Li-ion battery

Report date	Aug 31, 2025, 4:33:04 AM

Contents

1 Global Definitions

Date	Aug 13, 2025, 3:18:40 AM

GLOBAL SETTINGS

Name	PROJECT1.3.mph
Path	C:\Users\91880\Desktop\placement prep\self project\PROJECT1.3.mph
Version	COMSOL Multiphysics 6.3 (Build: 420)

USED PRODUCTS

COMSOL Multiphysics

COMPUTER INFORMATION

CPU	Intel64 Family 6 Model 140 Stepping 2, 2 cores, 7.65 GB RAM
Operating system	Windows 11

1.1 PARAMETERS

PARAMETERS 1

Name	Expression	Value	Description
T0	298.15[K]	298.15 K	initial temp
Te	298.15[K]	298.15 K	ambient temp
h_conv	10[W/m^2*K]	10 kg·K/s³	convective coefficient
Tm	333.15[K]	333.15 K	pcm melting point
dT	5[K]	5 K	smoothing interval for phase change
Lpcm	150000[J/kg]	1.5E5 J/kg	latent heat
rho_pcm	900[kg/m^3]	900 kg/m³	
k_pcm	0.25[W/m*K]	0.25 kg·m·K/s³	
Cp_pcm	2000[J/kg*K]	2000 m²·K/s²	base heat capacity
Q0	1e6[W/m^3]	1E6 W/m³	peak heat generation
t0	100[s]	100 s	time of initiation
tau	10[s]	10 s	duration of interval
k_cell	1[W/m*K]	1 kg·m·K/s³	
Cp_cell	900[J/kg*K]	900 m²·K/s²	
rho_cell	2500[kg/m^3]	2500 kg/m³	

2 Component 1

SETTINGS

Description	Value
Unit system	Same as global system (SI)

2.1 DEFINITIONS

2.1.1 Coordinate Systems

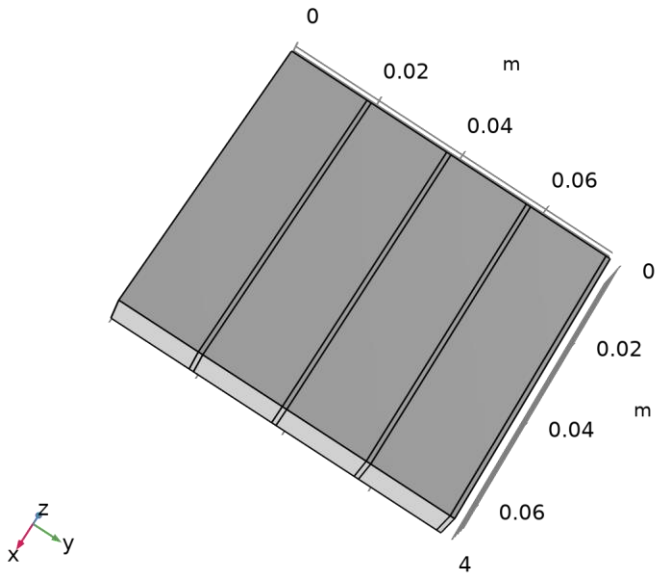
Boundary System 1

Coordinate system type	Boundary system
Tag	sys1

COORDINATE NAMES

First	Second	Third
t1	t2	n

2.2 GEOMETRY 1



Geometry 1

UNITS

Length unit	m
Angular unit	deg

GEOMETRY STATISTICS

Description	Value

Description	Value
Space dimension	3
Number of domains	8
Number of boundaries	41
Number of edges	68
Number of vertices	36

