

Hw3.2

Report date	Oct 19, 2025, 6:00:27 PM
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1 Global Definitions

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GLOBAL SETTINGS

Name	Hw3.2.mph
Path	\\clusterfsnew.ceas1.uc.edu\students\brooksl\desktop\hw3.2.mph
Version	COMSOL Multiphysics 6.3 (Build: 420)

USED PRODUCTS

COMSOL Multiphysics
Acoustics Module

COMPUTER INFORMATION

CPU	Intel64 Family 6 Model 198 Stepping 2, 28 cores, 63.46 GB RAM
Operating system	Windows 11

1.1 PARAMETERS

PARAMETERS 1

Name	Expression	Value	Description
ra	2700[kg/m^3]	2700 kg/m ³	
ca	6300[m/s]	6300 m/s	
rw	998[kg/m^3]	998 kg/m ³	
cw	1481[m/s]	1481 m/s	
pin	1[Pa]	1 Pa	
fin	2[MHz]	2E6 Hz	
W	1[cm]	0.01 m	
H	2[mm]	0.002 m	
Zw	rw*cw	1.478E6 kg/(m ² ·s)	
Za	ra*ca	1.701E7 kg/(m ² ·s)	
R	(Za - Zw)/(Zw + Za)	0.84011	
T	(2*Za)/(Zw + Za)	1.8401	
Ri	((Za - Zw)/(Zw + Za))^2	0.70578	
Ti	4*Za*Zw/(Zw + Za)^2	0.29422	
cL	sqrt(cw*ca)	3054.6 m/s	
L	cL/(4*fin)	3.8182E-4 m	
rL	sqrt(rw*ra)	1641.5 kg/m ³	

2 Component 1

SETTINGS

Description	Value
Unit system	Same as global system (SI)

2.1 DEFINITIONS

2.1.1 Coordinate Systems

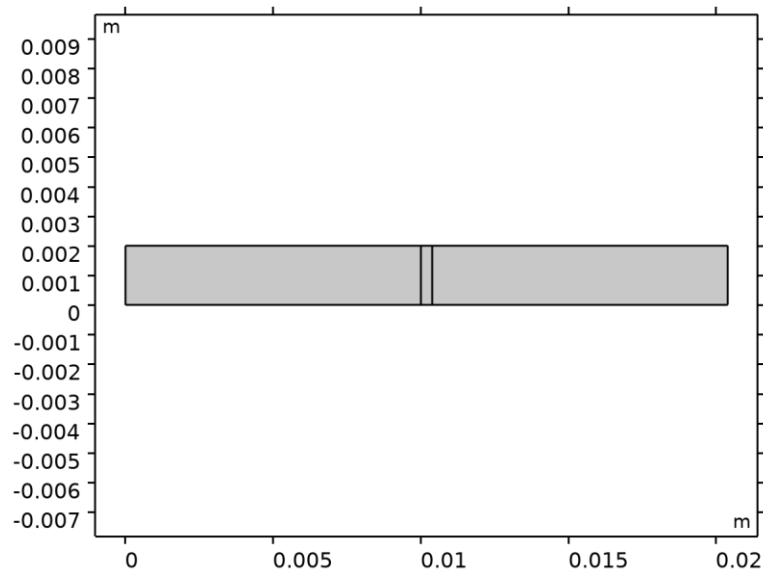
Boundary System 1

Coordinate system type	Boundary system
Tag	sys1

COORDINATE NAMES

First	Second	Third
t1	n	to

2.2 GEOMETRY 1



Geometry 1

UNITS

Length unit	m
Angular unit	deg

GEOMETRY STATISTICS

Description	Value
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Description	Value
Space dimension	2
Number of domains	3
Number of boundaries	10
Number of vertices	8

2.2.1 Air (r1)

SIZE AND SHAPE

Description	Value
Width	W
Height	H

POSITION

Description	Value
Position	{0, 0}

2.2.2 Wood (r2)

SIZE AND SHAPE

Description	Value
Width	W
Height	H

POSITION

Description	Value
Position	{W + L, 0}

2.2.3 Rectangle 3 (r3)

SIZE AND SHAPE

Description	Value
Width	L
Height	H

POSITION

Description	Value
Position	{W, 0}

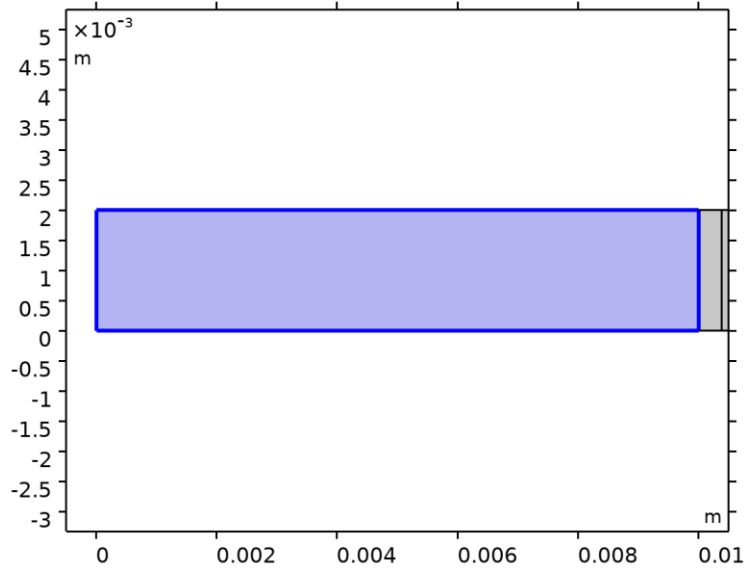
2.2.4 Form Union (fin)

INFORMATION

Description	Value
Build message	Formed union of 3 solid objects. Union has 3 domains, 10 boundaries, and 8 vertices.

