BITS F415: Introduction to MEMS

Experiment 2: Electrostatically Actuated Cantilever

September 08, 2021

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Report date

Sep 16, 2021 10:02:00 AM

Contents

1 Global Definitions

Date	Sep 16, 2021 10:01:52 AM

GLOBAL SETTINGS

Name	Mems lab2.mph
Path	C:\Users\abhis\Documents\COMSOl\mems_lab2.mph
Version	COMSOL Multiphysics 5.5 (Build: 359)

USED PRODUCTS

COMSOL Multiphysics
CAD Import Module
MEMS Module

1.1 PARAMETERS

PARAMETERS 1

Name	Expression	Value	Description
V0	5.5 [V]	5.5 V	Bias on Cantilever

2 Component 1

2.1 DEFINITIONS

2.1.1 Selections

Air_selection

Selection type
Explicit

Selection
Domains 1, 3–5

2.1.2 Coordinate Systems

Boundary System 1

Coordinate system type	Boundary system
Tag	sys1

COORDINATE NAMES

First	Second	Third
t1	t2	n

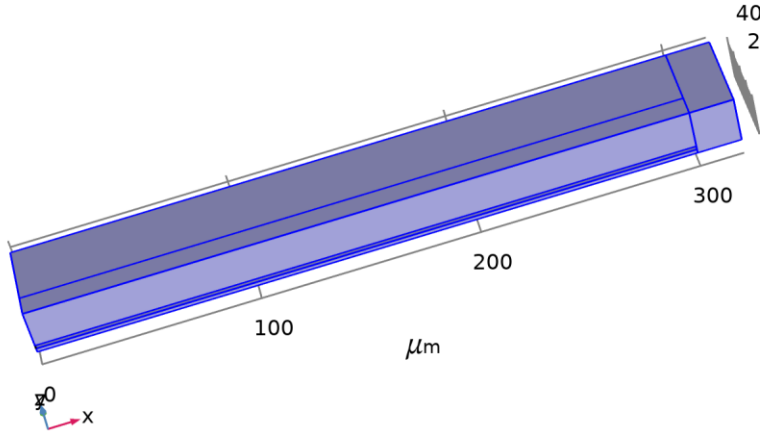
2.1.3 Moving Mesh

Deforming Domain 1

Tag	free1

SELECTION

Geometric entity level	Domain
Name	Air selection
Selection	Named sel1: Geometry geom1: Dimension 3: Domains 1, 3–5



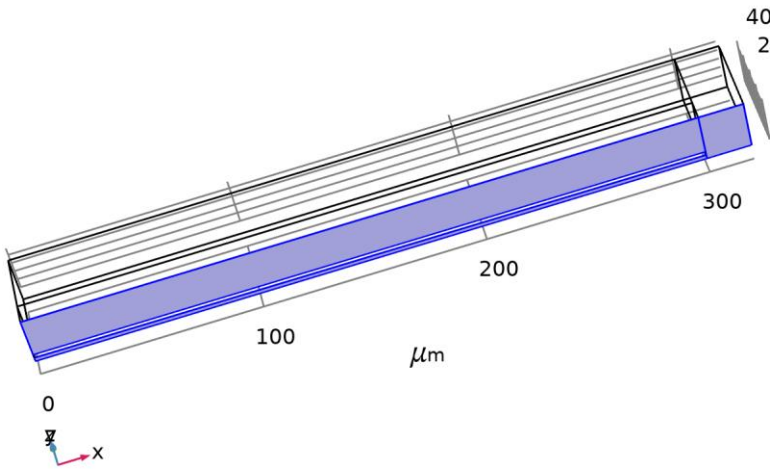
Selection

Symmetry/Roller 1

Tag	sym1

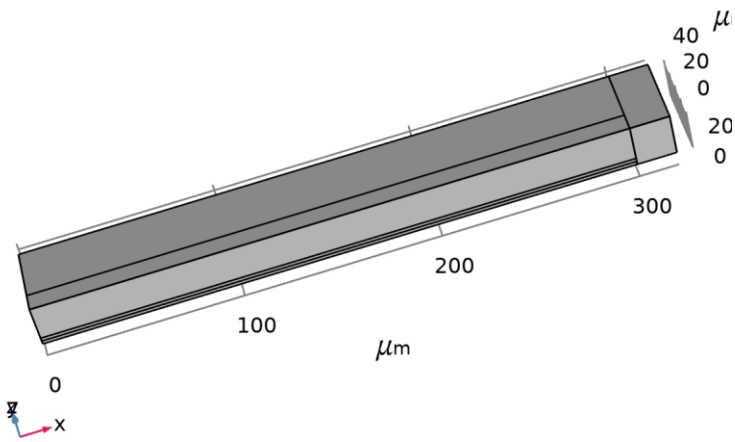
SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundaries 2, 8, 19



