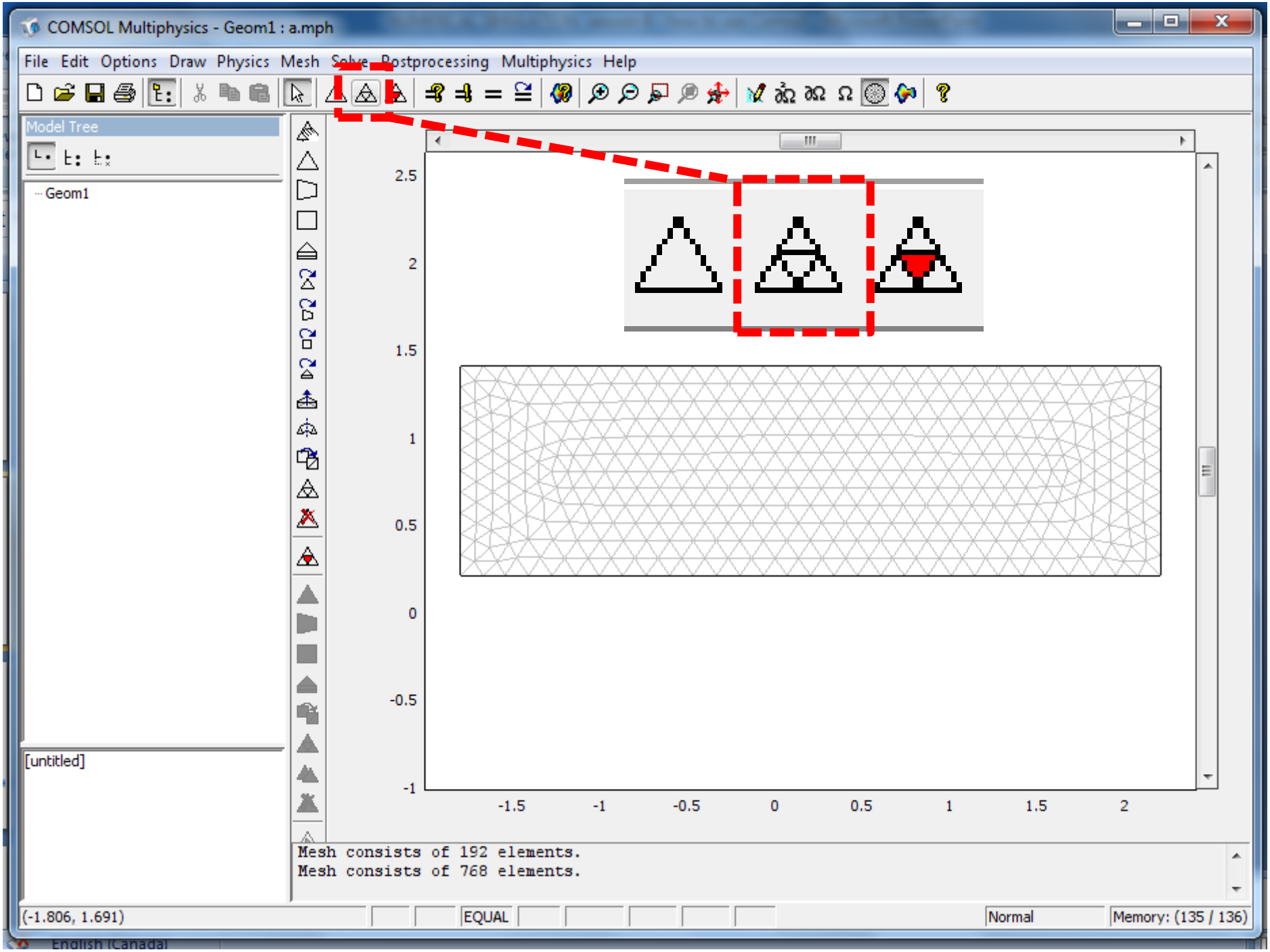
Mesh consists of 192 elements.

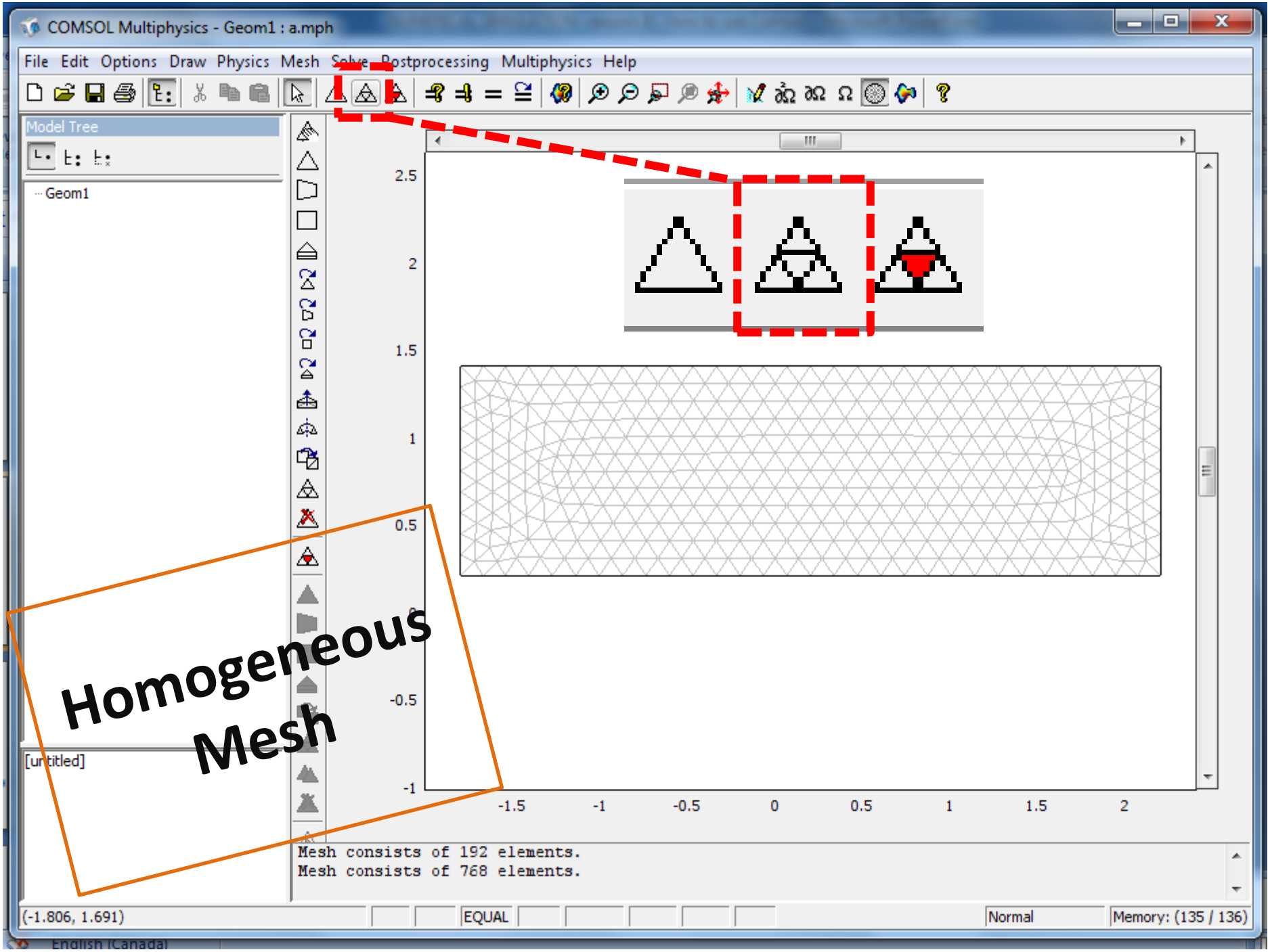
(-1.38, 2.458) EQUAL Normal Memory: (136 / 136)

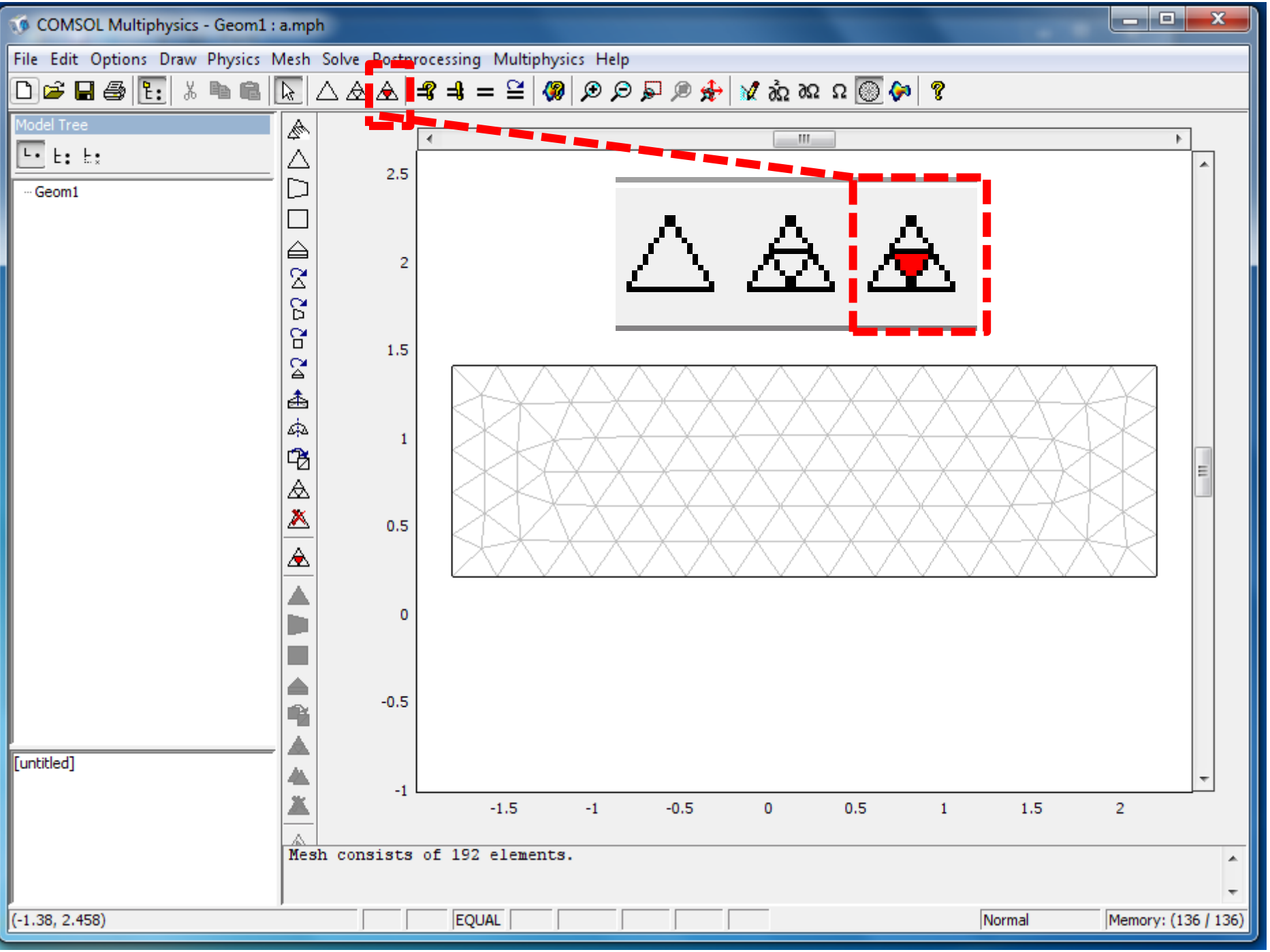

COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
1.5
2
Very coarse mesh
Mesh consists of 192 elements.
(-1.38, 2.458)
EQUAL
Normal
Memory: (136 / 136)

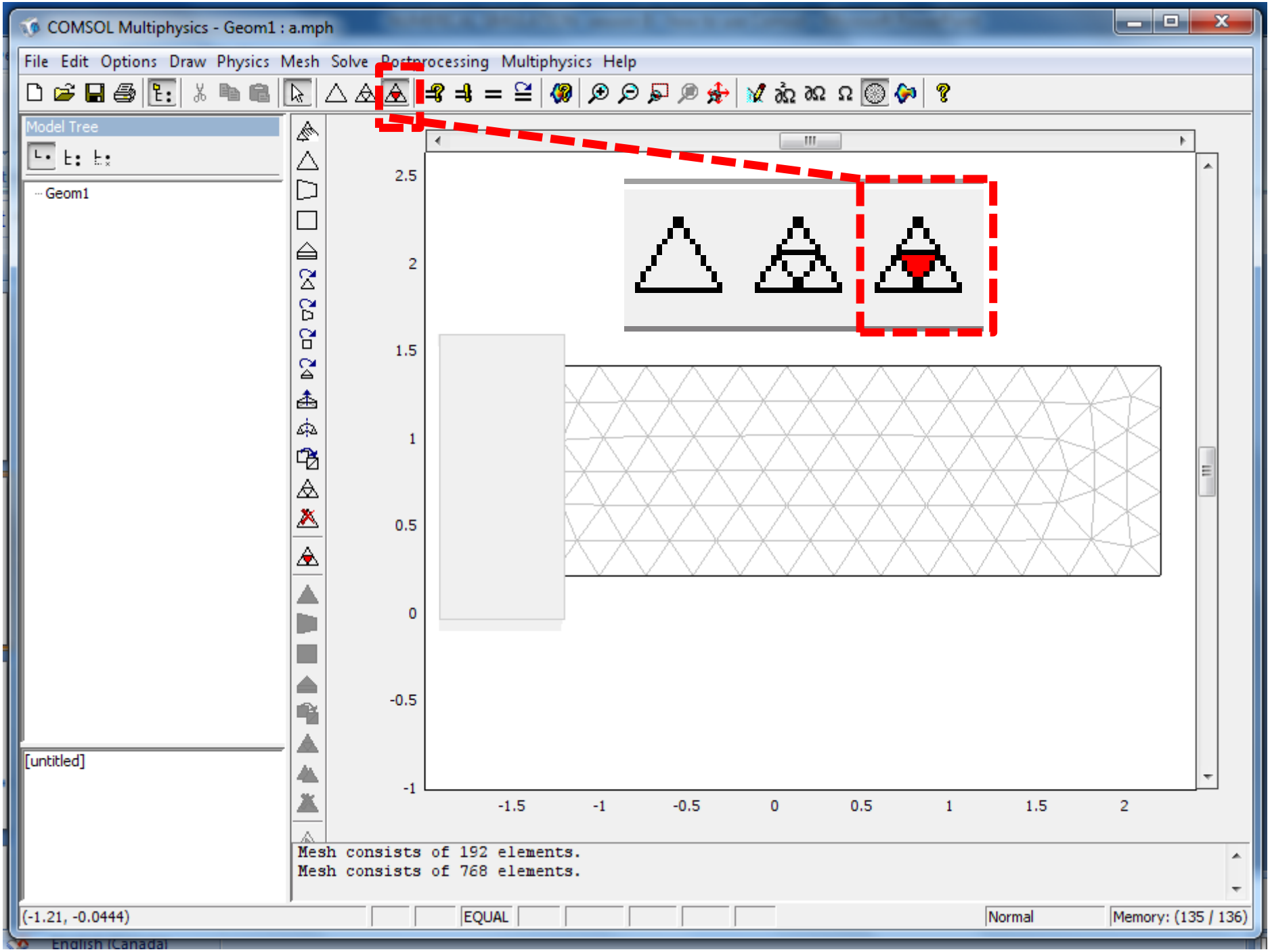

COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5 -1 -0.5 0 0.5 1 1.5 2
Mesh consists of 192 elements.
(-1.38, 2.458)
EQUAL
Normal
Memory: (136 / 136)

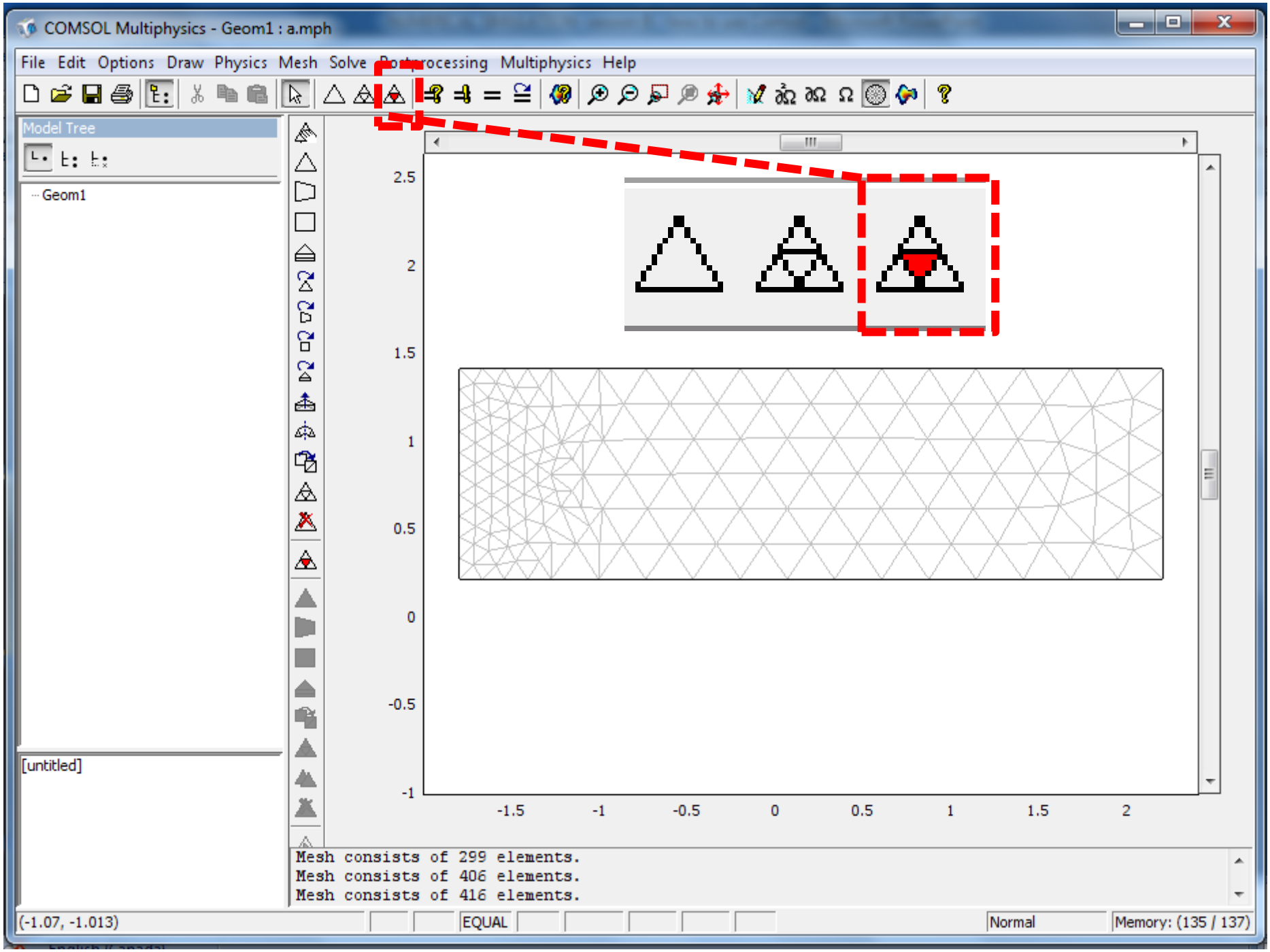

COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5 -1 -0.5 0 0.5 1 1.5 2
Mesh consists of 192 elements.
(-1.38, 2.458)
EQUAL
Normal
Memory: (136 / 136)

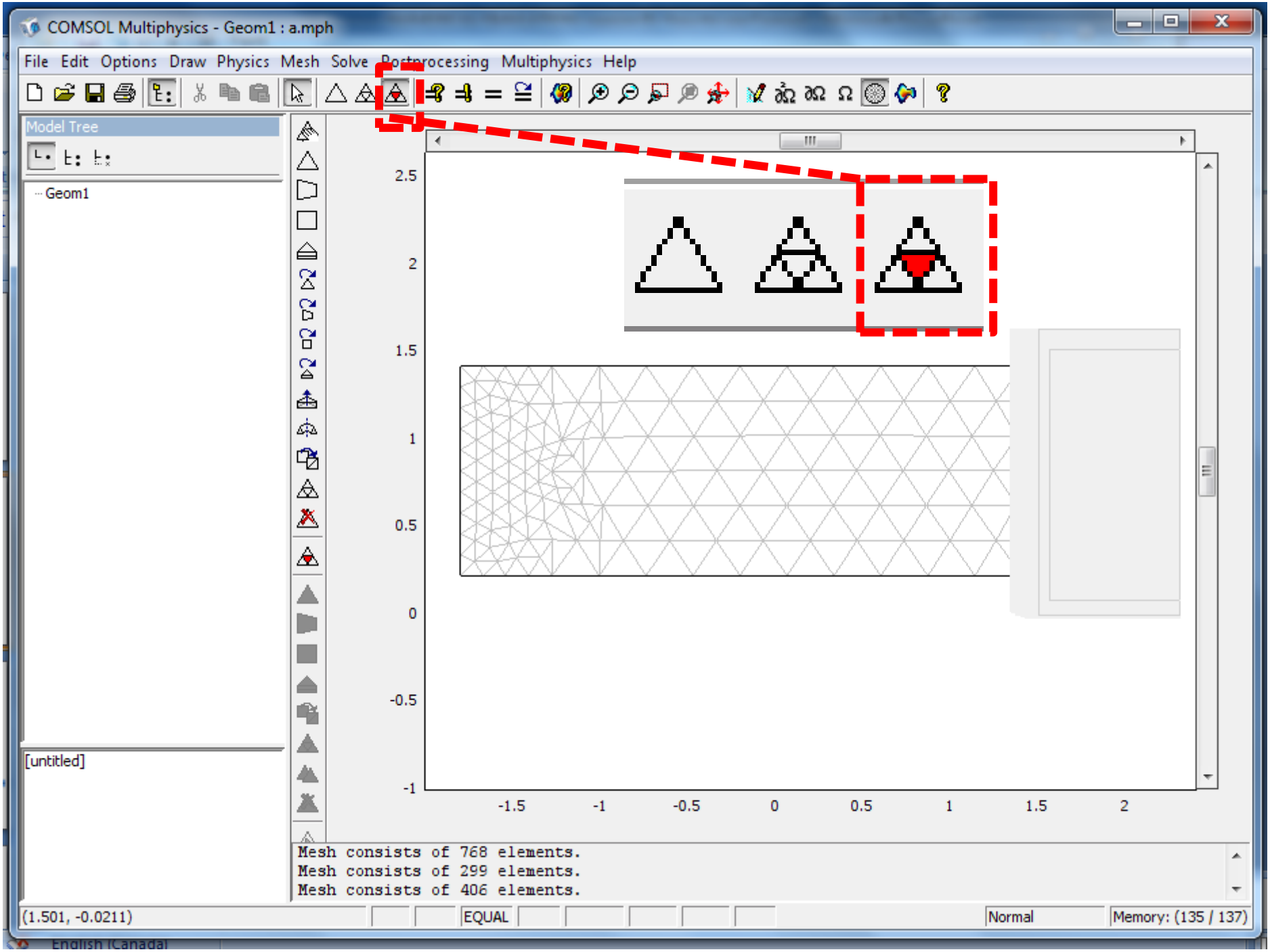

COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5 -1 -0.5 0 0.5 1 1.5 2
Mesh consists of 192 elements.
Mesh consists of 768 elements.
(-1.806, 1.691)
EQUAL
Normal
Memory: (135 / 136)

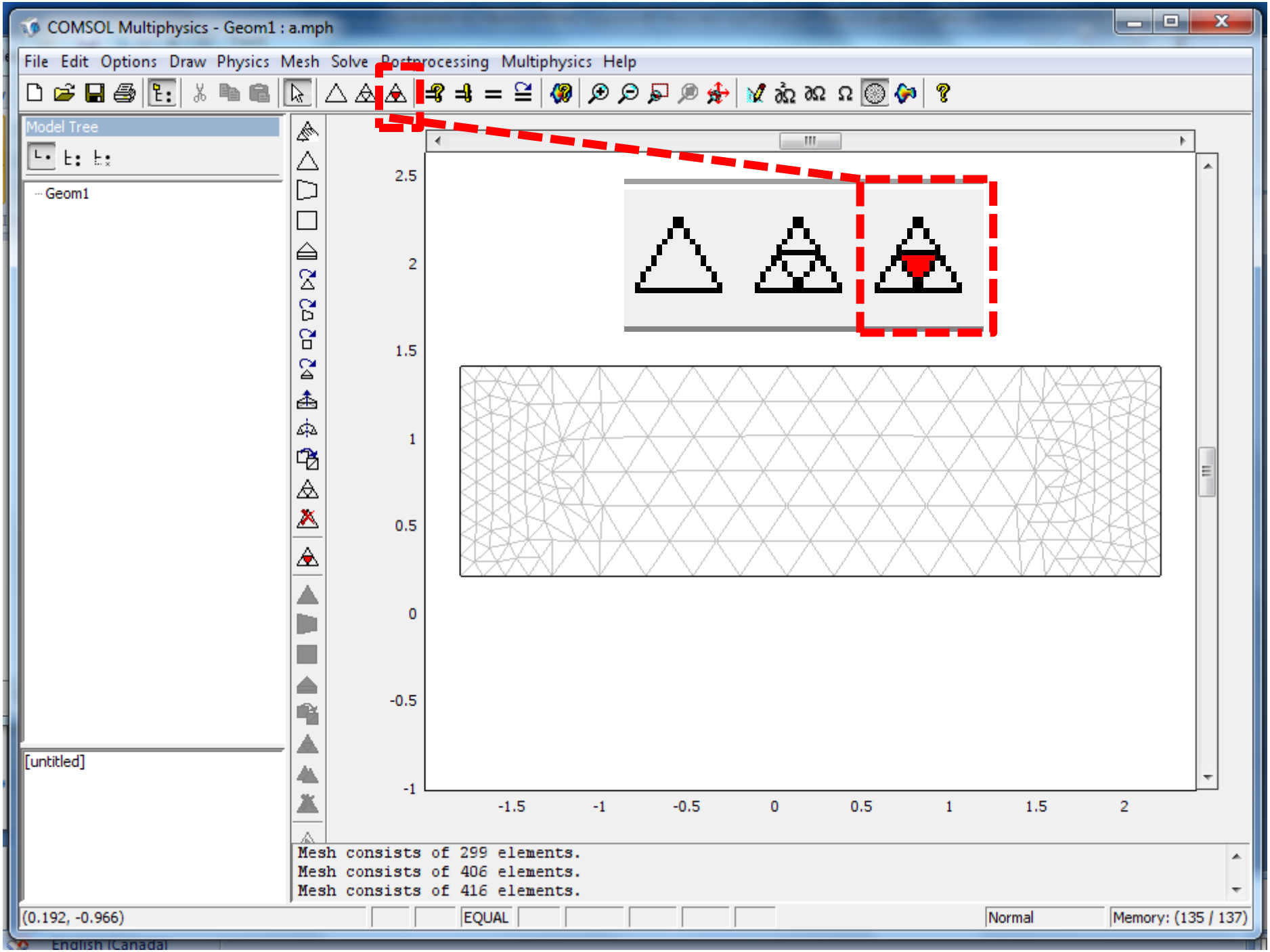

COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
1.5
2
Mesh consists of 192 elements.
Mesh consists of 768 elements.
(-1.806, 1.691)
EQUAL
Normal
Memory: (135 / 136)
Homogeneous Mesh

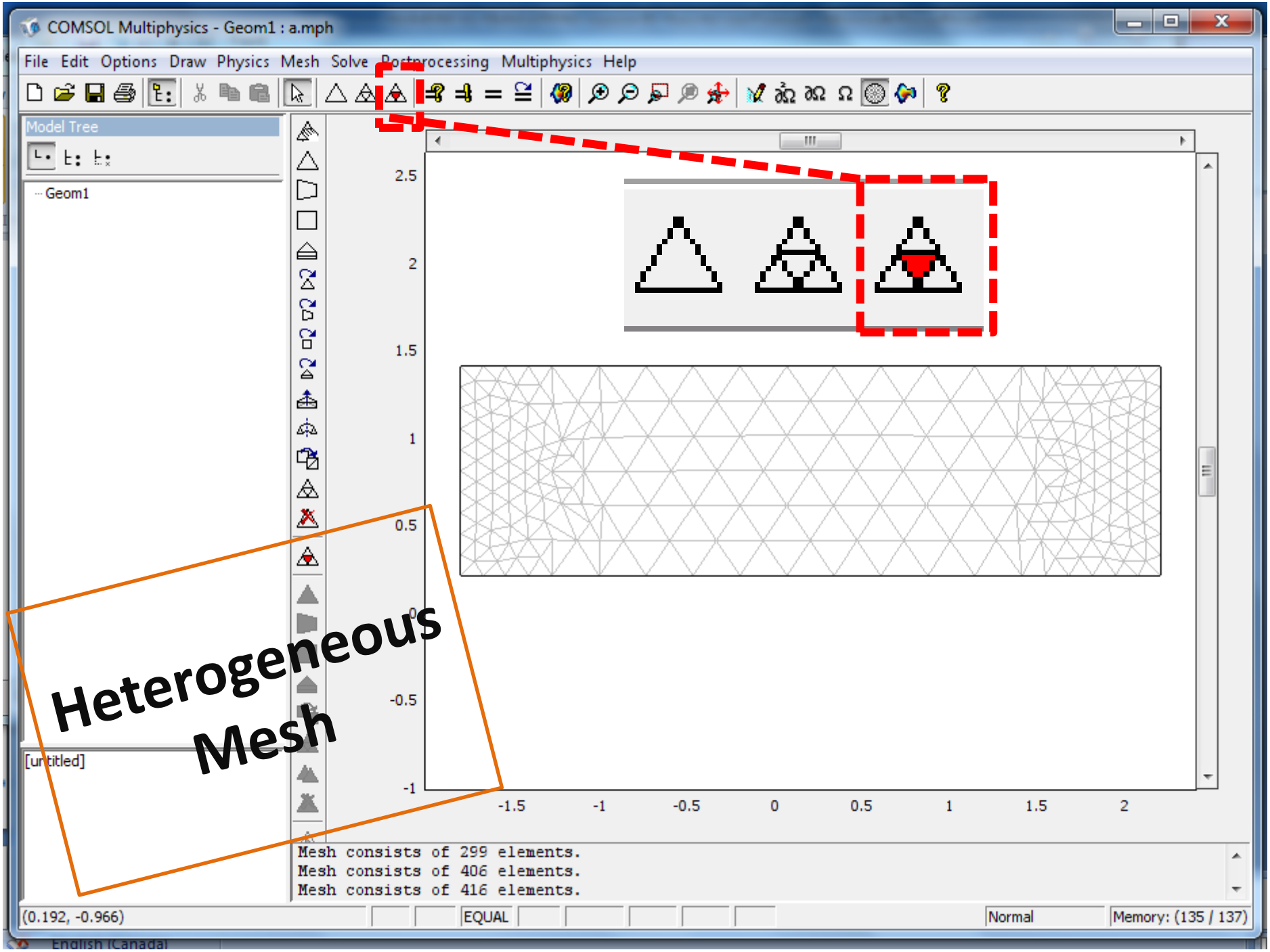

COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5 -1 -0.5 0 0.5 1 1.5 2
Mesh consists of 192 elements.
(-1.38, 2.458)
EQUAL
Normal
Memory: (136 / 136)


COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5 -1 -0.5 0 0.5 1 1.5 2
Mesh consists of 192 elements.
Mesh consists of 768 elements.
(-1.21, -0.0444)
EQUAL
Normal
Memory: (135 / 136)


COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5 -1 -0.5 0 0.5 1 1.5 2
Mesh consists of 299 elements.
Mesh consists of 406 elements.
Mesh consists of 416 elements.
(-1.07, -1.013)
EQUAL
Normal
Memory: (135 / 137)


COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5 -1 -0.5 0 0.5 1 1.5 2
Mesh consists of 768 elements.
Mesh consists of 299 elements.
Mesh consists of 406 elements.
(1.501, -0.0211)
EQUAL
Normal
Memory: (135 / 137)


COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5 -1 -0.5 0 0.5 1 1.5 2
Mesh consists of 299 elements.
Mesh consists of 406 elements.
Mesh consists of 416 elements.
(0.192, -0.966)
EQUAL
Normal
Memory: (135 / 137)

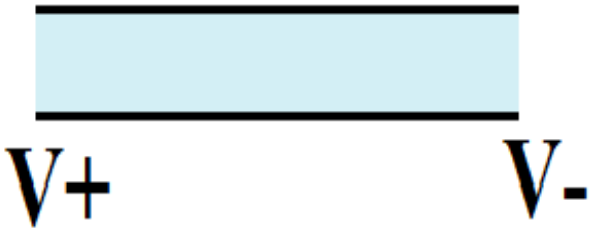

COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Heterogeneous Mesh
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5 -1 -0.5 0 0.5 1 1.5 2
Mesh consists of 299 elements.
Mesh consists of 406 elements.
Mesh consists of 416 elements.
(0.192, -0.966)
EQUAL
Normal
Memory: (135 / 137)

Step 4:

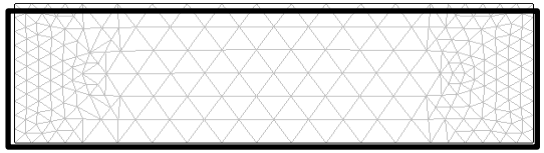
Determine the physics of your model

RECALL

The physics of problem



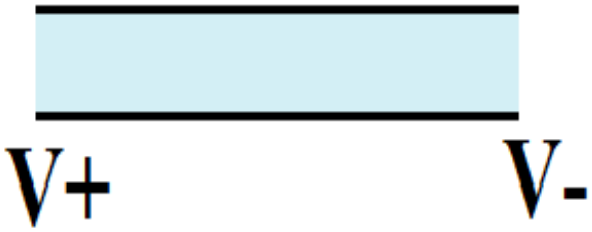
- Straight Microchannel
  - **2D: Rectangular geometry**

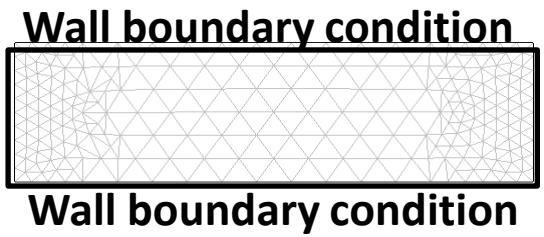


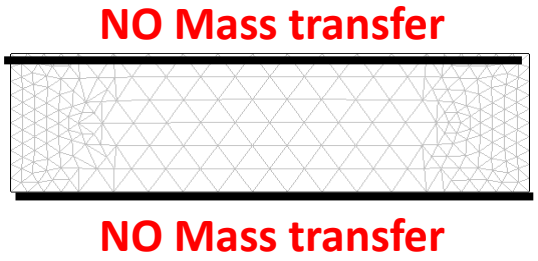
RECALL

The physics of problem

- Straight Microchannel
  - **2D: Rectangular geometry**
  - **Wall boundary condition**
  - **No mass transfer throw walls**

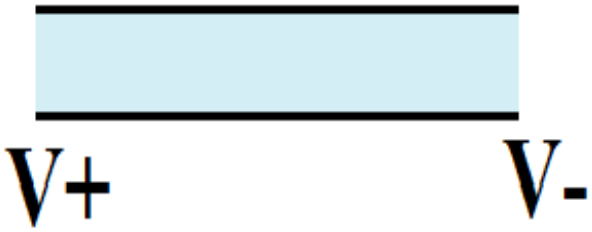




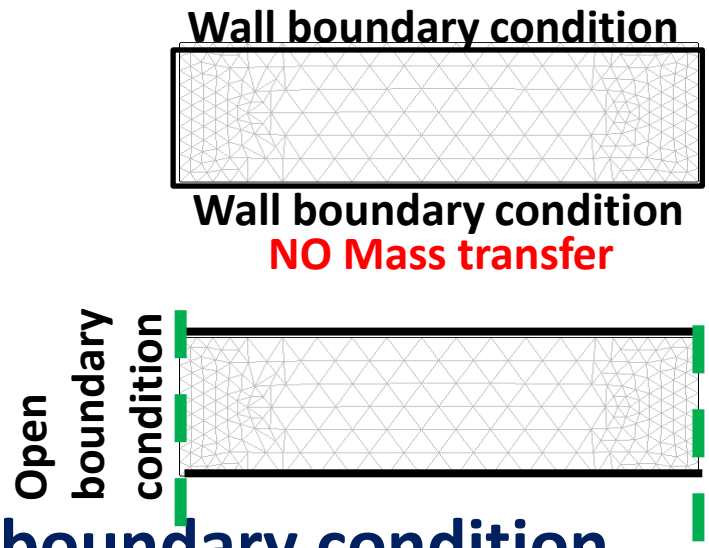


RECALL

The physics of problem

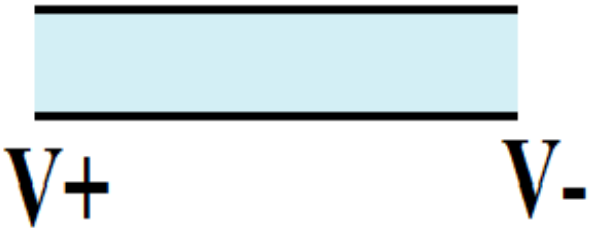


- Straight Microchannel
  - **2D: Rectangular geometry**
  - **Wall boundary condition**
  - **No mass transfer throw walls**
- Two big reservoirs
  - **Replace them with the open boundary condition**

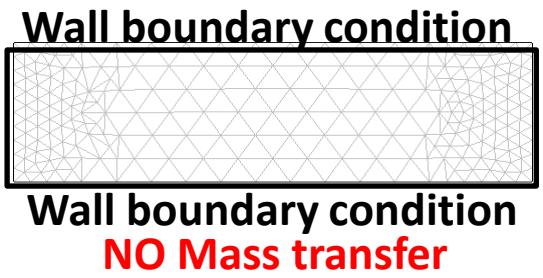


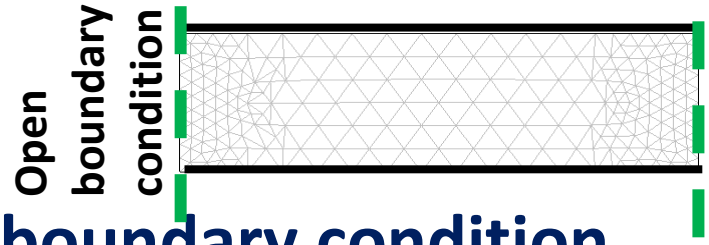
RECALL

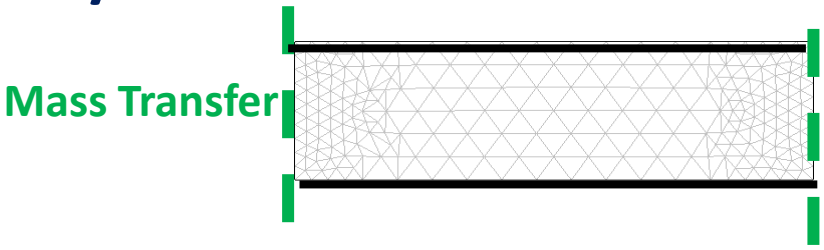
The physics of problem



- Straight Microchannel
  - **2D: Rectangular geometry**
  - **Wall boundary condition**
  - **No mass transfer throw walls**
- Two big reservoirs
  - **Replace them with the open boundary condition**
  - **No mass transfer throw inlet/outlet**