2.2.1 Block 1 (blk1)

SIZE AND SHAPE

Description	Value
Width	0.065
Depth	0.018
Height	0.01

POSITION

Description	Value
Position	{0, 0, 0}

AXIS

Description	Value
Axis type	z - axis

2.2.2 Block 2 (blk2)

SIZE AND SHAPE

Description	Value
Width	0.065
Depth	0.001
Height	0.01

POSITION

Description	Value
Position	{0, 0.018, 0}

AXIS

Description	Value
Axis type	z - axis

2.2.3 Array 1 (arr1)

INPUT OBJECTS

Description	Value
Input objects	geom1, Geometry geom1: Objects: blk1, blk2

SIZE

Description	Value
Array type	Linear
Size	4

DISPLACEMENT

Description	Value
Displacement	{0, 0.019, 0}

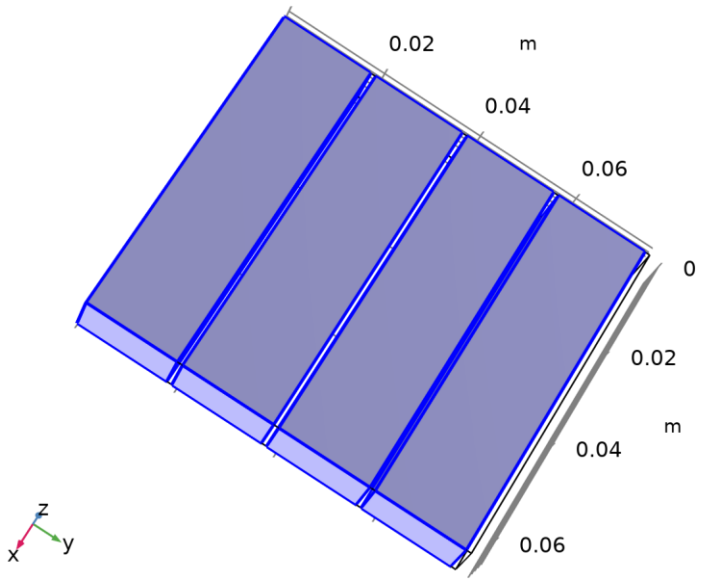
2.2.4 Form Union (fin)

INFORMATION

Description	Value
Build message	Formed union of 8 solid objects. Union has 8 domains, 41 boundaries, 68 edges, and 36 vertices.

2.3 MATERIALS

2.3.1 cell



cell

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: Domains 1, 3, 5, 7

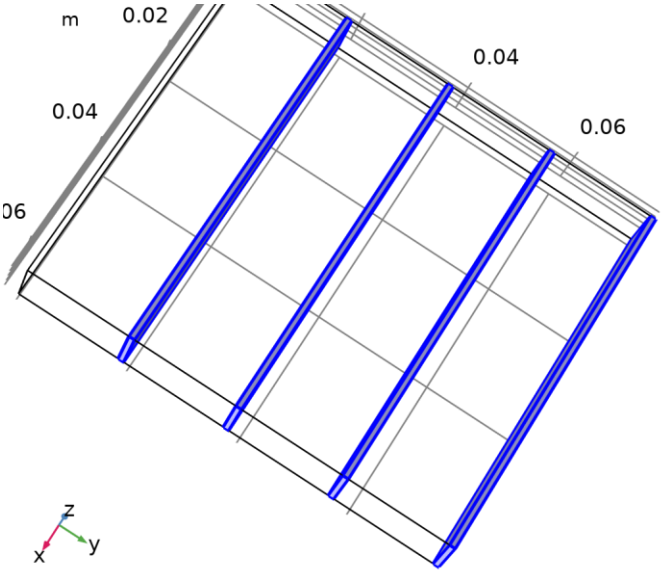
MATERIAL PARAMETERS

Name	Value	Unit	Property group
Density	rho_cell	kg/m³	Basic
Heat capacity at constant pressure	Cp_cell	J/(kg·K)	Basic
Thermal conductivity	k_cell	W/(m·K)	Basic

BASIC

Description	Value	Unit
Density	rho_cell	kg/m³
Heat capacity at constant pressure	Cp_cell	J/(kg·K)
Thermal conductivity	k_cell	W/(m·K)

2.3.2 pcm



pcm

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: Domains 2, 4, 6, 8

MATERIAL PARAMETERS

Name	Value	Unit	Property group
Thermal conductivity	k_pcm	W/(m·K)	Basic
Density	rho_pcm	kg/m³	Basic
Heat capacity at constant pressure	Cp_pcm+0.5*Lpcm*(1-tanh((T-Tm)/dT)^2)/dT	J/(kg·K)	Basic