Selection

2.2 GEOMETRY 1



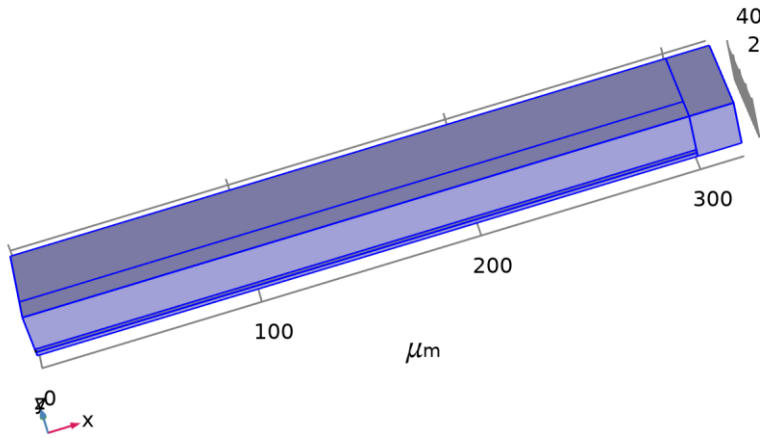
Geometry 1

UNITS

Length unit	μm
Angular unit	deg

2.3 MATERIALS

2.3.1 Air_mat

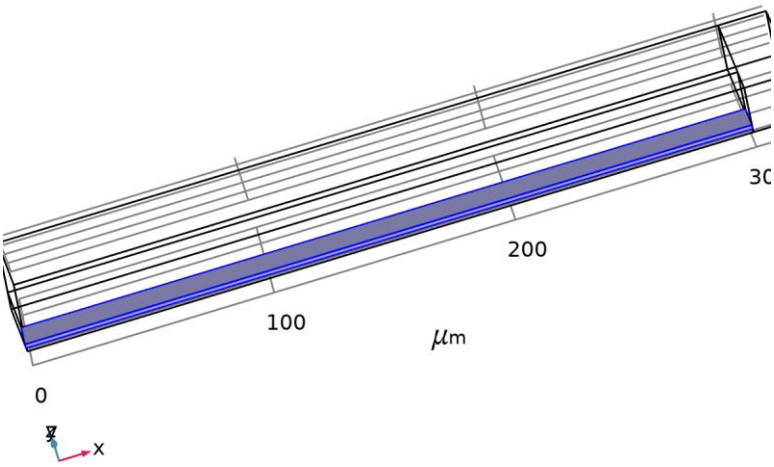


Air_mat

SELECTION

Geometric entity level	Domain
Name	Air selection
Selection	Named sel1: Geometry geom1: Dimension 3: Domains 1, 3–5