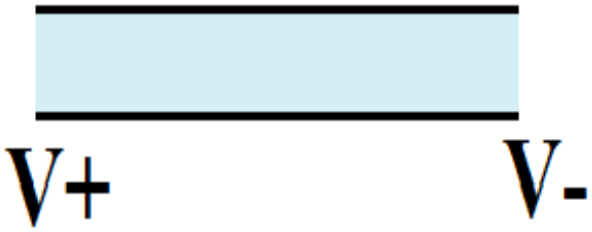




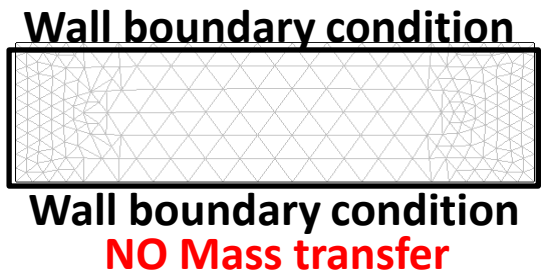


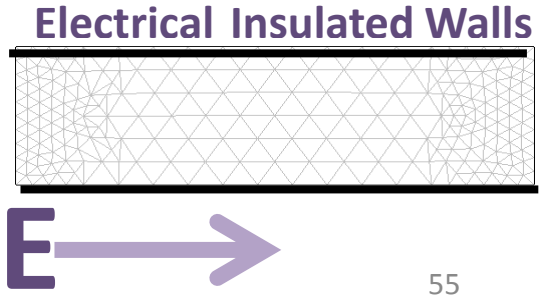
RECALL

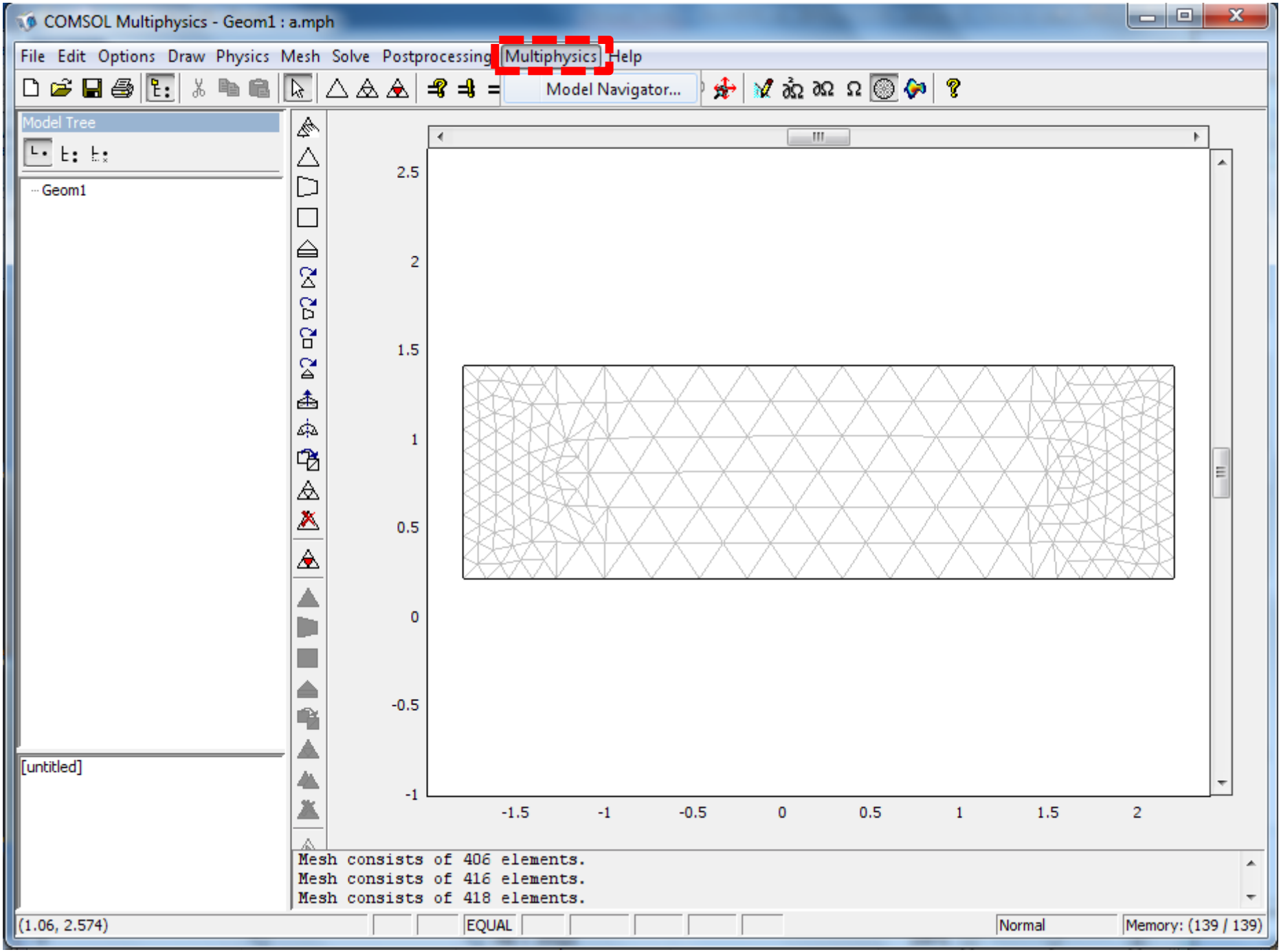
The physics of problem

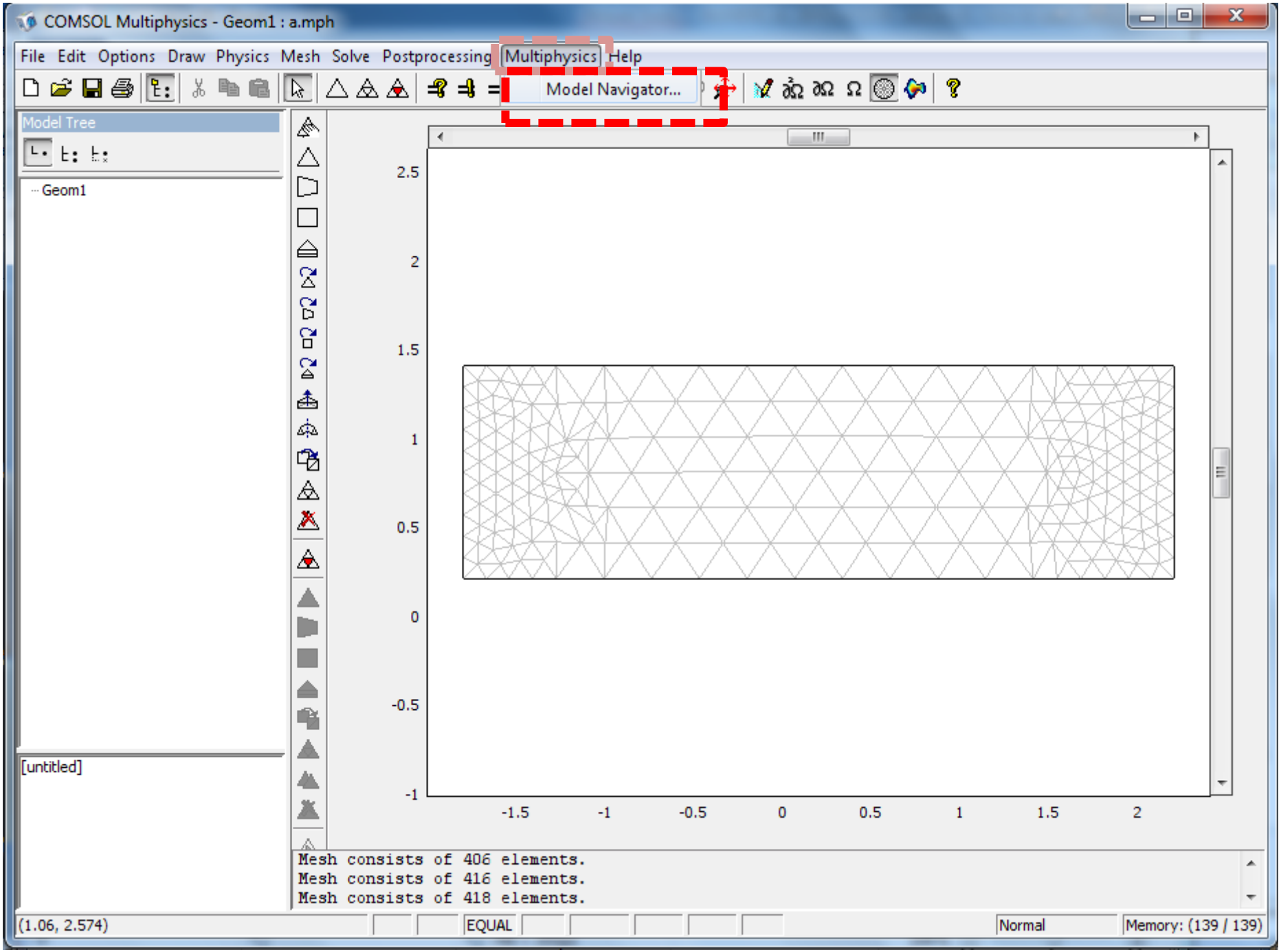


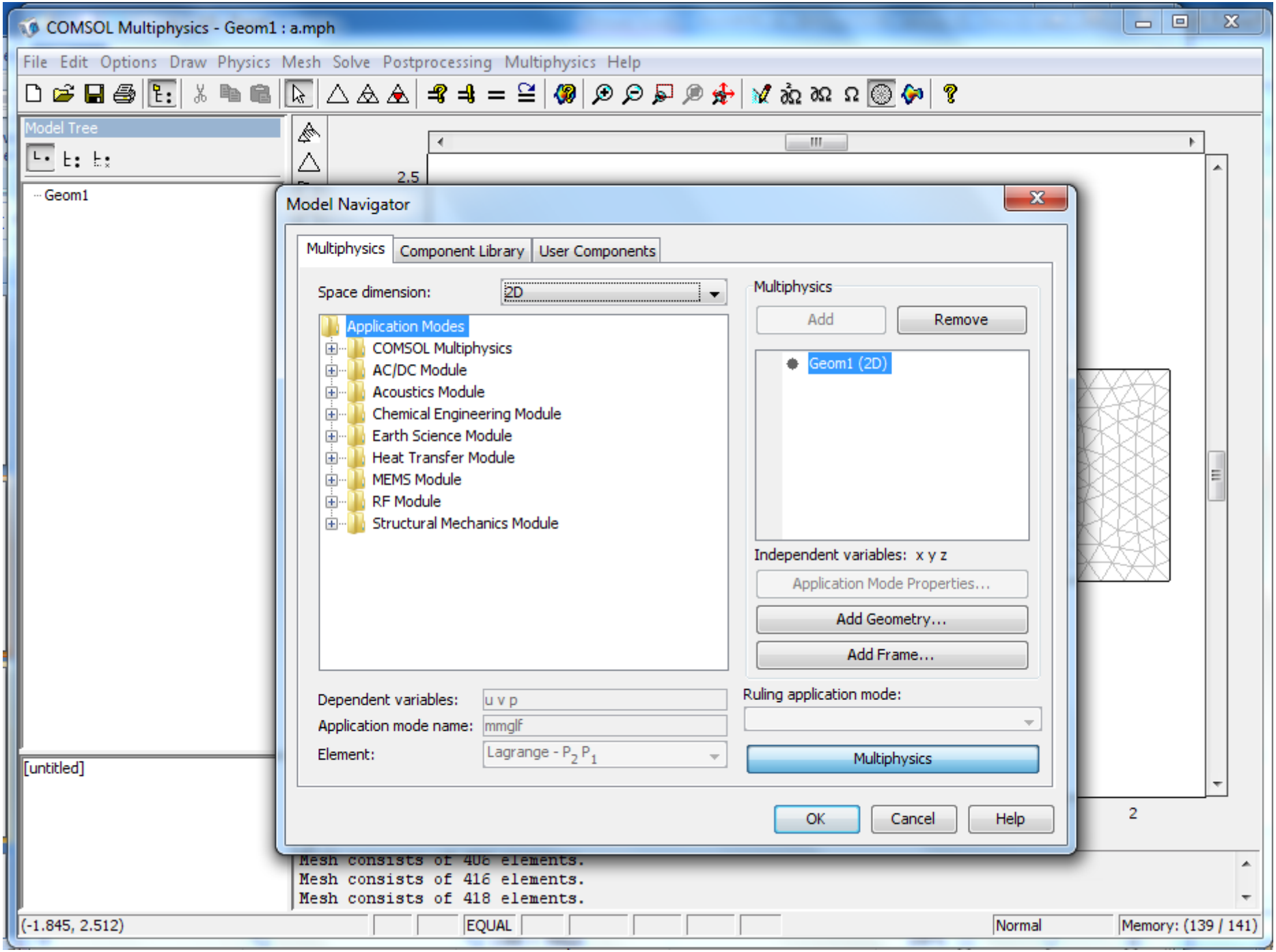
- Straight Microchannel
  - **2D: Rectangular geometry**
  - **Wall boundary condition**
  - **No mass transfer throw walls**
- Two big reservoirs
  - **Replace them with the open boundary condition**
  - **No mass transfer throw inlet/outlet**
- Voltage applies to the system
  - **DC Conductive Media**
  - **Electrical Insulated Walls**

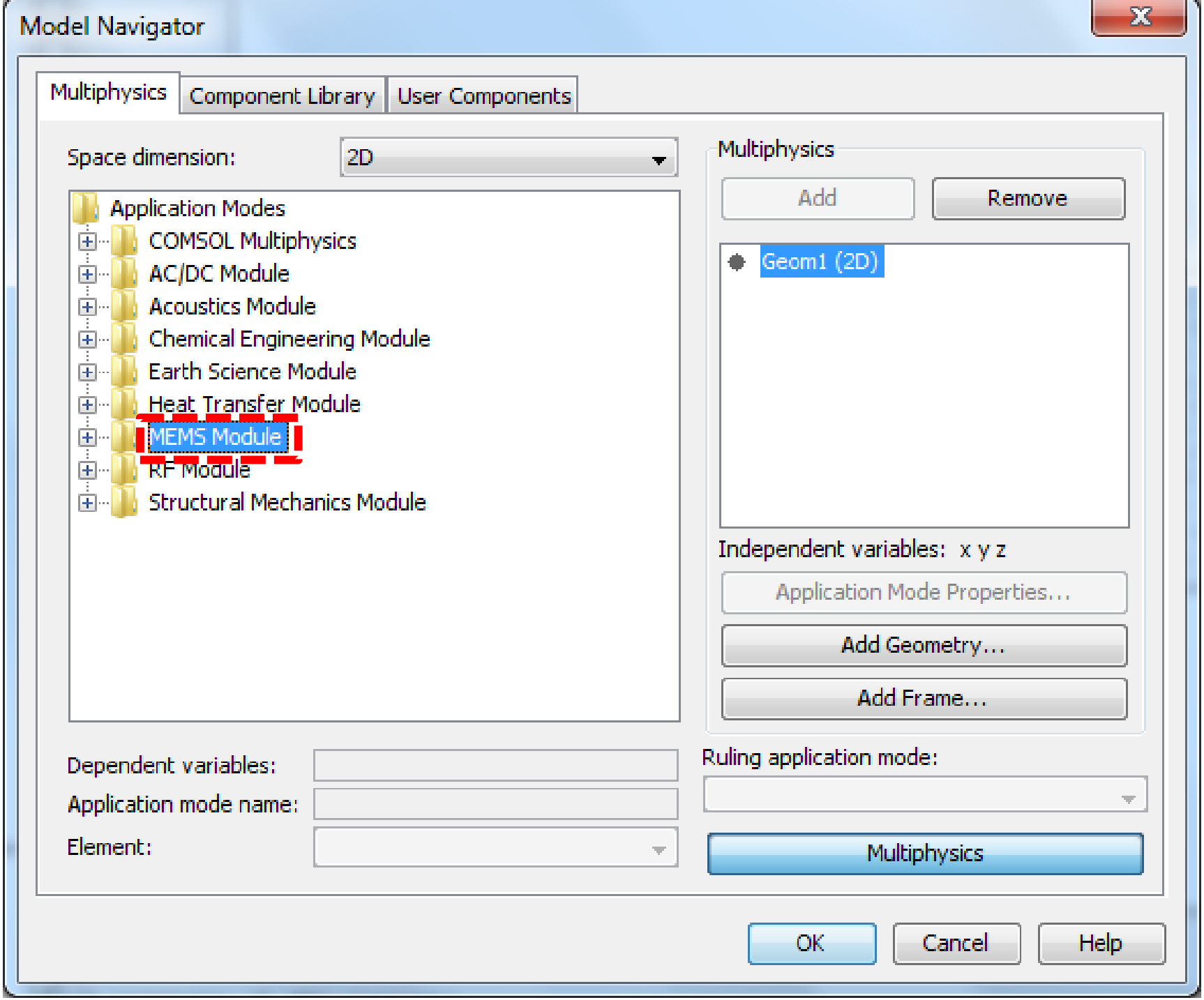


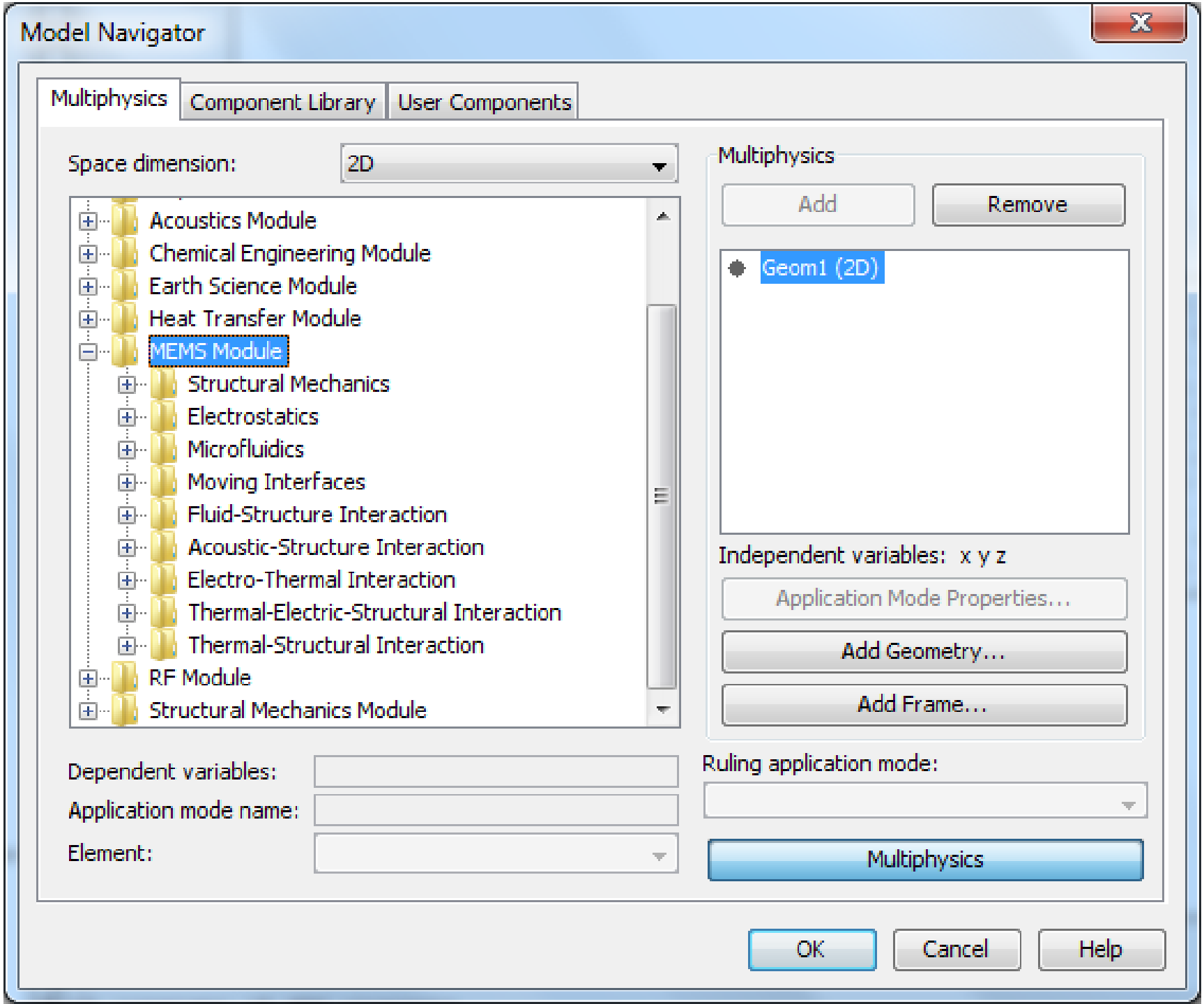


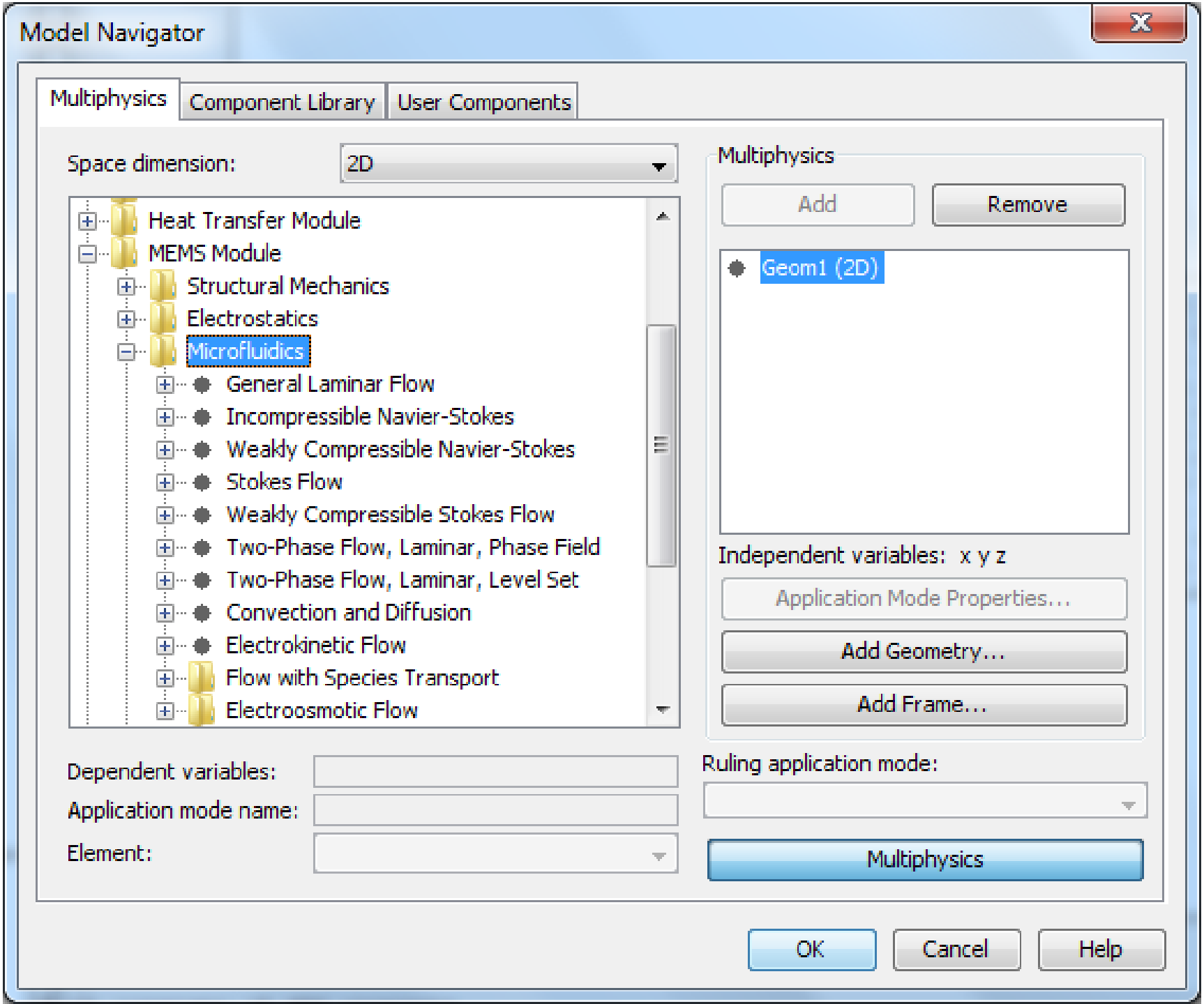

COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Navigator...
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5 -1 -0.5 0 0.5 1 1.5 2
Mesh consists of 406 elements.
Mesh consists of 416 elements.
Mesh consists of 418 elements.
(1.06, 2.574)
EQUAL
Normal
Memory: (139 / 139)

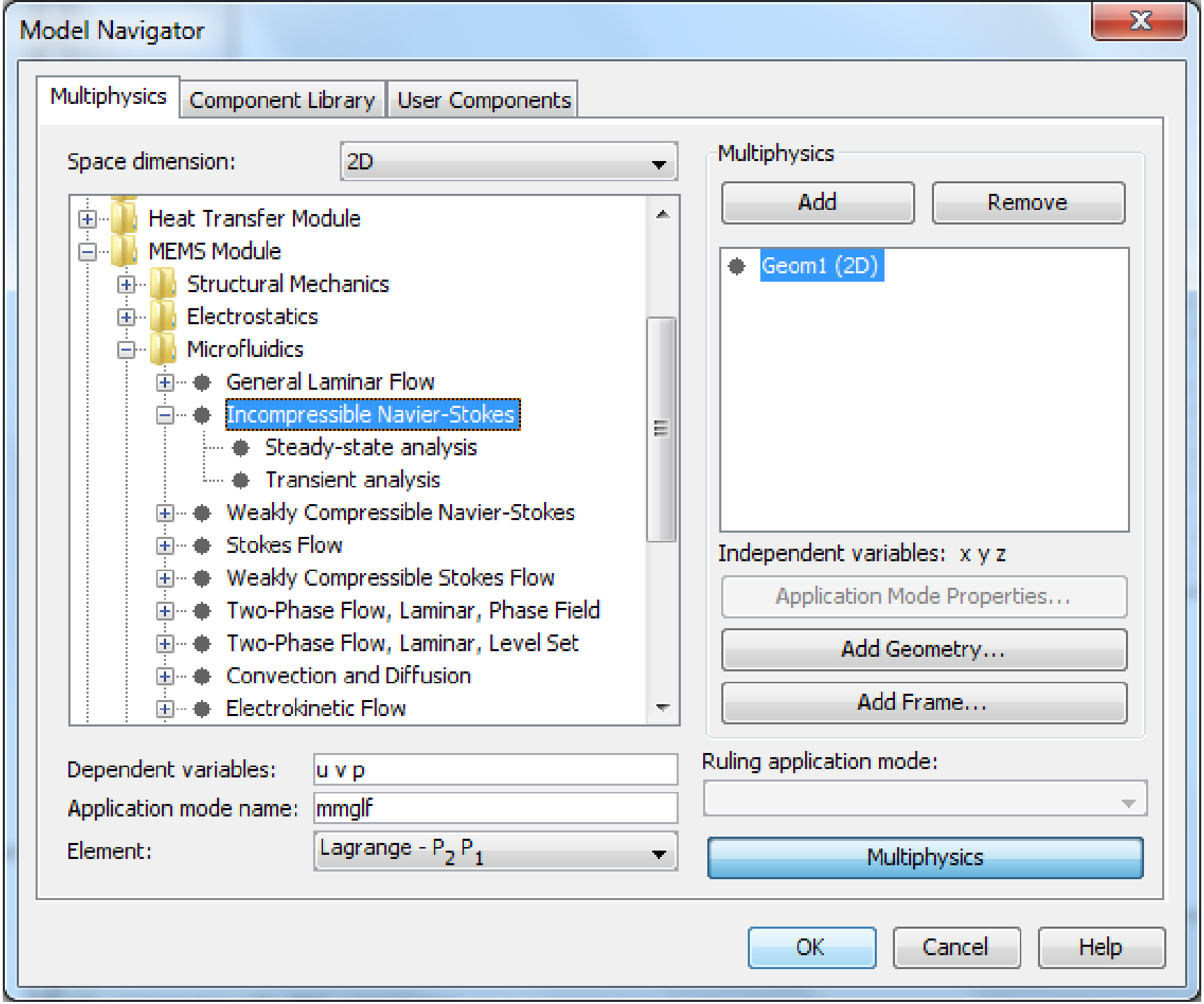

COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Navigator...
Model Tree
Geom1
[untitled]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5 -1 -0.5 0 0.5 1 1.5 2
Mesh consists of 406 elements.
Mesh consists of 416 elements.
Mesh consists of 418 elements.
(1.06, 2.574)
EQUAL
Normal
Memory: (139 / 139)

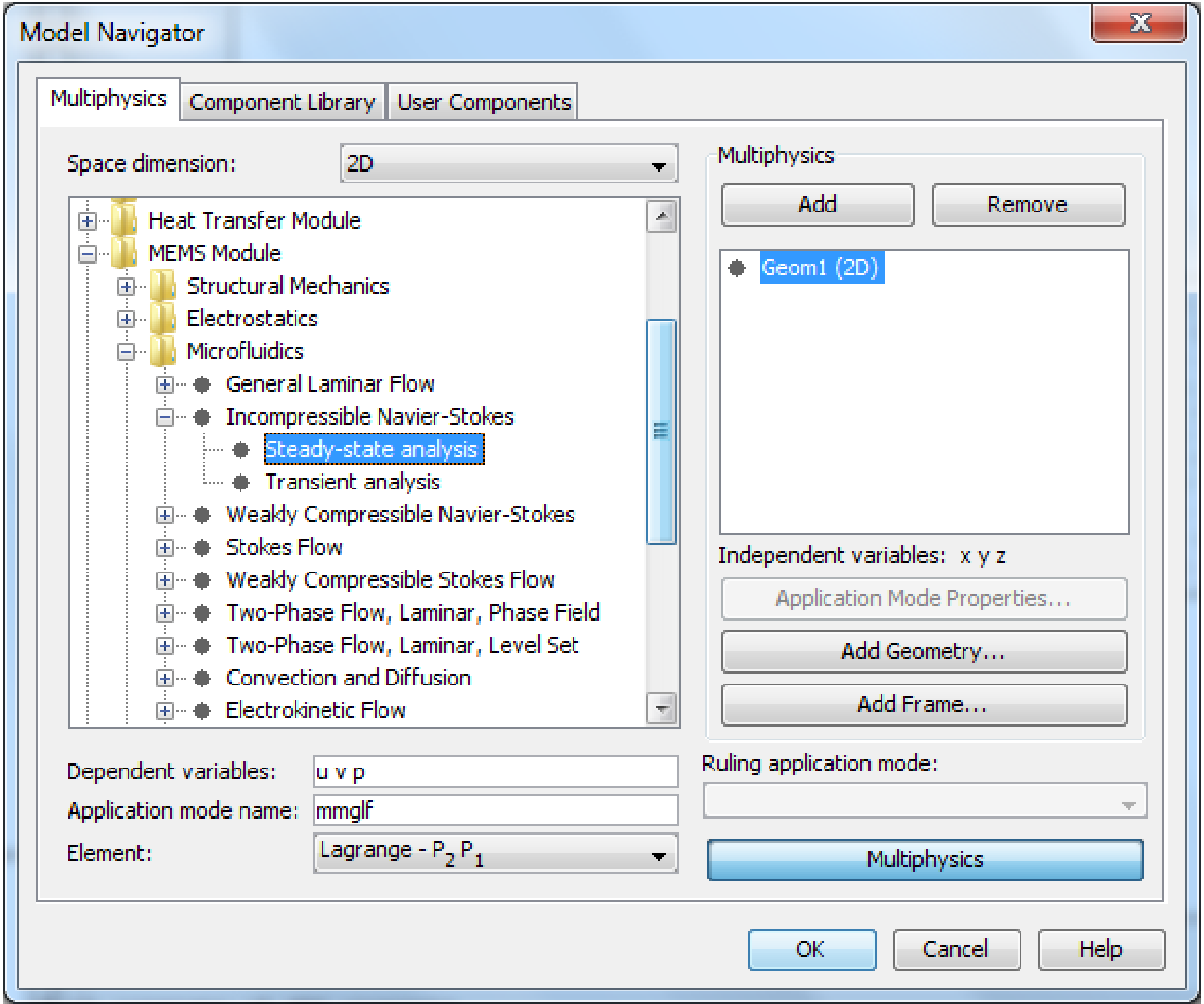

COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Application Modes
COMSOL Multiphysics
AC/DC Module
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
RF Module
Structural Mechanics Module
Multiphysics
Add
Remove
Geom1 (2D)
Independent variables: x y z
Application Mode Properties...
Add Geometry...
Add Frame...
Dependent variables: u v p
Application mode name: mmglf
Element: Lagrange - P2 P1
Ruling application mode:
Multiphysics
OK
Cancel
Help
Mesh consists of 406 elements.
Mesh consists of 416 elements.
Mesh consists of 418 elements.
(-1.845, 2.512)
EQUAL
Normal
Memory: (139 / 141)

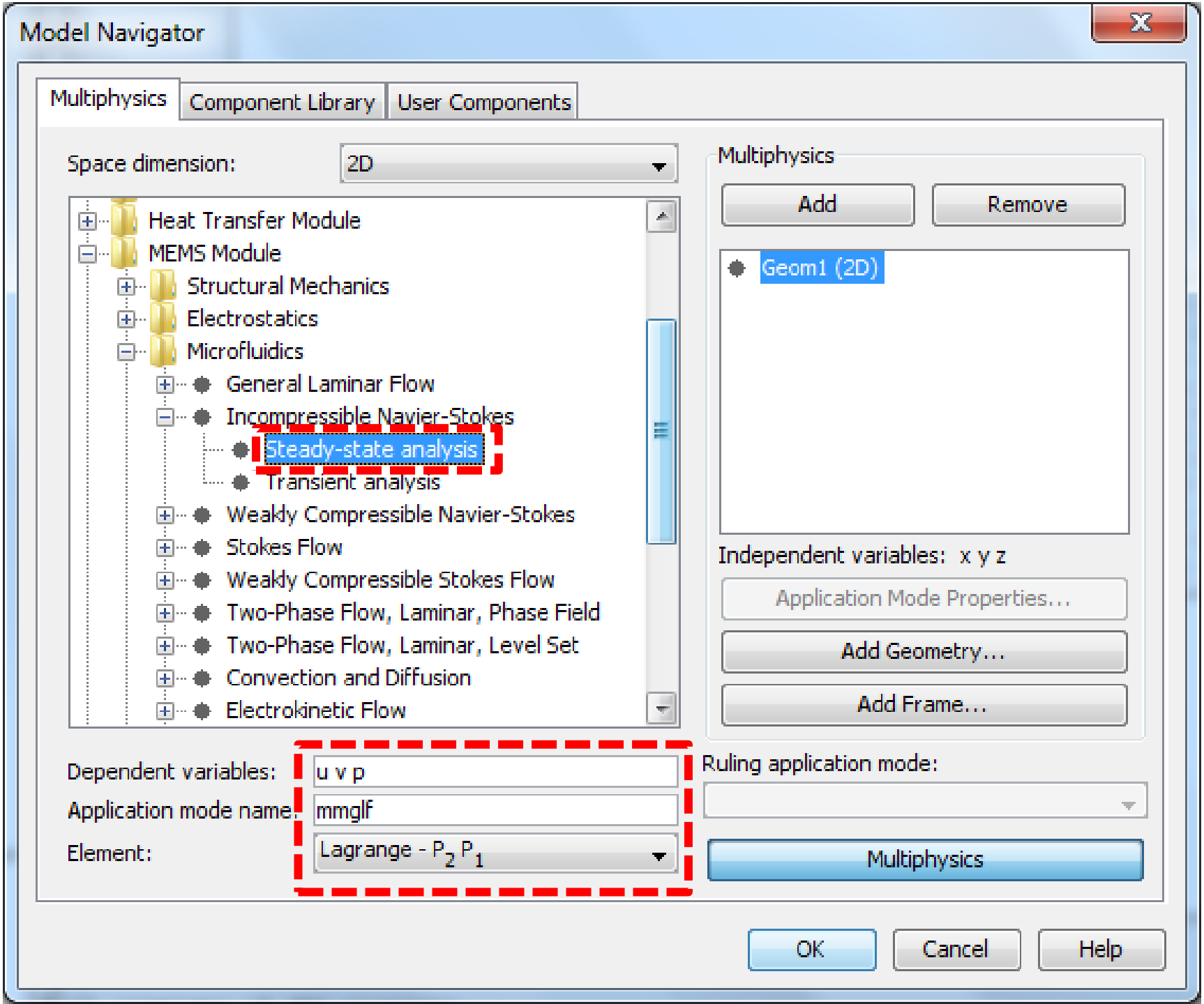

Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Application Modes
COMSOL Multiphysics
AC/DC Module
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
RF Module
Structural Mechanics Module
Multiphysics
Add
Remove
Geom1 (2D)
Independent variables: x y z
Application Mode Properties...
Add Geometry...
Add Frame...
Dependent variables:
Application mode name:
Element:
Ruling application mode:
Multiphysics
OK
Cancel
Help

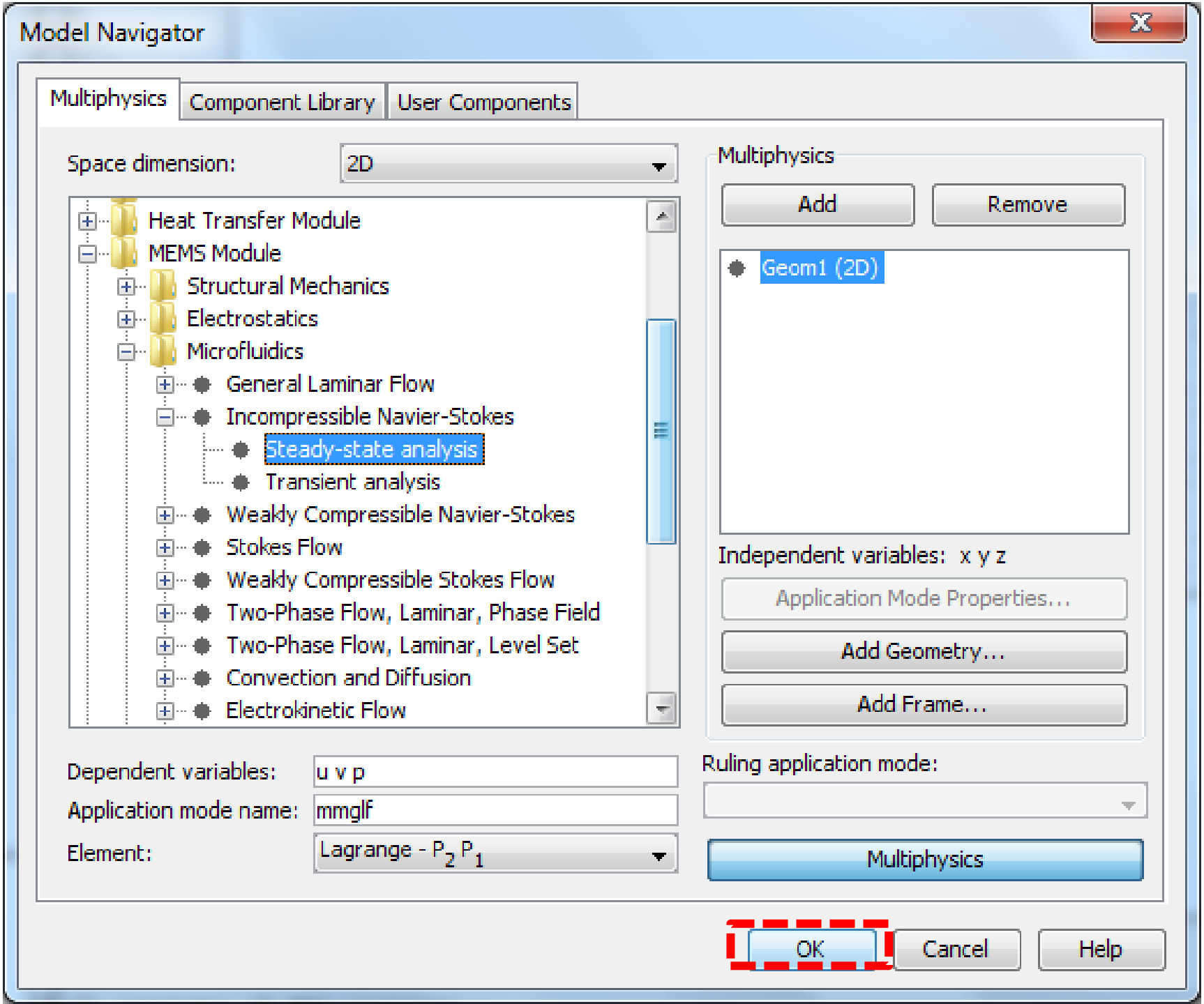

Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
Structural Mechanics
Electrostatics
Microfluidics
Moving Interfaces
Fluid-Structure Interaction
Acoustic-Structure Interaction
Electro-Thermal Interaction
Thermal-Electric-Structural Interaction
Thermal-Structural Interaction
RF Module
Structural Mechanics Module
Multiphysics
Add
Remove
Geom1 (2D)
Independent variables: x y z
Application Mode Properties...
Add Geometry...
Add Frame...
Dependent variables:
Application mode name:
Element:
Ruling application mode:
Multiphysics
OK
Cancel
Help

