

# Lab4 Q1 CounterCurrent

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# 1 Global Definitions

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## GLOBAL SETTINGS

Name	Lab4 Q1 CounterCurrent.mph
Path	C:\Users\A3dufres\Downloads\Lab4 Q1_CounterCurrent.mph
Version	COMSOL Multiphysics 6.1 (Build: 282)

## USED PRODUCTS

COMSOL Multiphysics
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## COMPUTER INFORMATION

CPU	Intel64 Family 6 Model 183 Stepping 1, 20 cores, 31.82 GB RAM
Operating system	Windows 10

## 1.1 PARAMETERS

### PARAMETERS 1

Name	Expression	Value	Description
Thick	0.001 [m]	0.001 m	Thickness of the Copper Tube
Di	0.1 [m]	0.1 m	Radius of Inner Tube
D	2*Di + Thick	0.201 m	Radius of Outer Tube
K_Cop	385 [W/(K*m)]	385 W/(m·K)	Copper Thermal Conductivity
rho	998 [kg/m^3]	998 kg/m <sup>3</sup>	Density of Water
vis	0.001 [Pa*s]	0.001 Pa·s	Viscosity of Water
Cp	4182 [J/(kg*K)]	4182 J/(kg·K)	Specific Heat capacity of Water
K_Water	0.6 [W/(m*K)]	0.6 W/(m·K)	Thermal Conductivity of Water
T_Hot	80 [degC]	353.15 K	Temperature of the Hot Water
V_Hot	0.02 [m/s]	0.02 m/s	Speed of the Hot Water
T_Cold	20 [degC]	293.15 K	Temperature of the Cold Water
V_Cold	0.01 [m/s]	0.01 m/s	Speed of the Cold Water
Length	0.5 [m]	0.5 m	Length of the Tube
Ri	Di/2	0.05 m	Diameter of Inner Tube
R_Tot	2*Ri + Thick	0.101 m	