2.3.2 Mat_Poly

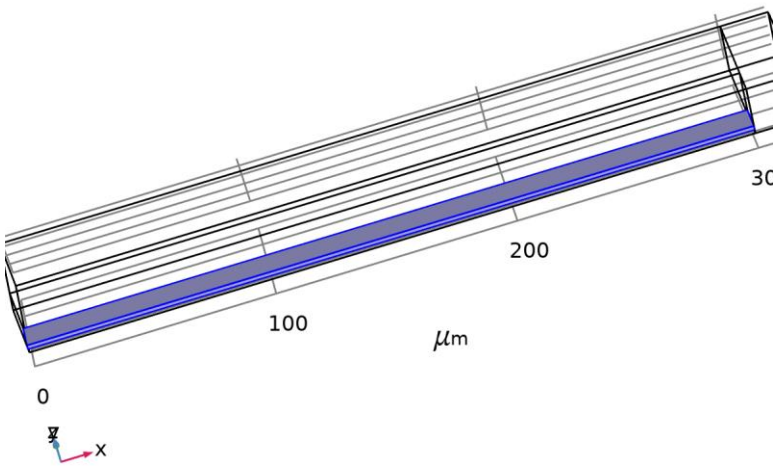


Mat_Poly

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: Domain 2

2.4 SOLID MECHANICS



Solid Mechanics

EQUATIONS

$$0 = \nabla \cdot (F S)^T + \mathbf{F}_V, \quad F = I + \nabla \mathbf{u}$$

FEATURES

Linear Elastic Material 1
Free 1
Initial Values 1
Fixed Constraint 1
Symmetry 1

2.4.1 Linear Elastic Material 1

EQUATIONS

$$0 = \nabla \cdot (F S)^T + \mathbf{F}_V, \quad F = I + \nabla \mathbf{u}$$
$$S = S_{ad} + J_i F_{inel}^{-1} \left(\mathbf{C} : \epsilon_{el} \right) F_{inel}^{-T}, \quad \epsilon_{el} = \frac{1}{2}\left(F_{el}^T F_{el} - I \right), \quad F_{el} = F F_{inel}^{-1}$$
$$S_{ad} = S_0 + S_{ext} + S_q$$
$$\epsilon = \frac{1}{2}\left[(\nabla \mathbf{u})^T + \nabla \mathbf{u} + (\nabla \mathbf{u})^T \nabla \mathbf{u} \right]$$
$$\mathbf{C} = \mathbf{C}(E, \nu)$$

2.4.2 Fixed Constraint 1

EQUATIONS

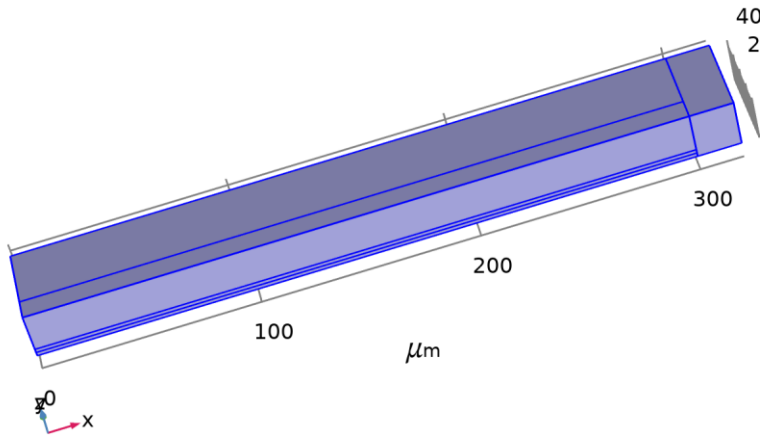
$$\mathbf{u} = \mathbf{0}$$

2.4.3 Symmetry 1

EQUATIONS

$$\mathbf{u} \cdot \mathbf{n} = 0$$

2.5 ELECTROSTATICS



Electrostatics

EQUATIONS

$$\nabla \cdot \mathbf{D} = \rho_v$$

$$\mathbf{E} = -\nabla V$$

FEATURES

Charge Conservation, Solid
Zero Charge 1
Initial Values 1
Air
Terminal 1
Ground 1

2.5.1 Charge Conservation, Solid

EQUATIONS

$$\mathbf{E} = -\nabla V$$

$$\nabla \cdot (\epsilon_0 \epsilon_r \mathbf{E}) = \rho_v$$

2.5.2 Zero Charge 1

EQUATIONS

$$\mathbf{n} \cdot \mathbf{D} = 0$$

2.5.3 Air

EQUATIONS

$$\mathbf{E} = -\nabla V$$
$$\nabla \cdot (\epsilon_0 \epsilon_r \mathbf{E}) = \rho_v$$