2.3 MATERIALS

2.3.1 Water



Water

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 2: Domain 1

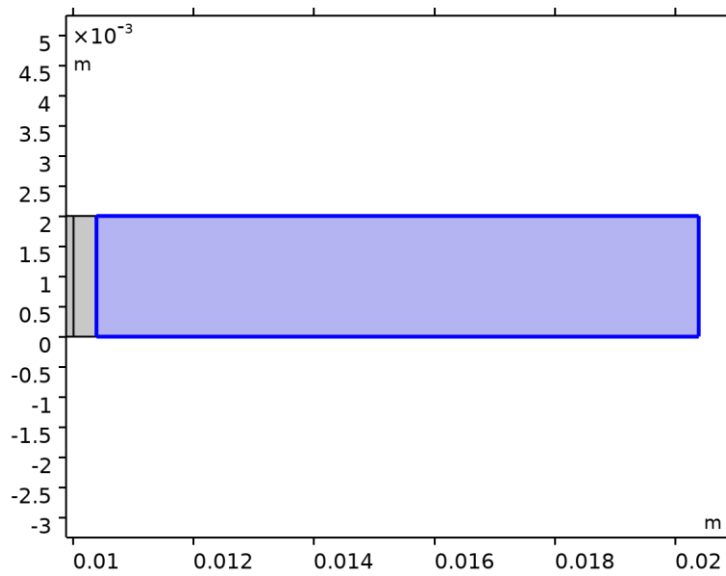
MATERIAL PARAMETERS

Name	Value	Unit	Property group
Density	rw	kg/m ³	Basic
Speed of sound	cw	m/s	Basic

BASIC

Description	Value	Unit
Density	rw	kg/m ³
Speed of sound	cw	m/s

2.3.2 Aluminum



Aluminum

SELECTION

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

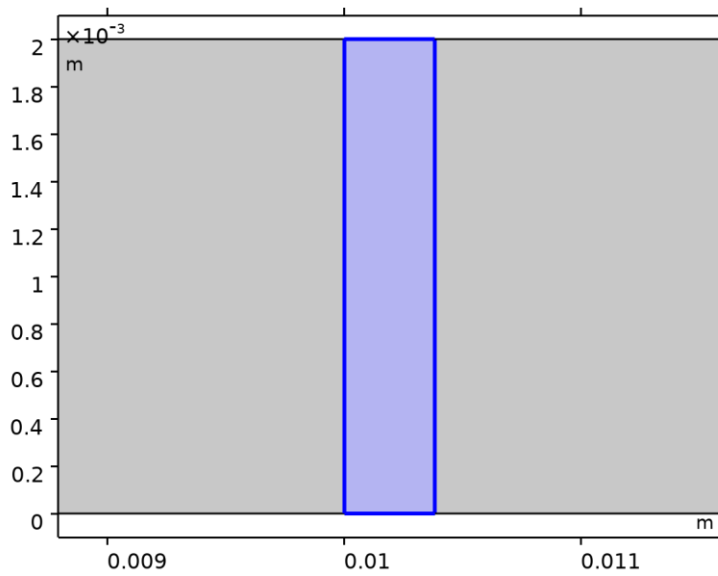
MATERIAL PARAMETERS

Name	Value	Unit	Property group
Density	ra	kg/m ³	Basic
Speed of sound	ca	m/s	Basic

BASIC

Description	Value	Unit
Density	ra	kg/m ³
Speed of sound	ca	m/s

2.3.3 Layer



Layer

SELECTION

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

MATERIAL PARAMETERS

Name	Value	Unit	Property group
Density	rL	kg/m ³	Basic
Speed of sound	cL	m/s	Basic

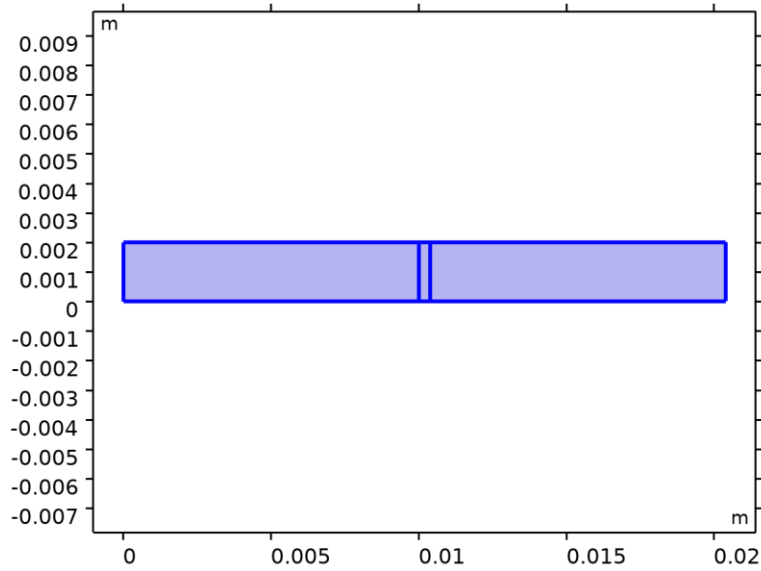
BASIC

Description	Value	Unit
Density	rL	kg/m ³
Speed of sound	cL	m/s

2.4 PRESSURE ACOUSTICS, FREQUENCY DOMAIN

USED PRODUCTS

COMSOL Multiphysics
Acoustics Module



Pressure Acoustics, Frequency Domain

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 2: All domains

EQUATIONS

$$\nabla \cdot \left(-\frac{1}{\rho_c} (\nabla p_t - \mathbf{q}_d) \right) - \frac{k_{eq}^2 p_t}{\rho_c} = Q_m$$