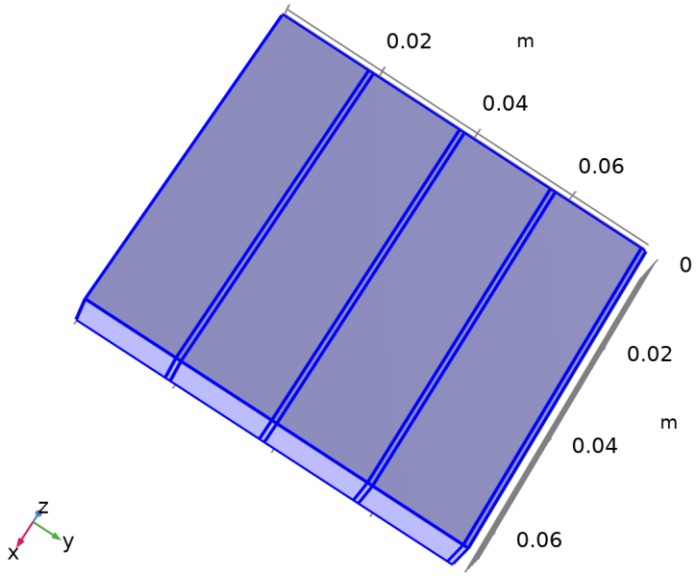
BASIC

Description	Value	Unit
Thermal conductivity	k_pcm	W/(m·K)
Density	rho_pcm	kg/m³
Heat capacity at constant pressure	Cp_pcm + 0.5*Lpcm*(1 - tanh((T - Tm)/dT)^2)/dT	J/(kg·K)

2.4 HEAT TRANSFER IN SOLIDS

USED PRODUCTS

COMSOL Multiphysics



Heat Transfer in Solids

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: All domains

EQUATIONS

$$\rho C_p \frac{\partial T}{\partial t} + \rho C_p \mathbf{u} \cdot \nabla T + \nabla \cdot \mathbf{q} = Q + Q_{ted}$$

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

2.4.1 Interface Settings

Discretization

SETTINGS

Description	Value

Description	Value
Temperature	Quadratic Lagrange

SETTINGS

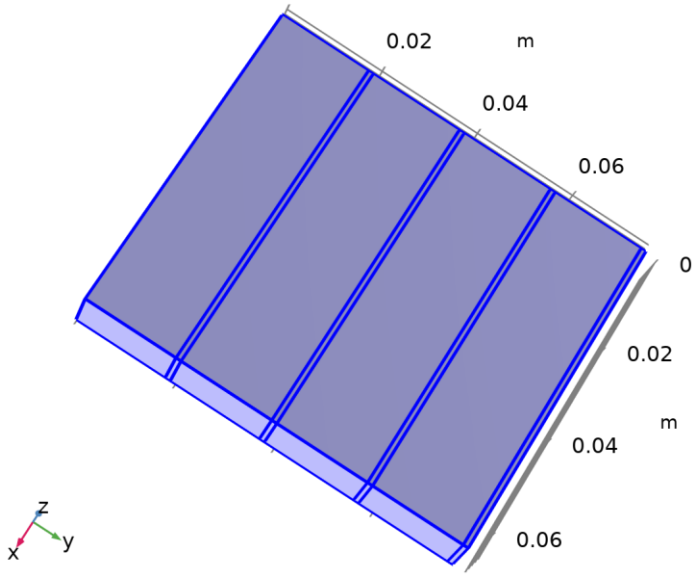
Description	Value
Equation form	Study controlled

Physical Model

SETTINGS

Description	Value	Unit
Reference temperature	User defined	
Reference temperature	293.15	K

2.4.2 Solid 1



Solid 1

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: All domains

EQUATIONS

$$\underline{\rho C_p \frac{\partial T}{\partial t}} + \rho C_p \mathbf{u} \cdot \nabla T + \underline{\nabla \cdot \mathbf{q}} = Q + Q_{ted}$$

$$\mathbf{q} = \underline{-k \nabla T}$$

Heat Conduction, Solid

SETTINGS

Description	Value
Thermal conductivity	From material

Thermodynamics, Solid

SETTINGS

Description	Value
Density	From material
Heat capacity at constant pressure	From material