## 1.2 MATERIALS

### 1.2.1 Copper 1

## 2 Component 1

### 2.1 DEFINITIONS

#### 2.1.1 Coordinate Systems

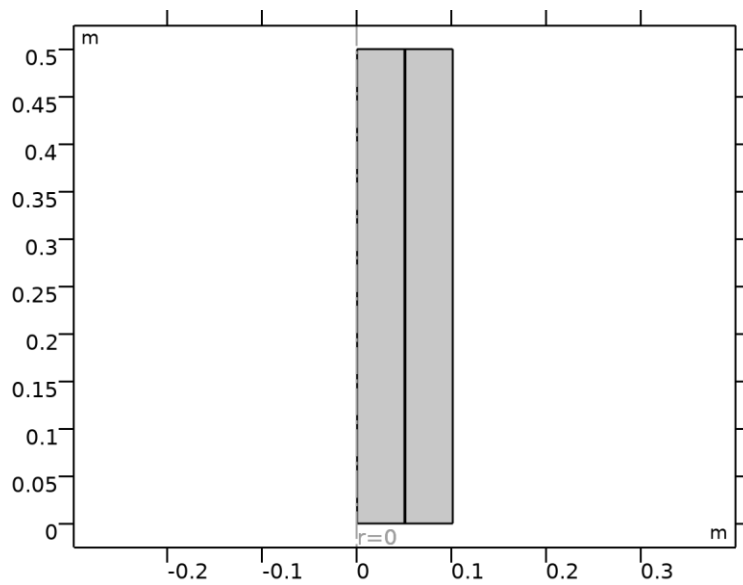
##### Boundary System 1

Coordinate system type	Boundary system
Tag	sys1

##### COORDINATE NAMES

First	Second	Third
t1	to	n

### 2.2 GEOMETRY 1



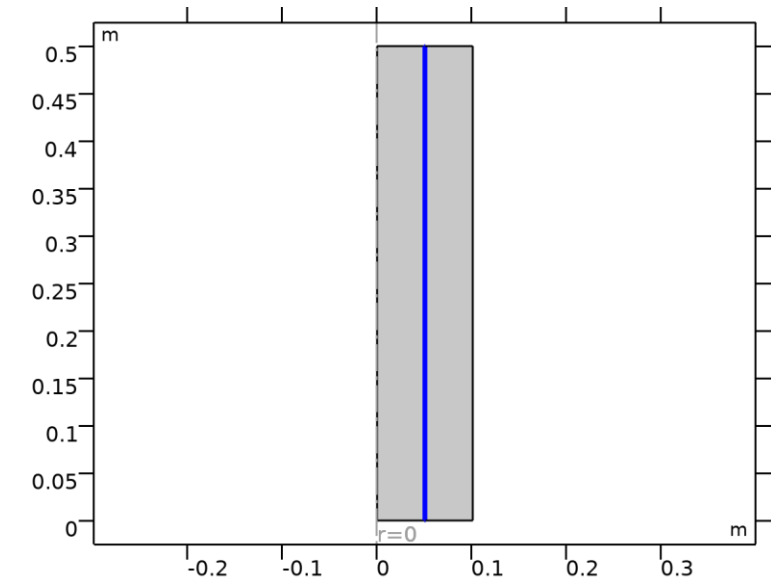
##### Geometry 1

##### UNITS

Length unit	m
Angular unit	deg

2.3 MATERIALS

2.3.1 Copper

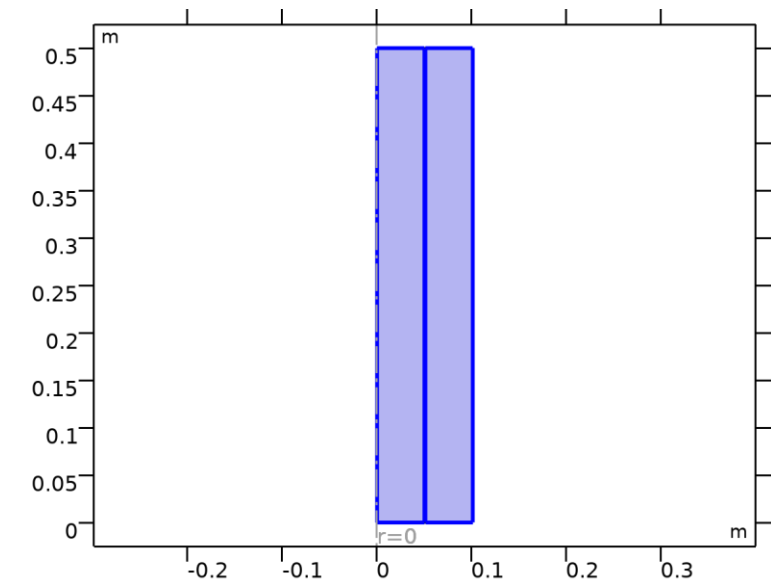


Copper

SELECTION

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

2.4 LAMINAR FLOW



Laminar Flow

## EQUATIONS

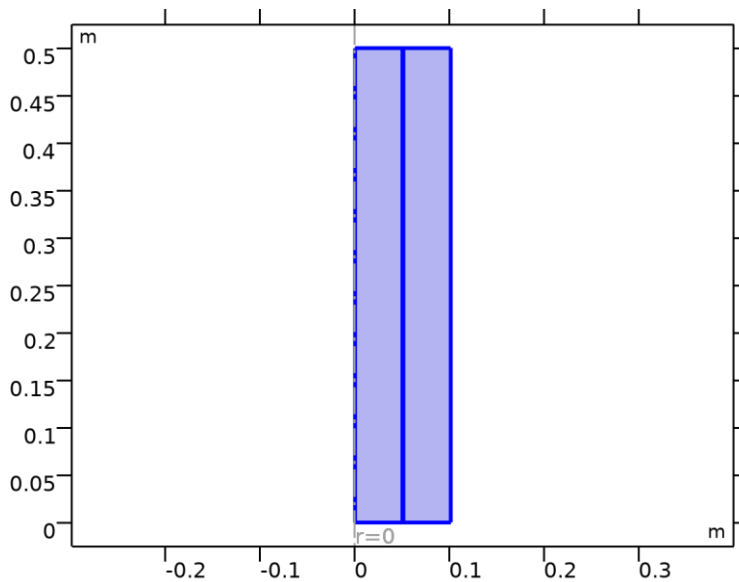
$$\rho(\mathbf{u} \cdot \nabla)\mathbf{u} = \nabla \cdot [-p\mathbf{I} + \mathbf{K}] + \mathbf{F}$$

$$\rho \nabla \cdot \mathbf{u} = 0$$

## FEATURES

Name	Level
Fluid Properties 1	Domain
Initial Values 1	Domain
Axial Symmetry 1	Boundary
Wall 1	Boundary
Hot Water In	Boundary
Cold Water In	Boundary
Hot Water Out	Boundary
Cold Water Out	Boundary