$$p_t = p + p_b$$

$$k_{eq}^2 = \left(\frac{\omega}{c_c} \right)^2 - k_z^2$$

2.4.1 Interface Settings

Physics Symbols

SETTINGS

Description	Value
Enable physics symbols	On

Discretization

SETTINGS

Description	Value
Element order	Quadratic Lagrange

Physics-Controlled Mesh

SETTINGS

Description	Value
Maximum mesh element size control parameter	From study
Number of mesh elements per wavelength	Automatic

Pressure Acoustics Equation Settings

SETTINGS

Description	Value	Unit
Out-of-plane wave number	0	rad/m

Global Port Settings

SETTINGS

Description	Value
Port sweep settings	No port sweep
Mode shape normalization	Amplitude normalization

Sound Pressure Level Settings

SETTINGS

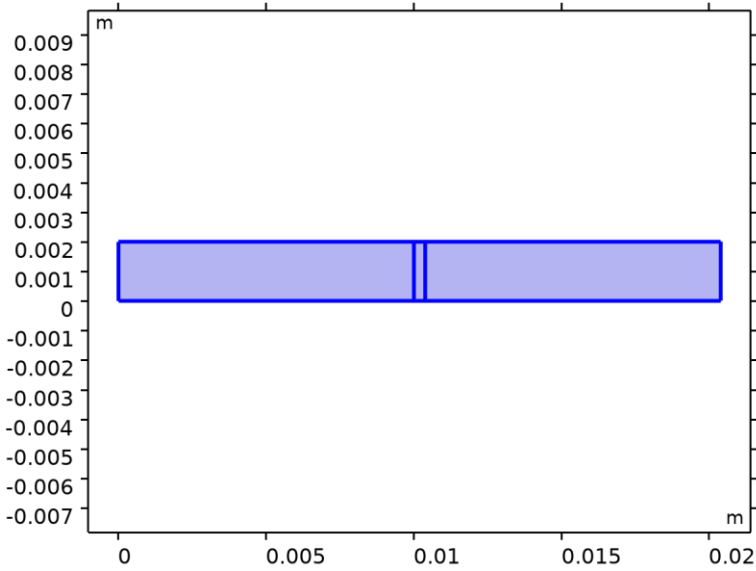
Description	Value
Reference pressure for the sound pressure level	Use reference pressure for air

Typical Wave Speed for Perfectly Matched Layers

SETTINGS

Description	Value	Unit
Typical wave speed for perfectly matched layers	real(acpr.c_c)	m/s

2.4.2 Pressure Acoustics 1



Pressure Acoustics 1

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 2: All domains

EQUATIONS

$$\nabla \cdot \left(-\frac{1}{\rho_c} (\nabla p_t - \mathbf{q}_d) \right) - \frac{k_{eq}^2 p_t}{\rho_c} = Q_m$$

.....

$$p_t = p + p_b$$
$$k_{eq}^2 = \left(\frac{\omega}{c_c} \right)^2 - k_z^2$$
$$c_c = c, \quad \rho_c = \rho$$

Pressure Acoustics Model

SETTINGS

Description	Value
Fluid model	Linear elastic
Specify	Density and speed of sound
Speed of sound	From material
Density	From material

Model Input

SETTINGS

Description	Value	Unit
Temperature	User defined	
Temperature	293.15	K
Absolute pressure	User defined	
Absolute pressure	1.0133E5	Pa

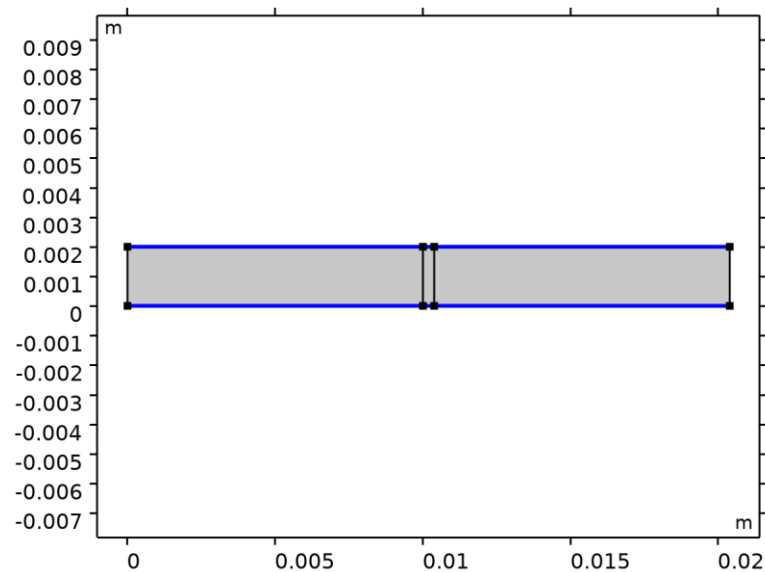
USED PRODUCTS

COMSOL Multiphysics

PROPERTIES FROM MATERIAL

Property	Material	Property group
Density	Water	Basic
Speed of sound	Water	Basic
Density	Aluminum	Basic
Speed of sound	Aluminum	Basic
Density	Layer	Basic
Speed of sound	Layer	Basic