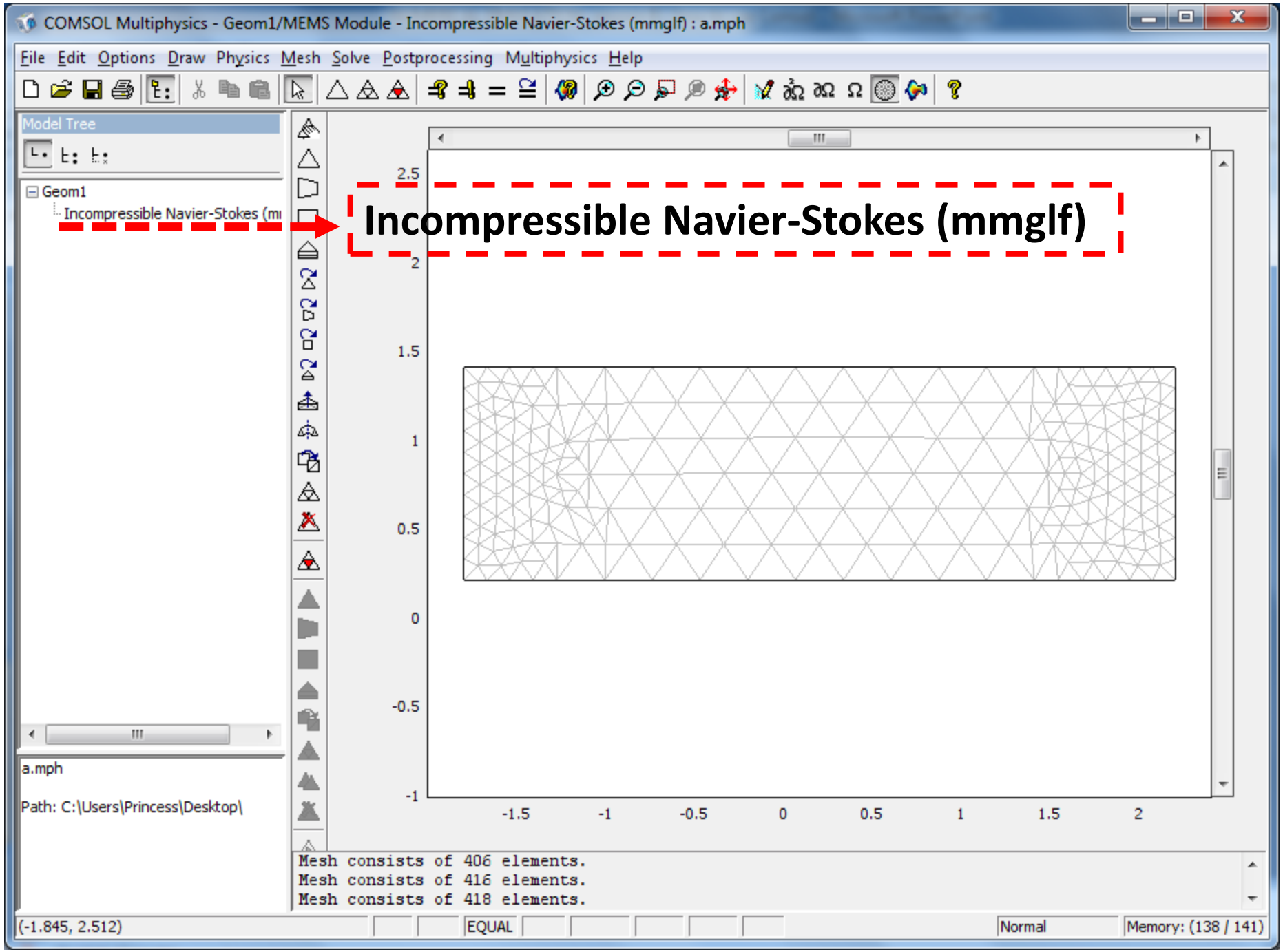

Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Heat Transfer Module
MEMS Module
Structural Mechanics
Electrostatics
Microfluidics
General Laminar Flow
Incompressible Navier-Stokes
Weakly Compressible Navier-Stokes
Stokes Flow
Weakly Compressible Stokes Flow
Two-Phase Flow, Laminar, Phase Field
Two-Phase Flow, Laminar, Level Set
Convection and Diffusion
Electrokinetic Flow
Flow with Species Transport
Electroosmotic Flow
Multiphysics
Add
Remove
Geom1 (2D)
Independent variables: x y z
Application Mode Properties...
Add Geometry...
Add Frame...
Dependent variables:
Application mode name:
Element:
Ruling application mode:
Multiphysics
OK
Cancel
Help

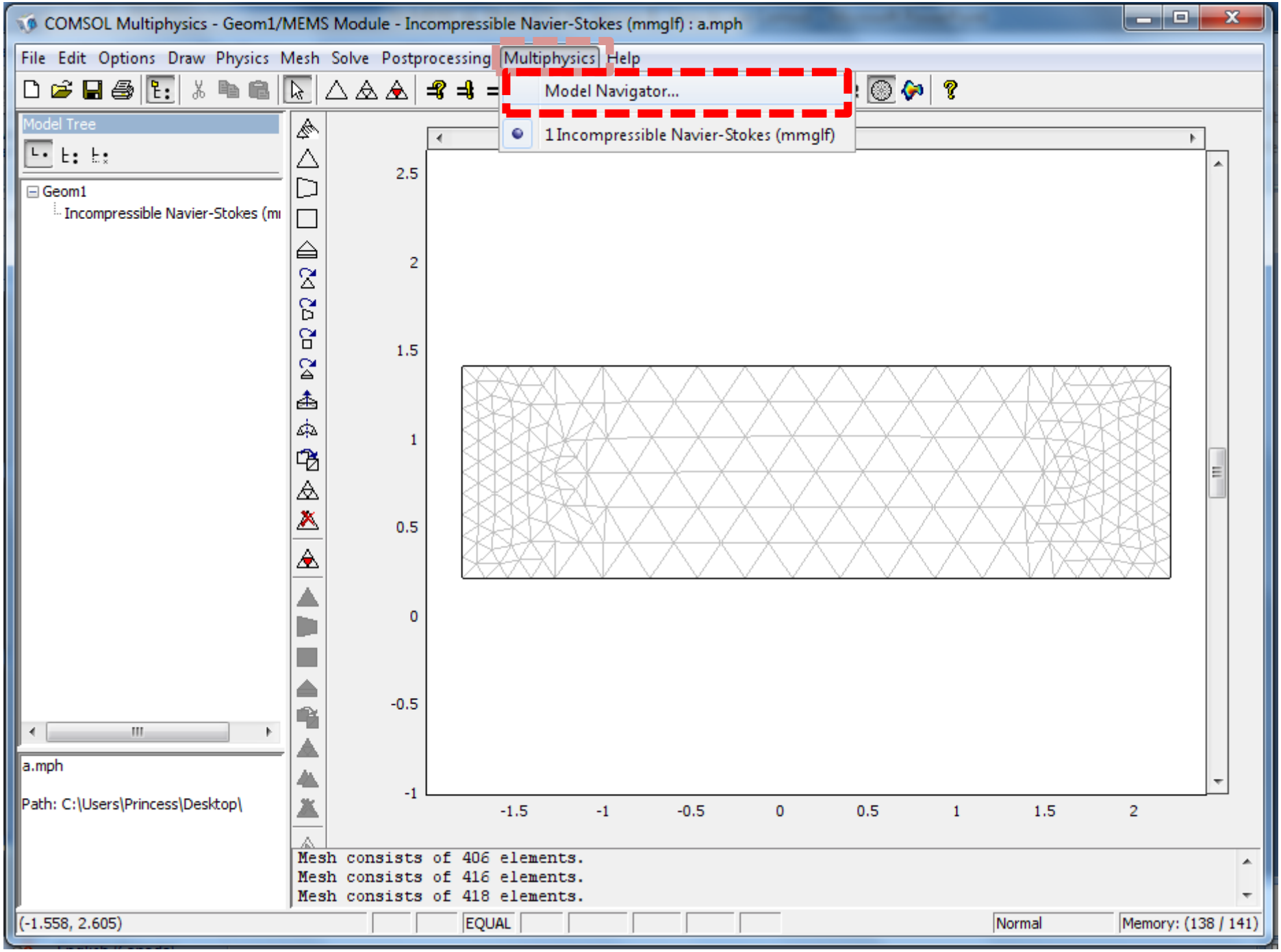

Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Heat Transfer Module
MEMS Module
Structural Mechanics
Electrostatics
Microfluidics
General Laminar Flow
Incompressible Navier-Stokes
Steady-state analysis
Transient analysis
Weakly Compressible Navier-Stokes
Stokes Flow
Weakly Compressible Stokes Flow
Two-Phase Flow, Laminar, Phase Field
Two-Phase Flow, Laminar, Level Set
Convection and Diffusion
Electrokinetic Flow
Multiphysics
Add
Remove
Geom1 (2D)
Independent variables: x y z
Application Mode Properties...
Add Geometry...
Add Frame...
Dependent variables:
u v p
Application mode name:
mmglf
Element:
Lagrange - P2 P1
Ruling application mode:
Multiphysics
OK
Cancel
Help

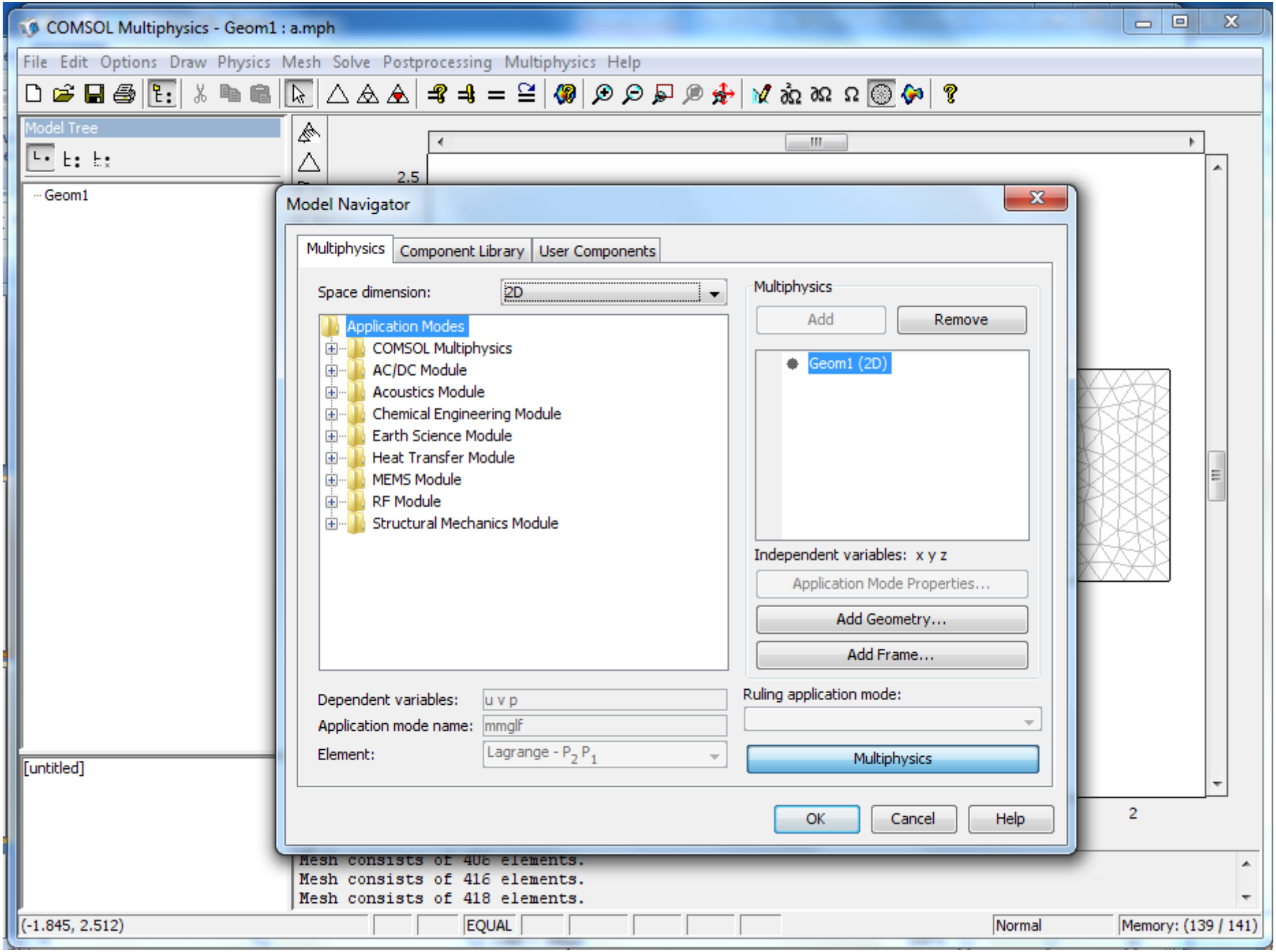

Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Heat Transfer Module
MEMS Module
Structural Mechanics
Electrostatics
Microfluidics
General Laminar Flow
Incompressible Navier-Stokes
Steady-state analysis
Transient analysis
Weakly Compressible Navier-Stokes
Stokes Flow
Weakly Compressible Stokes Flow
Two-Phase Flow, Laminar, Phase Field
Two-Phase Flow, Laminar, Level Set
Convection and Diffusion
Electrokinetic Flow
Multiphysics
Add
Remove
Geom1 (2D)
Independent variables: x y z
Application Mode Properties...
Add Geometry...
Add Frame...
Dependent variables:
u v p
Application mode name:
mmglf
Element:
Lagrange - P2 P1
Ruling application mode:
Multiphysics
OK
Cancel
Help

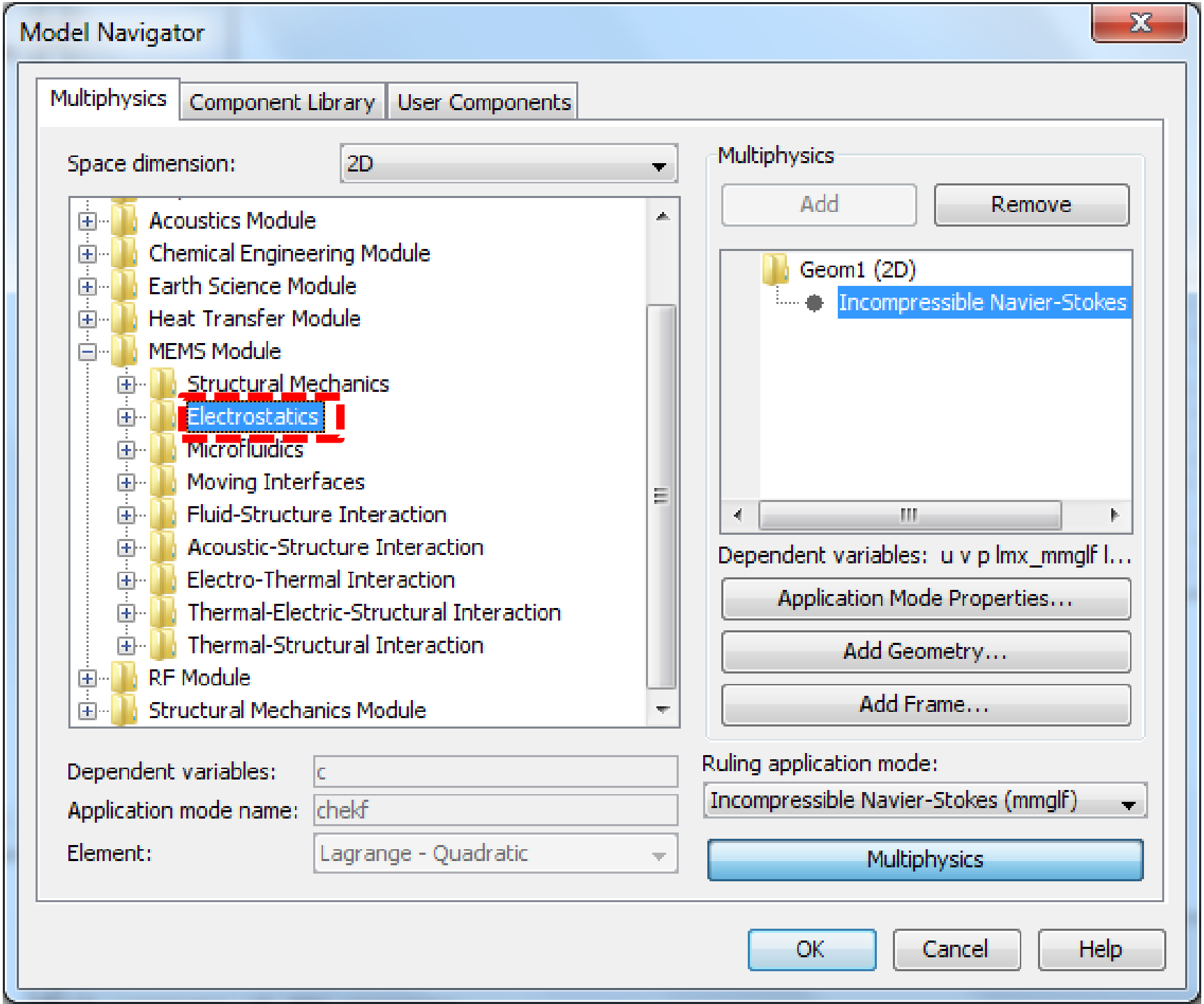

Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Heat Transfer Module
MEMS Module
Structural Mechanics
Electrostatics
Microfluidics
General Laminar Flow
Incompressible Navier-Stokes
Steady-state analysis
Transient analysis
Weakly Compressible Navier-Stokes
Stokes Flow
Weakly Compressible Stokes Flow
Two-Phase Flow, Laminar, Phase Field
Two-Phase Flow, Laminar, Level Set
Convection and Diffusion
Electrokinetic Flow
Multiphysics
Add
Remove
Geom1 (2D)
Independent variables: x y z
Application Mode Properties...
Add Geometry...
Add Frame...
Dependent variables:
u v p
Application mode name:
mmglf
Element:
Lagrange - P2 P1
Ruling application mode:
Multiphysics
OK
Cancel
Help

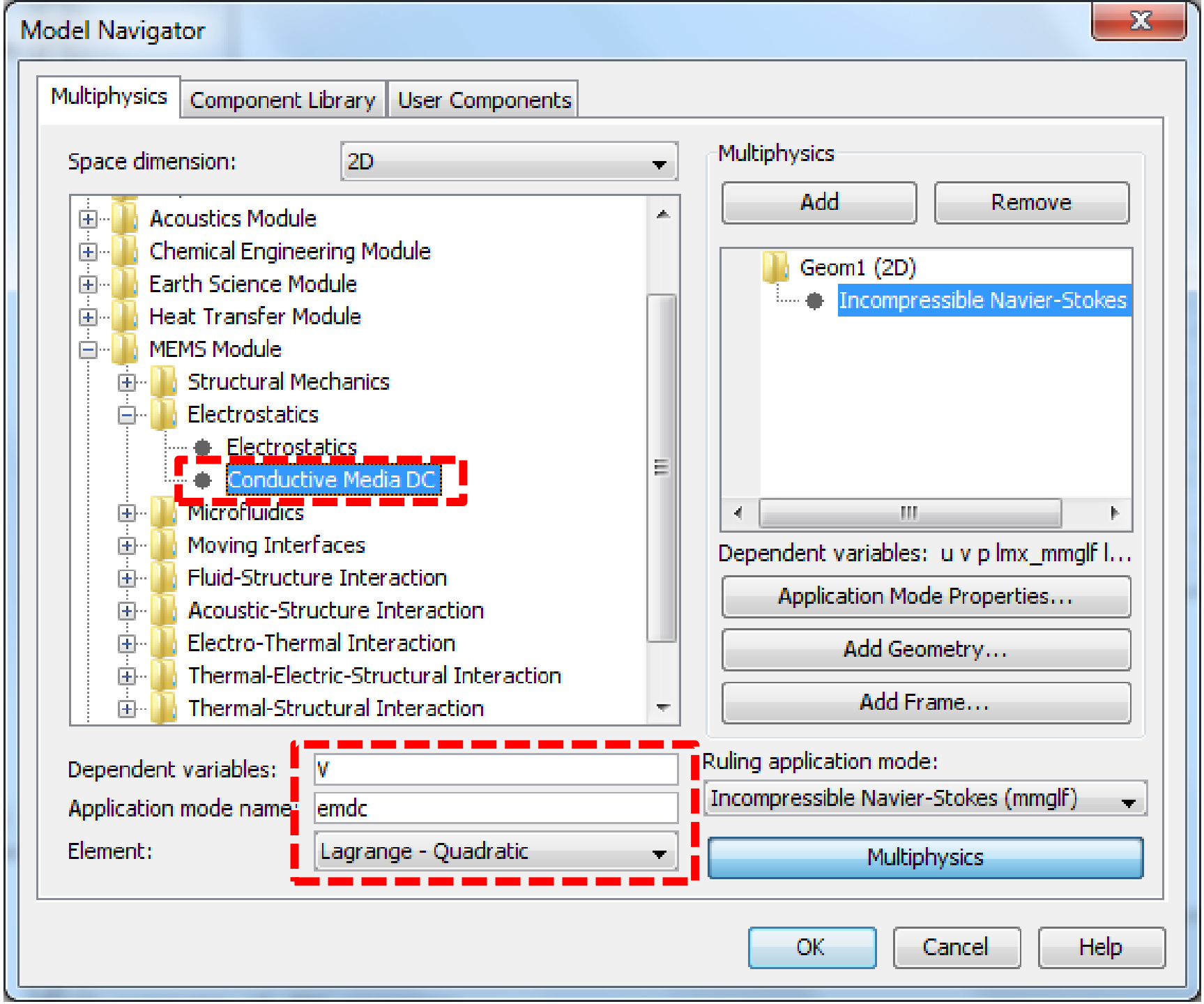

Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Heat Transfer Module
MEMS Module
Structural Mechanics
Electrostatics
Microfluidics
General Laminar Flow
Incompressible Navier-Stokes
Steady-state analysis
Transient analysis
Weakly Compressible Navier-Stokes
Stokes Flow
Weakly Compressible Stokes Flow
Two-Phase Flow, Laminar, Phase Field
Two-Phase Flow, Laminar, Level Set
Convection and Diffusion
Electrokinetic Flow
Multiphysics
Add
Remove
Geom1 (2D)
Independent variables: x y z
Application Mode Properties...
Add Geometry...
Add Frame...
Dependent variables:
u v p
Application mode name:
mmglf
Element:
Lagrange - P2 P1
Ruling application mode:
Multiphysics
OK
Cancel
Help

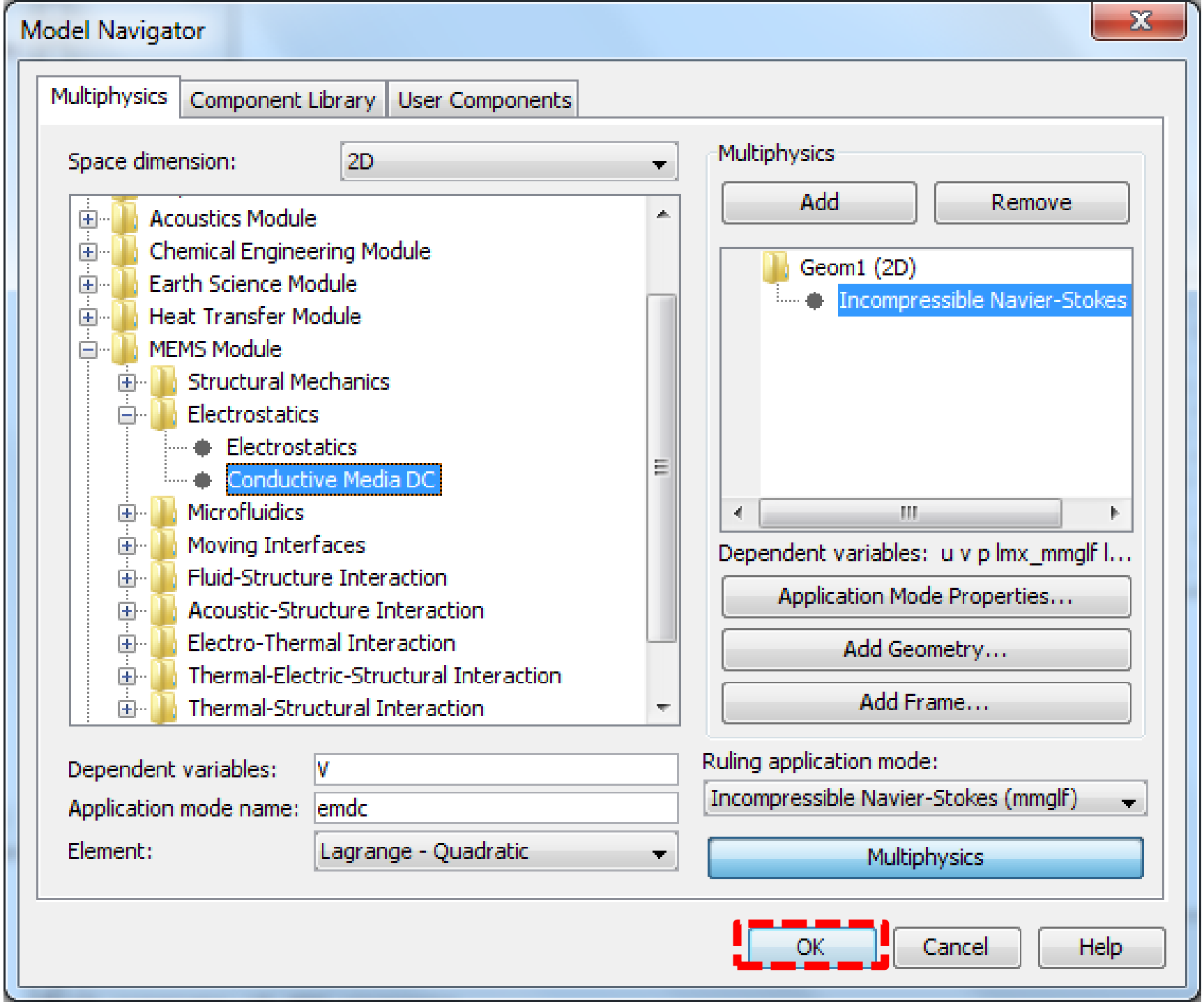

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (mi
Incompressible Navier-Stokes (mmglf)
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
1.5
2
a.mph
Path: C:\Users\Princess\Desktop\
Mesh consists of 406 elements.
Mesh consists of 416 elements.
Mesh consists of 418 elements.
(-1.845, 2.512)
EQUAL
Normal
Memory: (138 / 141)

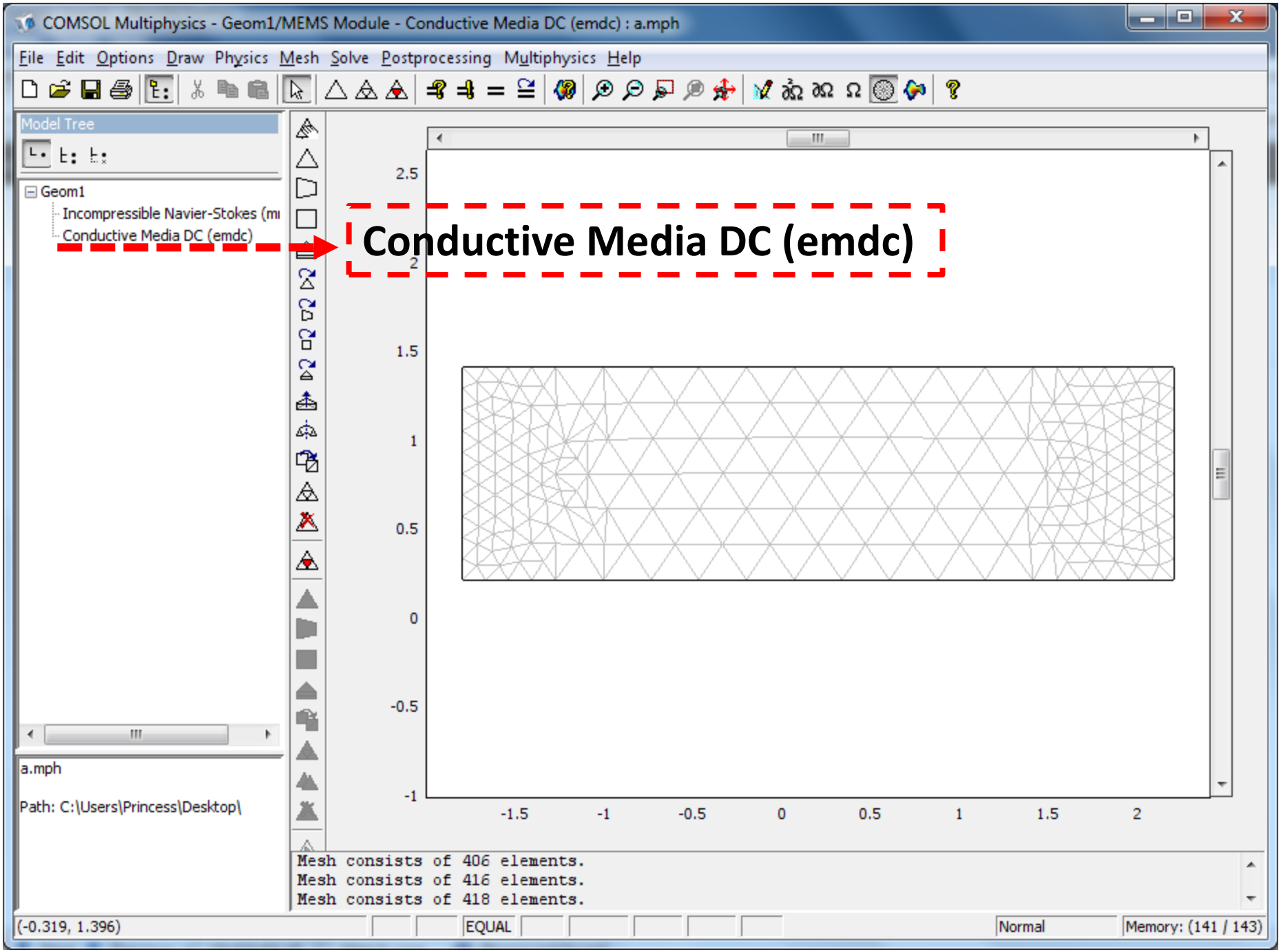

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Navigator...
1 Incompressible Navier-Stokes (mmglf)
Model Tree
Geom1
Incompressible Navier-Stokes (mı
a.mph
Path: C:\Users\Princess\Desktop\
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
1.5
2
Mesh consists of 406 elements.
Mesh consists of 416 elements.
Mesh consists of 418 elements.
(-1.558, 2.605)
EQUAL
Normal
Memory: (138 / 141)


COMSOL Multiphysics - Geom1 : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
[untitled]
Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Application Modes
COMSOL Multiphysics
AC/DC Module
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
RF Module
Structural Mechanics Module
Multiphysics
Add
Remove
Geom1 (2D)
Independent variables: x y z
Application Mode Properties...
Add Geometry...
Add Frame...
Dependent variables: u v p
Application mode name: mmglf
Element: Lagrange - P2 P1
Ruling application mode:
Multiphysics
OK
Cancel
Help
Mesh consists of 406 elements.
Mesh consists of 416 elements.
Mesh consists of 418 elements.
(-1.845, 2.512)
EQUAL
Normal
Memory: (139 / 141)


Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
Structural Mechanics
Electrostatics
Microfluidics
Moving Interfaces
Fluid-Structure Interaction
Acoustic-Structure Interaction
Electro-Thermal Interaction
Thermal-Electric-Structural Interaction
Thermal-Structural Interaction
RF Module
Structural Mechanics Module
Dependent variables:
c
Application mode name:
chekf
Element:
Lagrange - Quadratic
Multiphysics
Add
Remove
Geom1 (2D)
Incompressible Navier-Stokes
Dependent variables: u v p lmx_mmglf l...
Application Mode Properties...
Add Geometry...
Add Frame...
Ruling application mode:
Incompressible Navier-Stokes (mmglf)
Multiphysics
OK
Cancel
Help

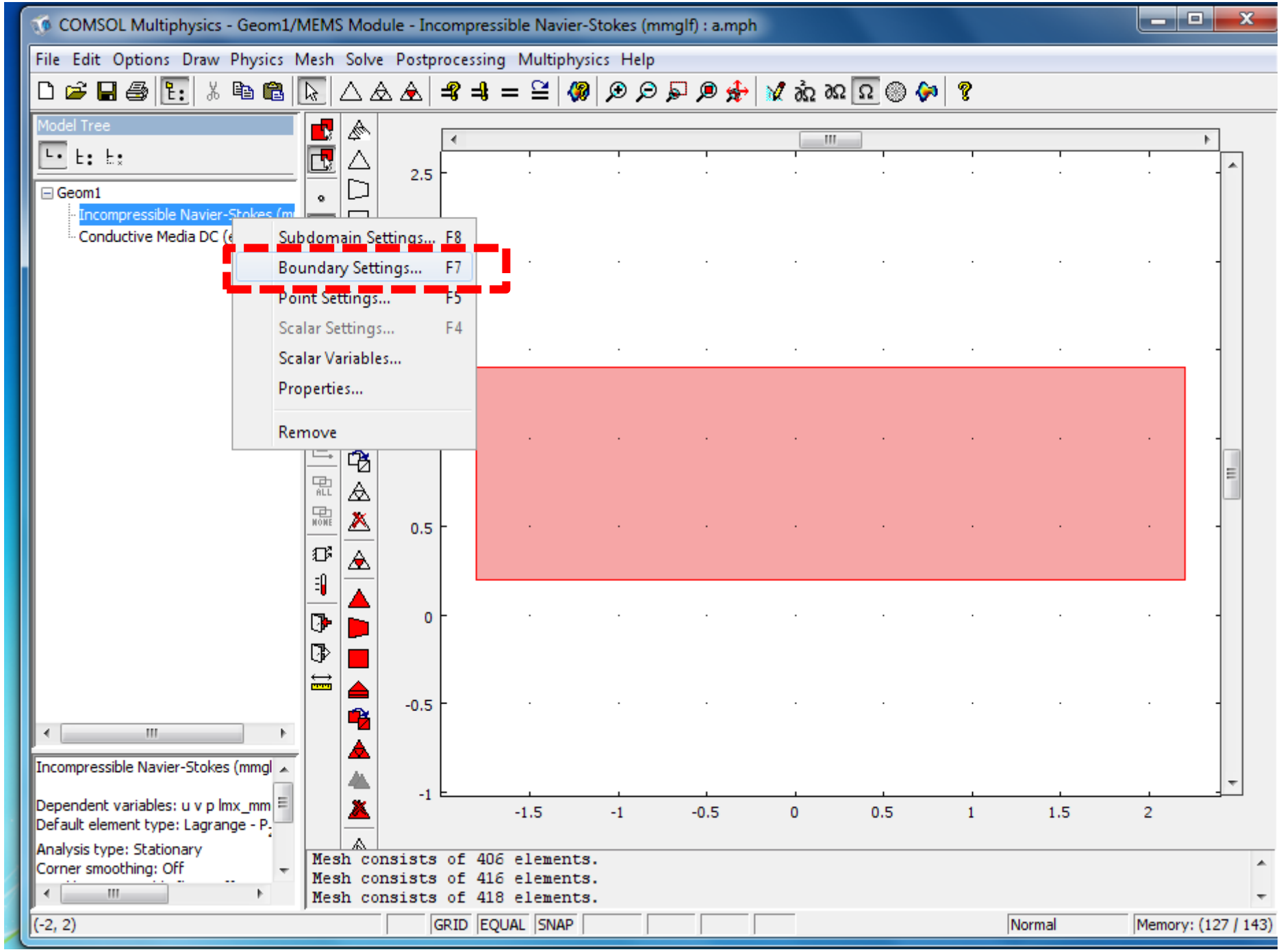

Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
Structural Mechanics
Electrostatics
Electrostatics
Conductive Media DC
Microfluidics
Moving Interfaces
Fluid-Structure Interaction
Acoustic-Structure Interaction
Electro-Thermal Interaction
Thermal-Electric-Structural Interaction
Thermal-Structural Interaction
Multiphysics
Add
Remove
Geom1 (2D)
Incompressible Navier-Stokes
Dependent variables: u v p lmx_mmglf l...
Application Mode Properties...
Add Geometry...
Add Frame...
Dependent variables:
V
Application mode name:
emdc
Element:
Lagrange - Quadratic
Ruling application mode:
Incompressible Navier-Stokes (mmglf)
Multiphysics
OK
Cancel
Help