Coordinate System Selection

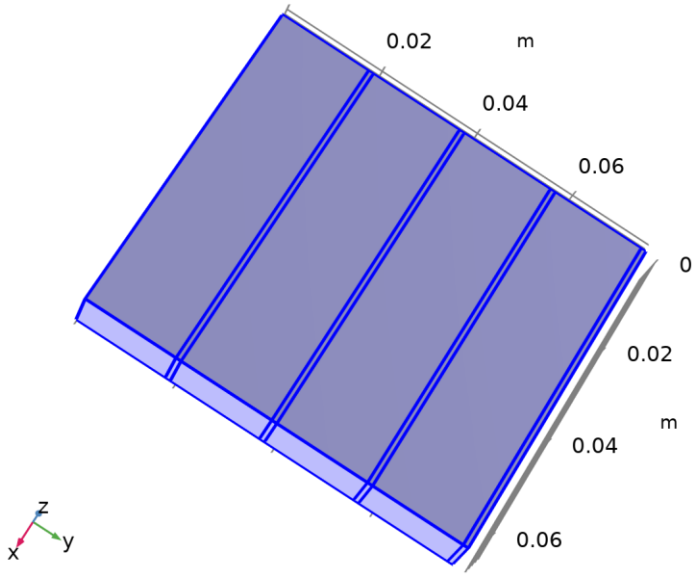
SETTINGS

Description	Value
Coordinate system	Global coordinate system

PROPERTIES FROM MATERIAL

Property	Material	Property group
Thermal conductivity	cell	Basic
Density	cell	Basic
Heat capacity at constant pressure	cell	Basic
Thermal conductivity	pcm	Basic
Density	pcm	Basic
Heat capacity at constant pressure	pcm	Basic

2.4.3 Initial Values 1



Initial Values 1

SELECTION

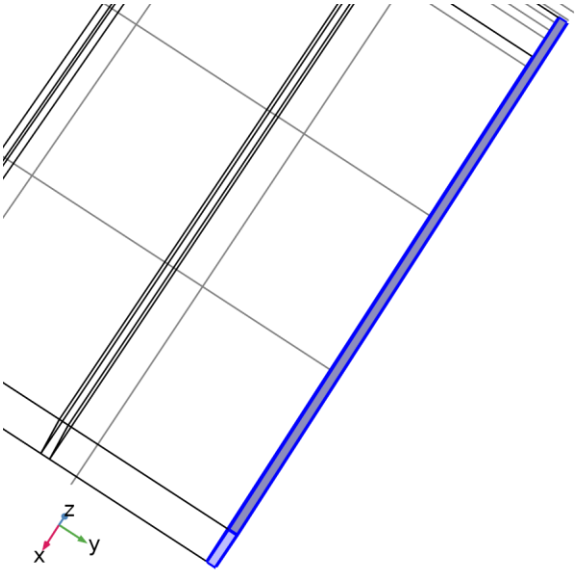
Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: All domains

Initial Values

SETTINGS

Description	Value	Unit
Temperature	User defined	
Temperature	T0	K

2.4.4 Thermal Insulation 1



Thermal Insulation 1

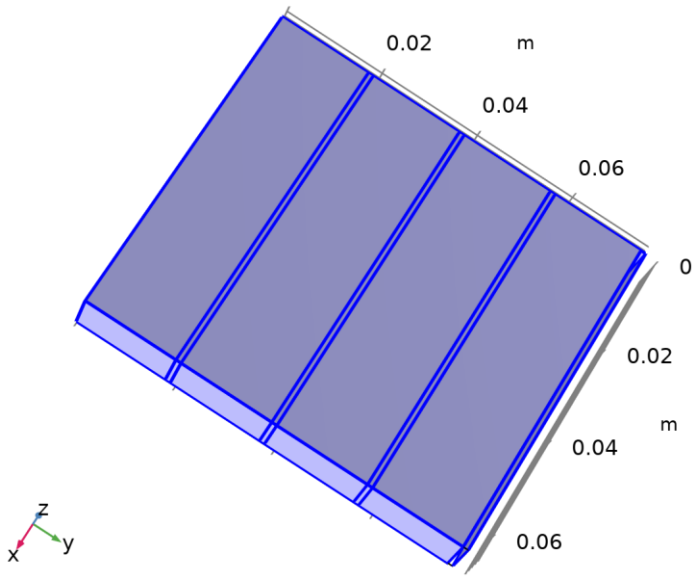
SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: All boundaries

EQUATIONS

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

2.4.5 Heat Flux 1



Heat Flux 1

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundaries 1–5, 7–9, 11–13, 15–17, 19–21, 23–25, 27–29, 33–40