2.4.3 Sound Hard Boundary (Wall) 1



Sound Hard Boundary (Wall) 1

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 1: All boundaries

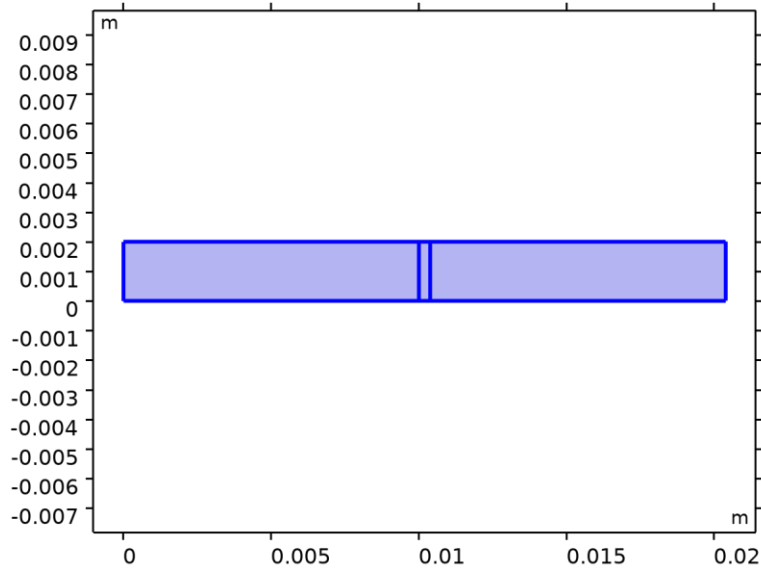
EQUATIONS

$$-\mathbf{n} \cdot \left(-\frac{1}{\rho_c} (\nabla p_t - \mathbf{q}_d) \right) = 0$$

USED PRODUCTS

COMSOL Multiphysics

2.4.4 Initial Values 1



Initial Values 1

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 2: All domains

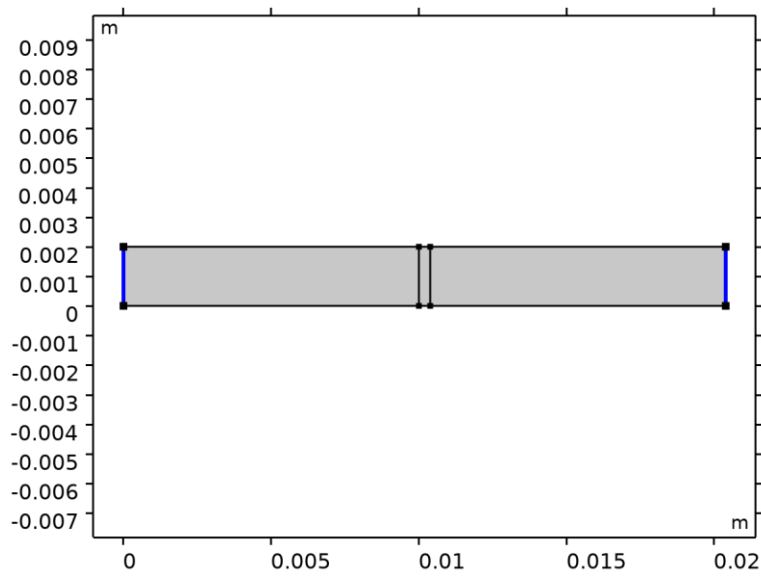
SETTINGS

Description	Value	Unit
Acoustic pressure	0	Pa

USED PRODUCTS

COMSOL Multiphysics

2.4.5 Plane Wave Radiation 1



Plane Wave Radiation 1

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 1: Boundaries 1, 10

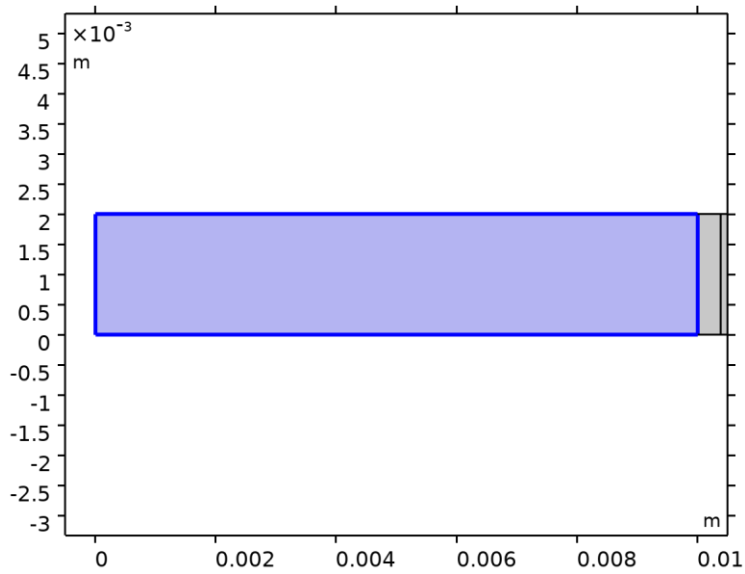
EQUATIONS

$$-\mathbf{n} \cdot \left(-\frac{1}{\rho_c} (\nabla p_t - \mathbf{q}_d) \right) + i \frac{k_{eq}}{\rho_c} p + \frac{i}{2k_{eq}\rho_c} \Delta_{||} p = Q_i$$