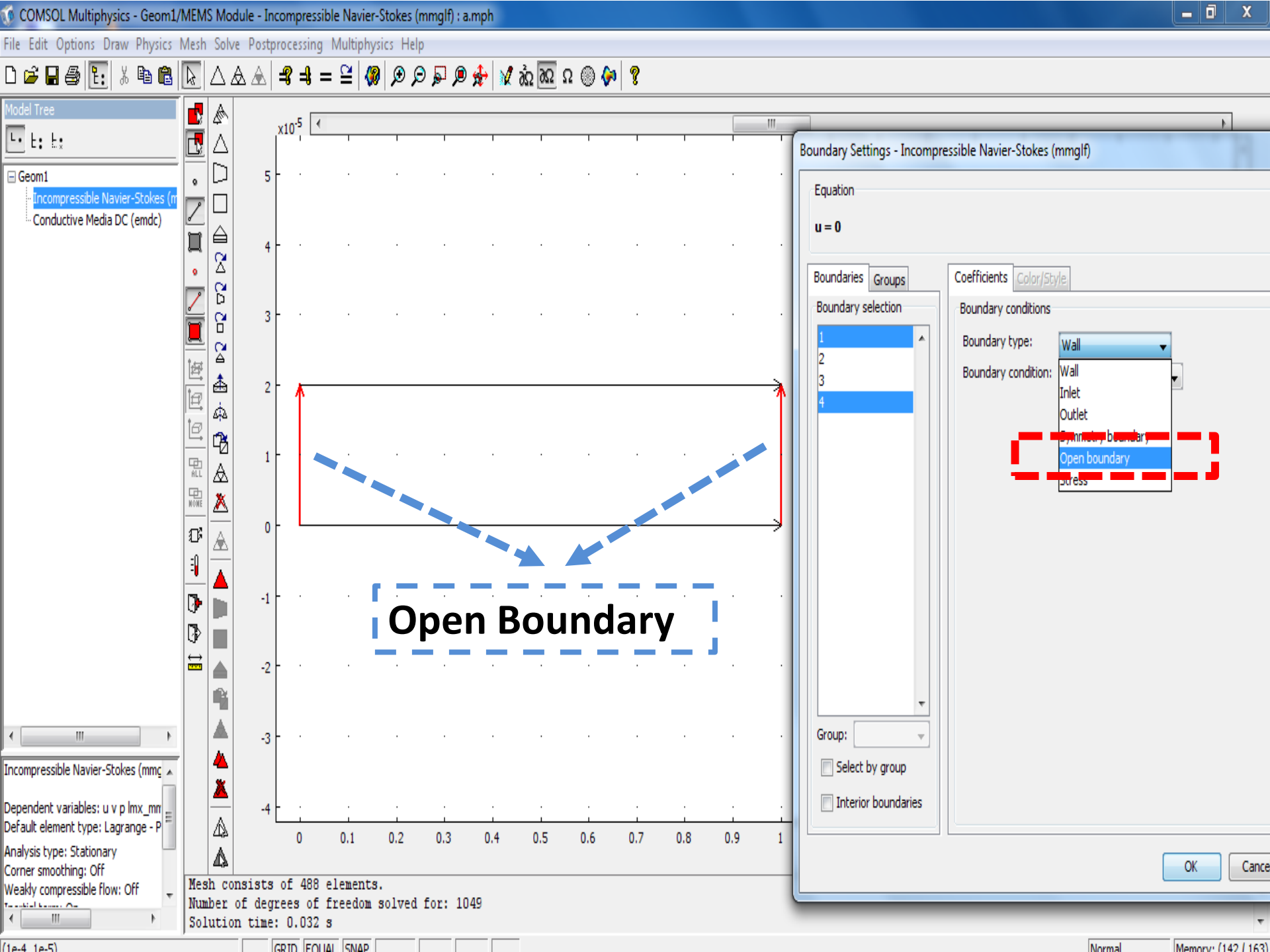

Model Navigator
Multiphysics
Component Library
User Components
Space dimension:
2D
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
Structural Mechanics
Electrostatics
Electrostatics
Conductive Media DC
Microfluidics
Moving Interfaces
Fluid-Structure Interaction
Acoustic-Structure Interaction
Electro-Thermal Interaction
Thermal-Electric-Structural Interaction
Thermal-Structural Interaction
Dependent variables:
V
Application mode name:
emdc
Element:
Lagrange - Quadratic
Multiphysics
Add
Remove
Geom1 (2D)
Incompressible Navier-Stokes
Dependent variables: u v p lmx_mmglf l...
Application Mode Properties...
Add Geometry...
Add Frame...
Ruling application mode:
Incompressible Navier-Stokes (mmglf)
Multiphysics
OK
Cancel
Help

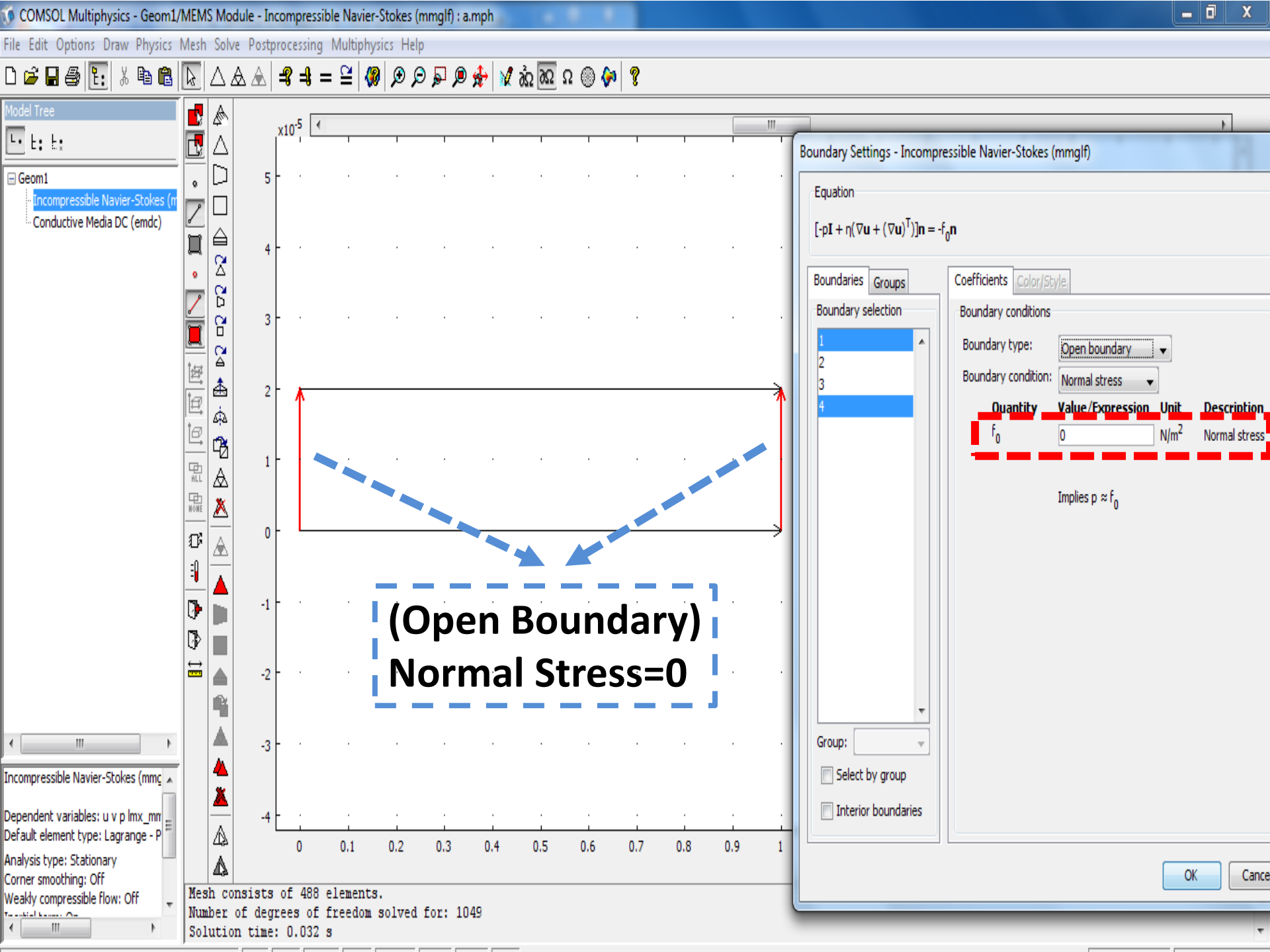

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (mi
Conductive Media DC (emdc)
Conductive Media DC (emdc)
a.mph
Path: C:\Users\Princess\Desktop\
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
1.5
2
Mesh consists of 406 elements.
Mesh consists of 416 elements.
Mesh consists of 418 elements.
(-0.319, 1.396)
EQUAL
Normal
Memory: (141 / 143)

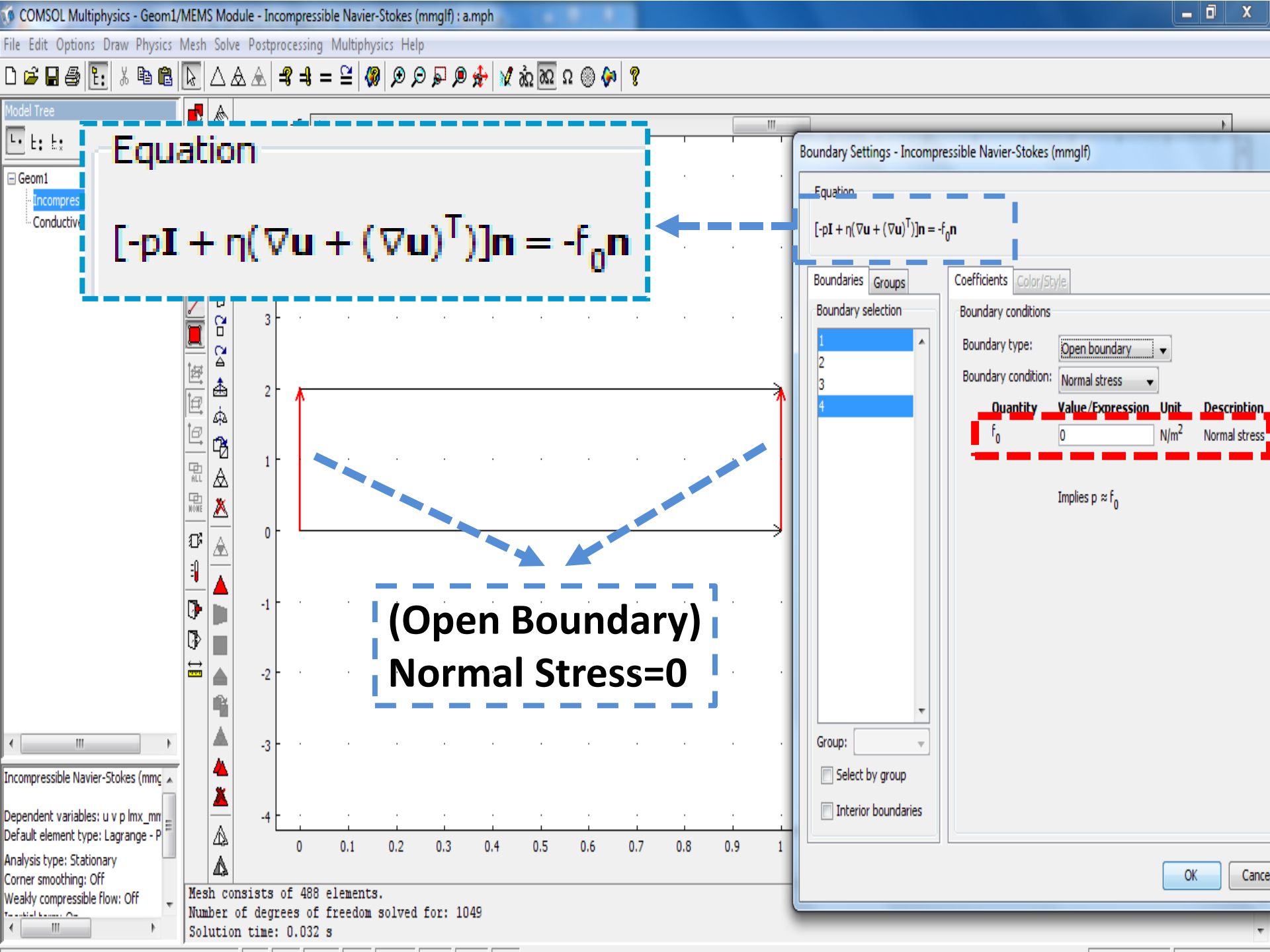
Step 5:

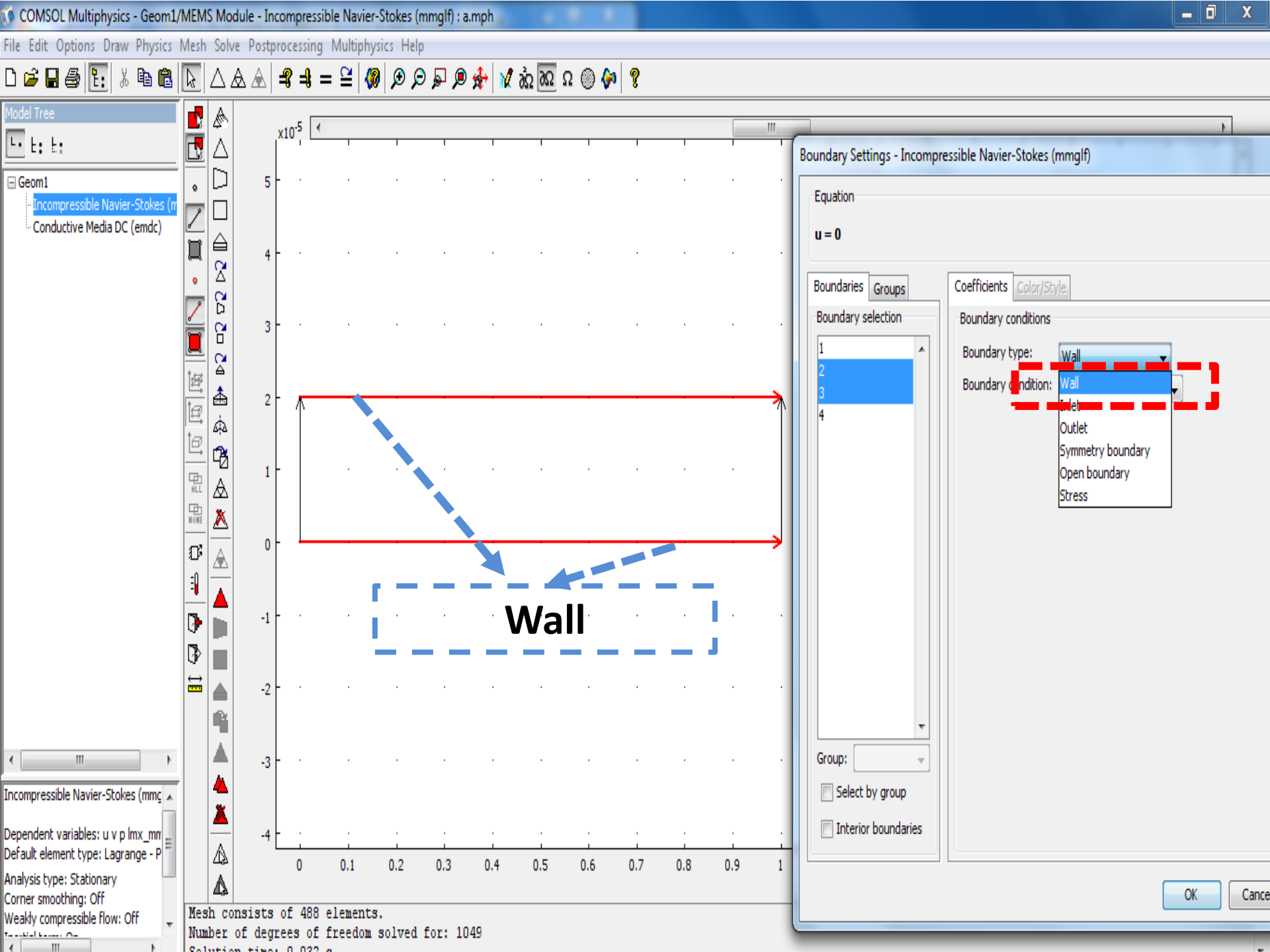
Define the Boundary Conditions

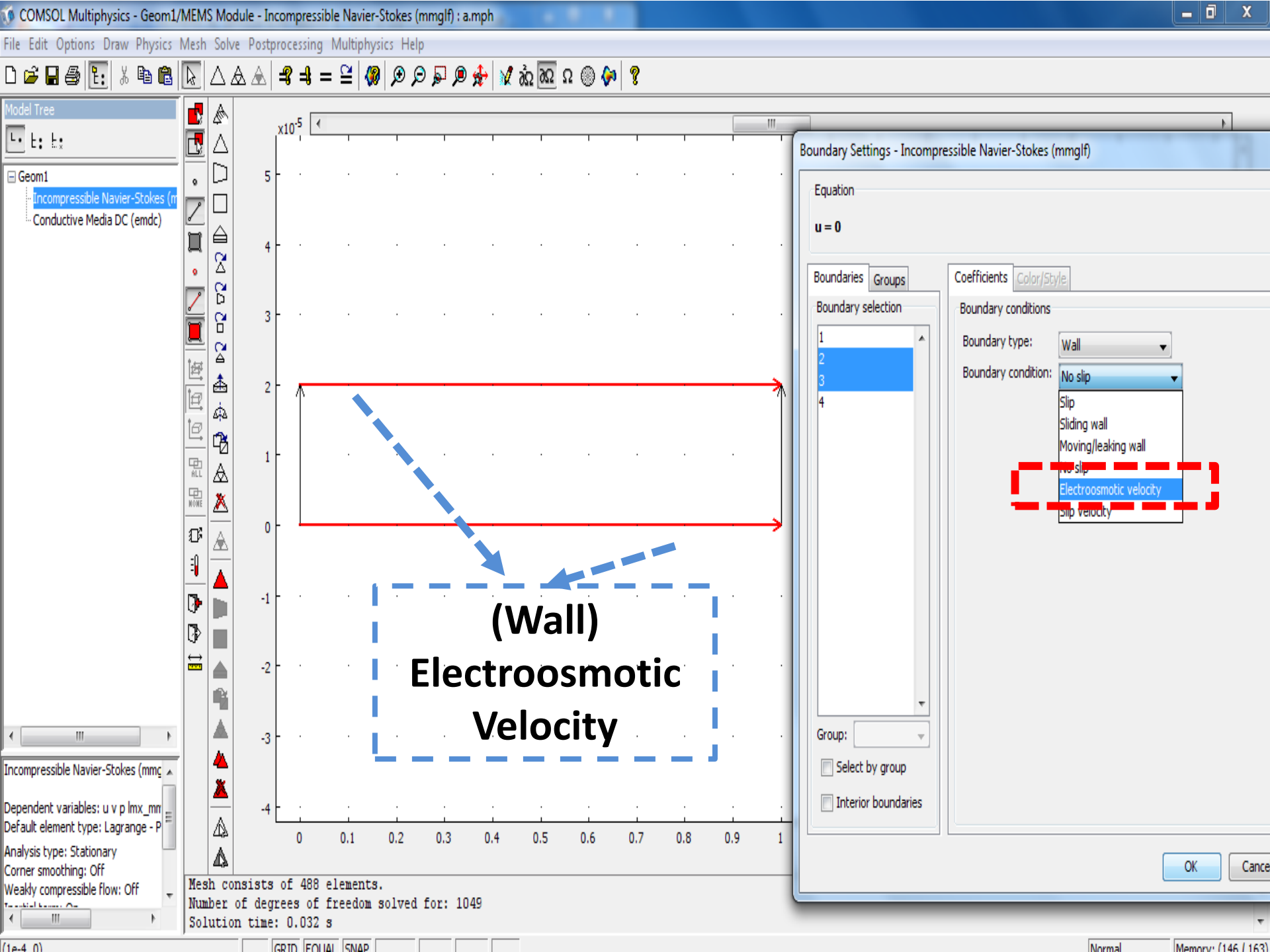

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (m
Conductive Media DC (
Subdomain Settings... F8
Boundary Settings... F7
Point Settings... F5
Scalar Settings... F4
Scalar Variables...
Properties...
Remove
2.5
0.5
0
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
1.5
2
Incompressible Navier-Stokes (mmgl
Dependent variables: u v p lmx_mm
Default element type: Lagrange - P
Analysis type: Stationary
Corner smoothing: Off
Mesh consists of 406 elements.
Mesh consists of 416 elements.
Mesh consists of 418 elements.
(-2, 2)
GRID EQUAL SNAP
Normal
Memory: (127 / 143)

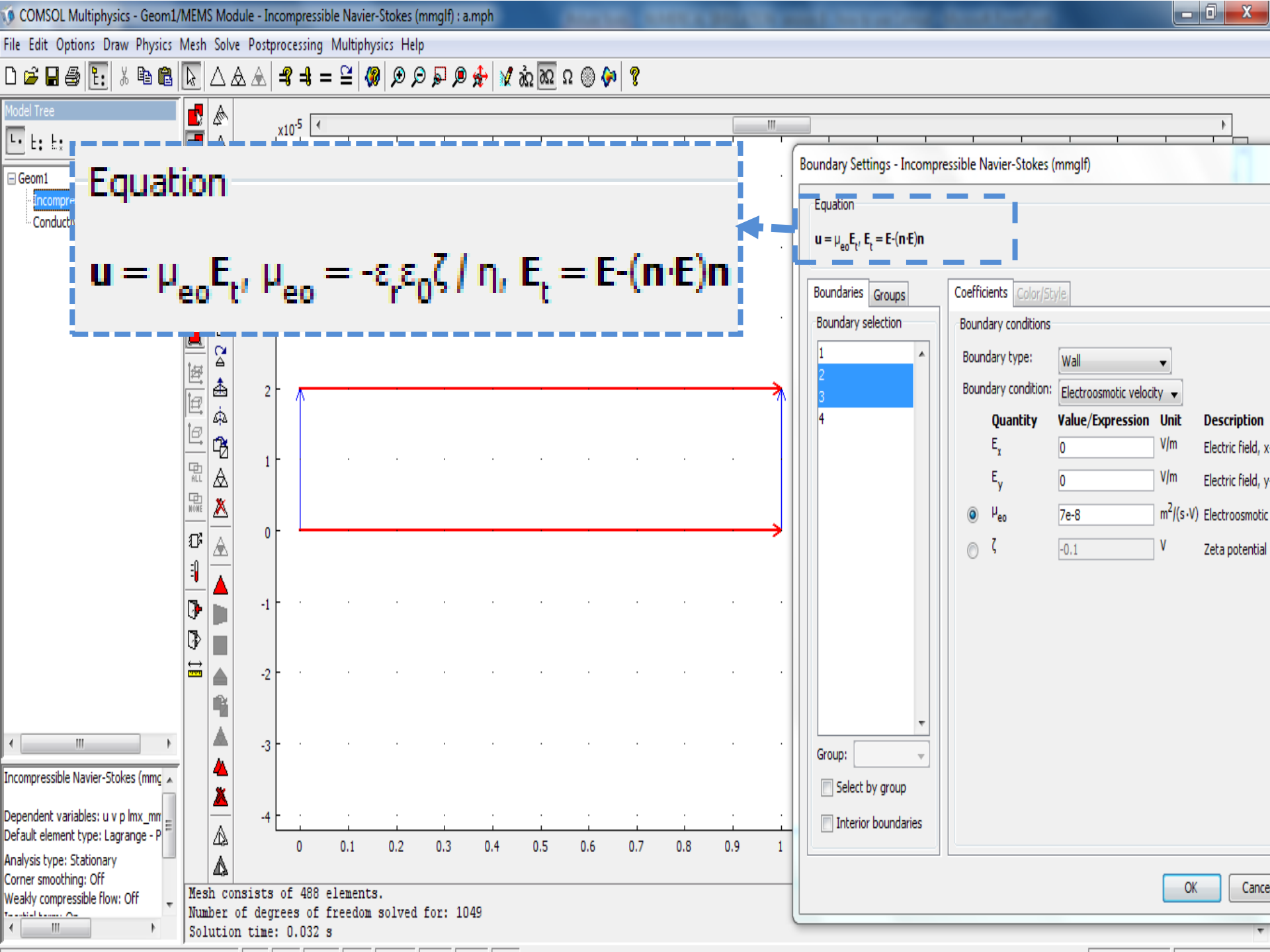

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (m
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmg
Dependent variables: u v p lmx_mm
Default element type: Lagrange - P
Analysis type: Stationary
Corner smoothing: Off
Weakly compressible flow: Off
x10-5
Open Boundary
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s
Boundary Settings - Incompressible Navier-Stokes (mmglf)
Equation
u = 0
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Coefficients
Color/Style
Boundary conditions
Boundary type:
Wall
Boundary condition:
Wall
Inlet
Outlet
Open boundary
Stress
OK
Cance
GRID EQUAL SNAP
Normal
Memory: (142 / 163)

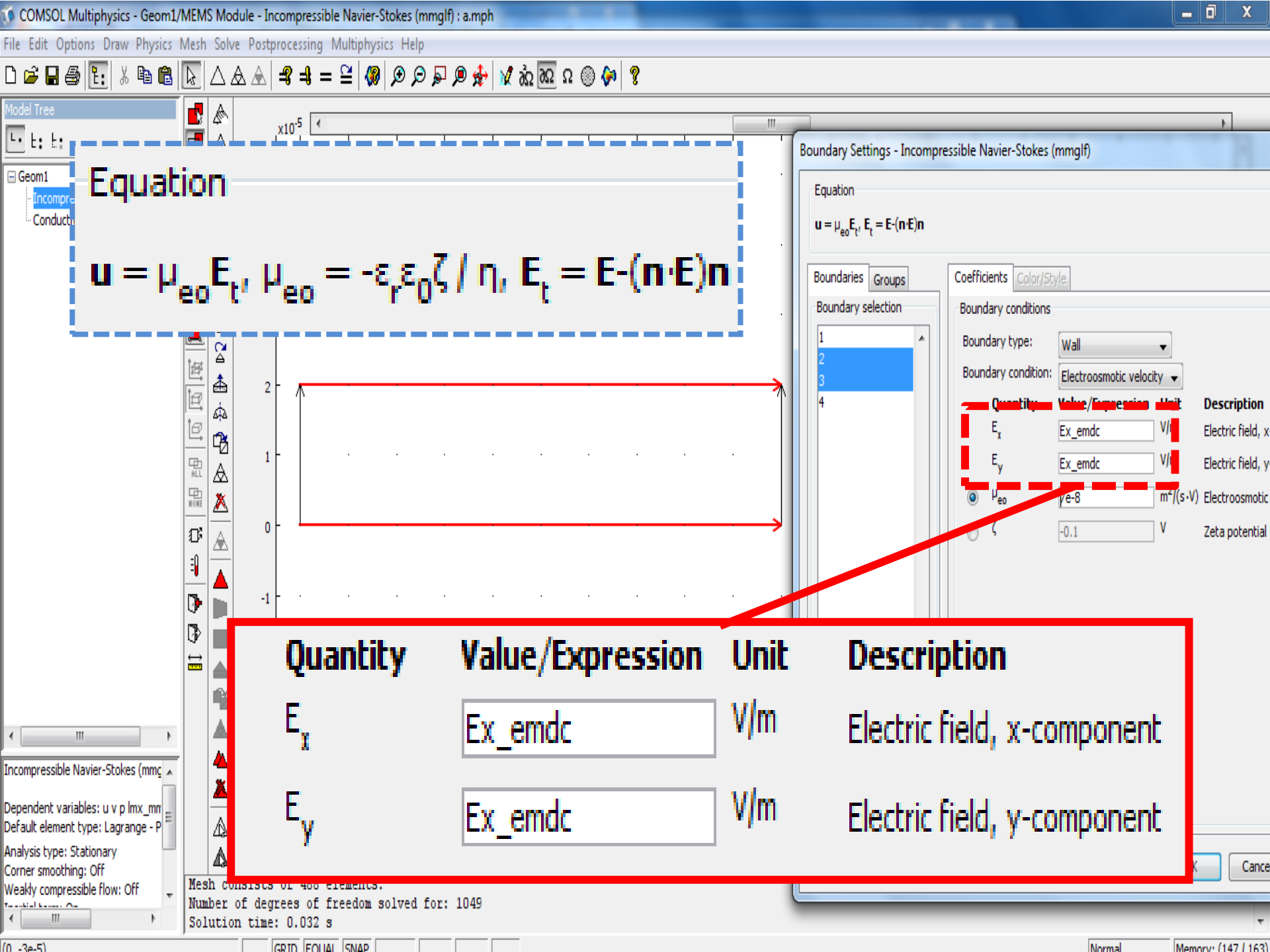

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (n
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmg
Dependent variables: u v p lmx_mm
Default element type: Lagrange - P
Analysis type: Stationary
Corner smoothing: Off
Weakly compressible flow: Off
x10-5
(Open Boundary)
Normal Stress=0
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s
Boundary Settings - Incompressible Navier-Stokes (mmglf)
Equation
[-pI + η(∇u + (∇u)T)]n = -f0n
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Coefficients
Color/Style
Boundary conditions
Boundary type:
Open boundary
Boundary condition:
Normal stress
Quantity
Value/Expression
Unit
Description
f0
0
N/m2
Normal stress
Implies p ≈ f0
OK
Cance

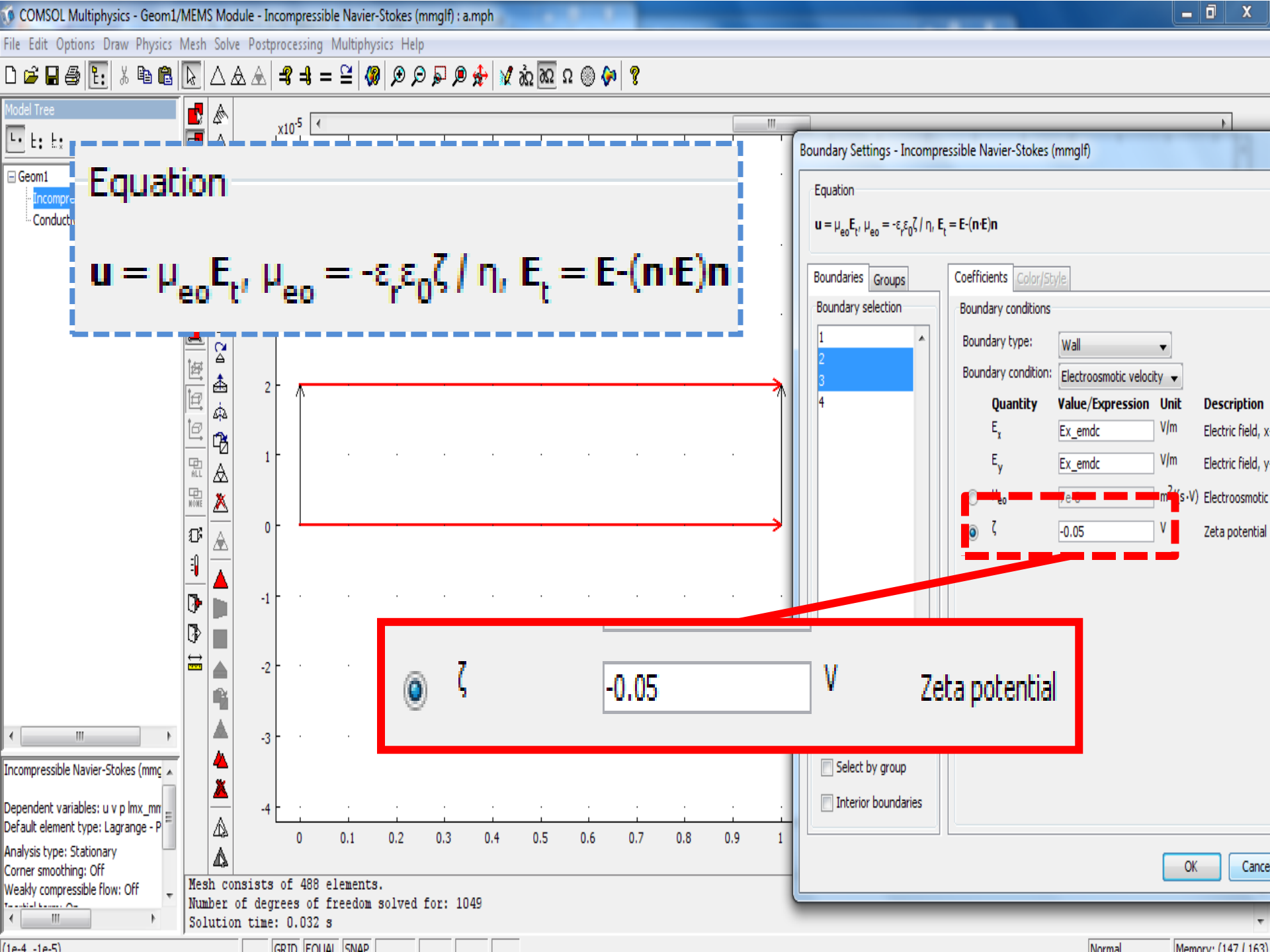

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompres
Conductiv
Equation
$[-pI + \eta(\nabla u + (\nabla u)^T)]n = -f_0 n$
(Open Boundary)
Normal Stress=0
Boundary Settings - Incompressible Navier-Stokes (mmglf)
Equation
$[-pI + \eta(\nabla u + (\nabla u)^T)]n = -f_0 n$
Boundaries
Groups
Coefficients
Color/Style
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Boundary conditions
Boundary type:
Open boundary
Boundary condition:
Normal stress
Quantity
Value/Expression
Unit
Description
f_0
0
N/m^2
Normal stress
Implies $p \approx f_0$
OK
Cance
Incompressible Navier-Stokes (mmg
Dependent variables: u v p lmx_mm
Default element type: Lagrange - P
Analysis type: Stationary
Corner smoothing: Off
Weakly compressible flow: Off
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s

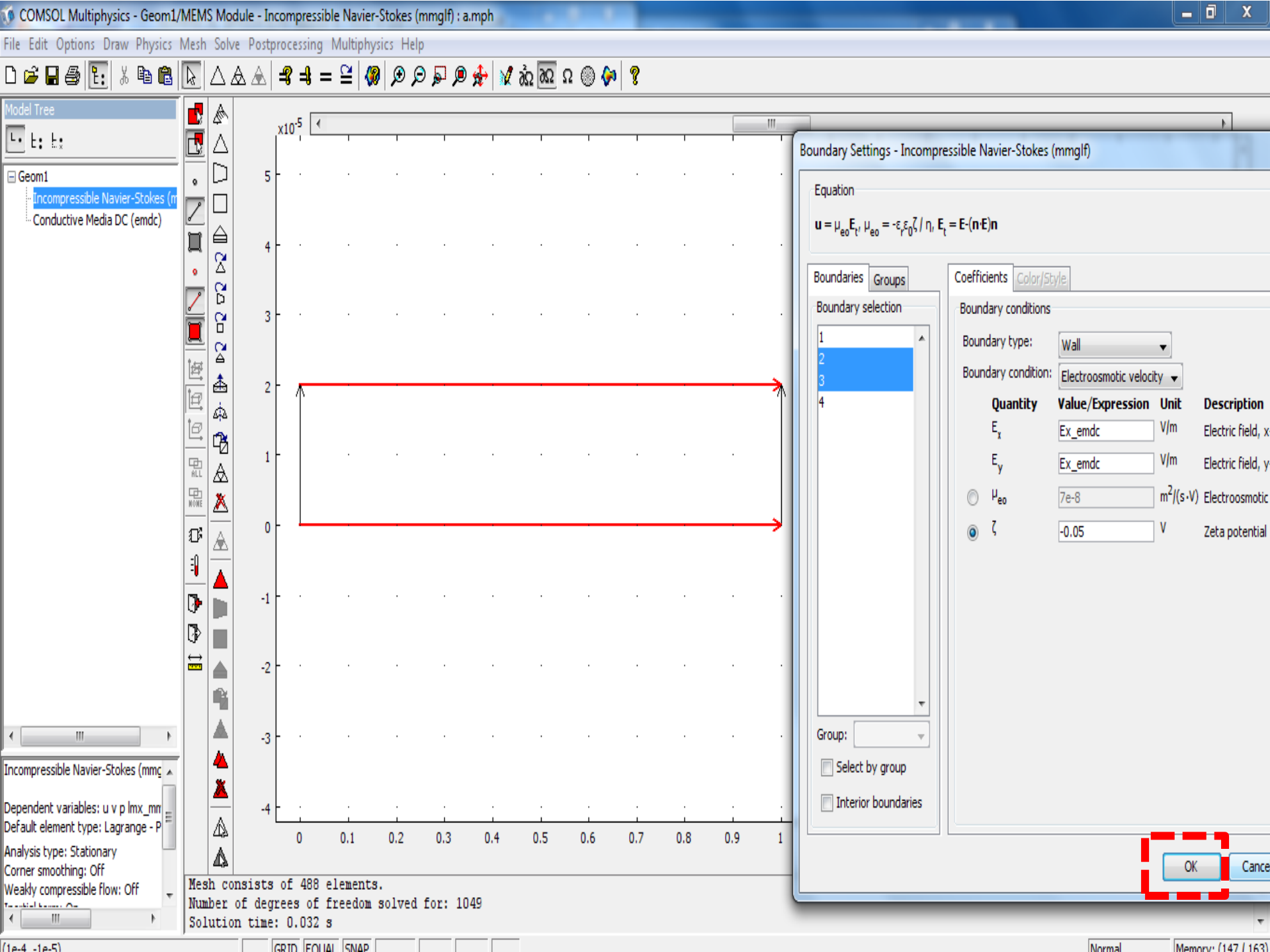

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (n
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmg
Dependent variables: u v p lmx_mm
Default element type: Lagrange - P
Analysis type: Stationary
Corner smoothing: Off
Weakly compressible flow: Off
x10-5
5
4
3
2
1
0
-1
-2
-3
-4
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Wall
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Boundary Settings - Incompressible Navier-Stokes (mmglf)
Equation
u = 0
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Coefficients
Color/Style
Boundary conditions
Boundary type:
Wall
Boundary condition:
Wall
Inlet
Outlet
Symmetry boundary
Open boundary
Stress
OK
Cance

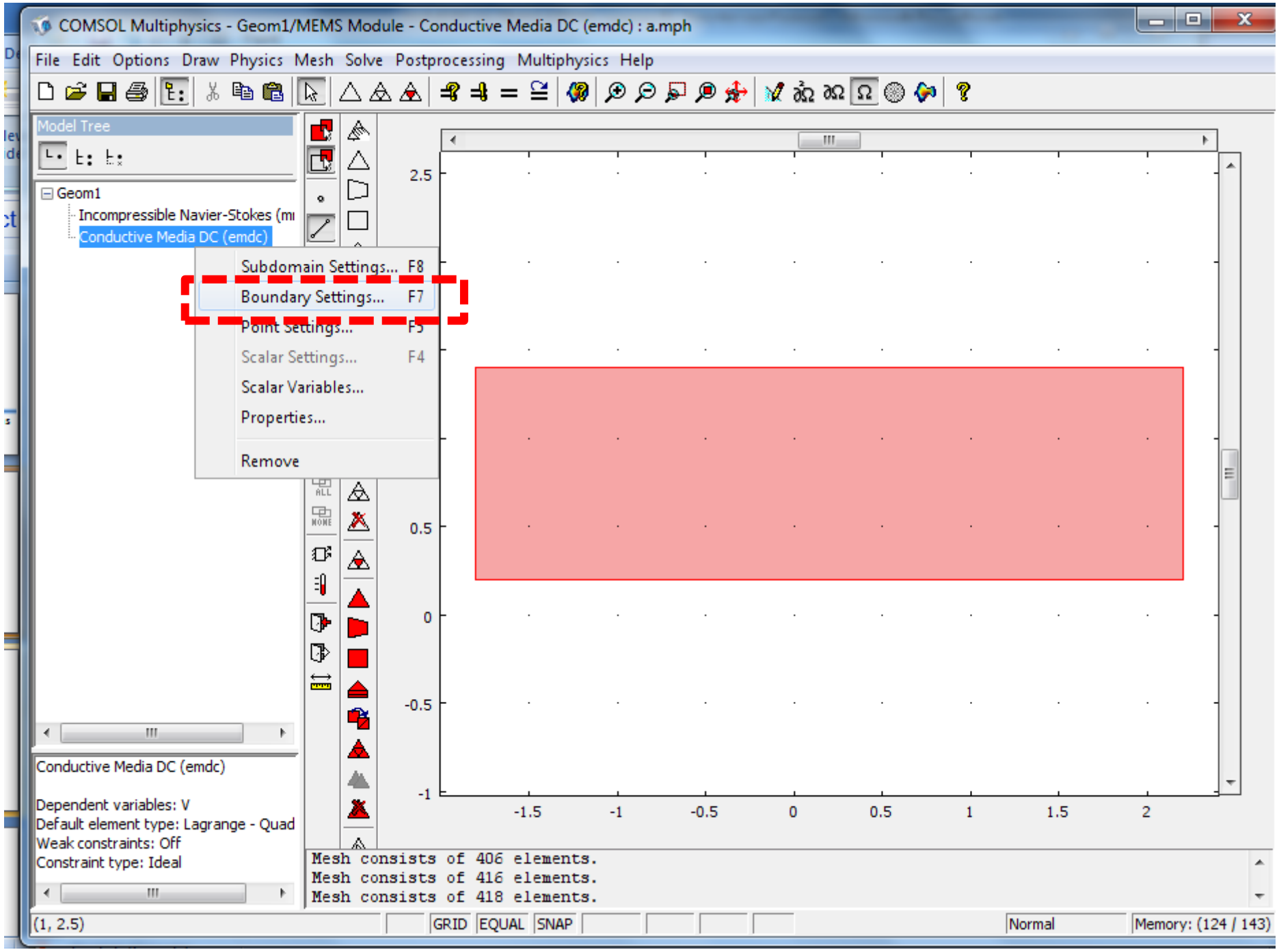

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (m
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmg
Dependent variables: u v p lmx_mm
Default element type: Lagrange - P
Analysis type: Stationary
Corner smoothing: Off
Weakly compressible flow: Off
x10-5
5
4
3
2
1
0
-1
-2
-3
-4
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
(Wall)
Electroosmotic
Velocity
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s
Boundary Settings - Incompressible Navier-Stokes (mmglf)
Equation
u = 0
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Coefficients
Color/Style
Boundary conditions
Boundary type:
Wall
Boundary condition:
No slip
Slip
Sliding wall
Moving/leaking wall
No slip
Electroosmotic velocity
Slip velocity
OK
Cance
(1e-4, 0)
GRID
EQUAL
SNAP
Normal
Memory: (146 / 163)