EQUATIONS

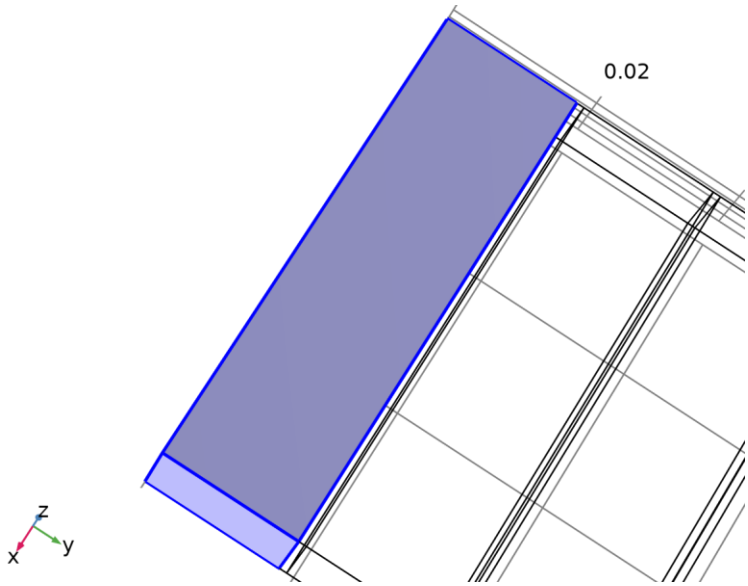
$$-\mathbf{n}\cdot\mathbf{q}=q_0$$
$$q_0=h(T_{ext}-T)$$

Heat Flux

SETTINGS

Description	Value	Unit
Flux type	Convective heat flux	
Heat transfer coefficient	User defined	
Heat transfer coefficient	h_conv	W/(m²·K)
External temperature	User defined	
External temperature	Te	K

2.4.6 Heat Source 1



Heat Source 1

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: Domain 1

EQUATIONS

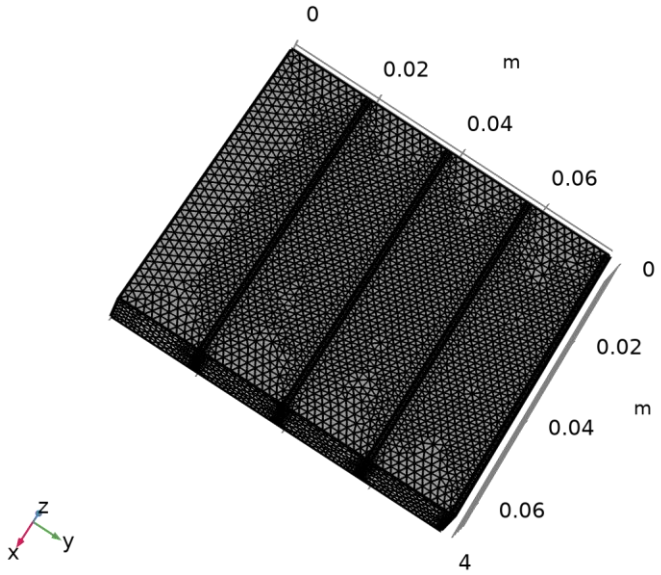
$$Q = Q_0$$

Heat Source

SETTINGS

Description	Value	Unit
Heat source	General source	
Heat source	User defined	
Heat source	Q0*exp(-0.5*(t - t0)^2/tau^2)	W/m³

2.5 MESH 1



Mesh 1

2.5.1 Size (size)

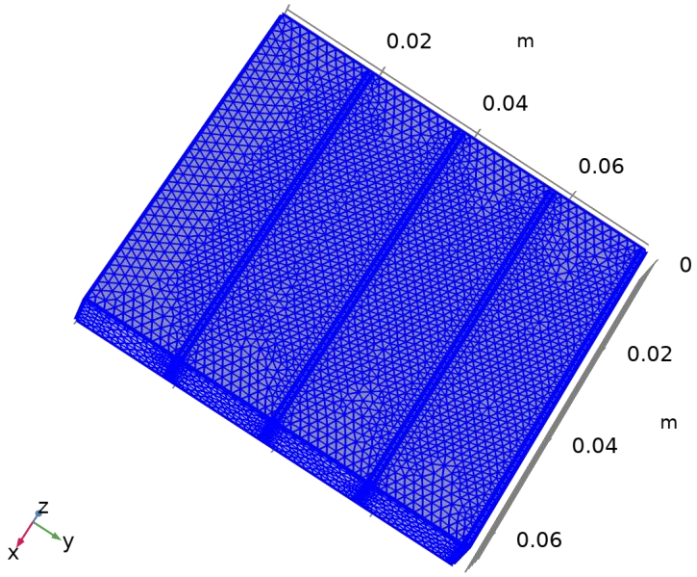
SETTINGS

Description	Value
Maximum element size	0.002186
Minimum element size	1.14E-4
Curvature factor	0.3
Resolution of narrow regions	0.85
Maximum element growth rate	1.35
Predefined size	Extra fine
Custom element size	Custom