USED PRODUCTS

COMSOL Multiphysics

2.4.6 Background Pressure Field 1



Background Pressure Field 1

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 2: Domain 1

EQUATIONS

$$\nabla \cdot \left(-\frac{1}{\rho_c} (\nabla p_t - \mathbf{q}_d) \right) - \frac{k_{eq}^2 p_t}{\rho_c} = Q_m$$

$$p_t = p + p_b$$

$$k_{eq}^2 = \left(\frac{\omega}{c} \right)^2 - k_z^2$$

$$p_b = p_0 e^{i\phi} e^{-ik_s \frac{(\mathbf{x} \cdot \mathbf{e}_k)}{|\mathbf{e}_k|}}$$

$$k_s^2 = \left(\frac{\omega}{c} \right)^2 - k_z^2$$

Background Pressure Field

SETTINGS

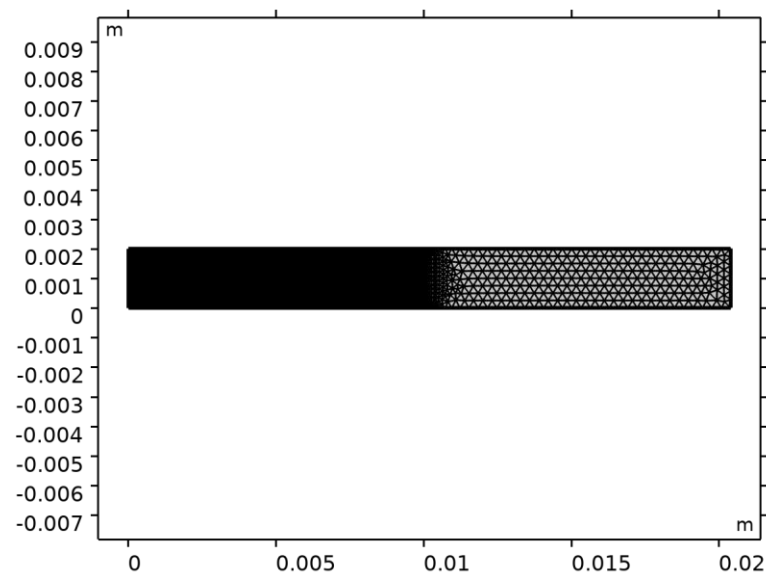
Description	Value	Unit
Pressure field type	Plane wave	
Pressure amplitude	pin	Pa
Speed of sound	From material	
Wave direction, x-component	1	
Wave direction, y-component	0	

Description	Value	Unit
Wave direction, z-component	0	
Phase	0	rad
Calculate background and scattered field intensity	Off	
Material	Domain material	

PROPERTIES FROM MATERIAL

Property	Material	Property group
Speed of sound	Water	Basic

2.5 MESH 1



Mesh 1

2.5.1 Size (size)

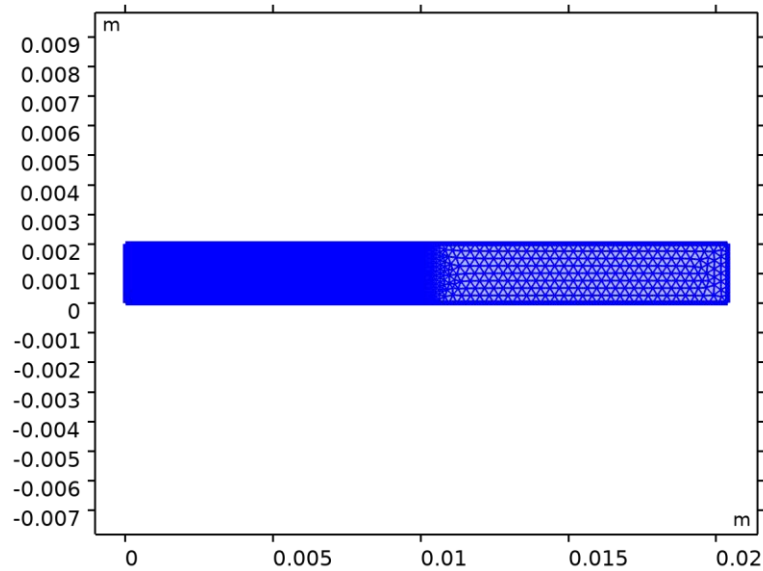
SETTINGS

Description	Value
Maximum element size	4.08E-4
Minimum element size	2.038E-7
Curvature factor	0.25
Maximum element growth rate	1.2
Predefined size	Extra fine
Custom element size	Custom