2.5.4 Terminal 1

EQUATIONS

$$V = V_0$$

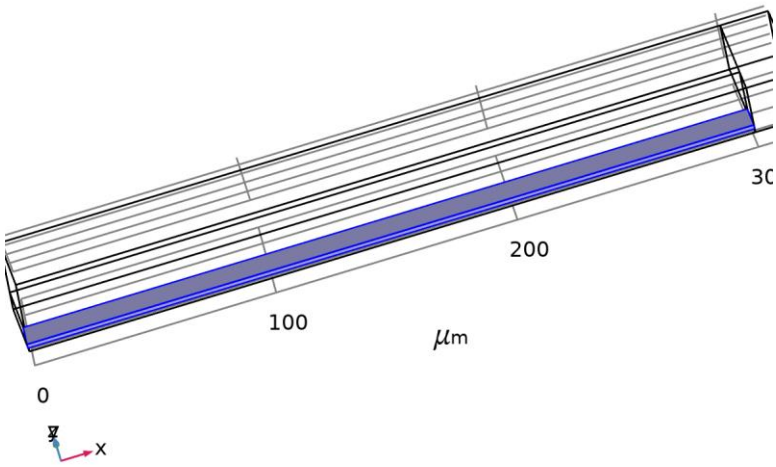
2.5.5 Ground 1

EQUATIONS

$$V = 0$$

2.6 MULTIPHYSICS

2.6.1 Electromechanical Forces 1



Electromechanical Forces 1

EQUATIONS

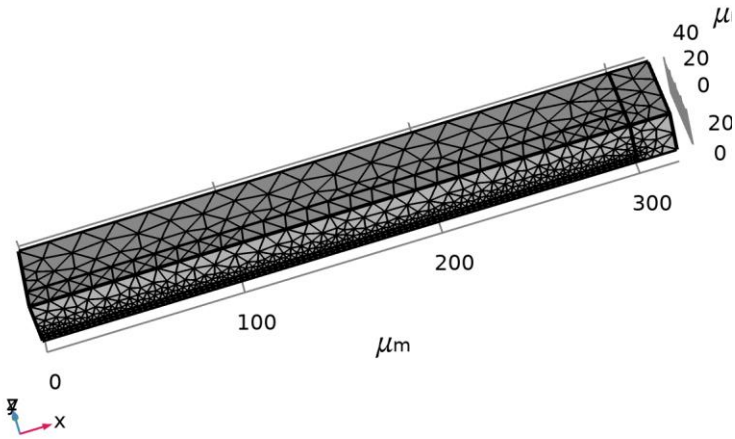
$$H_{eme} = W_s(\mathrm{C}) - \frac{1}{2}\epsilon_0 \epsilon_r \mathrm{JC}^{-1} : (\mathbf{E} \otimes \mathbf{E})$$

$$C = F^T F, \quad J = \det(F)$$

$$S = 2\frac{\partial H_{eme}}{\partial C}, \quad \mathbf{D} = -\frac{\partial H_{eme}}{\partial \mathbf{E}}$$

$$FS\mathbf{N}\,dA = \sigma_{EM}^{(out)}\mathbf{n}\,da$$

2.7 MESH 1



Mesh 1

3 Study 1

COMPUTATION INFORMATION

Computation time	41 s
CPU	Intel64 Family 6 Model 158 Stepping 10, 6 cores
Operating system	Windows 10

3.1 STATIONARY

STUDY SETTINGS

Description	Value
Include geometric nonlinearity	On

PHYSICS AND VARIABLES SELECTION

Physics interface	Discretization
Solid Mechanics (solid)	physics
Electrostatics (es)	physics