## 2.5 HEAT TRANSFER IN SOLIDS AND FLUIDS 3



*Heat Transfer in Solids and Fluids 3*

## EQUATIONS

$$\rho C_p \mathbf{u} \cdot \nabla T_3 + \nabla \cdot \mathbf{q} = Q + Q_{\text{ted}}$$

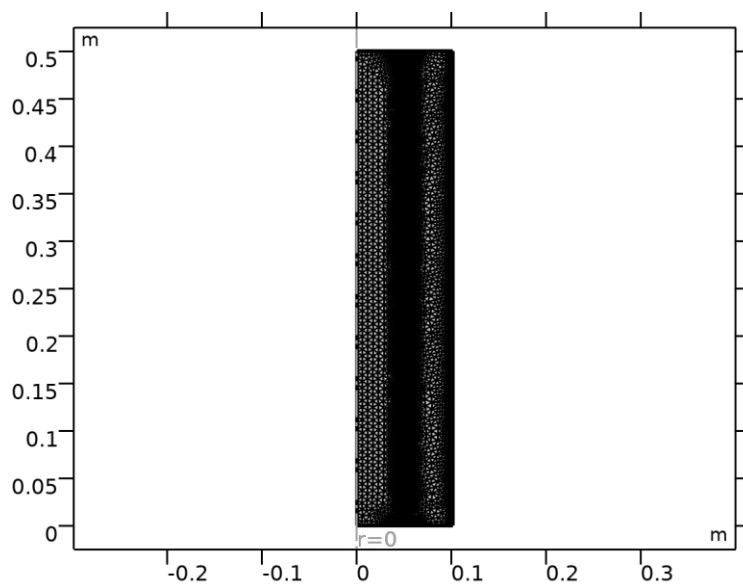
$$\mathbf{q} = -k \nabla T_3$$

## FEATURES

Name	Level
Copper	Domain
Water Hot	Domain

Name	Level
Initial Values 1	Domain
Axial Symmetry 1	Boundary
Thermal Insulation 1	Boundary
Cold Water Temp	Boundary
Hot Water Temp	Boundary
Cold Water Outflow	Boundary
Water Cold	Domain
Hot Water Outflow	Boundary

## 2.6 MESH 1



*Mesh 1*

### 3 Study 1

#### COMPUTATION INFORMATION

Computation time	4 s
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#### 3.1 STATIONARY

##### STUDY SETTINGS

Description	Value
Include geometric nonlinearity	Off

##### PHYSICS AND VARIABLES SELECTION

Physics interface	Solve for	Equation form
Laminar Flow (spf)	On	Automatic (Stationary)
Heat Transfer in Solids and Fluids 3 (ht3)	On	Automatic (Stationary)