2.5.2 Size Expression 1 (se1)

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 2: Domains 1–3



Size Expression 1

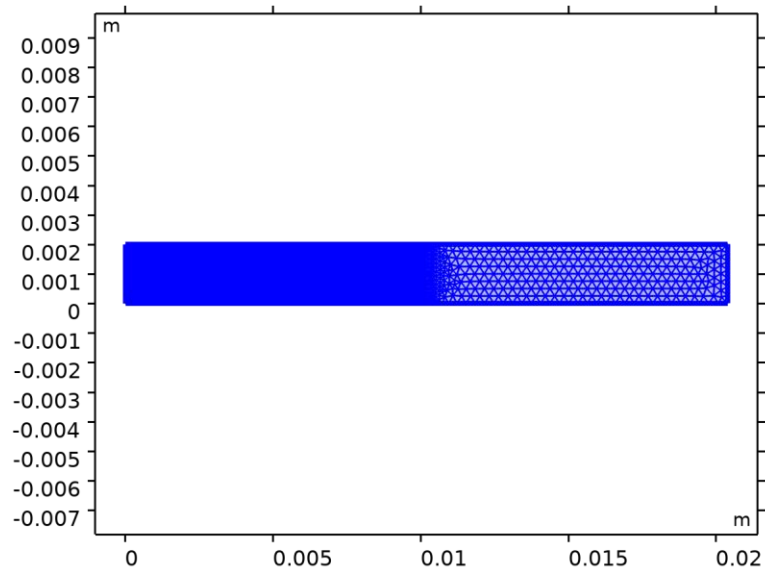
SETTINGS

Description	Value
Evaluate on	Initial expression
Study step	Study 1: Frequency Domain
Size expression	<code>subst(real(acpr.c_c), acpr.freq, freqmax)/freqmax/5</code>
Reevaluate with updated model	

2.5.3 Free Triangular 1 (ftri1)

SELECTION

Geometric entity level	Domain
Selection	Remaining



Free Triangular 1

SETTINGS

Description	Value
Number of iterations	4
Maximum element depth to process	4

INFORMATION

Description	Value
Last build time	< 1 second
Built with	COMSOL 6.3.0.420 (win64), Oct 19, 2025, 5:54:57 PM

3 Study 1

COMPUTATION INFORMATION

Computation time	3 s
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3.1 FREQUENCY DOMAIN

Frequencies (Hz)
fin range(100000,100000,4000000)

STUDY SETTINGS

Description	Value
Include geometric nonlinearity	Off

SETTINGS

Description	Value
Frequencies	{2E6, 1E5, 2E5, 3E5, 4E5, 5E5, 6E5, 7E5, 8E5, 9E5, 1E6, 1.1E6, 1.2E6, 1.3E6, 1.4E6, 1.5E6, 1.6E6, 1.7E6, 1.8E6, 1.9E6, 2E6, 2.1E6, 2.2E6, 2.3E6, 2.4E6, 2.5E6, 2.6E6, 2.7E6, 2.8E6, 2.9E6, 3E6, 3.1E6, 3.2E6, 3.3E6, 3.4E6, 3.5E6, 3.6E6, 3.7E6, 3.8E6, 3.9E6, 4E6}

PHYSICS AND VARIABLES SELECTION

Key	Solve for
Pressure Acoustics, Frequency Domain (acpr)	On

STORE IN OUTPUT

Interface	Output	Selection
Pressure Acoustics, Frequency Domain (acpr)	Physics controlled	

MESH SELECTION

Component	Mesh
Component 1	Mesh 1

3.2 SOLVER CONFIGURATIONS

3.2.1 Solution 1

Compile Equations: Frequency Domain (st1)

STUDY AND STEP

Description	Value
Use study	Study 1
Use study step	Frequency Domain

Dependent Variables 1 (v1)

GENERAL

Description	Value
Defined by study step	Step 1: Frequency Domain

INITIAL VALUE CALCULATION CONSTANTS

Constant name	Initial-value source
freq	fin range(100000,100000,4000000)[Hz]

Acoustic Pressure (comp1.p) (comp1_p)

GENERAL

Description	Value
Field components	comp1.p

Stationary Solver 1 (s1)

GENERAL

Description	Value
Defined by study step	Step 1: Frequency Domain

RESULTS WHILE SOLVING

Description	Value
Probes	None

Advanced (aDef)

ASSEMBLY SETTINGS

Description	Value
Reuse sparsity pattern	On
Allow complex-valued output from functions with real input	On

Parametric 1 (p1)

GENERAL

Description	Value
Defined by study step	Step 1: Frequency Domain
Run continuation for	No parameter

PARAMETERS

Parameter name	Parameter value list	Parameter unit
freq	fin range(100000,100000,4000000)	Hz

Fully Coupled 1 (fc1)