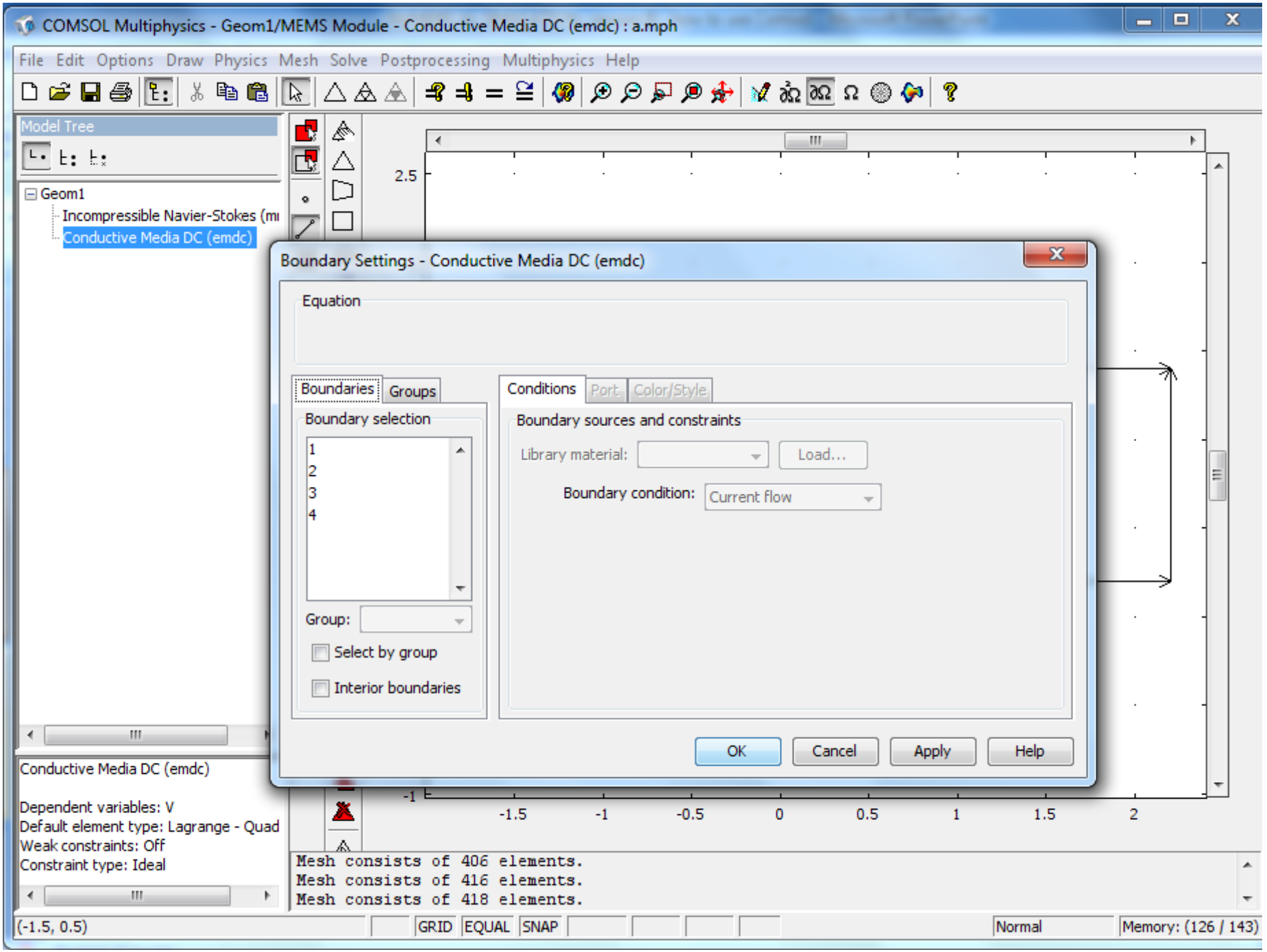

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Equation
u = μeo Et, μeo = -εr ε0 ζ / η, Et = E-(n·E)n
Boundary Settings - Incompressible Navier-Stokes (mmglf)
Equation
u = μeo Et, Et = E-(n·E)n
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Coefficients
Color/Style
Boundary conditions
Boundary type:
Wall
Boundary condition:
Electroosmotic velocity
Quantity
Value/Expression
Unit
Description
Ex
0
V/m
Electric field, x
Ey
0
V/m
Electric field, y
μeo
7e-8
m2/(s·V)
Electroosmotic
ζ
-0.1
V
Zeta potential
OK
Cance
Incompressible Navier-Stokes (mmg
Dependent variables: u v p lmx_mm
Default element type: Lagrange - P
Analysis type: Stationary
Corner smoothing: Off
Weakly compressible flow: Off
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s

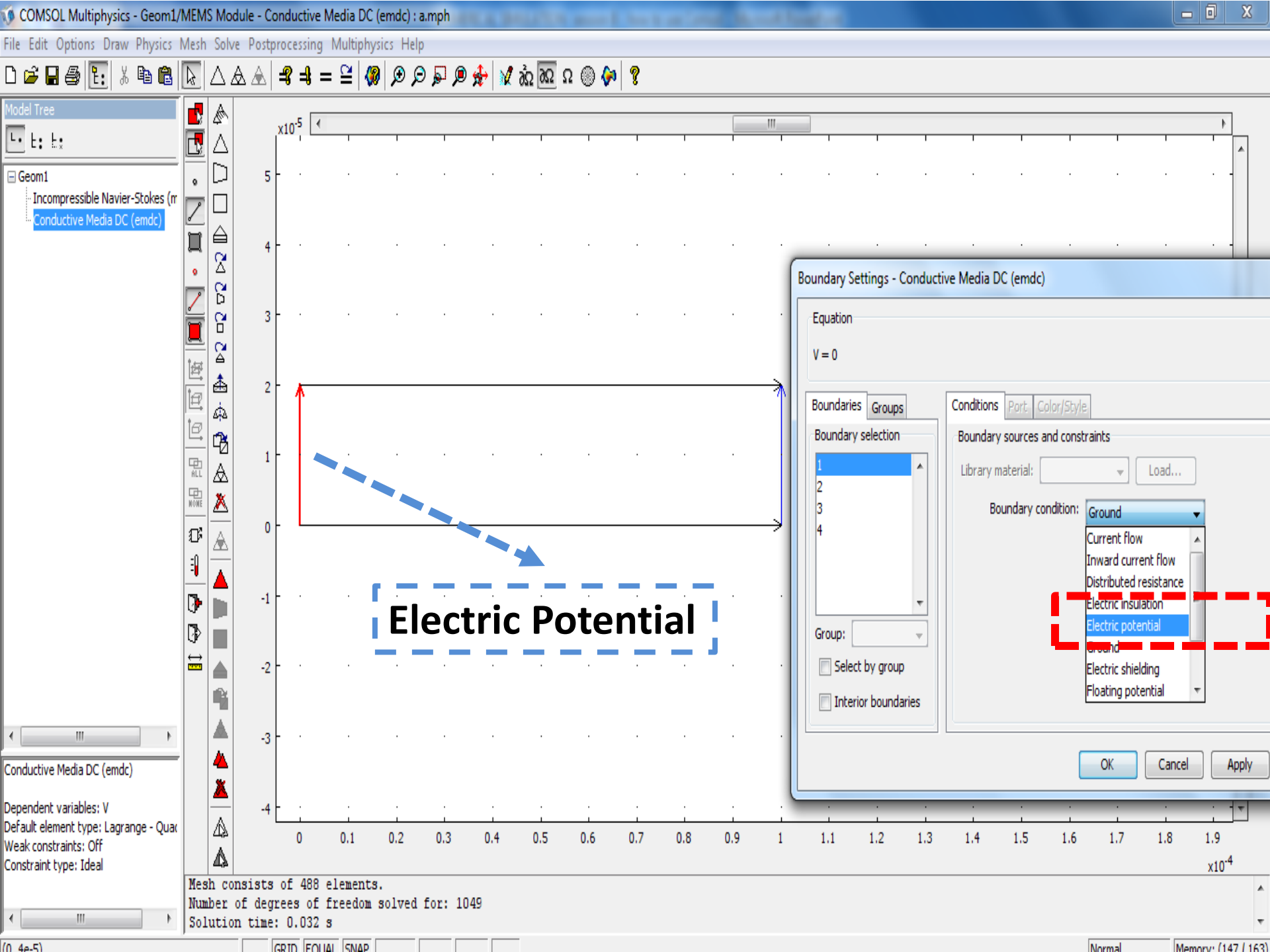

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Equation
$\mathbf{u} = \mu_{eo}\mathbf{E}_t,\ \mu_{eo} = -\varepsilon_r\varepsilon_0\zeta / \eta,\ \mathbf{E}_t = \mathbf{E}-(\mathbf{n}\cdot\mathbf{E})\mathbf{n}$
Boundary Settings - Incompressible Navier-Stokes (mmglf)
Equation
$\mathbf{u} = \mu_{eo}\mathbf{E}_t,\ \mathbf{E}_t = \mathbf{E}-(\mathbf{n}\cdot\mathbf{E})\mathbf{n}$
Boundaries
Groups
Boundary selection
1
2
3
4
Coefficients
Color/Style
Boundary conditions
Boundary type:
Wall
Boundary condition:
Electroosmotic velocity
Quantity
Value/Expression
Unit
Description
E_x
Ex_emdc
V/m
Electric field, x-component
E_y
Ex_emdc
V/m
Electric field, y-component
μ_{eo}
m²/(s·V)
Electroosmotic
ζ
-0.1
V
Zeta potential
Incompressible Navier-Stokes (mmg
Dependent variables: u v p lmx_mm
Default element type: Lagrange - P
Analysis type: Stationary
Corner smoothing: Off
Weakly compressible flow: Off
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s
Cancel

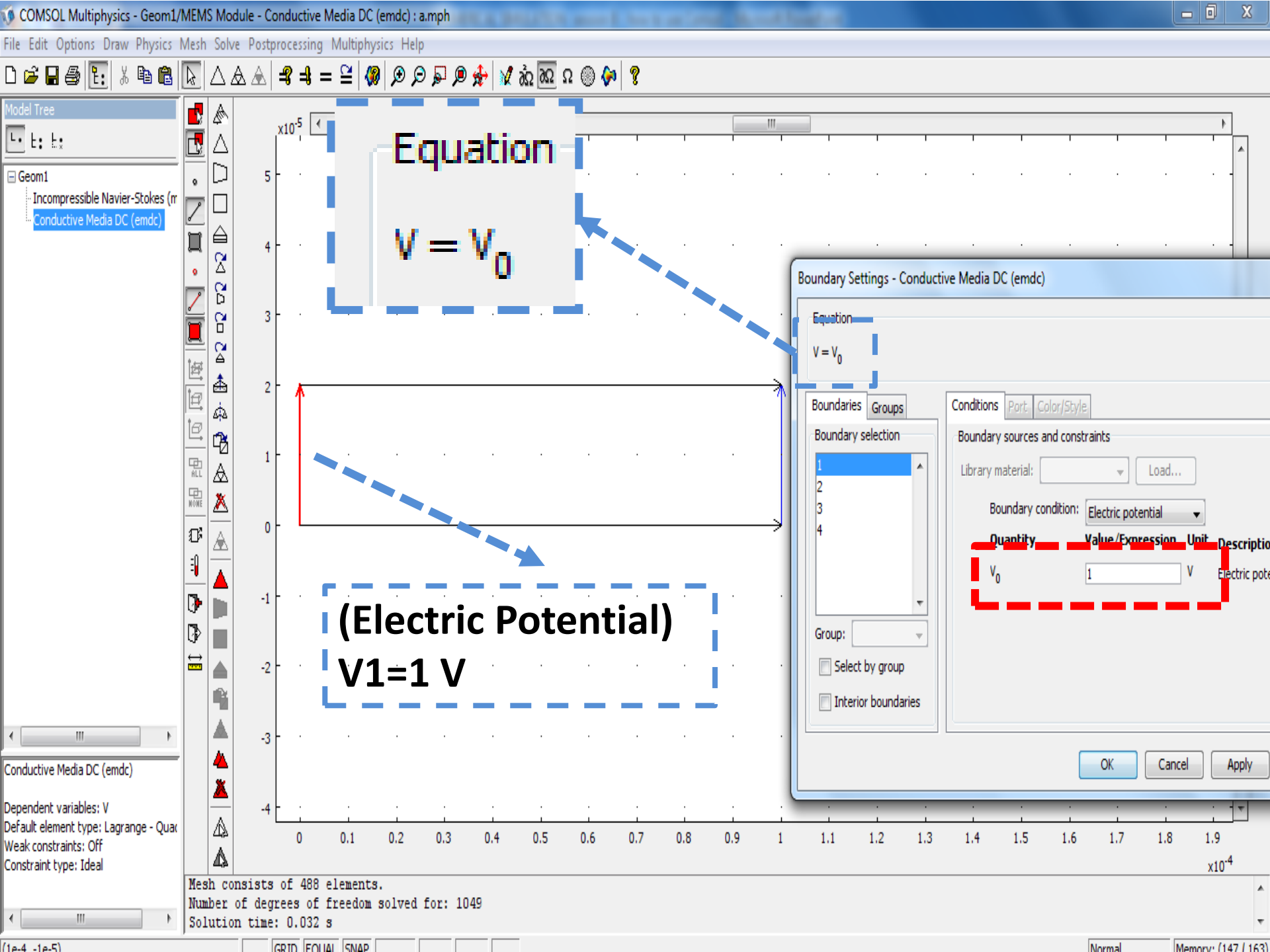

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Equation
$\mathbf{u} = \mu_{eo}\mathbf{E}_t,\ \mu_{eo} = -\varepsilon_r\varepsilon_0\zeta/\eta,\ \mathbf{E}_t = \mathbf{E}-(\mathbf{n}\cdot\mathbf{E})\mathbf{n}$
Boundary Settings - Incompressible Navier-Stokes (mmglf)
Equation
$\mathbf{u} = \mu_{eo}\mathbf{E}_t,\ \mu_{eo} = -\varepsilon_r\varepsilon_0\zeta/\eta,\ \mathbf{E}_t = \mathbf{E}-(\mathbf{n}\cdot\mathbf{E})\mathbf{n}$
Boundaries
Groups
Boundary selection
1
2
3
4
Coefficients
Color/Style
Boundary conditions
Boundary type: Wall
Boundary condition: Electroosmotic velocity
Quantity
Value/Expression
Unit
Description
E_x Ex_emdc V/m Electric field, x
E_y Ex_emdc V/m Electric field, y
μ_{eo} m²/(s·V) Electroosmotic
ζ -0.05 V Zeta potential
Select by group
Interior boundaries
OK
Cance
ζ -0.05 V Zeta potential
Incompressible Navier-Stokes (mmg
Dependent variables: u v p lmx_mm
Default element type: Lagrange - P
Analysis type: Stationary
Corner smoothing: Off
Weakly compressible flow: Off
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s
x10⁻⁵
2
1
0
-1
-2
-3
-4
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
GRID EQUAL SNAP
Normal
Memory: 147 / 163

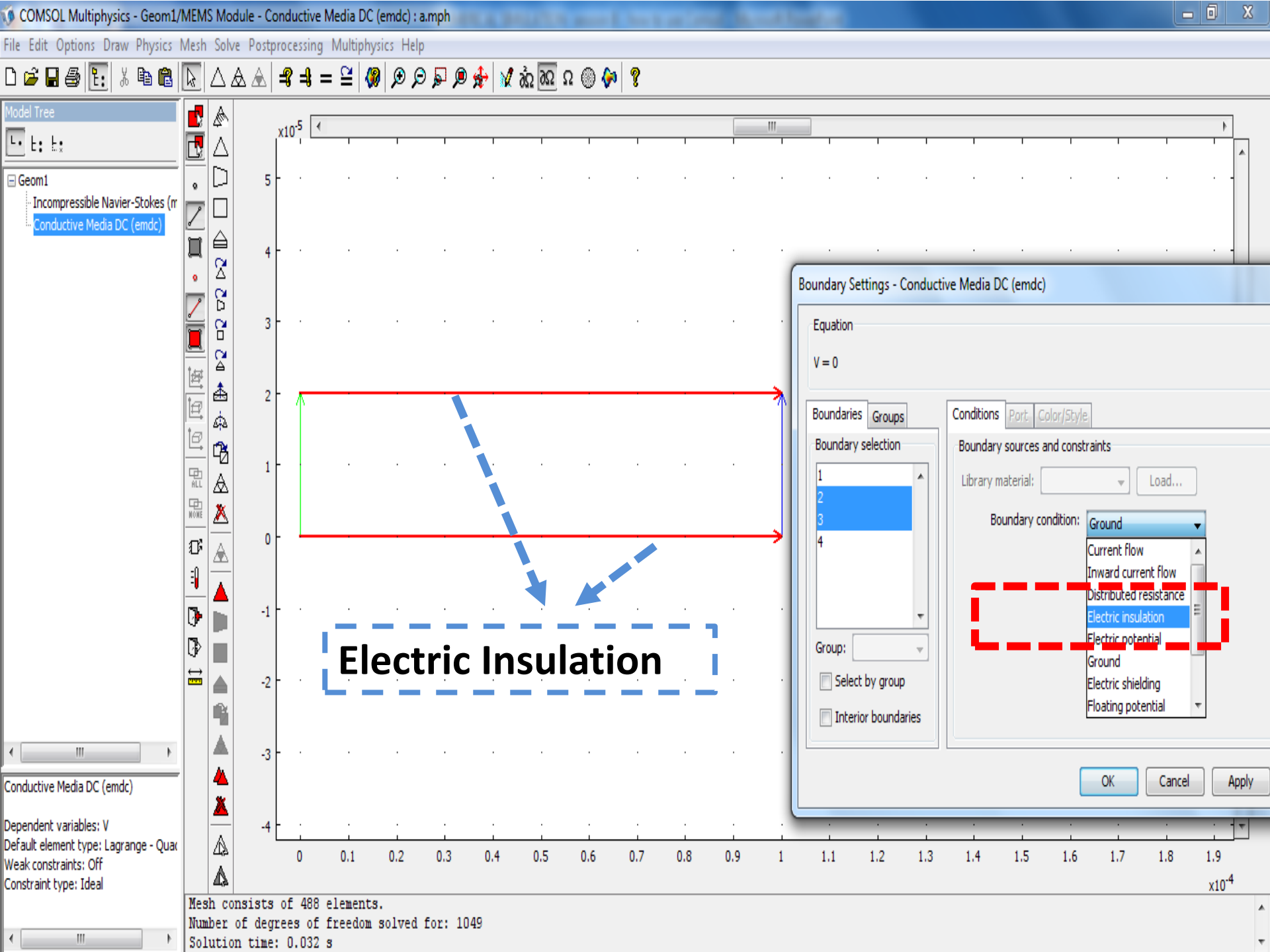

COMSOL Multiphysics - Geom1/MEMS Module - Incompressible Navier-Stokes (mmglf) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (m
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmg
Dependent variables: u v p lmx_mm
Default element type: Lagrange - P
Analysis type: Stationary
Corner smoothing: Off
Weakly compressible flow: Off
x10-5
5
4
3
2
1
0
-1
-2
-3
-4
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s
Boundary Settings - Incompressible Navier-Stokes (mmglf)
Equation
u = μeoEt, μeo = -εfε0ζ / η, Et = E-(n·E)n
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Coefficients
Color/Style
Boundary conditions
Boundary type:
Wall
Boundary condition:
Electroosmotic velocity
Quantity
Value/Expression
Unit
Description
Ex
Ex_emdc
V/m
Electric field, x
Ey
Ex_emdc
V/m
Electric field, y
μeo
7e-8
m2/(s·V)
Electroosmotic
ζ
-0.05
V
Zeta potential
OK
Cance
Normal
Memory: (147 / 163)

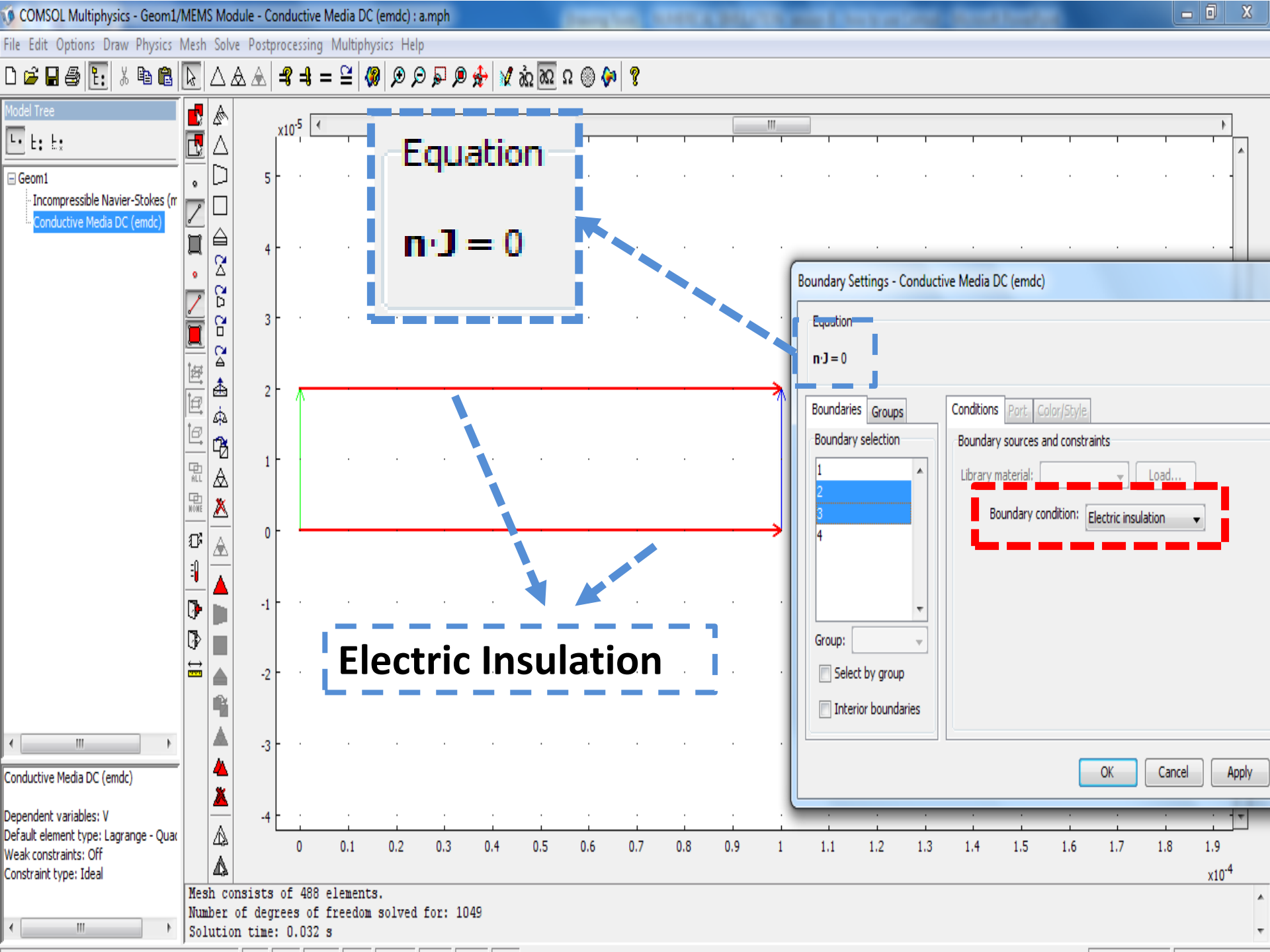

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (mı
Conductive Media DC (emdc)
Subdomain Settings... F8
Boundary Settings... F7
Point Settings... F5
Scalar Settings... F4
Scalar Variables...
Properties...
Remove
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quad
Weak constraints: Off
Constraint type: Ideal
2.5
0.5
0
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
1.5
2
Mesh consists of 406 elements.
Mesh consists of 416 elements.
Mesh consists of 418 elements.
(1, 2.5)
GRID EQUAL SNAP
Normal
Memory: (124 / 143)

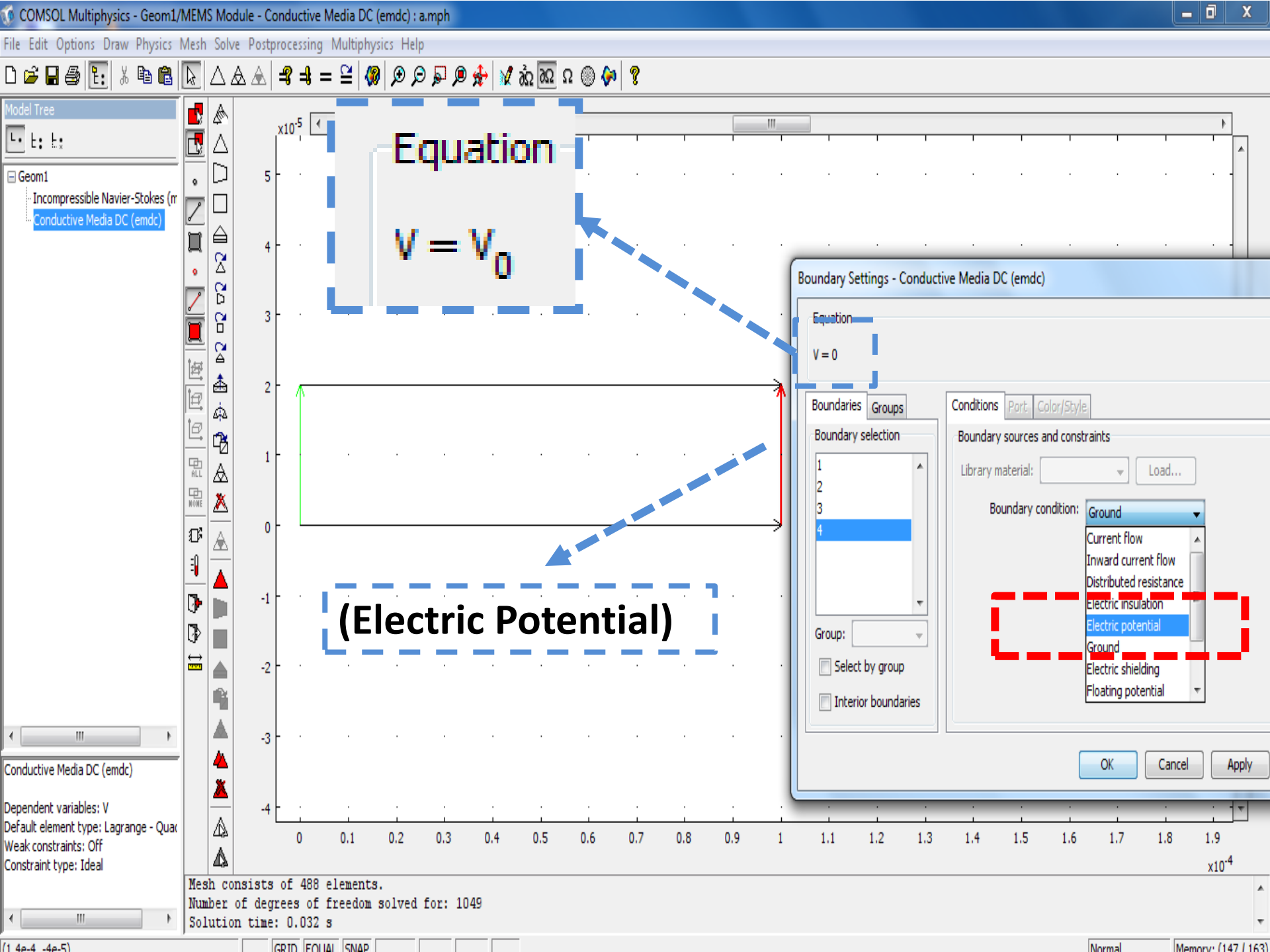

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (mi
Conductive Media DC (emdc)
Boundary Settings - Conductive Media DC (emdc)
Equation
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Conditions
Port
Color/Style
Boundary sources and constraints
Library material:
Load...
Boundary condition:
Current flow
OK
Cancel
Apply
Help
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quad
Weak constraints: Off
Constraint type: Ideal
Mesh consists of 406 elements.
Mesh consists of 416 elements.
Mesh consists of 418 elements.
(-1.5, 0.5)
GRID EQUAL SNAP
Normal
Memory: (126 / 143)

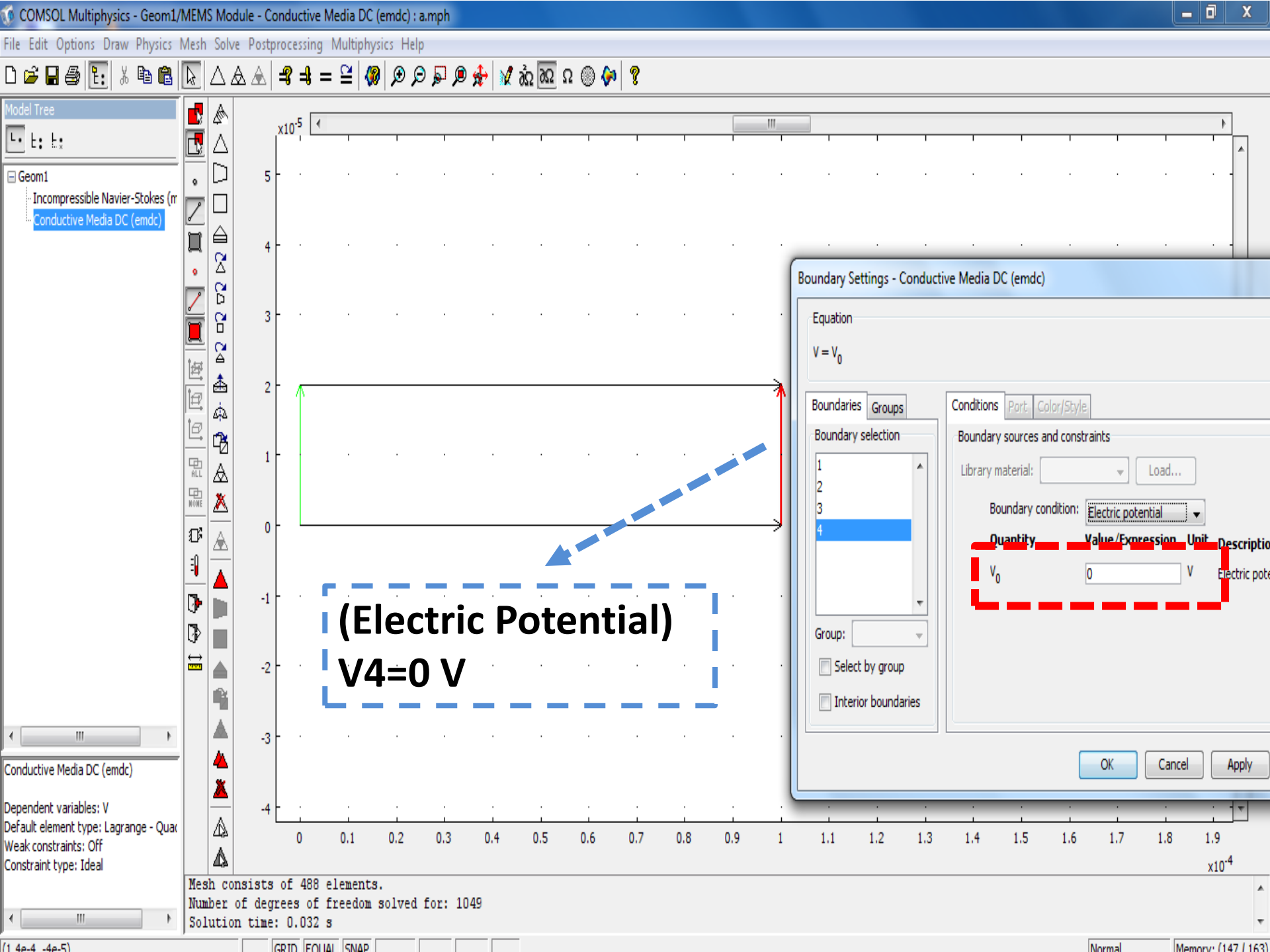

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (n
Conductive Media DC (emdc)
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quac
Weak constraints: Off
Constraint type: Ideal
x10-5
Electric Potential
Boundary Settings - Conductive Media DC (emdc)
Equation
V = 0
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Conditions
Port
Color/Style
Boundary sources and constraints
Library material:
Load...
Boundary condition:
Ground
Current flow
Inward current flow
Distributed resistance
Electric insulation
Electric potential
Electric shielding
Floating potential
OK
Cancel
Apply
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s
x10-4

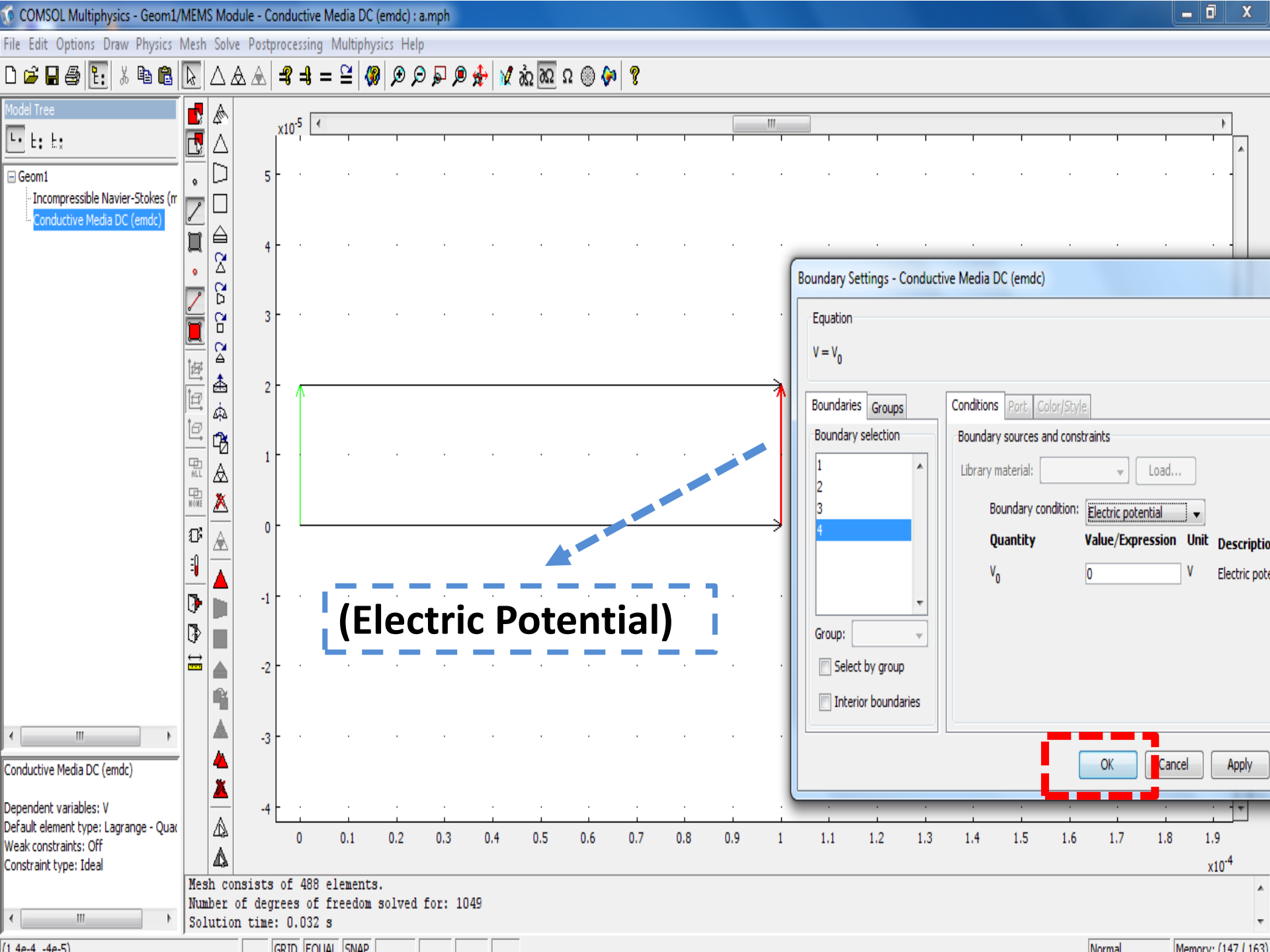

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (n
Conductive Media DC (emdc)
Equation
$V = V_0$
(Electric Potential)
V1=1 V
Boundary Settings - Conductive Media DC (emdc)
Equation
$V = V_0$
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Conditions
Port
Color/Style
Boundary sources and constraints
Library material:
Load...
Boundary condition:
Electric potential
Quantity
Value/Expression
Unit
Description
V_0
1
V
Electric pote
OK
Cancel
Apply
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quac
Weak constraints: Off
Constraint type: Ideal
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s
x10-5
x10-4


COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (n
Conductive Media DC (emdc)
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quac
Weak constraints: Off
Constraint type: Ideal
Electric Insulation
Boundary Settings - Conductive Media DC (emdc)
Equation
V = 0
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Conditions
Port
Color/Style
Boundary sources and constraints
Library material:
Load...
Boundary condition:
Ground
Current flow
Inward current flow
Distributed resistance
Electric insulation
Electric potential
Ground
Electric shielding
Floating potential
OK
Cancel
Apply
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s


COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (n
Conductive Media DC (emdc)
Equation
n·J = 0
Boundary Settings - Conductive Media DC (emdc)
Equation
n·J = 0
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Conditions
Port
Color/Style
Boundary sources and constraints
Library material:
Load...
Boundary condition:
Electric insulation
OK
Cancel
Apply
Electric Insulation
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quac
Weak constraints: Off
Constraint type: Ideal
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s