##### MESH SELECTION

Component	Mesh
Component 1	Mesh 1



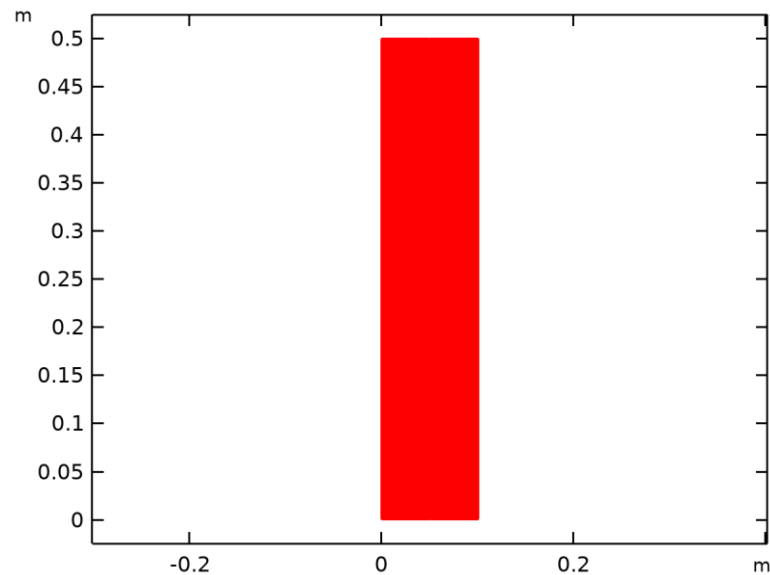
## 4 Results

### 4.1 DATASETS

#### 4.1.1 Study 1/Solution 1

##### SOLUTION

Description	Value
Solution	Solution 1
Component	Component 1 (comp1)



*Dataset: Study 1/Solution 1*

#### 4.1.2 Revolution 2D

##### DATA

Description	Value
Dataset	<a href="#">Study 1/Solution 1</a>

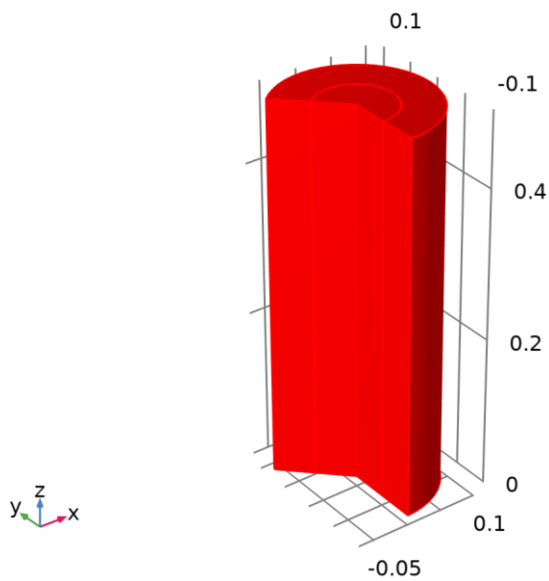
##### AXIS DATA

Description	Value
Axis entry method	Two points
Points	{{0, 0}, {0, 1}}

##### REVOLUTION LAYERS

Description	Value
Start angle	-90

Description	Value
Revolution angle	225



Dataset: Revolution 2D

#### 4.1.3 Study 1/Parametric Solutions 1

##### SOLUTION

Description	Value
Solution	Parametric Solutions 1
Component	Component 1 (comp1)

#### 4.1.4 Cut Line

##### DATA

Description	Value
Dataset	<a href="#">Study 1/Solution 1</a>

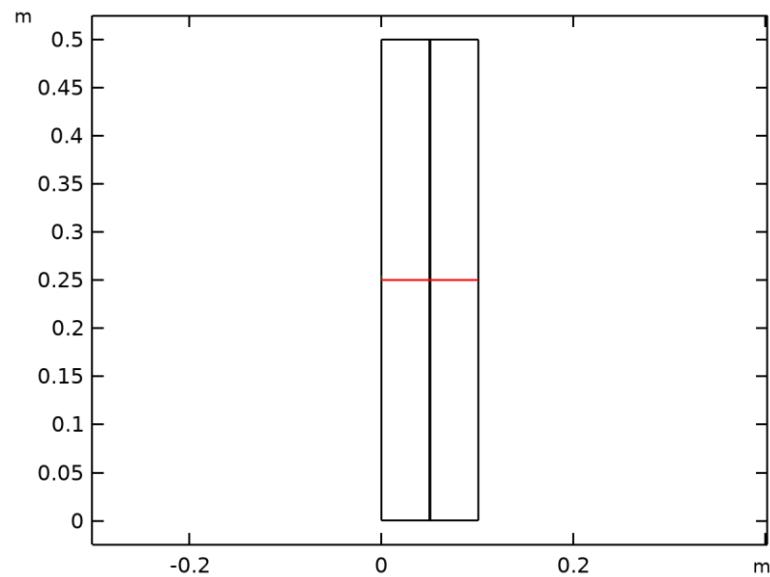
##### LINE DATA

Description	Value
Line entry method	Two points
Points	{{0, Length/2}, {R_Tot, Length/2}}