GENERAL

Description	Value
Linear solver	Direct

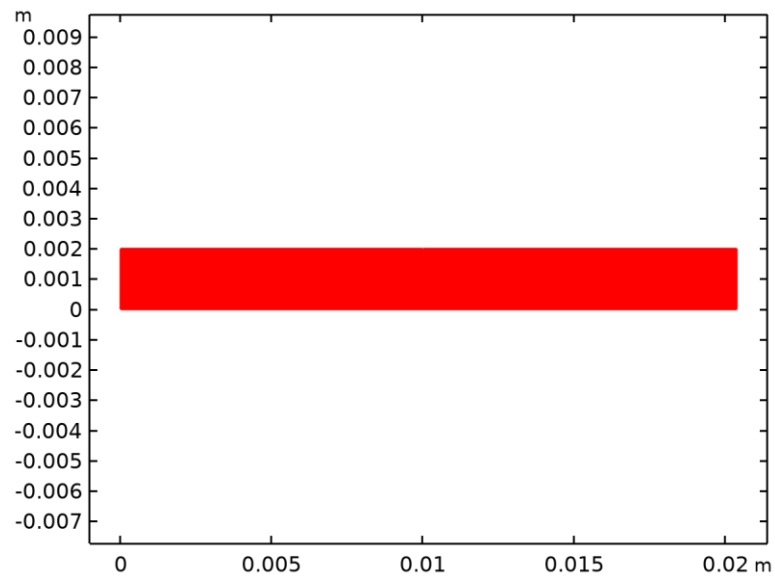
4 Results

4.1 DATASETS

4.1.1 Study 1/Solution 1

SOLUTION

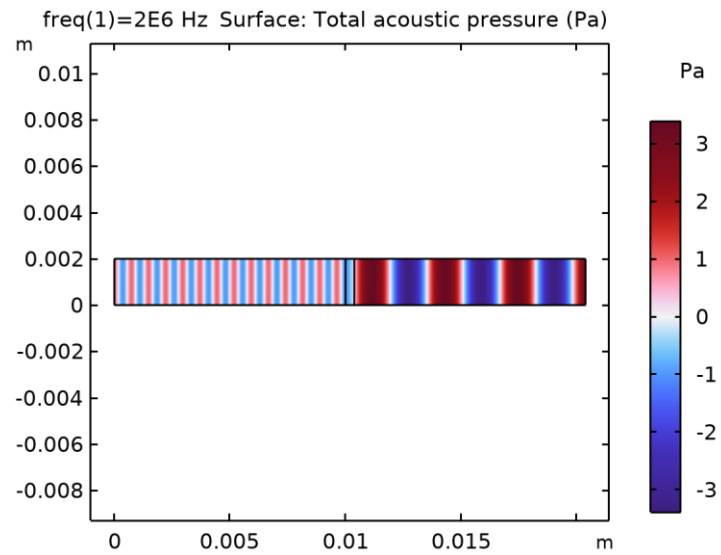
Description	Value
Solution	Solution 1 (sol1)
Component	Component 1 (comp1)



Dataset: Study 1/Solution 1

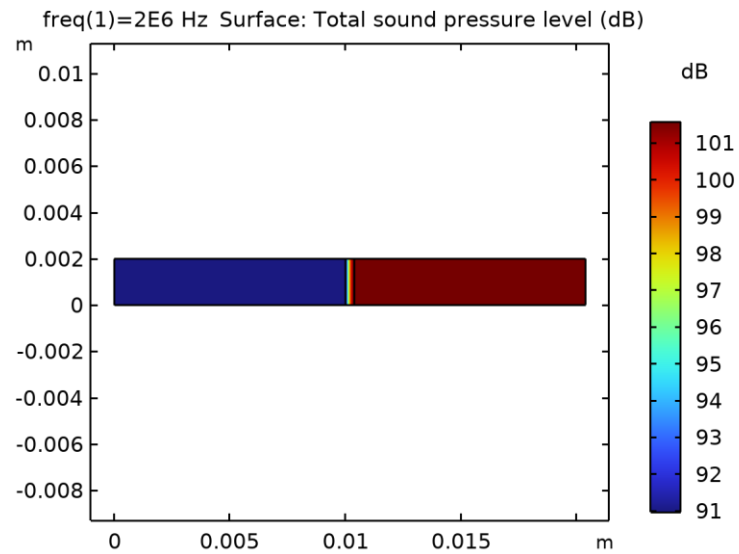
4.2 PLOT GROUPS

4.2.1 Acoustic Pressure (acpr)



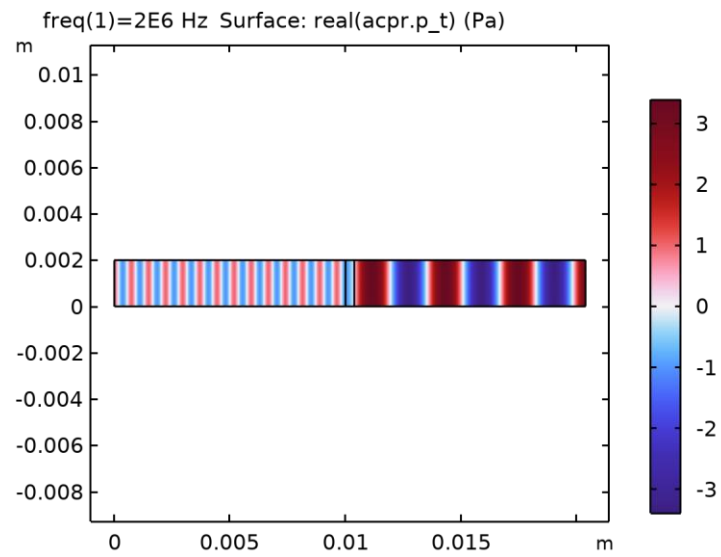
Surface: Total acoustic pressure (Pa)

4.2.2 Sound Pressure Level (acpr)



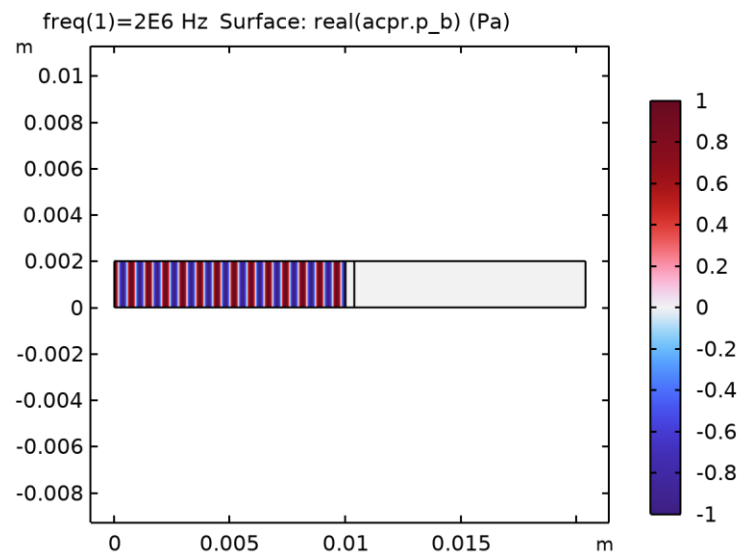
Surface: Total sound pressure level (dB)