2.5.2 Size 1 (size1)

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundaries 1–41



Size 1

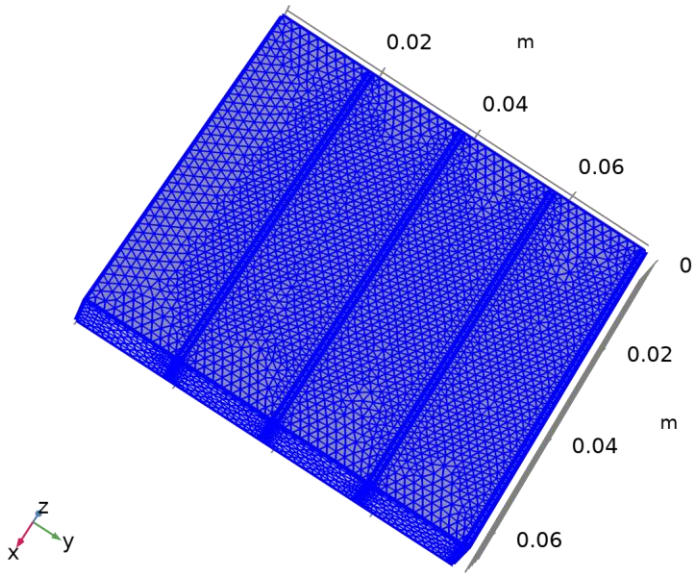
SETTINGS

Description	Value
Maximum element size	0.001878
Minimum element size	5.634E-5
Curvature factor	0.3
Curvature factor	Off
Resolution of narrow regions	0.85
Resolution of narrow regions	Off
Maximum element growth rate	1.35
Maximum element growth rate	Off
Predefined size	Extra fine
Custom element size	Custom

2.5.3 Free Tetrahedral 1 (ftet1)

SELECTION

Geometric entity level	Domain
Selection	Remaining



Free Tetrahedral 1

SETTINGS

Description	Value
Avoid inverted curved elements	On

INFORMATION

Description	Value
Last build time	2 seconds
Built with	COMSOL 6.3.0.420 (win64), Aug 13, 2025, 3:02:11 AM

3 Study 1

COMPUTATION INFORMATION

Computation time	2 min 37 s

3.1 TIME DEPENDENT

Times	Unit
range(0,1,300)	s

STUDY SETTINGS

Description	Value
Include geometric nonlinearity	Off

STUDY SETTINGS

Description	Value
Output times	{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300}

PHYSICS AND VARIABLES SELECTION

Key	Solve for
Heat Transfer in Solids (ht)	On

STORE IN OUTPUT

Interface	Output	Selection
Heat Transfer in Solids (ht)	Physics controlled	

MESH SELECTION

Component	Mesh
Component 1	Mesh 1

3.2 SOLVER CONFIGURATIONS

3.2.1 Solution 1

Compile Equations: Time Dependent (st1)

STUDY AND STEP

Description	Value
Use study	Study 1
Use study step	Time Dependent

Dependent Variables 1 (v1)

GENERAL

Description	Value
Defined by study step	Step 1: Time Dependent

INITIAL VALUE CALCULATION CONSTANTS

Constant name	Initial-value source
t	{range(0, 1, 300)}[s]
timestep	0.3[s]

Temperature (comp1.T) (comp1_T)

GENERAL

Description	Value
Field components	comp1.T
Internal variables	{comp1.ht.dt2Inv_T, comp1.uflux.T, comp1.dflux.T}

Time-Dependent Solver 1 (t1)

GENERAL

Description	Value
Defined by study step	Step 1: Time Dependent
Output times	{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195,