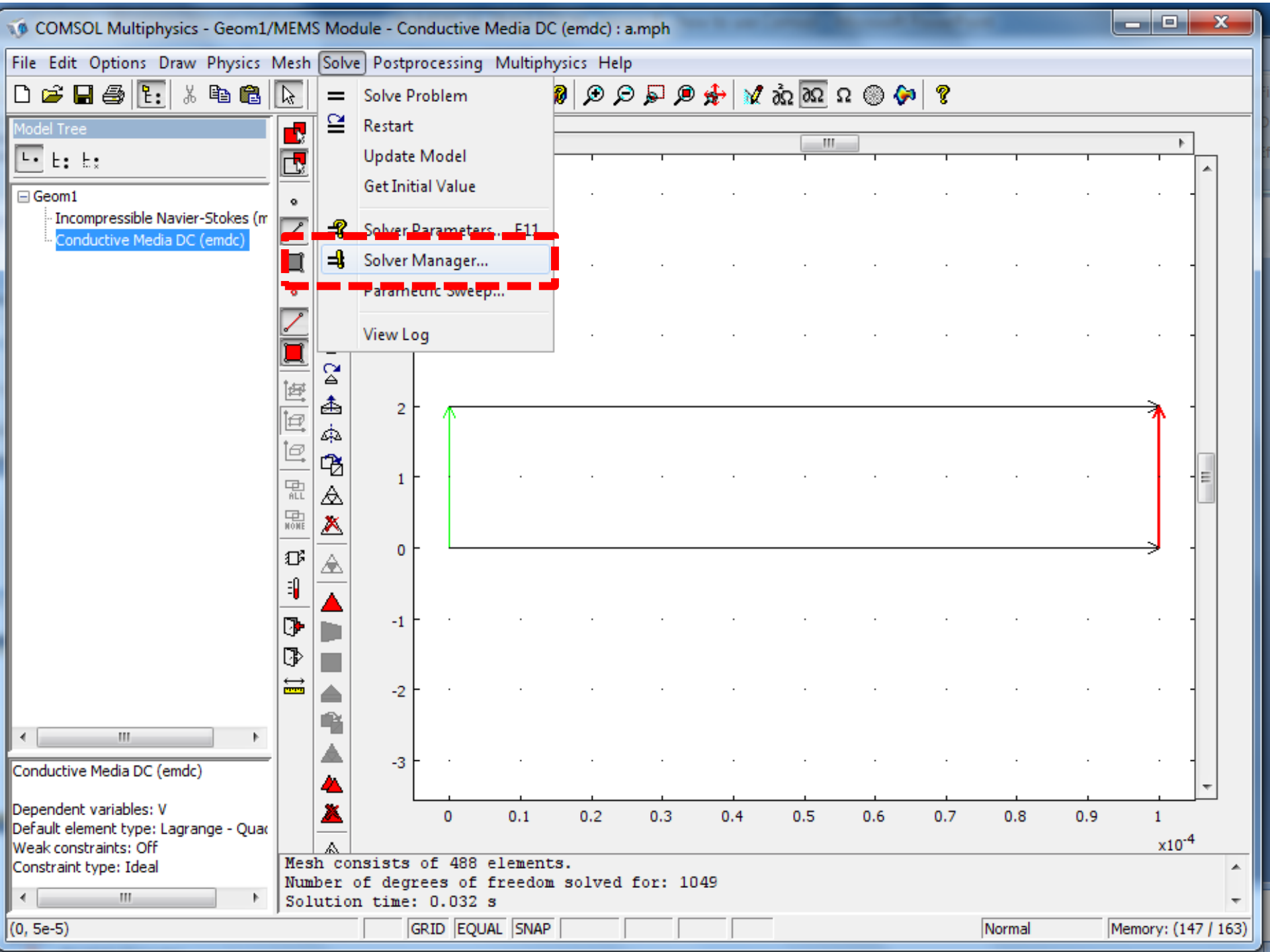

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (n
Conductive Media DC (emdc)
Equation
$V = V_0$
(Electric Potential)
Boundary Settings - Conductive Media DC (emdc)
Equation
V = 0
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Conditions
Port
Color/Style
Boundary sources and constraints
Library material:
Load...
Boundary condition:
Ground
Current flow
Inward current flow
Distributed resistance
Electric insulation
Electric potential
Ground
Electric shielding
Floating potential
OK
Cancel
Apply
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quac
Weak constraints: Off
Constraint type: Ideal
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s

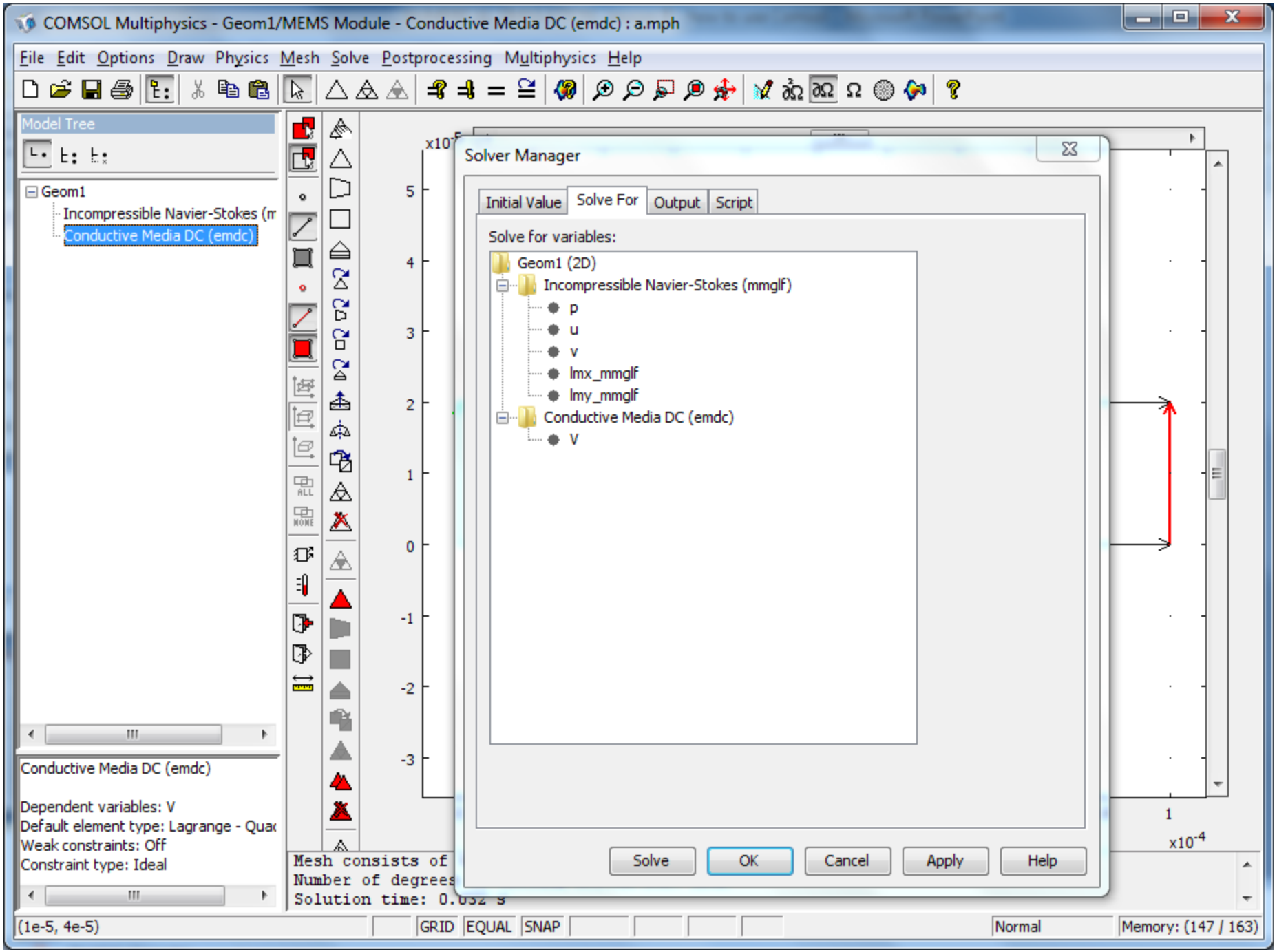

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (n
Conductive Media DC (emdc)
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quac
Weak constraints: Off
Constraint type: Ideal
x10-5
5
4
3
2
1
0
-1
-2
-3
-4
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9
x10-4
(Electric Potential)
V4=0 V
Boundary Settings - Conductive Media DC (emdc)
Equation
V = V0
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Conditions
Port
Color/Style
Boundary sources and constraints
Library material:
Load...
Boundary condition:
Electric potential
Quantity
Value/Expression
Unit
Description
V0
0
V
Electric pote
OK
Cancel
Apply
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s
GRID EQUAL SNAP
Normal
Memory: (147 / 163)

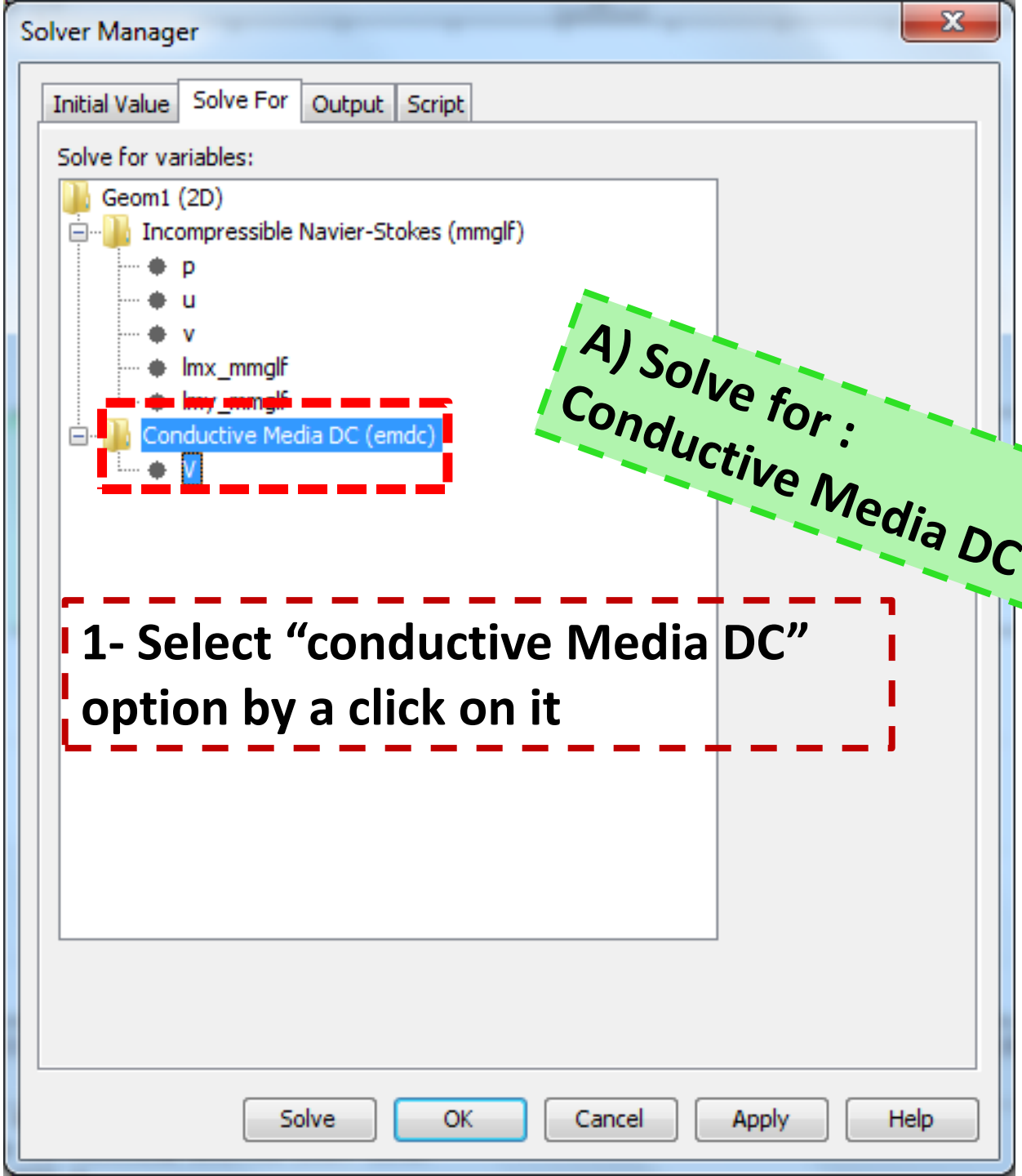

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (n
Conductive Media DC (emdc)
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quac
Weak constraints: Off
Constraint type: Ideal
x10-5
5
4
3
2
1
0
-1
-2
-3
-4
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
x10-4
(Electric Potential)
Boundary Settings - Conductive Media DC (emdc)
Equation
V = V0
Boundaries
Groups
Boundary selection
1
2
3
4
Group:
Select by group
Interior boundaries
Conditions
Port
Color/Style
Boundary sources and constraints
Library material:
Load...
Boundary condition:
Electric potential
Quantity
Value/Expression
Unit
Description
V0
0
V
Electric pote
OK
Cancel
Apply
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s
GRID
EQUAL
SNAP
Normal
Memory: (147 / 163)

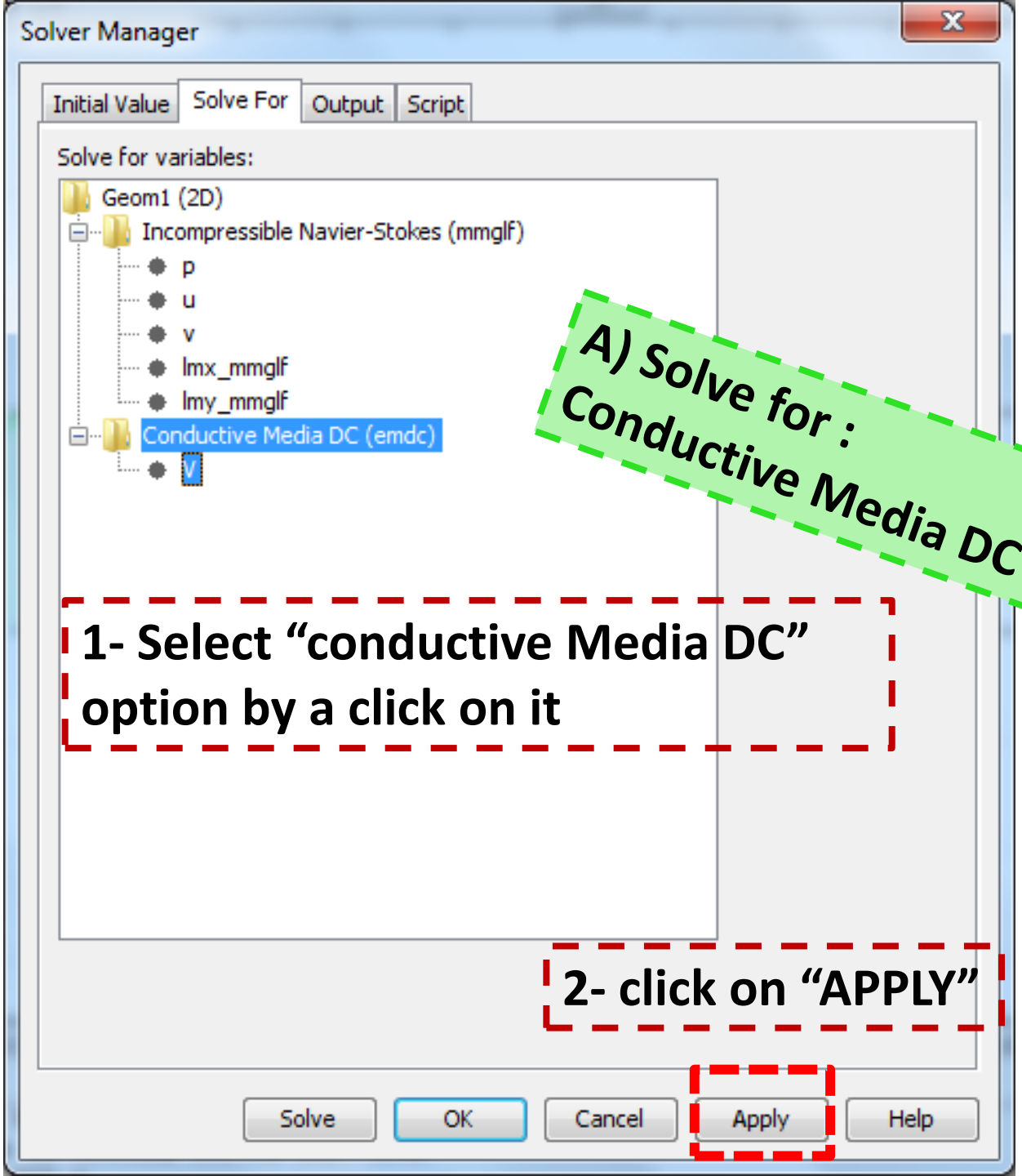
Step 6:

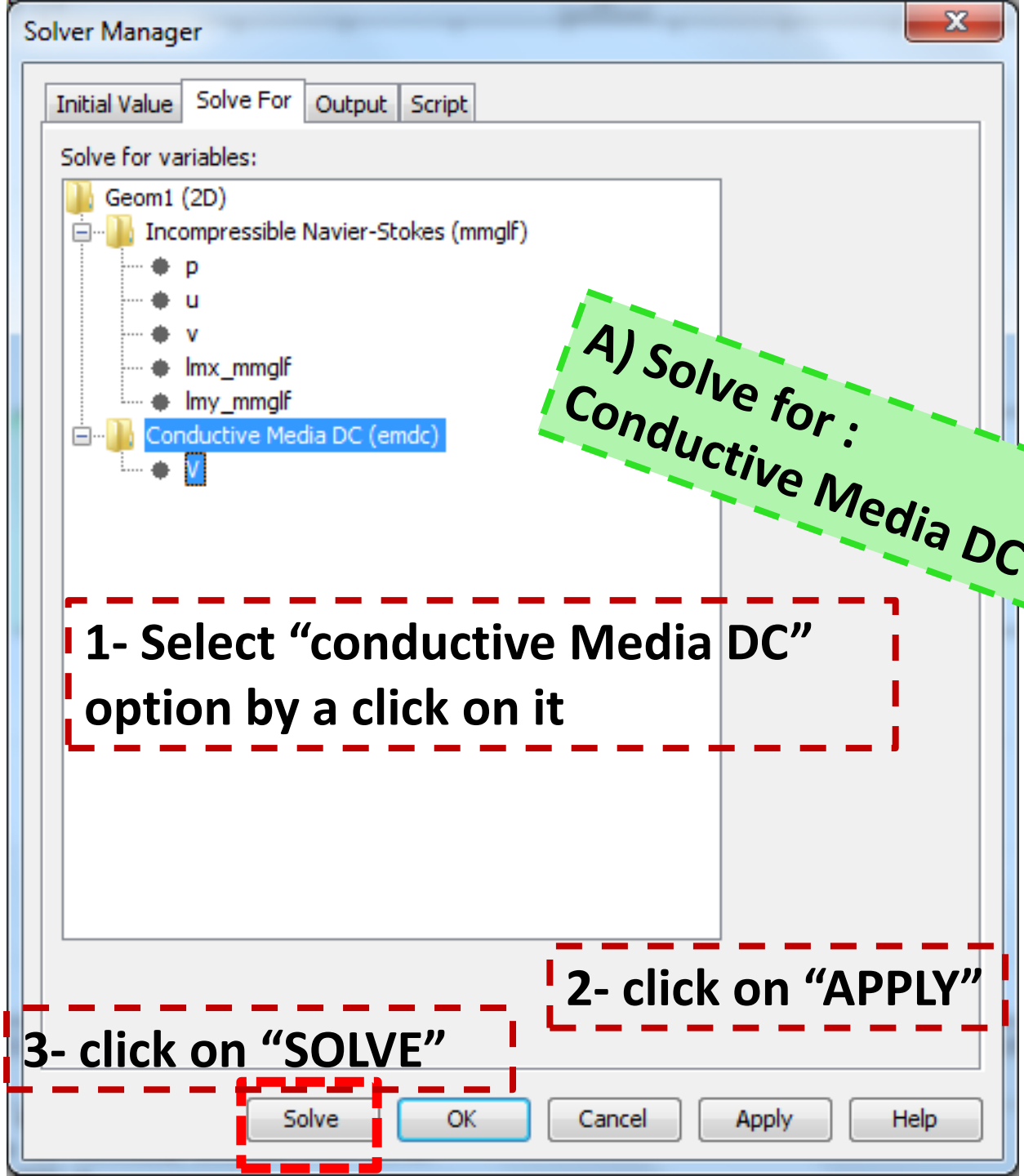
Solve your problem

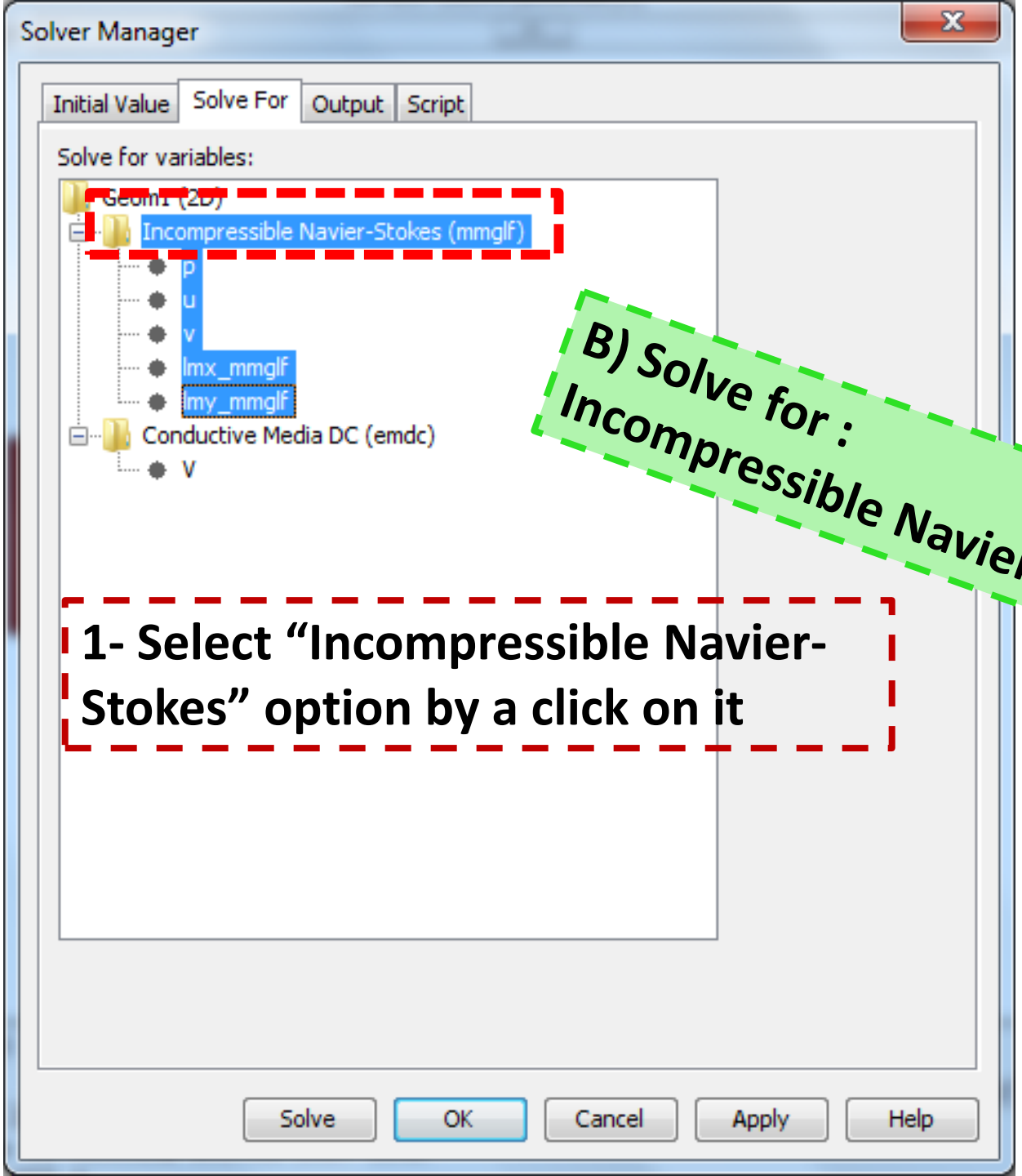

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Solve Problem
Restart
Update Model
Get Initial Value
Solver Parameters... F11
Solver Manager...
Parametric Sweep...
View Log
Model Tree
Geom1
Incompressible Navier-Stokes (n
Conductive Media DC (emdc)
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quac
Weak constraints: Off
Constraint type: Ideal
2
1
0
-1
-2
-3
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
x10-4
Mesh consists of 488 elements.
Number of degrees of freedom solved for: 1049
Solution time: 0.032 s
(0, 5e-5)
GRID EQUAL SNAP
Normal
Memory: (147 / 163)

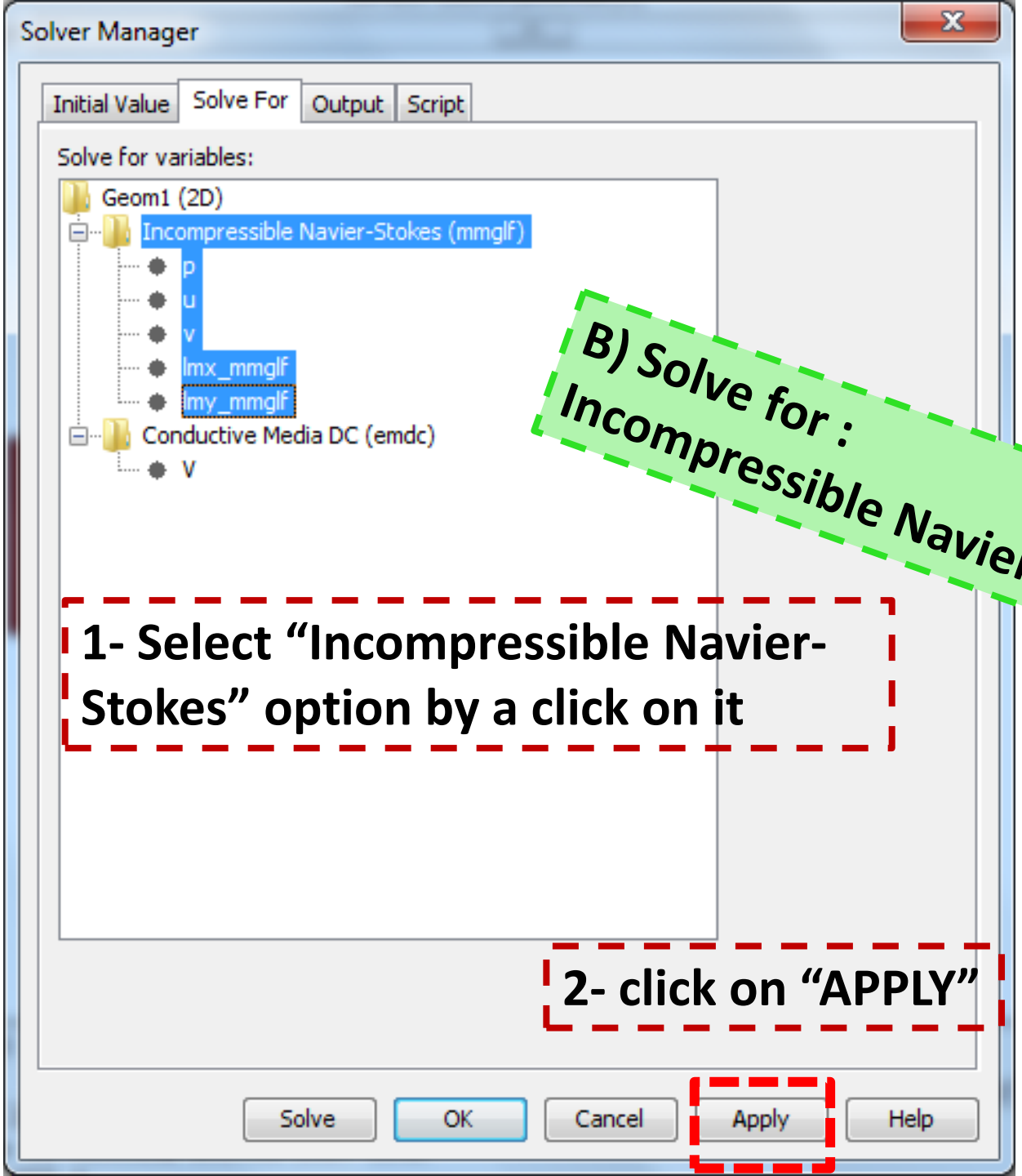

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (m
Conductive Media DC (emdc)
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quac
Weak constraints: Off
Constraint type: Ideal
Solver Manager
Initial Value
Solve For
Output
Script
Solve for variables:
Geom1 (2D)
Incompressible Navier-Stokes (mmglf)
p
u
v
lmx_mmglf
lmy_mmglf
Conductive Media DC (emdc)
V
Solve
OK
Cancel
Apply
Help
Mesh consists of
Number of degrees
Solution time: 0.032 s
(1e-5, 4e-5)
GRID
EQUAL
SNAP
Normal
Memory: (147 / 163)

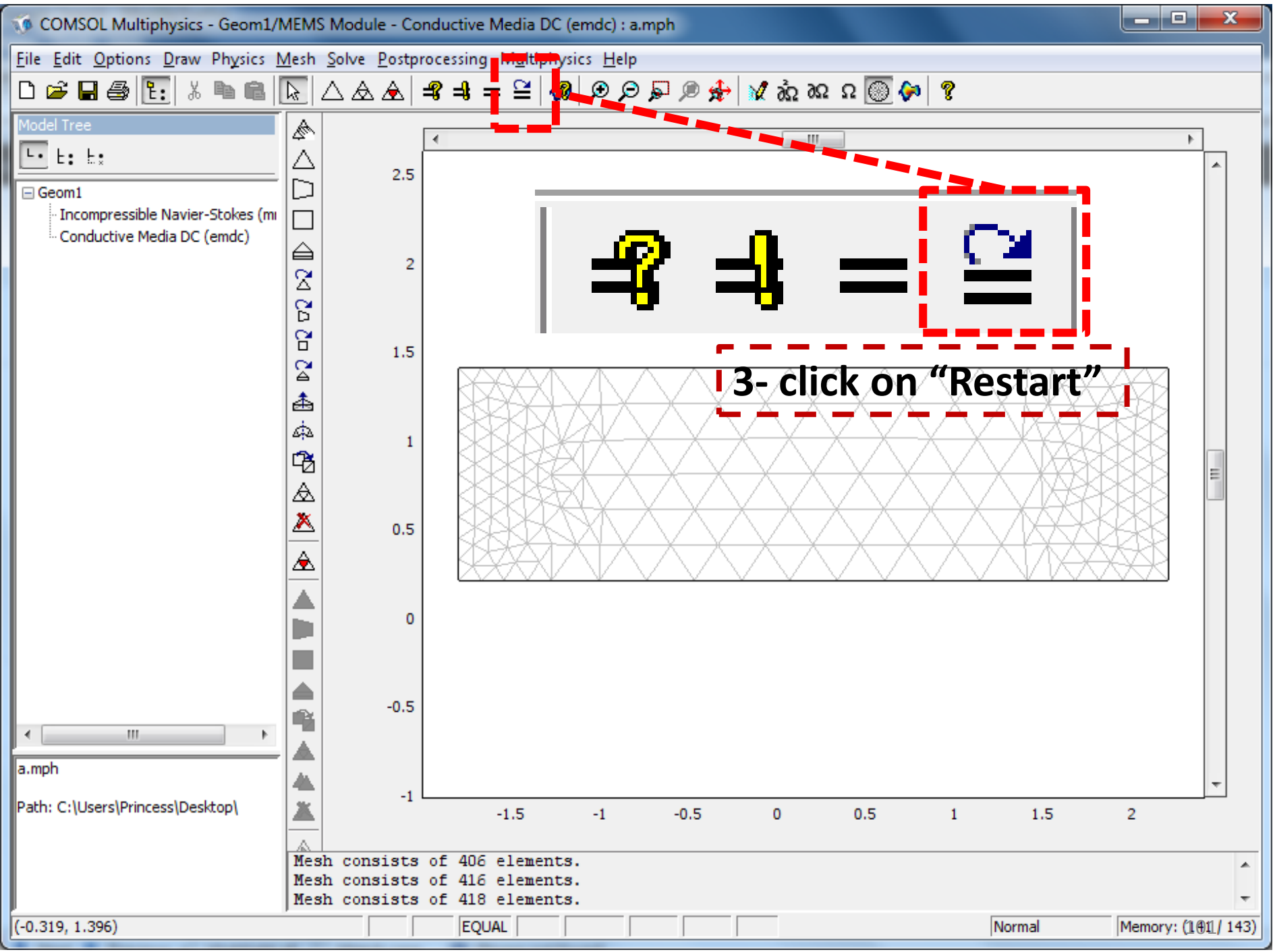

Solver Manager
Initial Value
Solve For
Output
Script
Solve for variables:
Geom1 (2D)
Incompressible Navier-Stokes (mmglf)
p
u
v
lmx_mmglf
Conductive Media DC (emdc)
V
A) Solve for : Conductive Media DC
1- Select “conductive Media DC” option by a click on it
Solve
OK
Cancel
Apply
Help

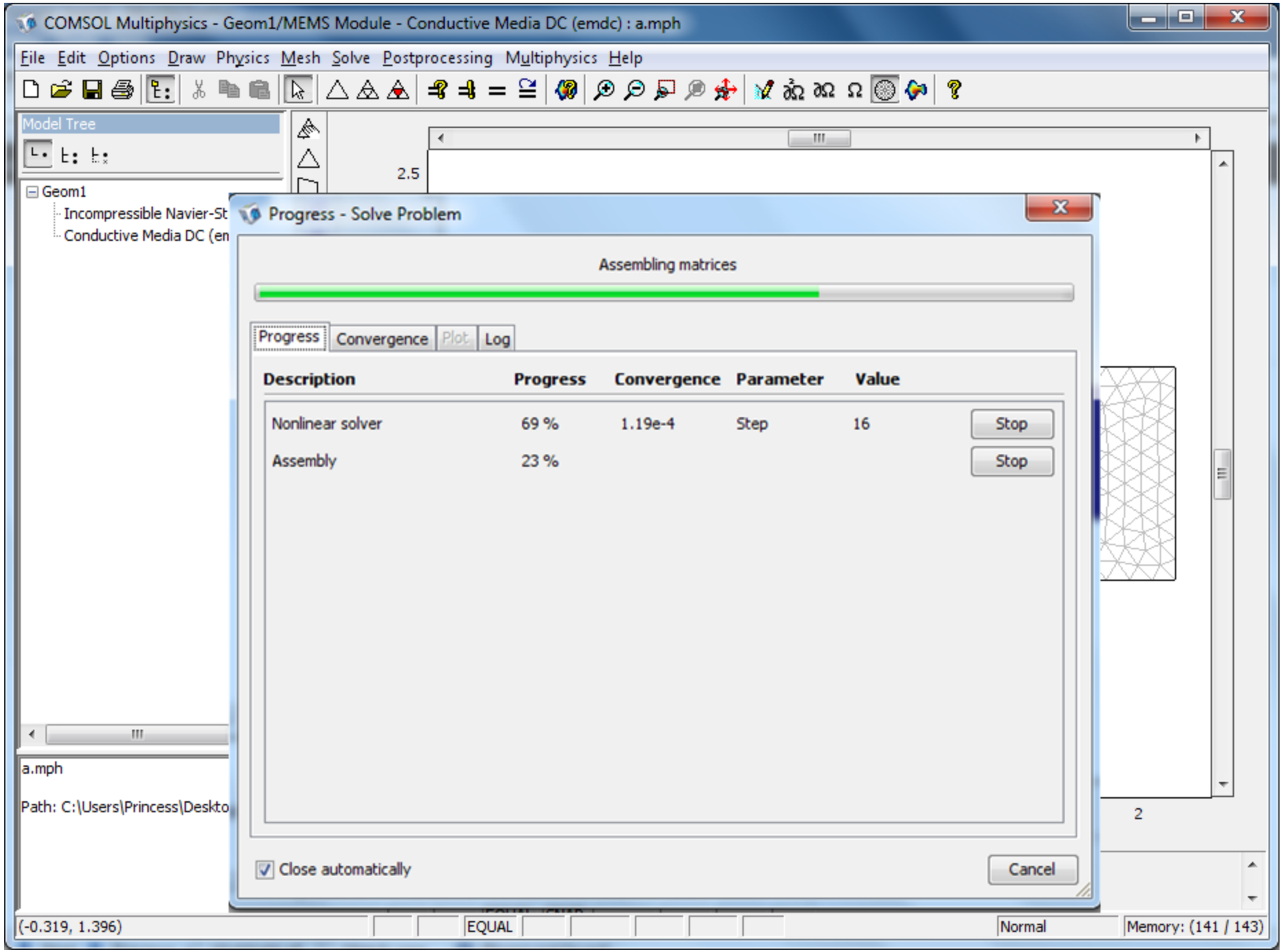

Solver Manager
Initial Value
Solve For
Output
Script
Solve for variables:
Geom1 (2D)
Incompressible Navier-Stokes (mmglf)
p
u
v
lmx_mmglf
lmy_mmglf
Conductive Media DC (emdc)
V
A) Solve for : Conductive Media DC
1- Select “conductive Media DC” option by a click on it
2- click on “APPLY”
Solve
OK
Cancel
Apply
Help


Solver Manager
Initial Value
Solve For
Output
Script
Solve for variables:
Geom1 (2D)
Incompressible Navier-Stokes (mmglf)
p
u
v
lmx_mmglf
lmy_mmglf
Conductive Media DC (emdc)
V
A) Solve for : Conductive Media DC
1- Select “conductive Media DC” option by a click on it
2- click on “APPLY”
3- click on “SOLVE”
Solve
OK
Cancel
Apply
Help


Solver Manager
Initial Value
Solve For
Output
Script
Solve for variables:
Geom1 (2D)
Incompressible Navier-Stokes (mmglf)
p
u
v
lmx_mmglf
lmy_mmglf
Conductive Media DC (emdc)
V
B) Solve for : Incompressible Navier-Stokes
1- Select “Incompressible Navier-Stokes” option by a click on it
Solve
OK
Cancel
Apply
Help