##### ADVANCED

Description	Value
Space variable	cln1x
Normal variables	{cln1nx, cln1ny}

Description	Value
Tangent variables	{c1n1tx, c1n1ty}



Dataset: Cut Line

## 4.2 DERIVED VALUES

### 4.2.1 Hot Water Avg Out

#### OUTPUT

Evaluated in	<a href="#">Table 6</a>
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#### DATA

Description	Value
Dataset	<a href="#">Study 1/Solution 1</a>

#### EXPRESSIONS

Expression	Unit	Description
T3	K	Temperature

#### INTEGRATION SETTINGS

Description	Value
Integration order	4
Compute surface integral	On

### 4.2.2 Cold Water Avg Out

#### OUTPUT

Evaluated in	<a href="#">Table 5</a>
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#### DATA

Description	Value
Dataset	<a href="#">Study 1/Solution 1</a>

#### EXPRESSIONS

Expression	Unit	Description
T3	K	Temperature

#### INTEGRATION SETTINGS

Description	Value
Integration order	4
Compute surface integral	On

### 4.3 TABLES

#### 4.3.1 Evaluation 3D

Interactive 3D values

x	y	z	Value
0.049186	0.053169	0.5	321.02
0.015289	0.011451	0.5	321.02
0.032141	0.041288	0.5	321.02
1.5774E-4	-0.007018	0.5	321.02
0.013571	-0.040626	0.5	321.02
0	-0.081705	0.4376	321.02