MESH SELECTION

Geometry	Mesh
Geometry 1 (geom1)	mesh1

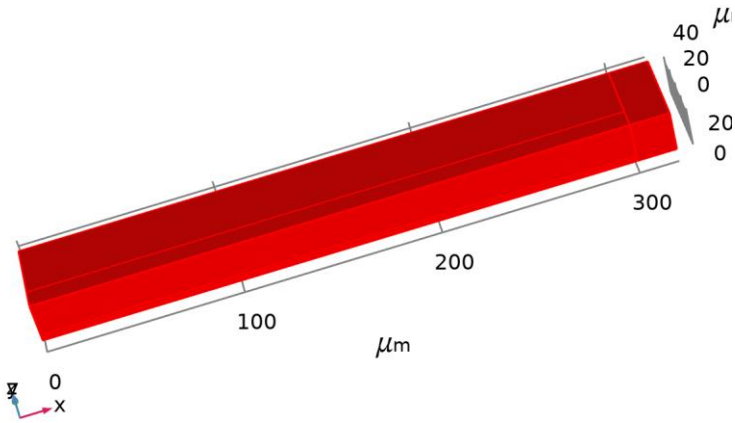
4 Results

4.1 DATASETS

4.1.1 Study 1/Solution 1

SOLUTION

Description	Value
Solution	Solution 1
Component	Save Point Geometry 1



Dataset: Study 1/Solution 1

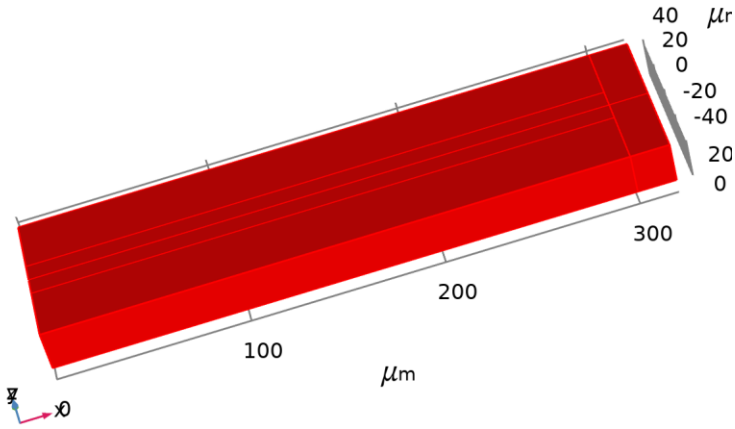
4.1.2 Mirror 3D 1

DATA

Description	Value
Dataset	Study 1/Solution 1

PLANE DATA

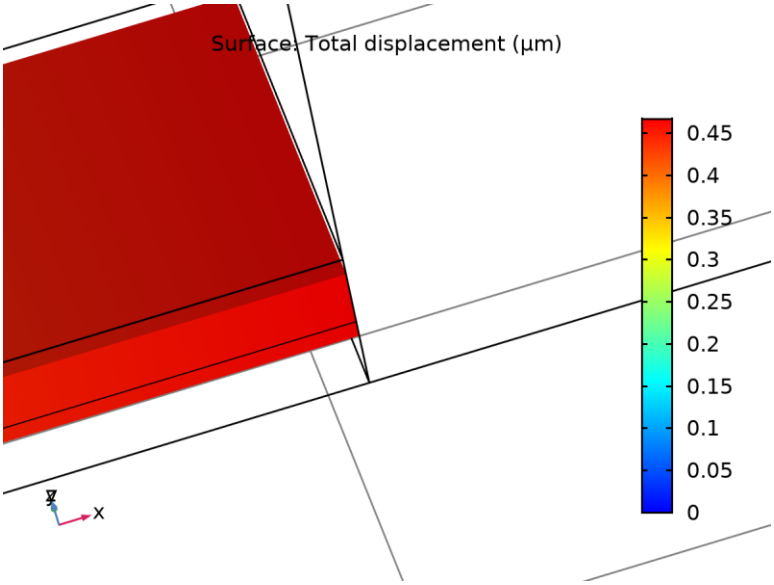
Description	Value
Plane type	Quick
Plane	zx - planes
y-coordinate	0