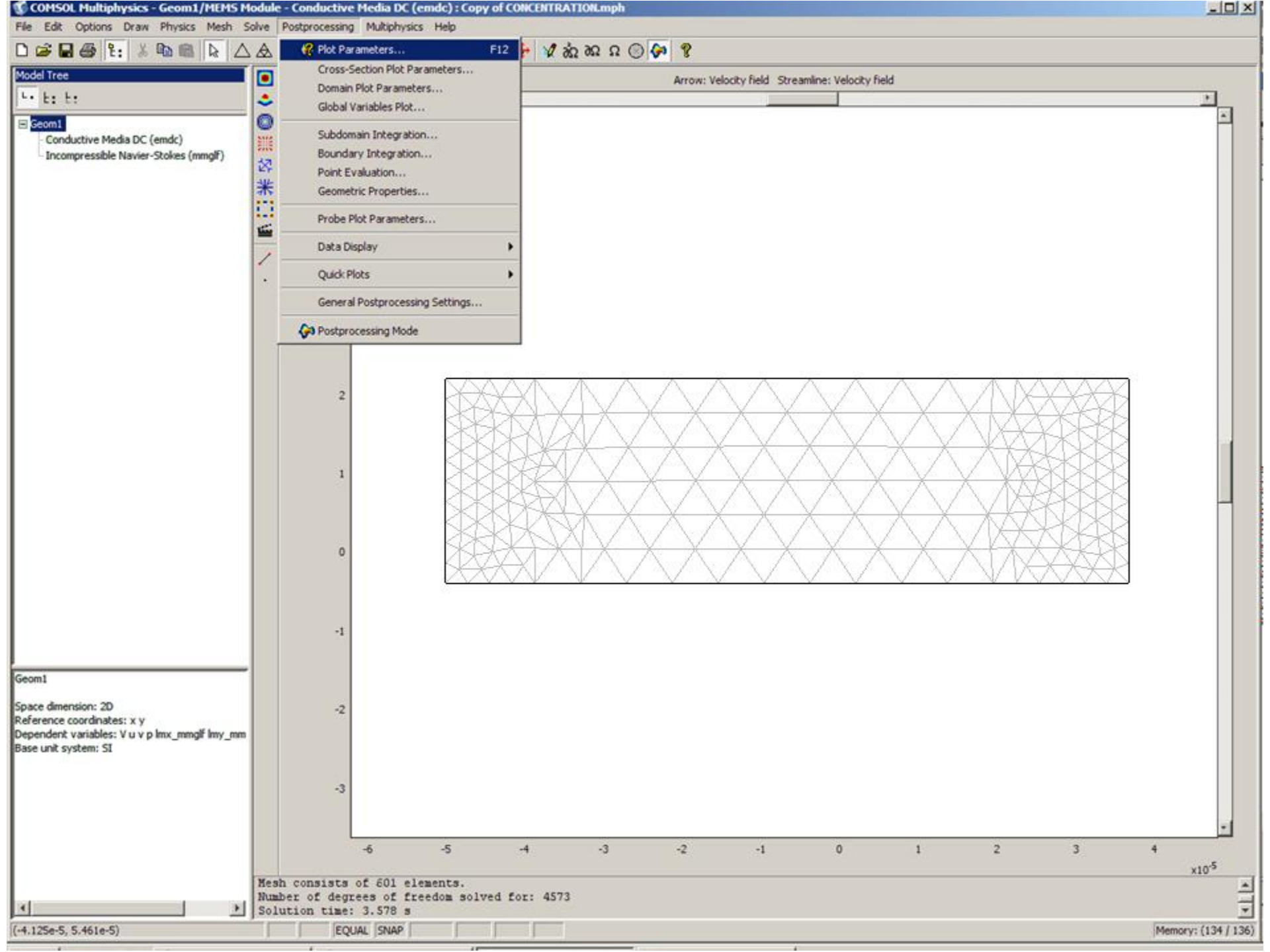

Solver Manager
Initial Value
Solve For
Output
Script
Solve for variables:
Geom1 (2D)
Incompressible Navier-Stokes (mmglf)
p
u
v
lmx_mmglf
lmy_mmglf
Conductive Media DC (emdc)
V
B) Solve for : Incompressible Navier-Stokes
1- Select “Incompressible Navier-Stokes” option by a click on it
2- click on “APPLY”
Solve
OK
Cancel
Apply
Help

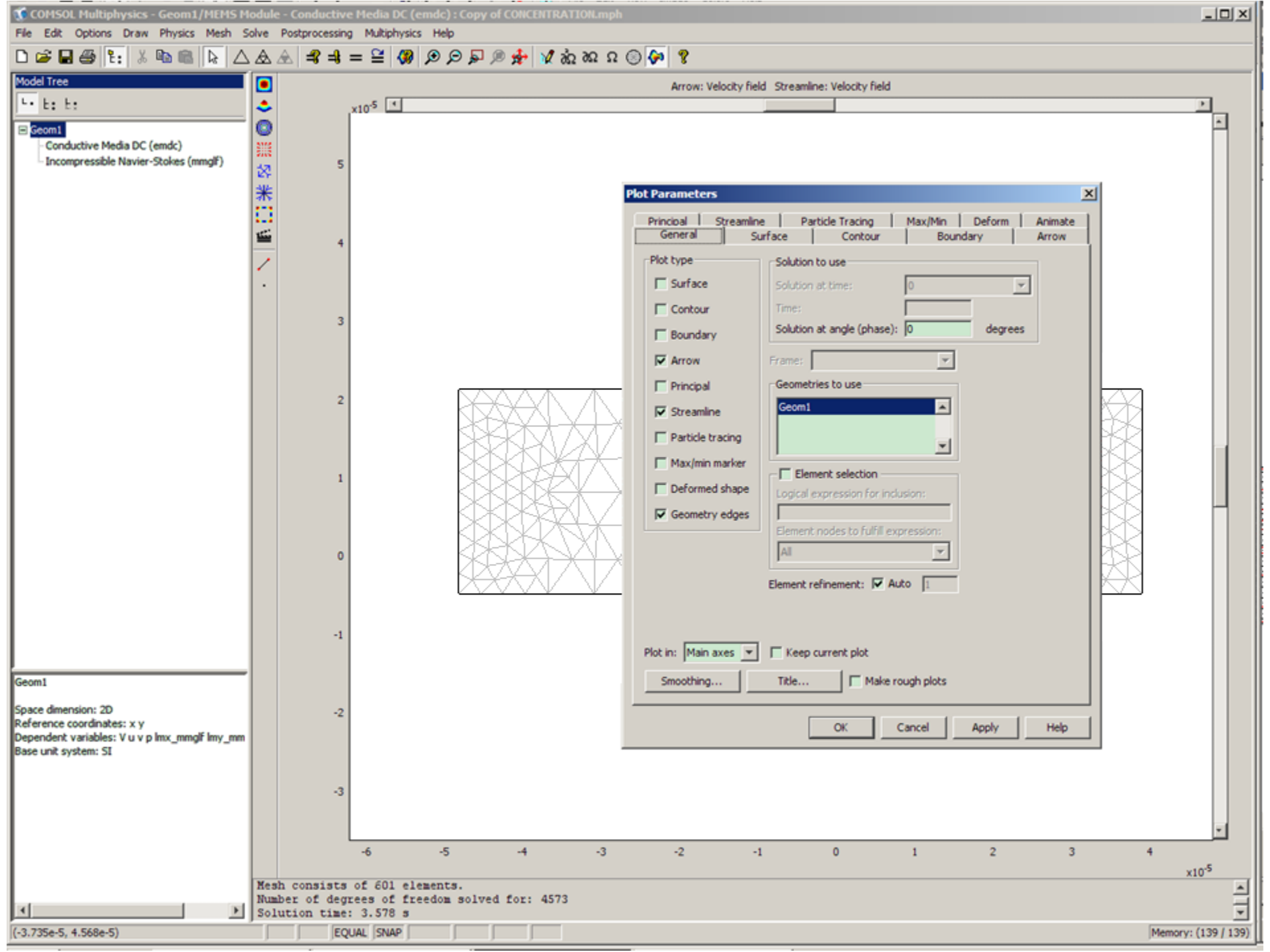

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (mi
Conductive Media DC (emdc)
3- click on “Restart”
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-1
-0.5
0
0.5
1
1.5
2
a.mph
Path: C:\Users\Princess\Desktop\
Mesh consists of 406 elements.
Mesh consists of 416 elements.
Mesh consists of 418 elements.
(-0.319, 1.396)
EQUAL
Normal
Memory: (101/ 143)

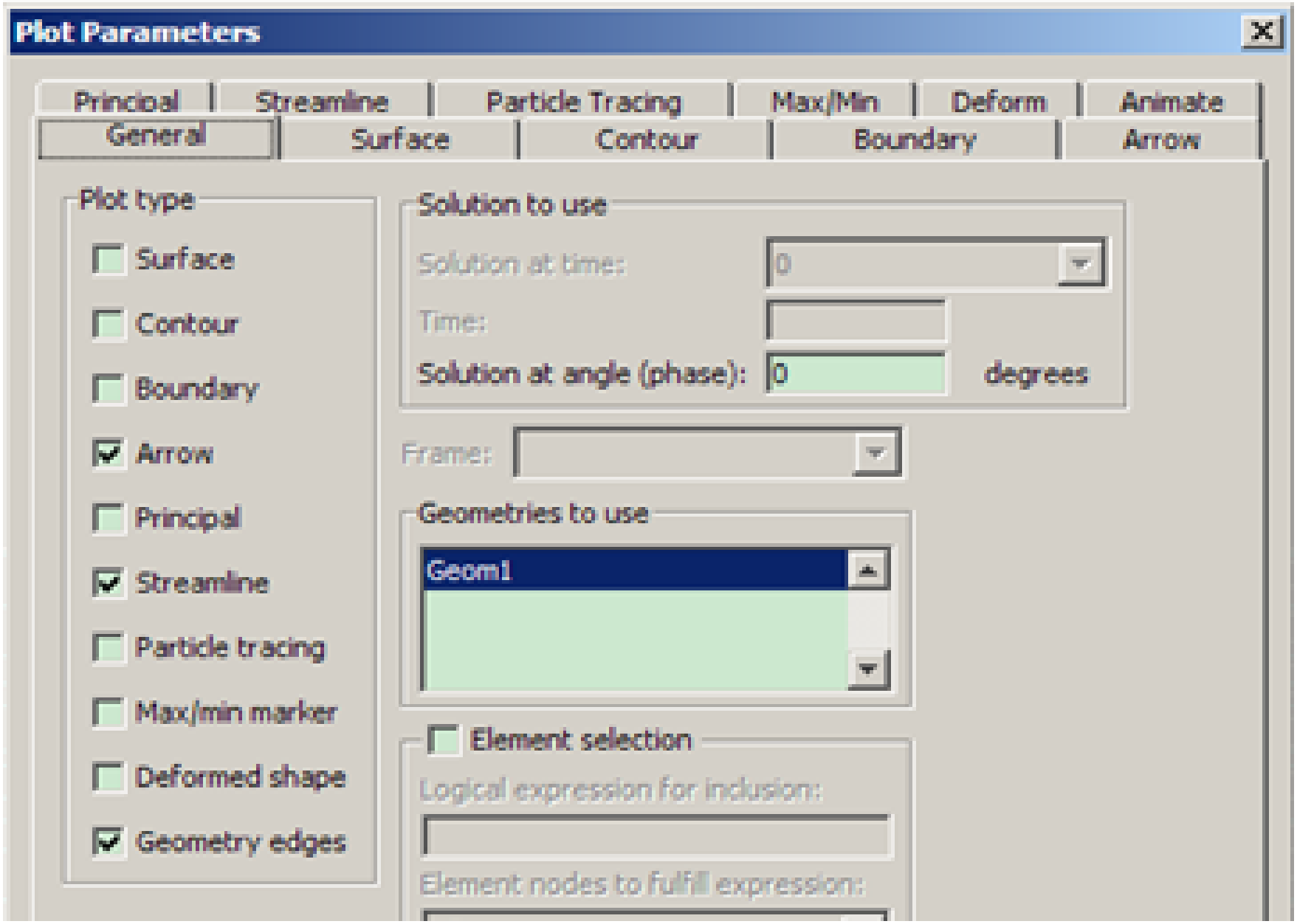

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-St
Conductive Media DC (en
2.5
Progress - Solve Problem
Assembling matrices
Progress
Convergence
Plot
Log
Description
Progress
Convergence
Parameter
Value
Nonlinear solver
69 %
1.19e-4
Step
16
Stop
Assembly
23 %
Stop
Close automatically
Cancel
a.mph
Path: C:\Users\Princess\Deskto
2
(-0.319, 1.396)
EQUAL
Normal
Memory: (141 / 143)

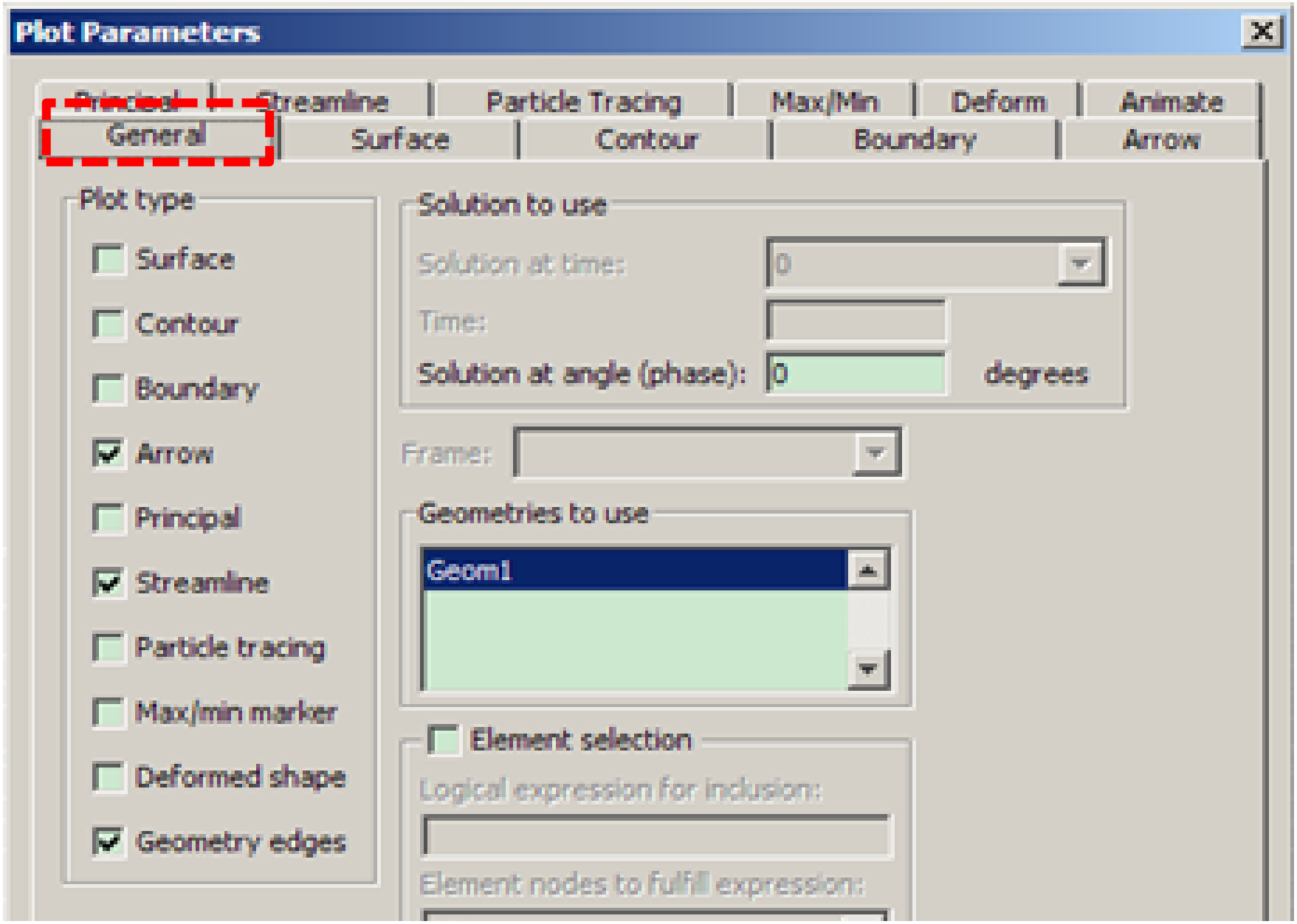
Step 7:

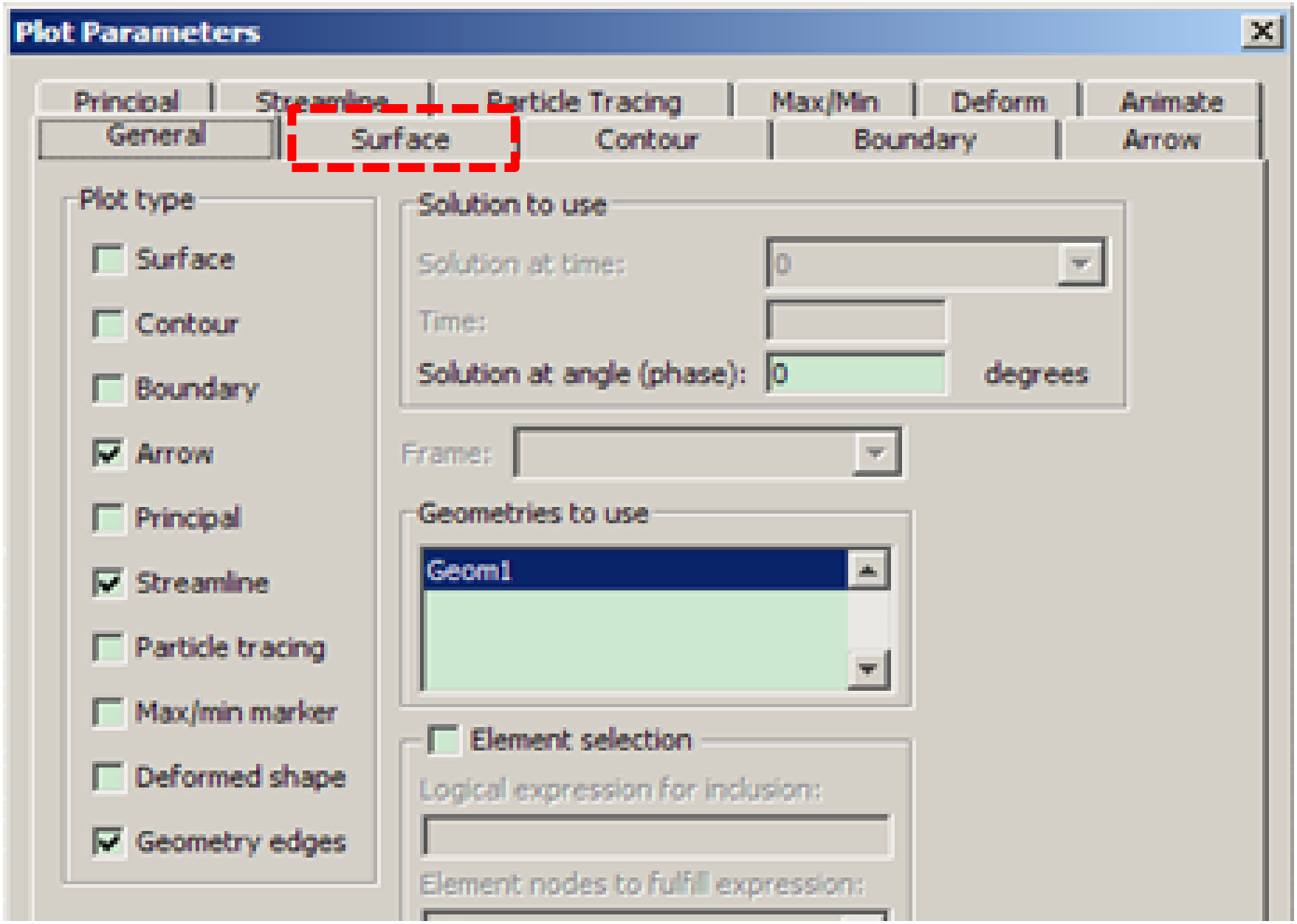
Post-processing

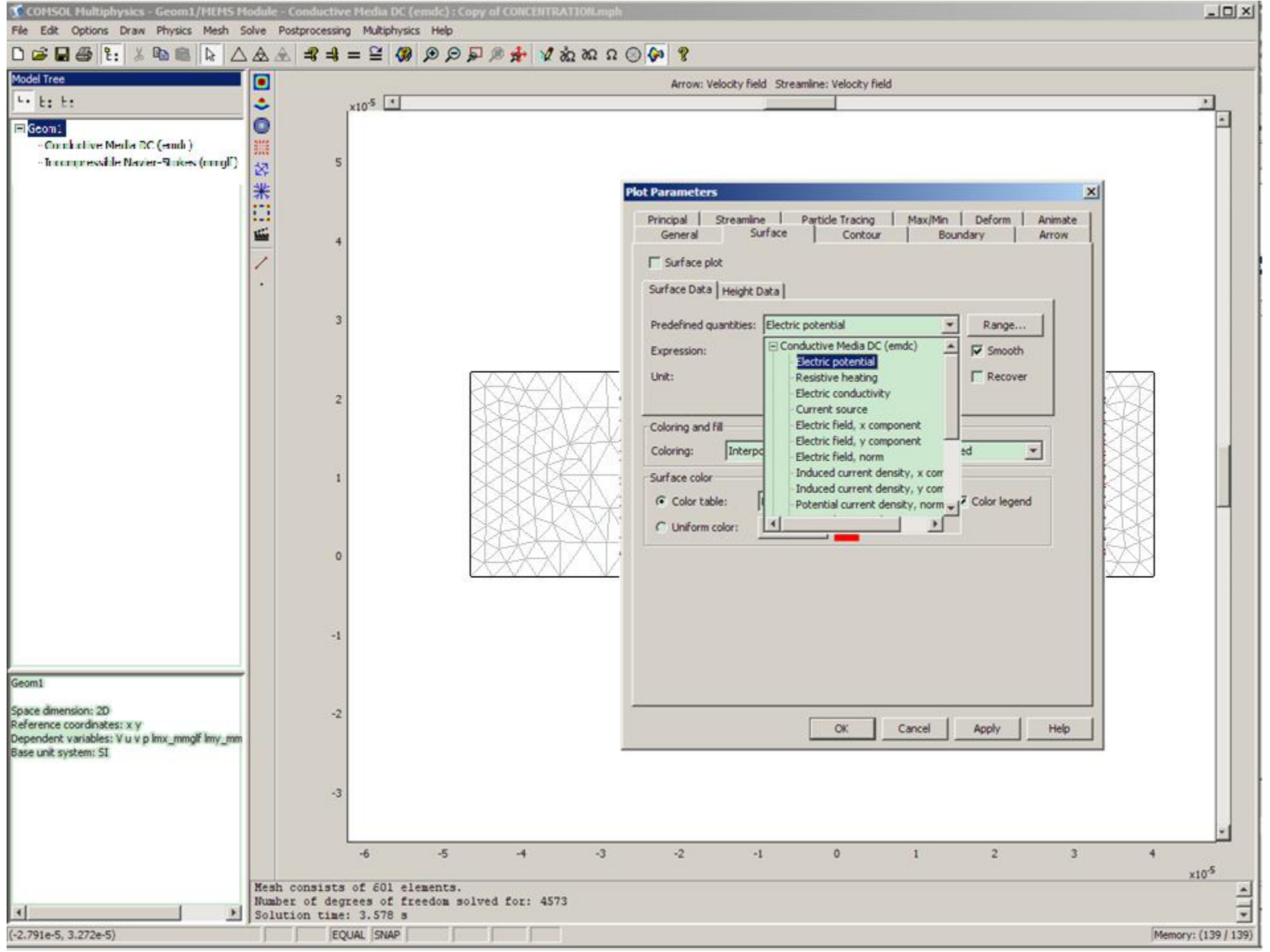

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : Copy of CONCENTRATION.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Plot Parameters... F12
Cross-Section Plot Parameters...
Domain Plot Parameters...
Global Variables Plot...
Subdomain Integration...
Boundary Integration...
Point Evaluation...
Geometric Properties...
Probe Plot Parameters...
Data Display
Quick Plots
General Postprocessing Settings...
Postprocessing Mode
Model Tree
Geom1
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmglf)
Arrow: Velocity field Streamline: Velocity field
Geom1
Space dimension: 2D
Reference coordinates: x y
Dependent variables: V u v p lmx_mmglf lmy_mm
Base unit system: SI
Mesh consists of 601 elements.
Number of degrees of freedom solved for: 4573
Solution time: 3.578 s
x10-5
EQUAL SNAP
Memory: (134 / 136)

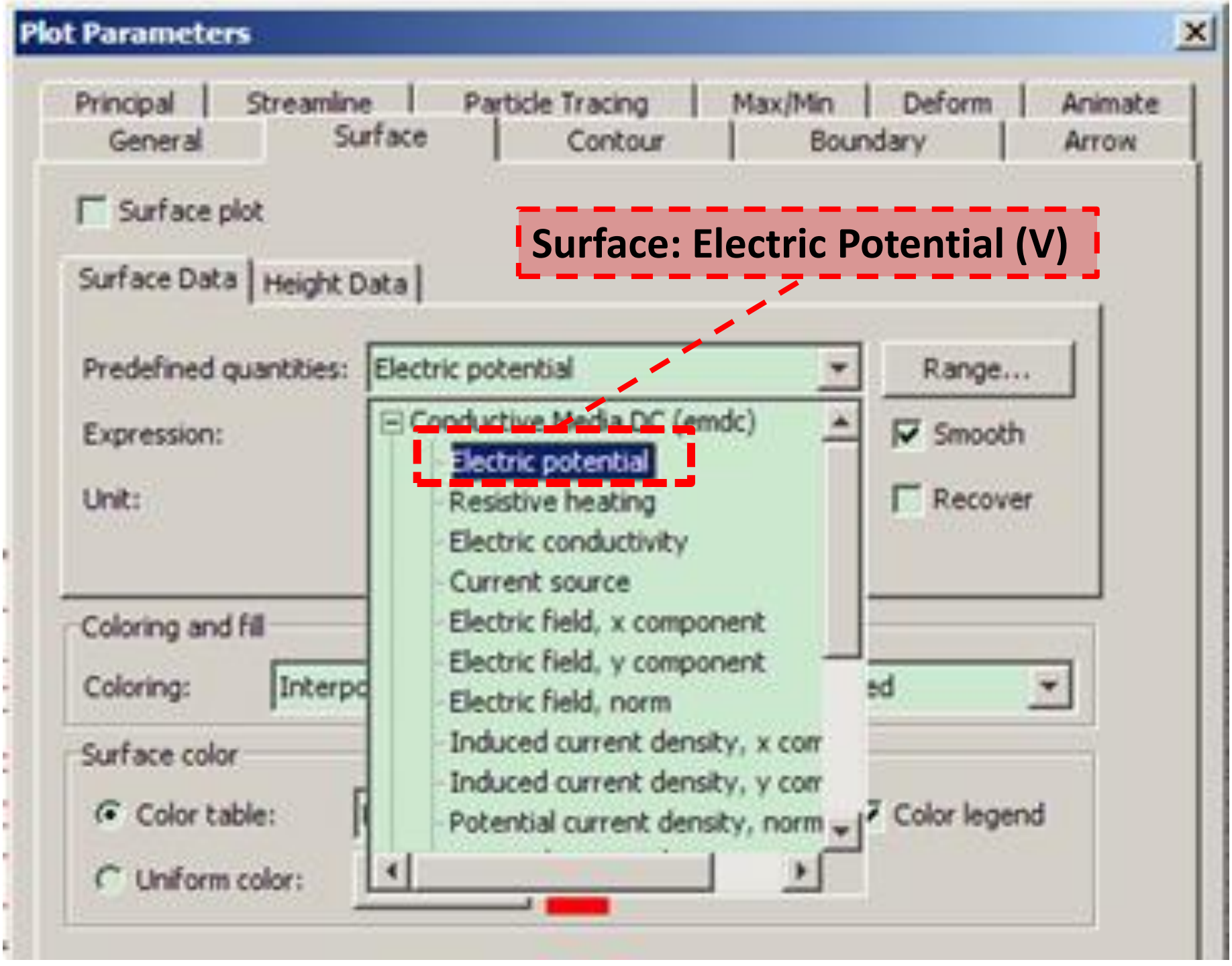

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : Copy of CONCENTRATION.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmglf)
Geom1
Space dimension: 2D
Reference coordinates: x y
Dependent variables: V u v p lmx_mmglf lmy_mm
Base unit system: SI
Arrow: Velocity field Streamline: Velocity field
x10-5
Plot Parameters
Principal Streamline Particle Tracing Max/Min Deform Animate
General Surface Contour Boundary Arrow
Plot type
Surface
Contour
Boundary
Arrow
Principal
Streamline
Particle tracing
Max/min marker
Deformed shape
Geometry edges
Solution to use
Solution at time:
Time:
Solution at angle (phase): 0 degrees
Frame:
Geometries to use
Geom1
Element selection
Logical expression for inclusion:
Element nodes to fulfill expression:
All
Element refinement: Auto 1
Plot in: Main axes
Keep current plot
Smoothing...
Title...
Make rough plots
OK
Cancel
Apply
Help
Mesh consists of 601 elements.
Number of degrees of freedom solved for: 4573
Solution time: 3.578 s
(-3.735e-5, 4.568e-5)
EQUAL SNAP
Memory: (139 / 139)


Plot Parameters
Principal
Streamline
Particle Tracing
Max/Min
Deform
Animate
General
Surface
Contour
Boundary
Arrow
Plot type
Surface
Contour
Boundary
Arrow
Principal
Streamline
Particle tracing
Max/min marker
Deformed shape
Geometry edges
Solution to use
Solution at time:
0
Time:
Solution at angle (phase):
0
degrees
Frame:
Geometries to use
Geom1
Element selection
Logical expression for inclusion:
Element nodes to fulfill expression:


Plot Parameters
Principal
Streamline
Particle Tracing
Max/Min
Deform
Animate
General
Surface
Contour
Boundary
Arrow
Plot type
Surface
Contour
Boundary
Arrow
Principal
Streamline
Particle tracing
Max/min marker
Deformed shape
Geometry edges
Solution to use
Solution at time:
0
Time:
Solution at angle (phase):
0
degrees
Frame:
Geometries to use
Geom1
Element selection
Logical expression for inclusion:
Element nodes to fulfill expression:


Plot Parameters
Principal
Streamline
Particle Tracing
Max/Min
Deform
Animate
General
Surface
Contour
Boundary
Arrow
Plot type
Surface
Contour
Boundary
Arrow
Principal
Streamline
Particle tracing
Max/min marker
Deformed shape
Geometry edges
Solution to use
Solution at time:
0
Time:
Solution at angle (phase):
0
degrees
Frame:
Geometries to use
Geom1
Element selection
Logical expression for inclusion:
Element nodes to fulfill expression:


COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : Copy of CONCENTRATION.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmglf)
Arrow: Velocity field Streamline: Velocity field
Plot Parameters
Principal Streamline Particle Tracing Max/Min Deform Animate
General Surface Contour Boundary Arrow
Surface plot
Surface Data Height Data
Predefined quantities: Electric potential
Range...
Expression:
Unit:
Smooth
Recover
Conductive Media DC (emdc)
Electric potential
Resistive heating
Electric conductivity
Current source
Electric field, x component
Electric field, y component
Electric field, norm
Induced current density, x com
Induced current density, y com
Potential current density, norm
Coloring and fill
Coloring:
Surface color
Color table:
Color legend
Uniform color:
OK
Cancel
Apply
Help
Geom1
Space dimension: 2D
Reference coordinates: x y
Dependent variables: V u v p lmx_mmglf lmy_mm
Base unit system: SI
Mesh consists of 601 elements.
Number of degrees of freedom solved for: 4573
Solution time: 3.578 s
(-2.791e-5, 3.272e-5)
EQUAL SNAP
Memory: (139 / 139)


Plot Parameters
Principal
Streamline
Particle Tracing
Max/Min
Deform
Animate
General
Surface
Contour
Boundary
Arrow
Surface plot
Surface: Electric Potential (V)
Surface Data
Height Data
Predefined quantities:
Electric potential
Range...
Expression:
Conductive Media DC (emdc)
Smooth
Electric potential
Unit:
Resistive heating
Recover
Electric conductivity
Current source
Electric field, x component
Coloring and fill
Electric field, y component
Coloring:
Electric field, norm
Induced current density, x com
Surface color
Induced current density, y com
Color table:
Potential current density, norm
Color legend
Uniform color:

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph

File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help

Model Tree

Geom1

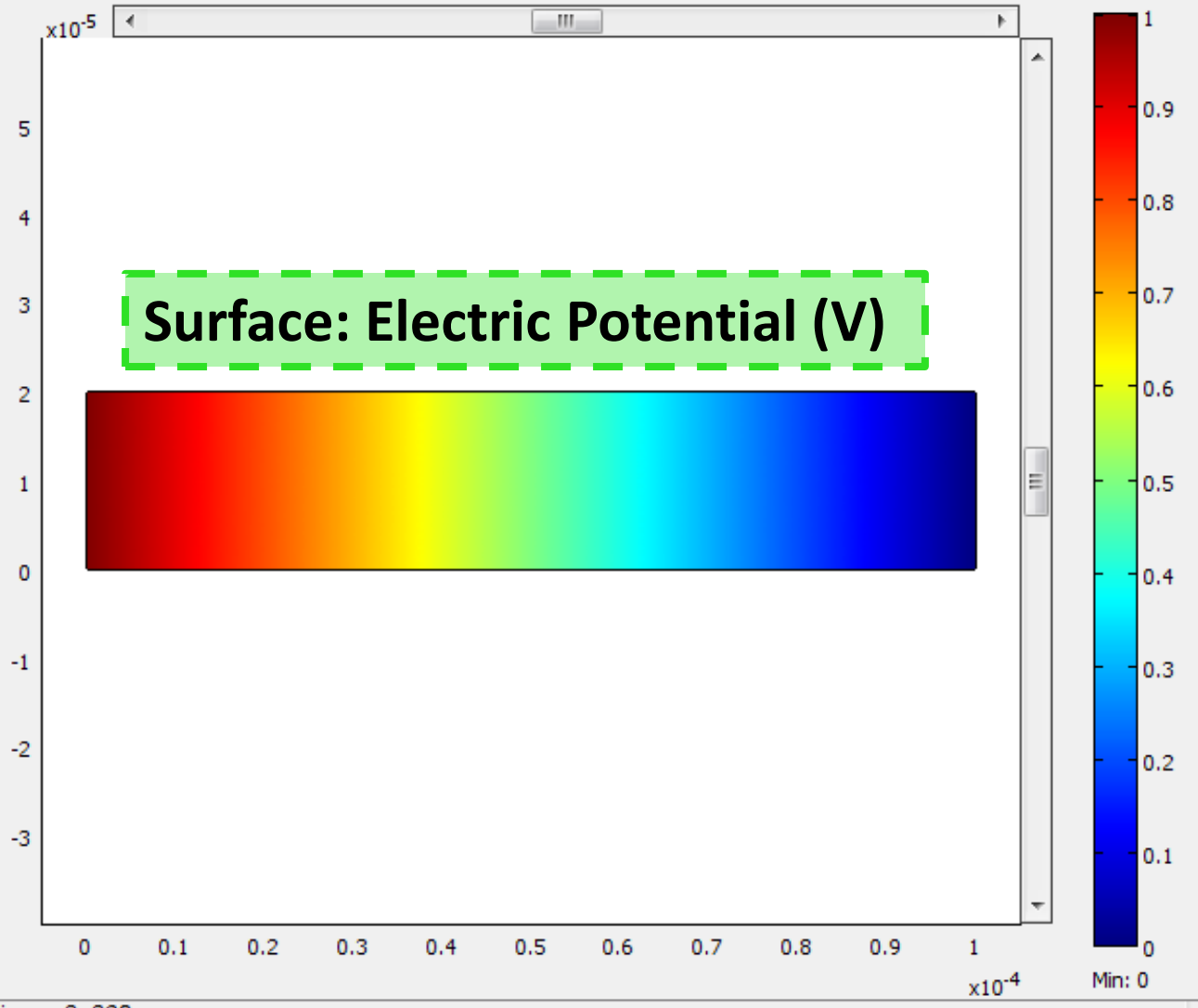
Incompressible Navier-Stokes (m

Conductive Media DC (emdc)

Conductive Media DC (emdc)

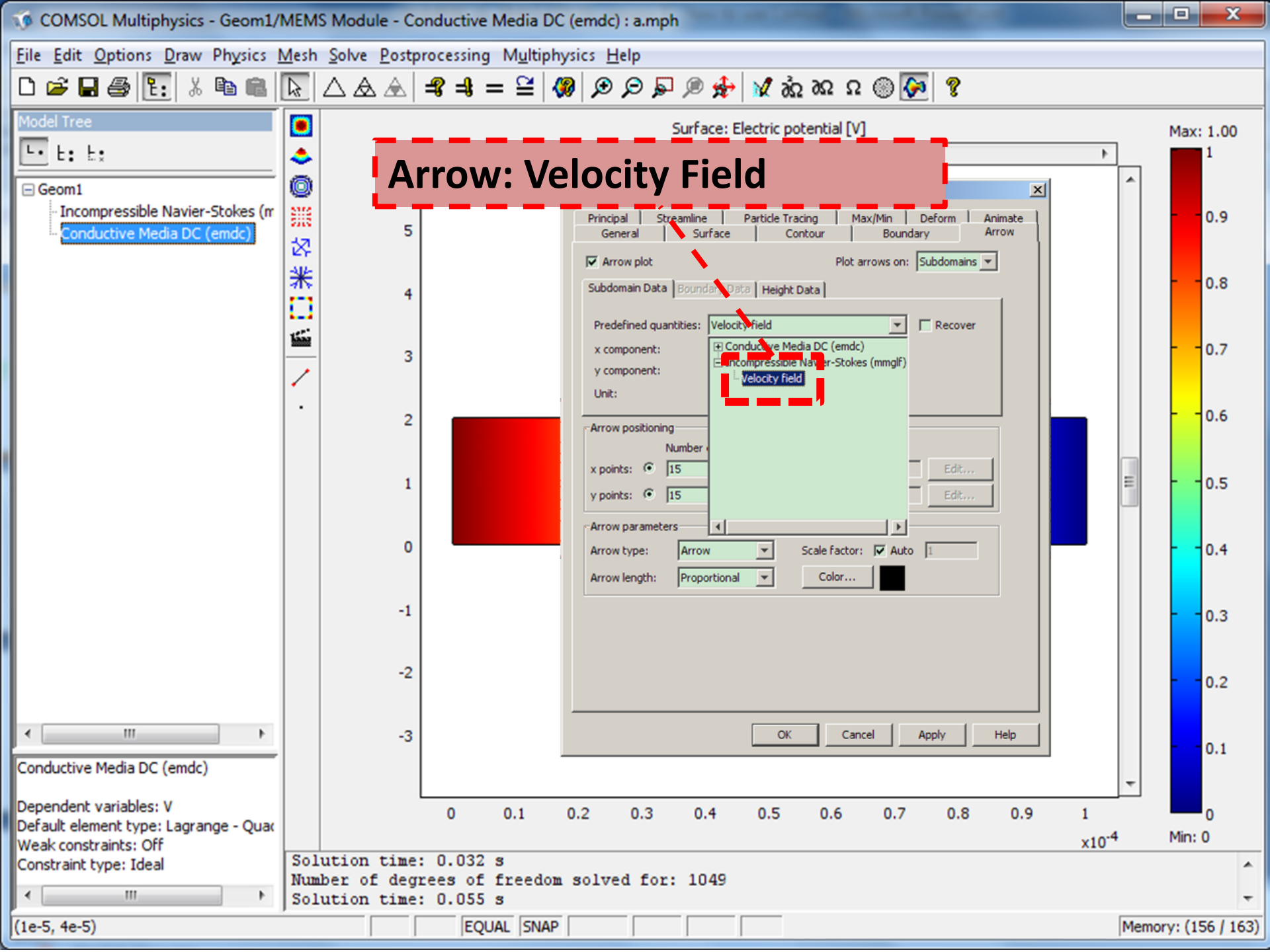
Dependent variables: V
Default element type: Lagrange - Quac
Weak constraints: Off
Constraint type: Ideal