#### 4.3.2 Table 3

Hot Temp Avg

Temperature (K)	Temperature (K)
350.56	351.03

#### 4.3.3 Table 4

Cold Temp Avg

Temperature (K)
294.56

#### 4.3.4 Table 5

Cold Water Avg Out

Temperature (K)	Temperature (K)
295.49	295.49

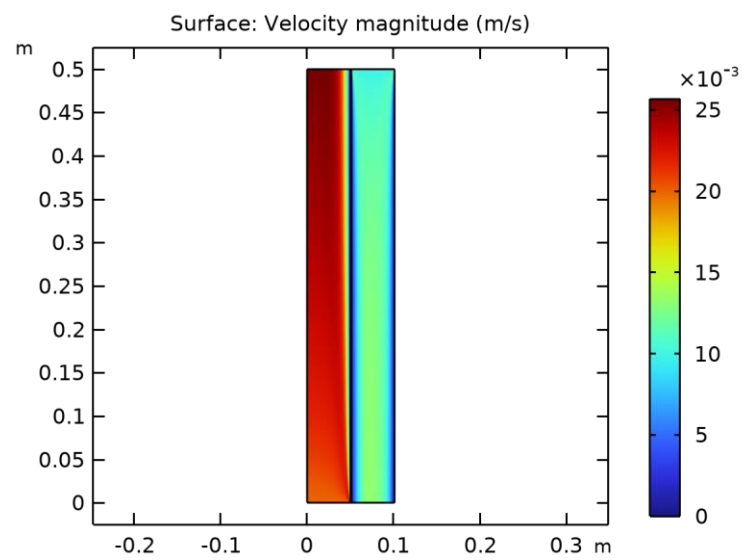
#### 4.3.5 Table 6

Hot Water Avg Out

Temperature (K)	Temperature (K)
348.45	348.45

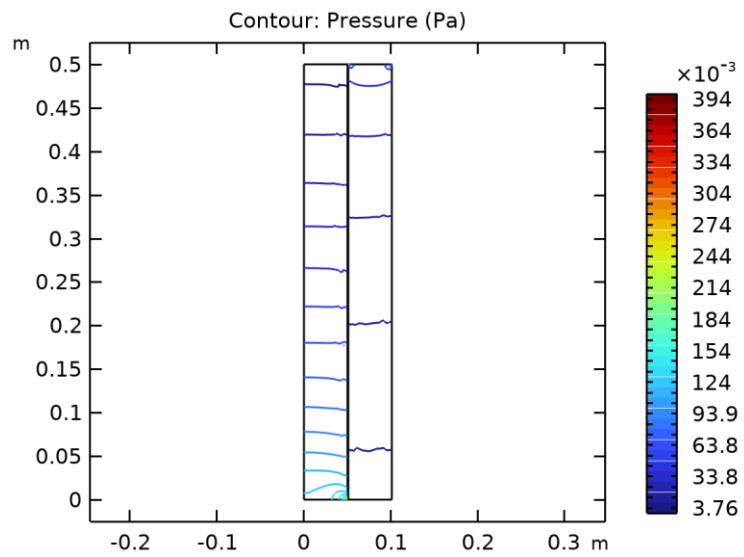
### 4.4 PLOT GROUPS

#### 4.4.1 Velocity (spf)



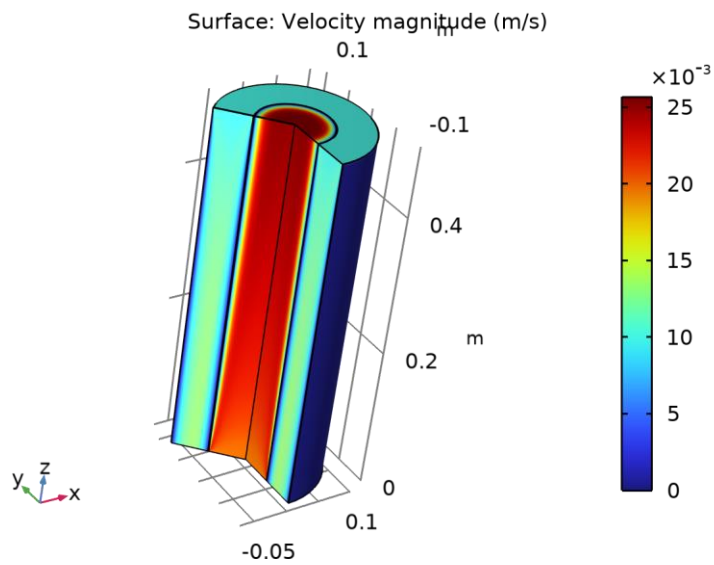
Surface: Velocity magnitude (m/s)

#### 4.4.2 Pressure (spf)



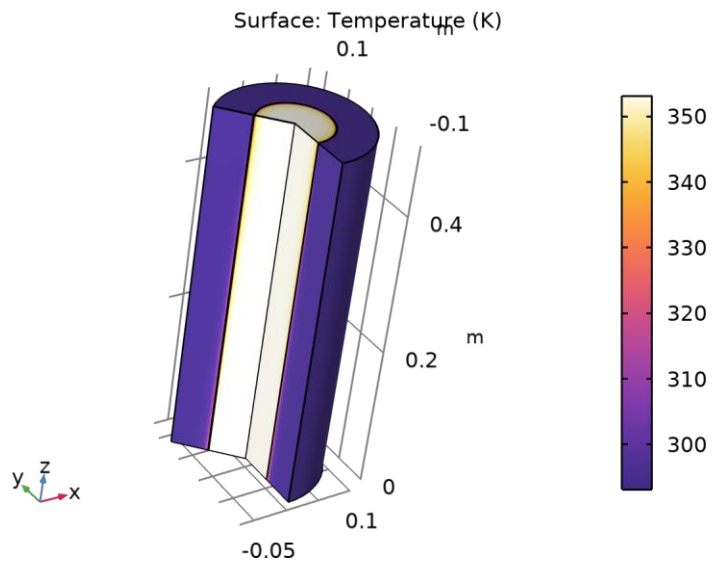
Contour: Pressure (Pa)