Description	Value
	196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300}

ABSOLUTE TOLERANCE

Field	Method	Tolerance method	Tolerance factor	Derivative tolerance method	Time derivative factor	Tolerance	Tolerance for time derivatives
Temperature (comp1.T)	Use global	Factor	0.1	Automatic	1	0.001	0.001

TIME STEPPING

Description	Value
Maximum BDF order	2
Error estimation	Exclude algebraic

Fully Coupled 1 (fc1)

GENERAL

Description	Value
Linear solver	AMG, heat transfer variables (ht)

METHOD AND TERMINATION

Description	Value
Damping factor	0.9
Jacobian update	Once per time step
Stabilization and acceleration	Anderson acceleration
Dimension of iteration space	5
Mixing parameter	0.9
Iteration delay	1

AMG, heat transfer variables (ht) (i1)

ERROR

Description	Value
Factor in error estimate	20

Multigrid 1 (mg1)

GENERAL

Description	Value
Solver	Smoothed aggregation AMG
Maximum number of DOFs at coarsest level	50000
Construct prolongators componentwise	On
Prolongator smoothing	Off

Presmoother (pr)

SOR 1 (so1)

GENERAL

Description	Value
Relaxation factor	0.9

Postsmoother (po)

SOR 1 (so1)

GENERAL

Description	Value
Relaxation factor	0.9

Coarse Solver (cs)

Direct 1 (d1)

GENERAL

Description	Value
Solver	PARDISO
Pivoting perturbation	1E-13

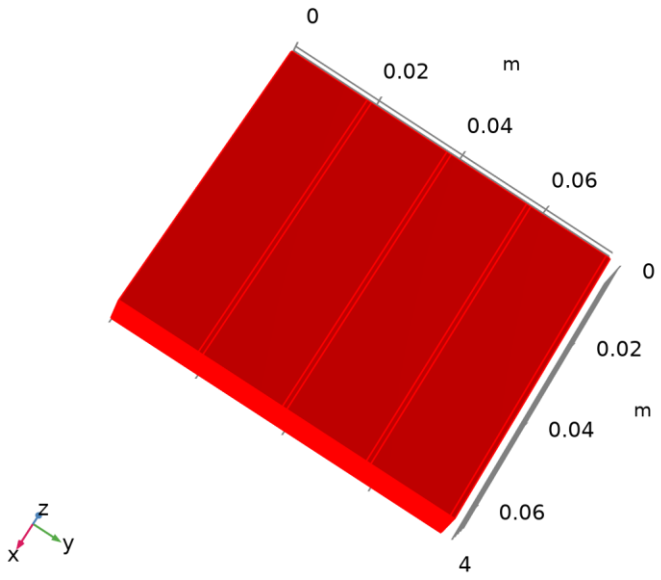
4 Results

4.1 DATASETS

4.1.1 Study 1/Solution 1

SOLUTION

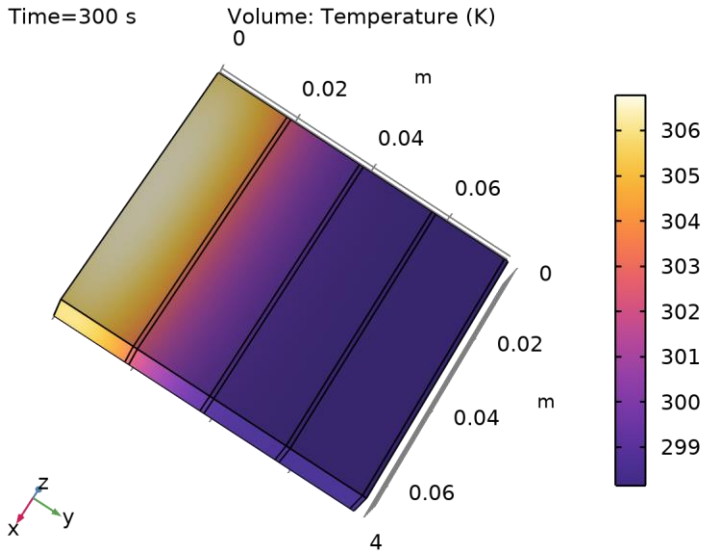
Description	Value
Solution	Solution 1 (sol1)
Component	Component 1 (comp1)



Dataset: Study 1/Solution 1

4.2 PLOT GROUPS

4.2.1 Temperature (ht)



Volume: Temperature (K)