Dataset: Mirror 3D 1

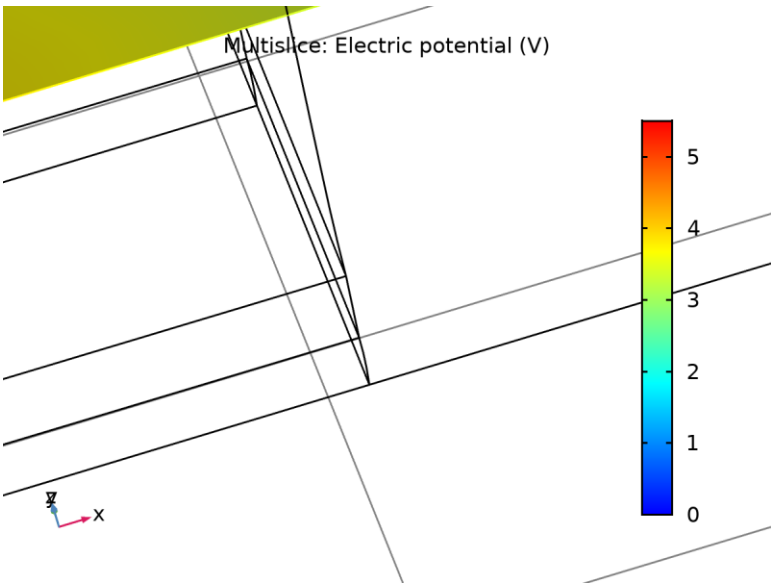
4.2 PLOT GROUPS

4.2.1 Displacement (solid)



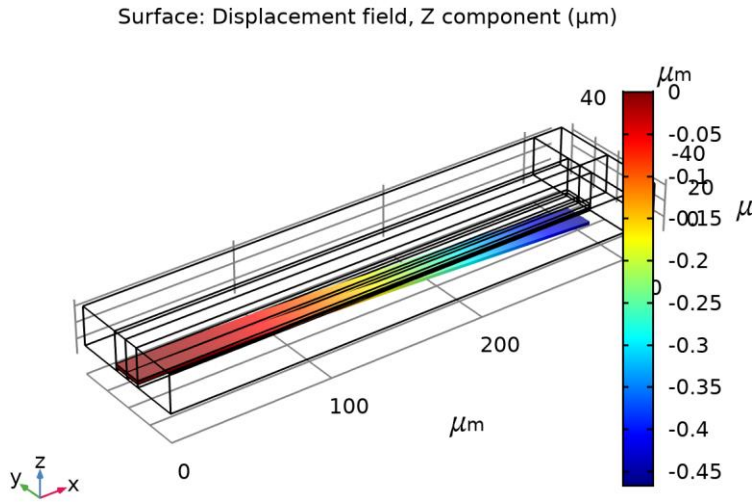
Surface: Total displacement (μm)

4.2.2 Electric Potential (es)



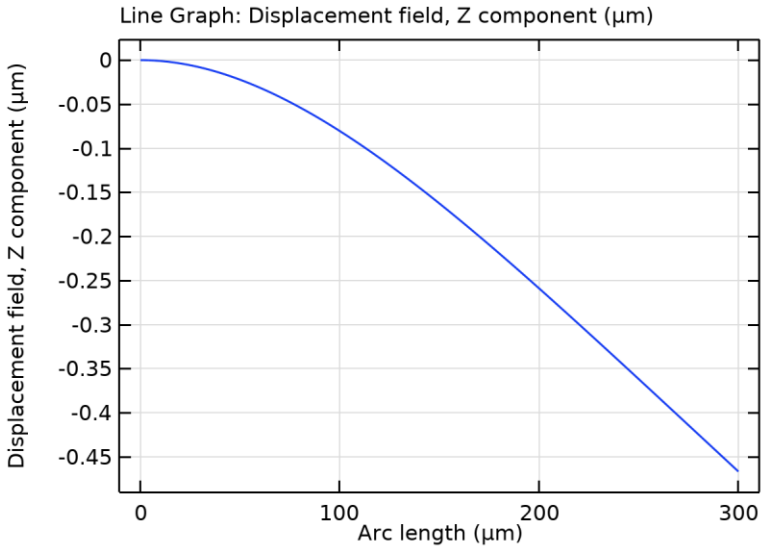
Multislice: Electric potential (V)

4.2.3 Vertical Displacement



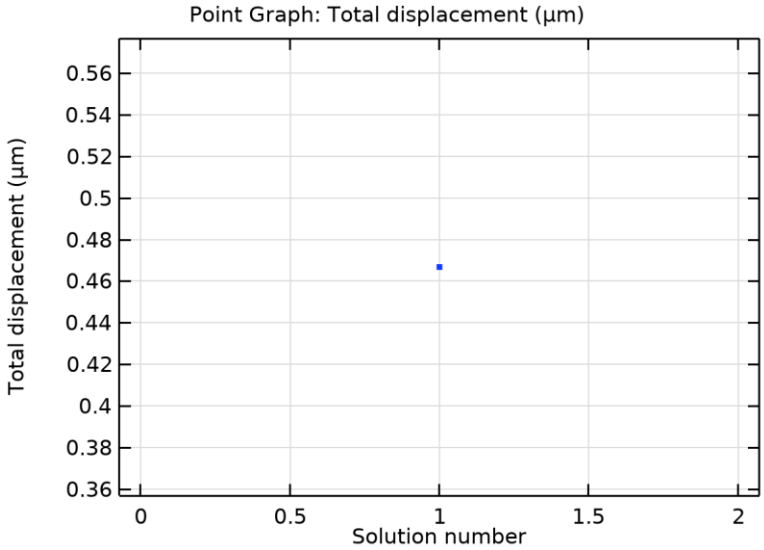
Surface: Displacement field, Z component (µm)

4.2.4 1D Plot Group 4



Line Graph: Displacement field, Z component (µm)

4.2.5 1D Plot Group 5



Point Graph: Total displacement (µm)