#### 4.4.3 Velocity, 3D (spf)



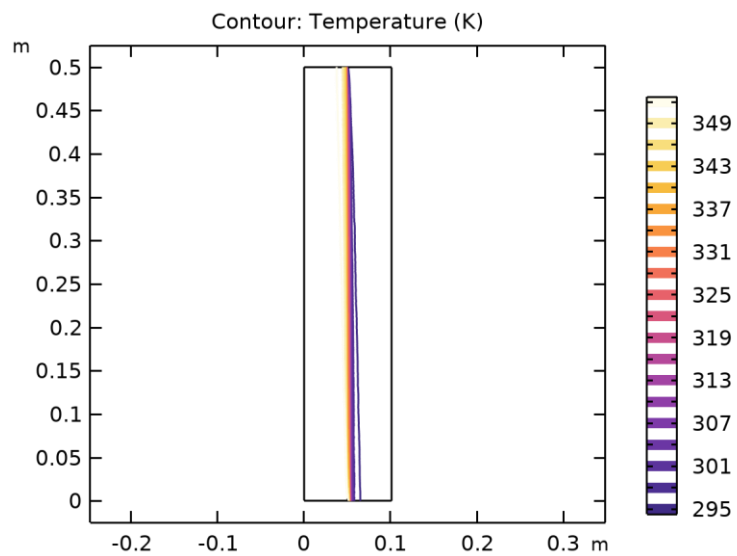
Surface: Velocity magnitude (m/s)

#### 4.4.4 Temperature, 3D (ht3)



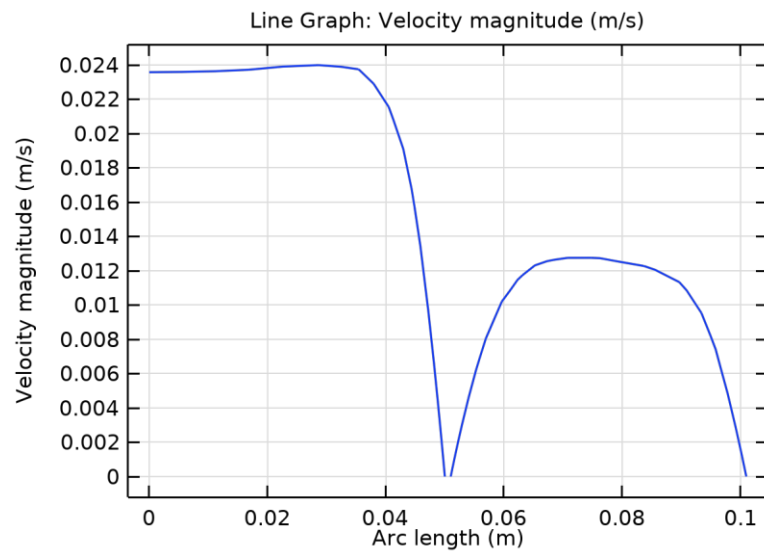
*Surface: Temperature (K)*

#### 4.4.5 Isothermal Contours (ht3)



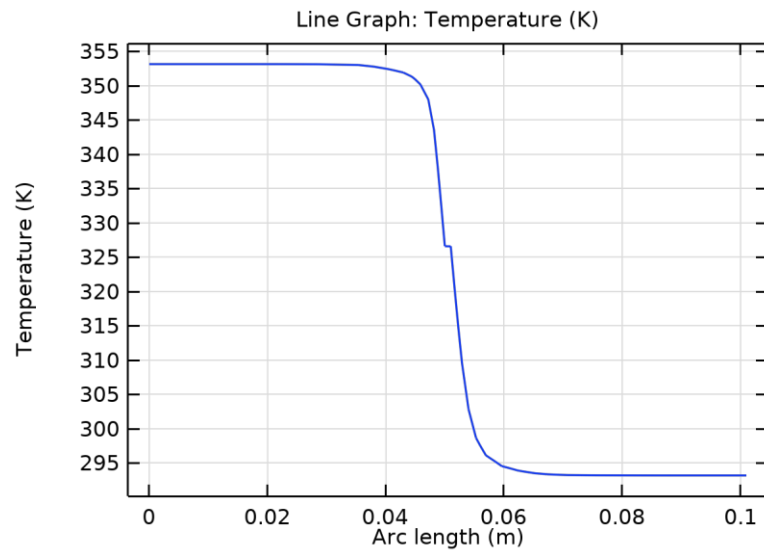
*Contour: Temperature (K)*

#### 4.4.6 1D Plot Group 6



*Line Graph: Velocity magnitude (m/s)*

#### 4.4.7 Temperature Group



*Line Graph: Temperature (K)*