4.2.3 2D Plot Group 3



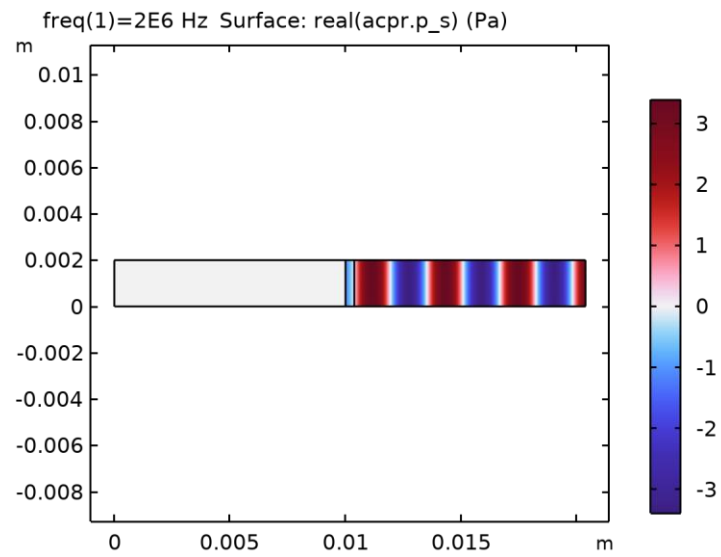
Surface: real(acpr.p_t) (Pa)

4.2.4 2D Plot Group 4



Surface: real(acpr.p_b) (Pa)

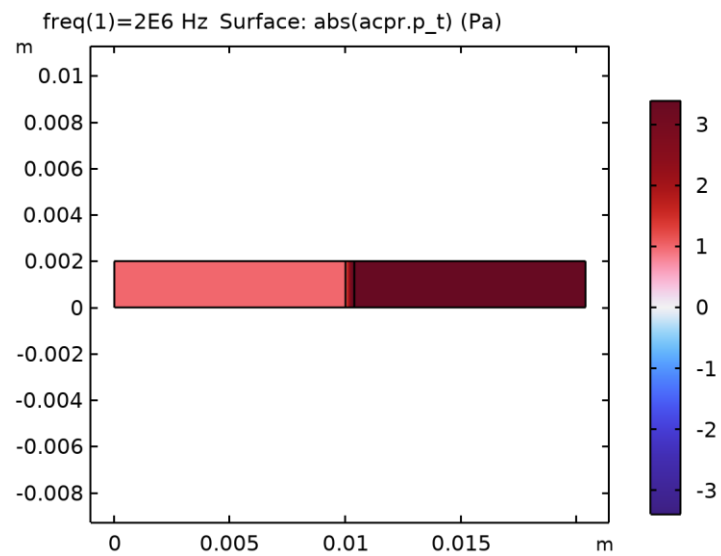
4.2.5 2D Plot Group 5



Surface: real(acpr.p_s) (Pa)

4.2.6 1D Plot Group 6

4.2.7 2D Plot Group 7



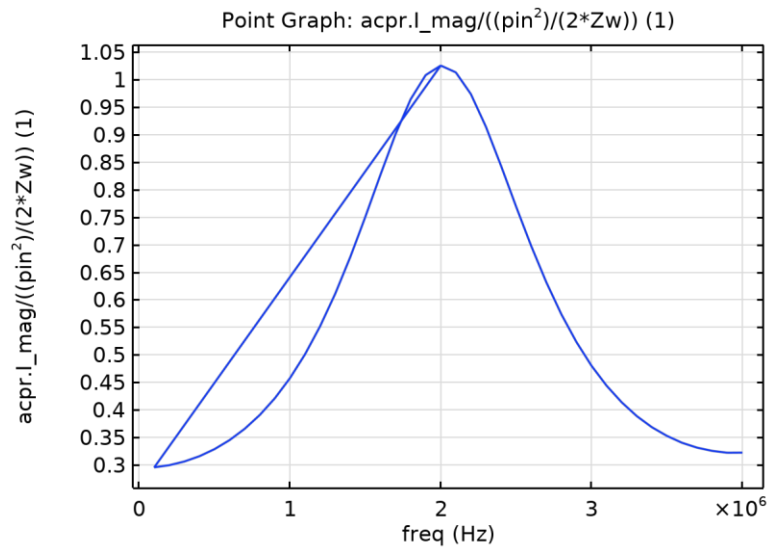
Surface: abs(acpr.p_t) (Pa)

4.2.8 1D Plot Group 8

4.2.9 1D Plot Group 9

4.2.10 1D Plot Group 10

4.2.11 1D Plot Group 11



Point Graph: $\text{acpr.l_mag}/((\text{pin}^2)/(2*Zw))$ (1)