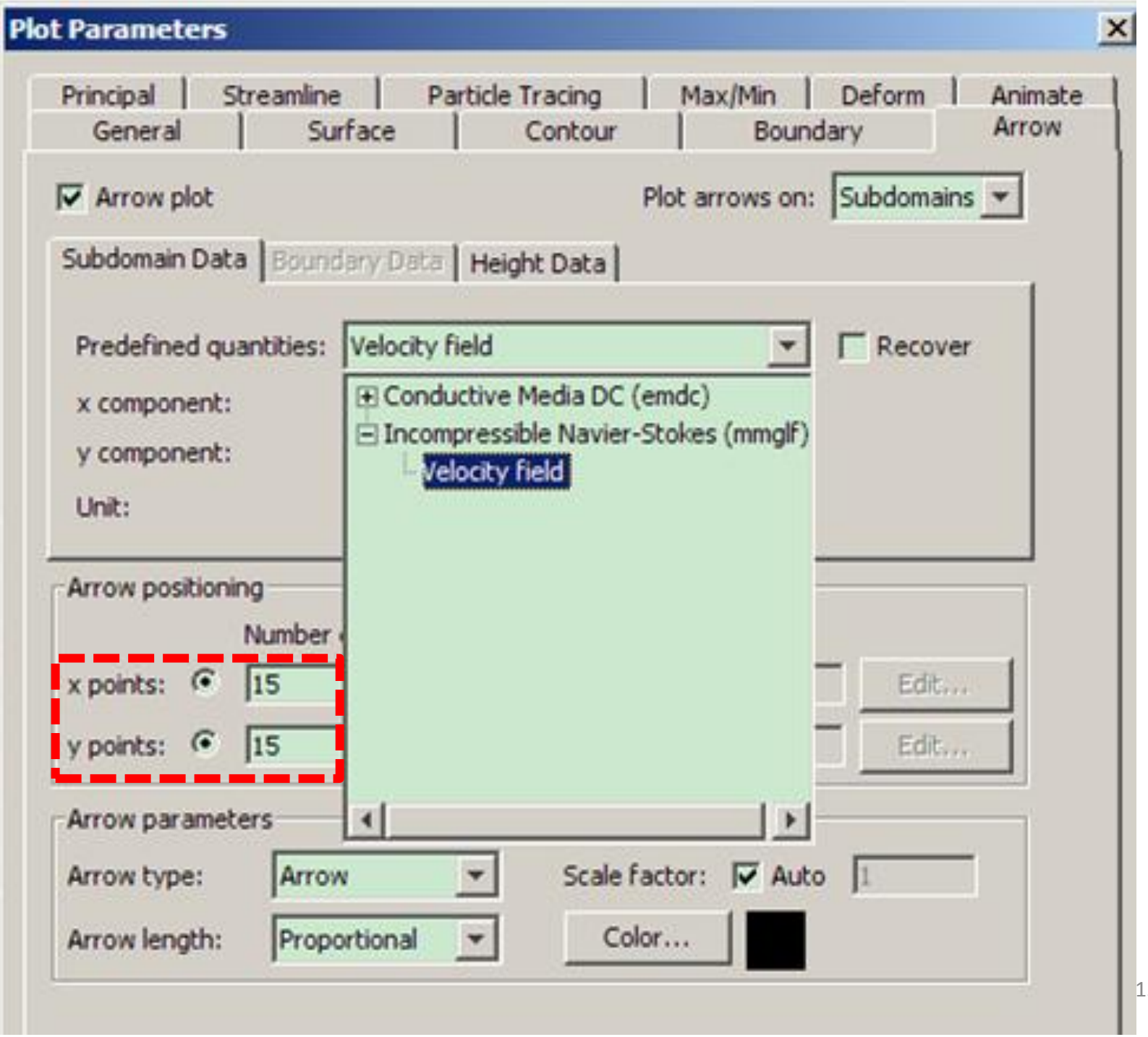
Surface: Electric potential [V]

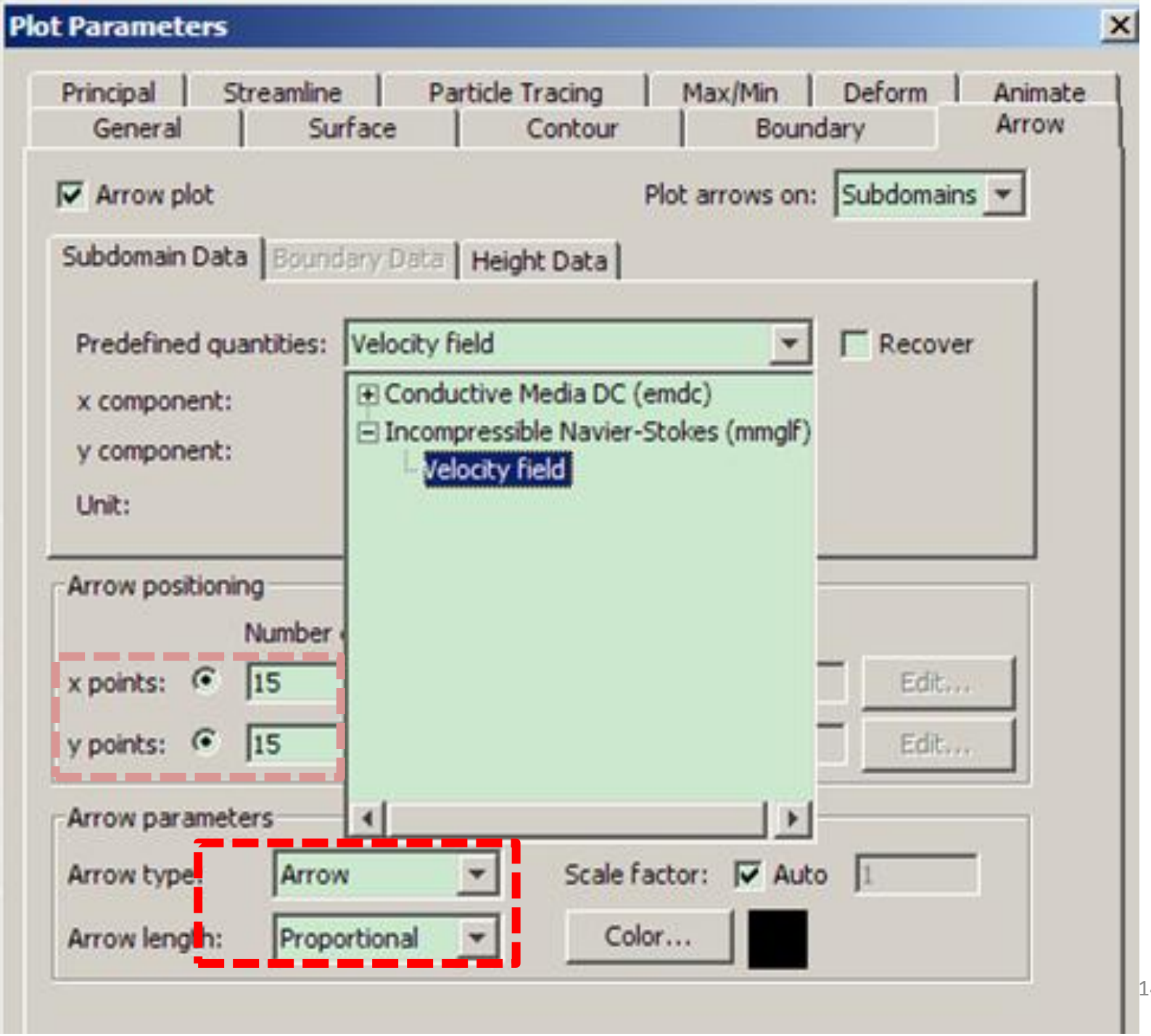


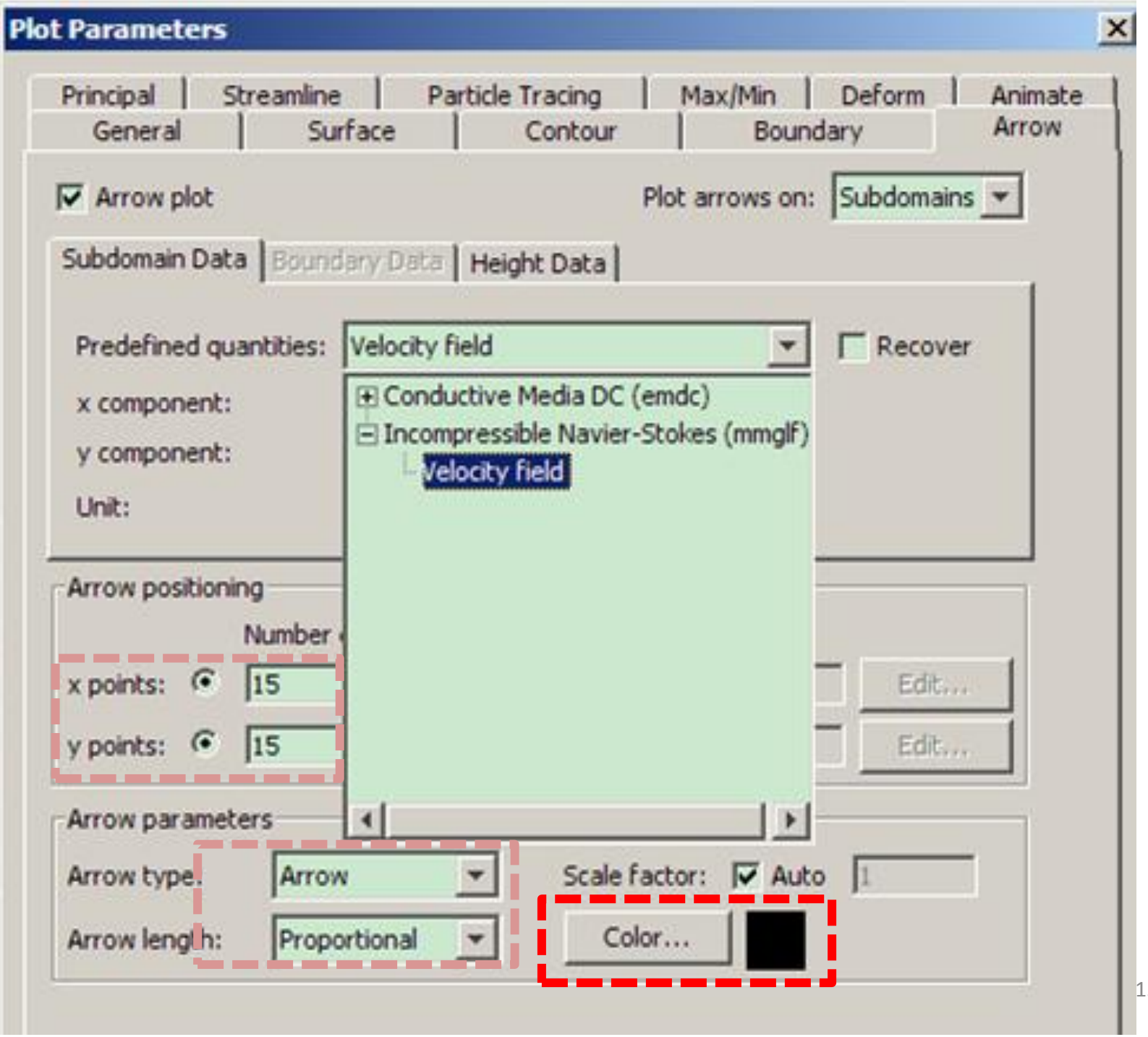
Solution time: 0.032 s
Number of degrees of freedom solved for: 1049
Solution time: 0.055 s

(1e-5, 4e-5) EQUAL SNAP Memory: (156 / 163)


COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : a.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompressible Navier-Stokes (n
Conductive Media DC (emdc)
Surface: Electric potential [V]
Arrow: Velocity Field
Max: 1.00
Min: 0
Principal Streamline Particle Tracing Max/Min Deform Animate
General Surface Contour Boundary Arrow
Arrow plot
Plot arrows on: Subdomains
Subdomain Data Height Data
Predefined quantities: Velocity field
Recover
x component:
y component:
Unit:
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmglf)
Velocity field
Arrow positioning
Number
x points: 15
y points: 15
Edit...
Arrow parameters
Arrow type: Arrow
Scale factor: Auto
Arrow length: Proportional
Color...
OK Cancel Apply Help
Conductive Media DC (emdc)
Dependent variables: V
Default element type: Lagrange - Quac
Weak constraints: Off
Constraint type: Ideal
Solution time: 0.032 s
Number of degrees of freedom solved for: 1049
Solution time: 0.055 s
(1e-5, 4e-5)
EQUAL
SNAP
Memory: (156 / 163)


Plot Parameters
Principal
Streamline
Particle Tracing
Max/Min
Deform
Animate
General
Surface
Contour
Boundary
Arrow
Arrow plot
Plot arrows on:
Subdomains
Subdomain Data
Boundary Data
Height Data
Predefined quantities:
Velocity field
Recover
x component:
y component:
Unit:
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmglf)
Velocity field
Arrow positioning
Number
x points:
15
y points:
15
Edit...
Edit...
Arrow parameters
Arrow type:
Arrow
Scale factor:
Auto
1
Arrow length:
Proportional
Color...


Plot Parameters
Principal
Streamline
Particle Tracing
Max/Min
Deform
Animate
General
Surface
Contour
Boundary
Arrow
Arrow plot
Plot arrows on:
Subdomains
Subdomain Data
Boundary Data
Height Data
Predefined quantities:
Velocity field
Recover
x component:
y component:
Unit:
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmglf)
Velocity field
Arrow positioning
Number
x points:
15
y points:
15
Edit...
Edit...
Arrow parameters
Arrow type:
Arrow
Scale factor:
Auto
1
Arrow length:
Proportional
Color...


Plot Parameters
Principal
Streamline
Particle Tracing
Max/Min
Deform
Animate
General
Surface
Contour
Boundary
Arrow
Arrow plot
Plot arrows on:
Subdomains
Subdomain Data
Boundary Data
Height Data
Predefined quantities:
Velocity field
Recover
x component:
y component:
Unit:
Conductive Media DC (emdc)
Incompressible Navier-Stokes (mmglf)
Velocity field
Arrow positioning
Number
x points:
15
y points:
15
Edit...
Edit...
Arrow parameters
Arrow type:
Arrow
Scale factor:
Auto
1
Arrow length:
Proportional
Color...

COMSOL Multiphysics - Geom1/MEMS Module - Conductive Media DC (emdc) : Copy of CONCENTRATION.mph

File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help

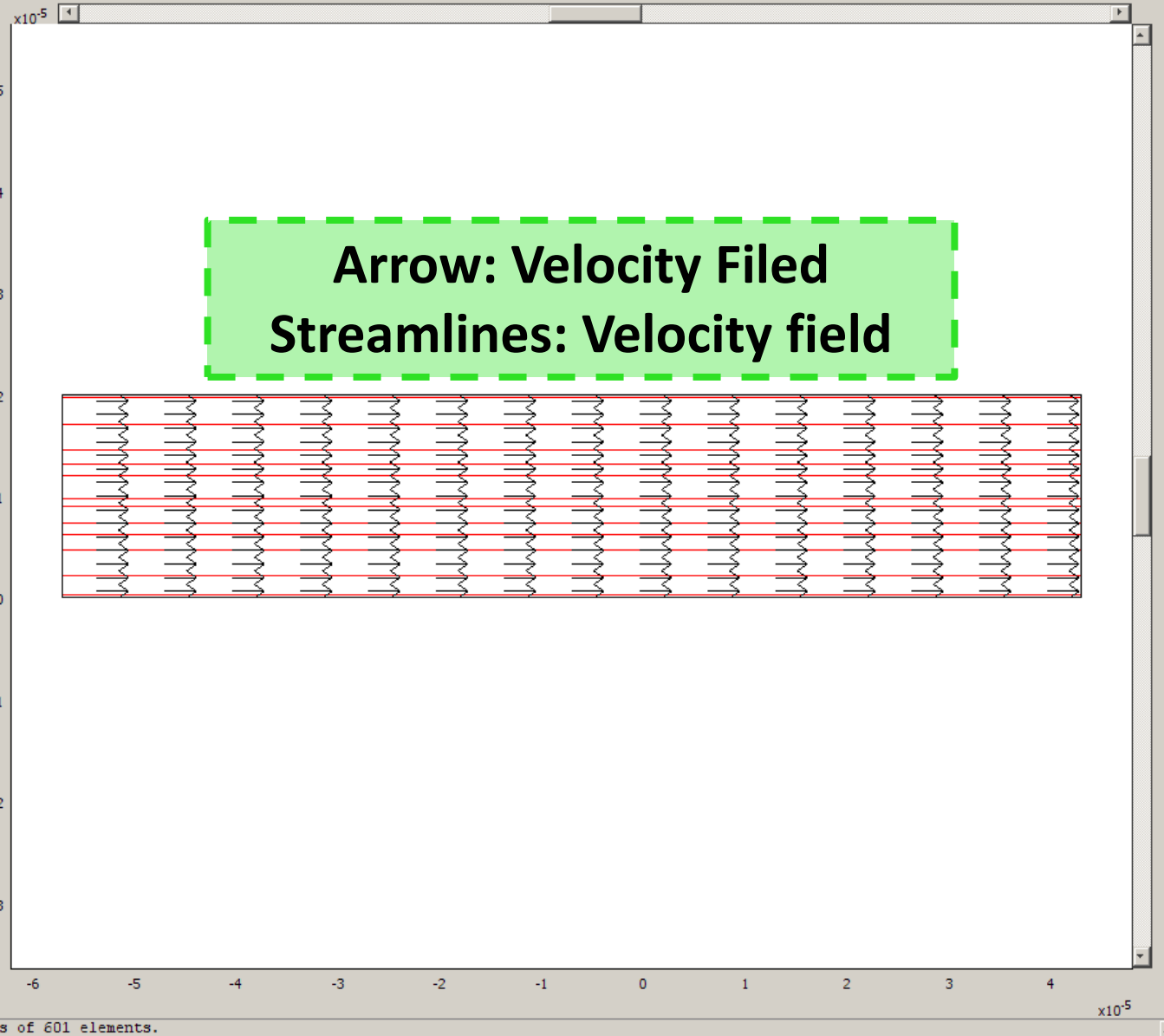
Model Tree

- Geom1
  - Conductive Media DC (emdc)
  - Incompressible Navier-Stokes (mmglf)

Geom1

Space dimension: 2D
Reference coordinates: x y
Dependent variables: V u v p lmx_mmglf lmy_mm
Base unit system: SI

Arrow: Velocity field Streamline: Velocity field



Mesh consists of 601 elements.
Number of degrees of freedom solved for: 4573
Solution time: 3.578 s

(-5.748e-5, 5.55e-5) EQUAL SNAP Memory: (134 / 136)

Any Question up to here?

HINT:

Comsol Library


Computer
MATLAB R2009a
Recycle Bin
Tecplot 8.0
Adobe Acrobat 7....
FILES
COMSOL Multiphysics 3.5
Dropbox
COMSOL Reaction ...
xyExtract
COMSOL Script 1.3
iTunes


Computer
MATLAB R2009a
Recycle Bin
Tecplot 8.0
Adobe Acrobat 7....
FILES
COMSOL Multiphysics 3.5
Dropbox
COMSOL Reaction ...
xyExtract
COMSOL Script 1.3
iTunes
COMSOL
MULTIPHYSICS®
COMSOL
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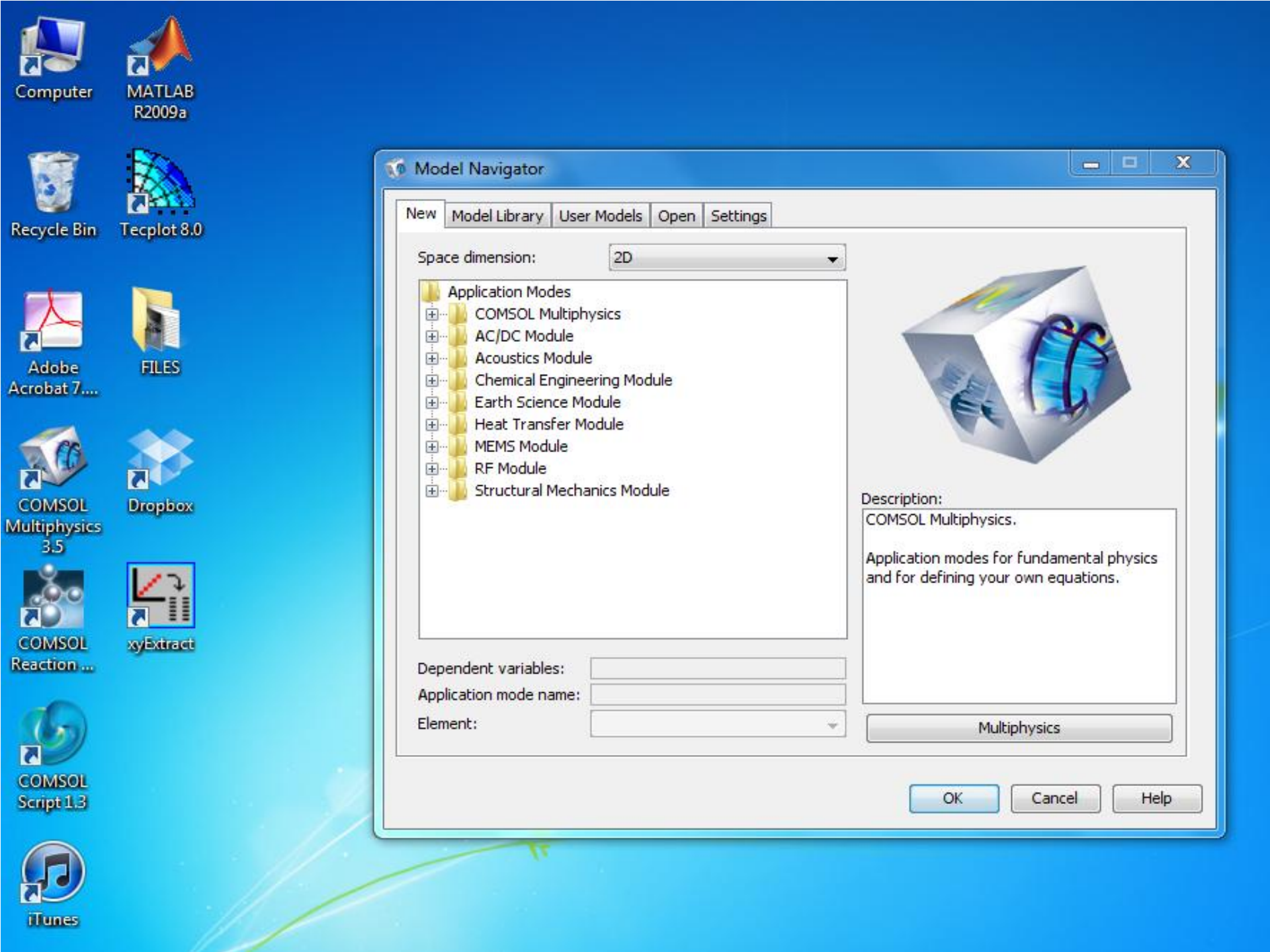
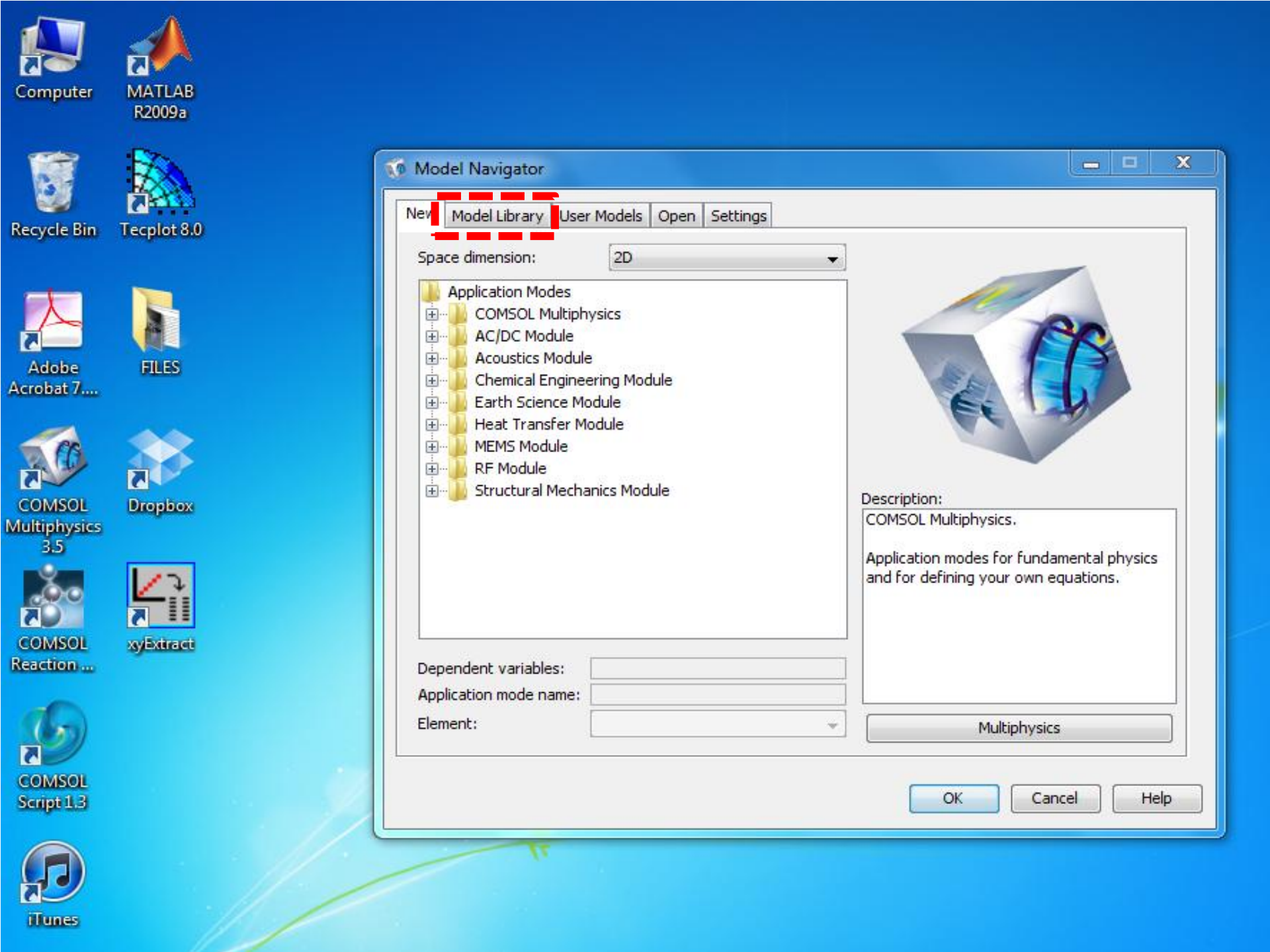
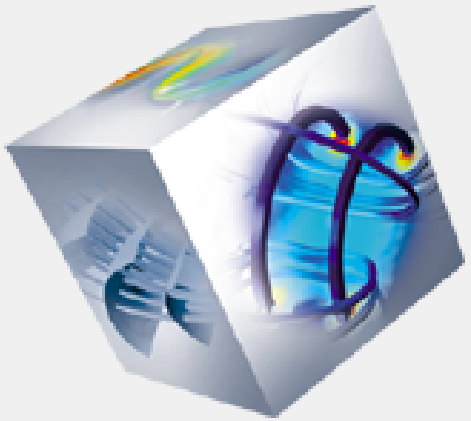

Computer
MATLAB R2009a
Recycle Bin
Tecplot 8.0
Adobe Acrobat 7....
FILES
COMSOL Multiphysics 3.5
Dropbox
COMSOL Reaction ...
xyExtract
COMSOL Script 1.3
iTunes
Model Navigator
New
Model Library
User Models
Open
Settings
Space dimension:
2D
Application Modes
COMSOL Multiphysics
AC/DC Module
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
RF Module
Structural Mechanics Module
Description:
COMSOL Multiphysics.
Application modes for fundamental physics and for defining your own equations.
Dependent variables:
Application mode name:
Element:
Multiphysics
OK
Cancel
Help


Computer
MATLAB R2009a
Recycle Bin
Tecplot 8.0
Adobe Acrobat 7....
FILES
COMSOL Multiphysics 3.5
Dropbox
COMSOL Reaction ...
xyExtract
COMSOL Script 1.3
iTunes
Model Navigator
New
Model Library
User Models
Open
Settings
Space dimension:
2D
Application Modes
COMSOL Multiphysics
AC/DC Module
Acoustics Module
Chemical Engineering Module
Earth Science Module
Heat Transfer Module
MEMS Module
RF Module
Structural Mechanics Module
Description:
COMSOL Multiphysics.
Application modes for fundamental physics and for defining your own equations.
Dependent variables:
Application mode name:
Element:
Multiphysics
OK
Cancel
Help

Model Navigator

New | Model Library | User Models | Open | Settings

- Model Library
  - COMSOL Multiphysics
  - AC/DC Module
  - Acoustics Module
  - Chemical Engineering Module
  - Component Library
  - Earth Science Module
  - Heat Transfer Module
  - MEMS Module
  - Reaction Engineering Lab
  - RF Module
  - Structural Mechanics Module



Description:

Show all files

Documentation

Library Root...

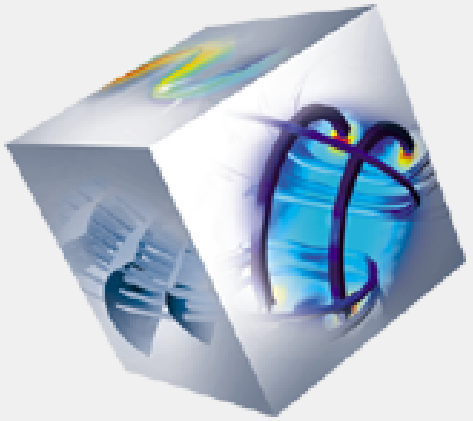
Refresh

OK | Cancel | Help

Model Navigator

New | Model Library | User Models | Open | Settings

- Model Library
  - COMSOL Multiphysics
  - AC/DC Module
  - Acoustics Module
  - Chemical Engineering Module
  - Component Library
  - Earth Science Module
  - Heat Transfer Module
  - MEMS Module
  - Reaction Engineering Lab
  - RF Module
  - Structural Mechanics Module



Description:

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Documentation

Library Root...

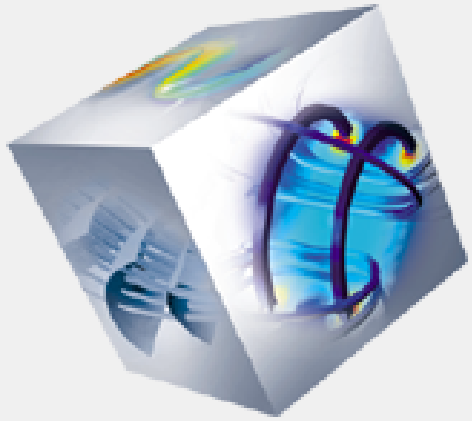
Refresh

OK | Cancel | Help

Model Navigator

New | Model Library | User Models | Open | Settings

- Model Library
  - COMSOL Multiphysics
  - AC/DC Module
  - Acoustics Module
  - Chemical Engineering Module
  - Component Library
  - Earth Science Module
  - Heat Transfer Module
  - MEMS Module
    - Actuator Models
    - Microfluidics Models
    - Piezo Models
    - Sensor Models
  - Reaction Engineering Lab
  - RF Module
  - Structural Mechanics Module



Description:

Show all files

Documentation

Library Root...

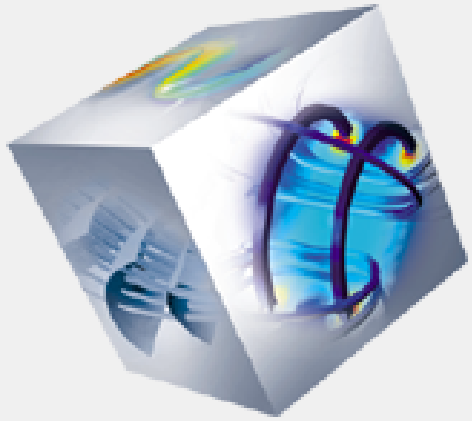
Refresh

OK | Cancel | Help

Model Navigator

New | Model Library | User Models | Open | Settings

- Model Library
  - COMSOL Multiphysics
  - AC/DC Module
  - Acoustics Module
  - Chemical Engineering Module
  - Component Library
  - Earth Science Module
  - Heat Transfer Module
  - MEMS Module
    - Actuator Models
    - Microfluidics Models
    - Piezo Models
    - Sensor Models
  - Reaction Engineering Lab
  - RF Module
  - Structural Mechanics Module



Description:

Show all files

Documentation

Library Root...

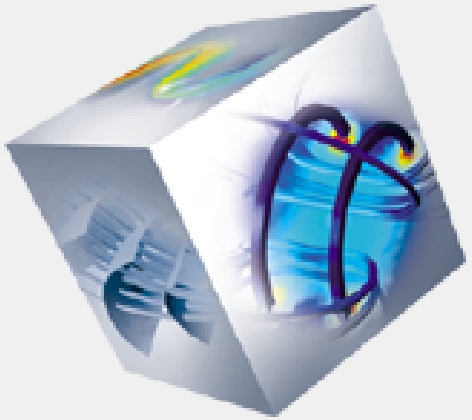
Refresh

OK | Cancel | Help

Model Navigator

New | Model Library | User Models | Open | Settings

- Actuator Models
- Microfluidics Models
  - ac electrokinetic 2d
  - capillary filling ls
  - capillary filling pf
  - droplet breakup
  - electrokinetic valve 3d
  - electroosmotic biochip
  - electroosmotic micropump 2d
  - electroosmotic mixer
  - fluid structure interaction
  - inkjet nozzle ls
  - inkjet nozzle pf
  - lamella mixer
  - microchannel h cell
  - star chip
  - tortuous reactor
  - twophase fsi



Description:

Show all files

Documentation

Library Root...

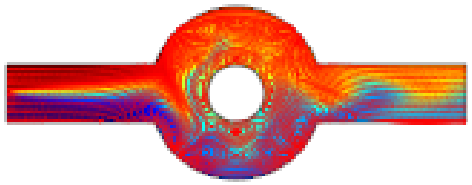
Refresh

OK | Cancel | Help

Model Navigator

New | Model Library | User Models | Open | Settings

- Actuator Models
- Microfluidics Models
  - ac electrokinetic 2d
  - capillary filling ls
  - capillary filling pf
  - droplet breakup
  - electrokinetic valve 3d
  - electroosmotic biochip
  - electroosmotic micropump 2d
  - electroosmotic mixer
  - fluid structure interaction
  - inkjet nozzle ls
  - inkjet nozzle pf
  - lamella mixer
  - microchannel h cell
  - star chip
  - tortuous reactor
  - twophase fsi



Description:

Electroosmotic Micromixer

This micromixer model shows a micromixer that takes advantage of electroosmosis to mix fluids. A time-dependent electric field is applied, and the resulting electroosmosis perturbs the low Reynolds number flow. Animations of the particle traces show an extensive folding and stretching of material lines.

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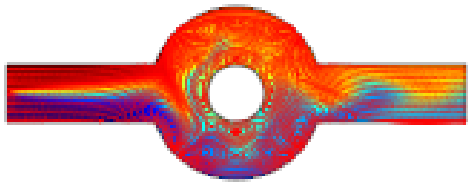
  - electroosmotic micropump 2d
  - electroosmotic mixer
  - fluid structure interaction
  - inkjet nozzle ls
  - inkjet nozzle pf
  - lamella mixer
  - microchannel h cell
  - star chip
  - tortuous reactor
  - twophase fsi



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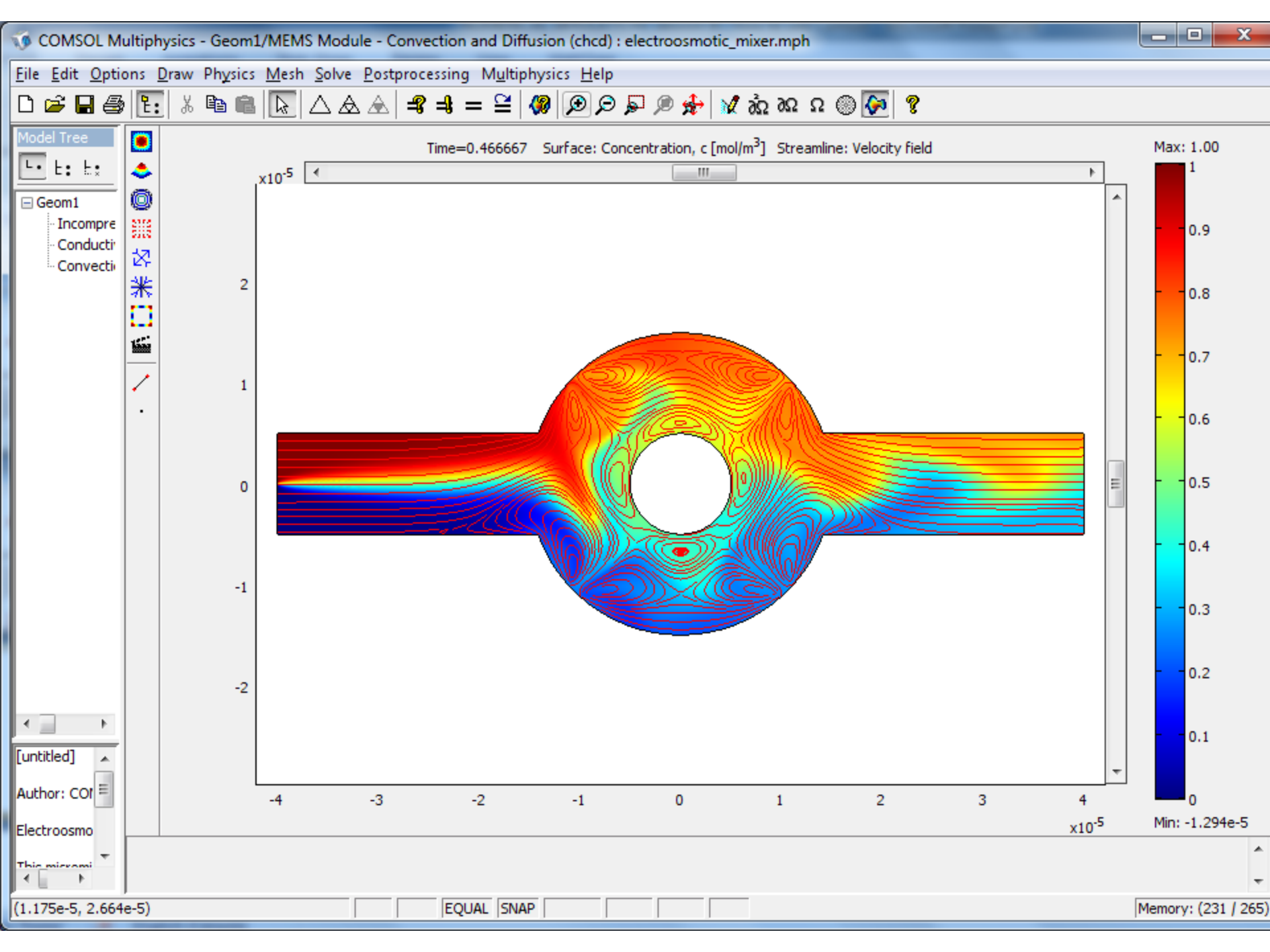
COMSOL Multiphysics - Geom1/MEMS Module - Convection and Diffusion (chcd) : electroosmotic_mixer.mph
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Model Tree
Geom1
Incompre
Conducti
Convecti
Time=0.466667 Surface: Concentration, c [mol/m3] Streamline: Velocity field
x10-5
2
1
0
-1
-2
-4 -3 -2 -1 0 1 2 3 4
x10-5
Max: 1.00
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Min: -1.294e-5
[untitled]
Author: COI
Electroosmo
(1.175e-5, 2.664e-5)
EQUAL
SNAP
Memory: (231 / 265)

Thank You