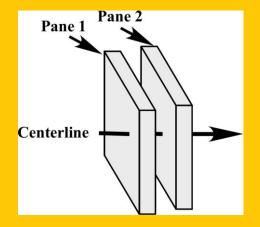
The APP as a Tool, A First Principles Approach

Roger W. Pryor, Ph.D. CEO Pryor Knowledge Systems

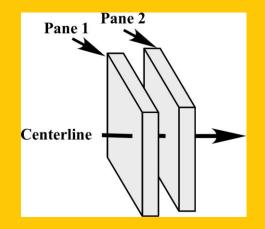


Introduction

COMSOL Multiphysics[®] 1D Heat Transfer Model

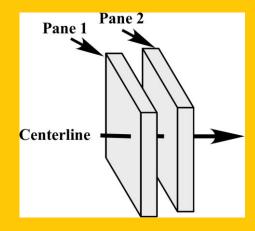


COMSOL Multiphysics® 1D Heat Transfer Model



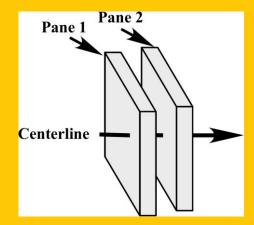
This APP models the calculation of heat loss (gain) under stationary (steady-state) conditions, for a wide range of applied conditions.

COMSOL Multiphysics® 1D Heat Transfer Model



$$\Gamma C_{P} \frac{\partial T}{\partial t} + \nabla i q = 0$$
where $q = -k\nabla T$

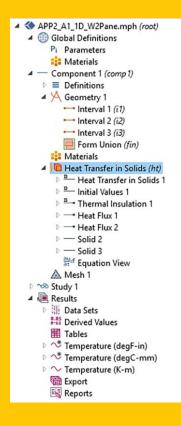
COMSOL Multiphysics® 1D Heat Transfer Model



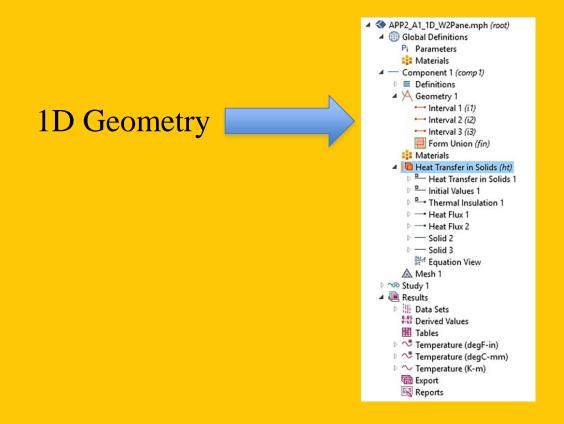
$$\Gamma C_{P} \frac{\partial T}{\partial t} + \nabla i q = 0$$
where $q = -k\nabla T$

ρ is the density of the material (kg/m³)
C_P is the heat capacity at constant pressure (J/kg*K)
T is the absolute temperature (K)
k is the thermal conductivity (W/m*K)
q is the conductive heat flux (W/m²)

COMSOL Multiphysics® 1D Heat Transfer Model

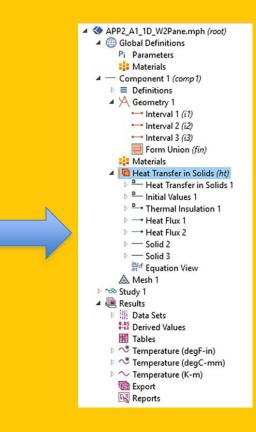


COMSOL Multiphysics® 1D Heat Transfer Model

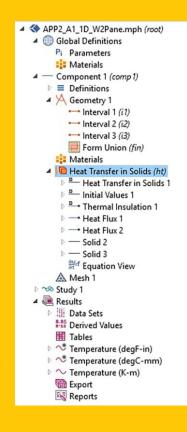


COMSOL Multiphysics® 1D Heat Transfer Model

Heat Transfer Parameters

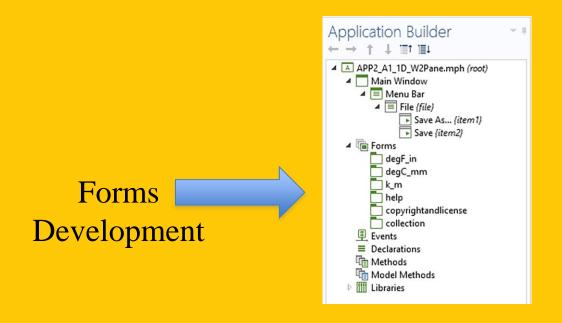


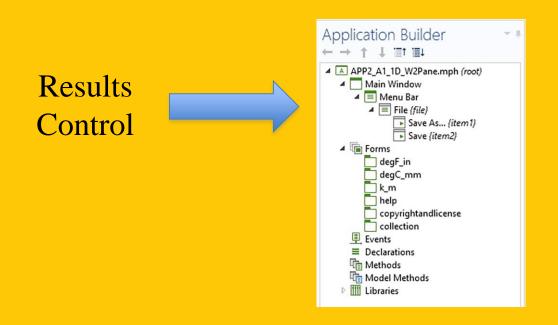
COMSOL Multiphysics® 1D Heat Transfer Model



Results Plots

Building The APP







APP Front Panel

						APP2 A1	1D W2Pane			—		>
ile												
DegF_in	DegC_mm	K_m	Help	Copyri	ighta	andLicense						
Interior T	emperature:	70)		۴F	Heat Capaci	ty Pane1:	703	J/(kg·K)			
Exterior T	emperature:	0			°F	Density Mat	erial Pane 1:	2203	kg/m³			
Pane 1 TI	hickness:	5	e-3		m	Thermal Cor	nductivity Pane 1:	1.38	W/(m·K)			
Gas Spac	e Thickness:	15	5e-3		m	Heat Capaci	ty Gas1:	1005	J/(kg·K)			
Pane 2 TI	hickness:	5	e-3		m	Density Mate	erial Gas 1:	1.293	kg/m ¹			
						Thermal Cor	nductivity Gas 1:	2.43e-2	W/(m·K)			
						Heat Capaci	ty Pane 2:	703	J/(kg·K)			
						Density Mat	erial Pane 2:	2203	kg/m³			
						Thermal Cor	nductivity Pane 2:	1.38	W/(m·K)			
C	Compute					Temperature	e Initial:	273.15	к			
						Heat Flux Ins	ide:	15	W/(m²·K)	i.		
						Heat Flux Ou	itside:	15	W/(m²·K)			
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Ĕ	10								-			
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Results



APP Front Panel DegF_in

DegC_mm	K_m	Help	Сору	right	andLicense								
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emperature:	and the second	D		۴F	Density Ma	aterial Pa	ne 1:	2203		kg/m³			
ickness:	1	5e-3		m	Thermal C	onductiv	ity Pane 1:	1.38		W/(m·K	0		
e Thickness:	E	15e-3		m	Heat Capa	city Gas1	:	1005		J/(kg⋅K)			
ickness:		5e-3		m	Density Ma	aterial Ga	is 1:	1.293		kg/m³			
					Thermal C	onductiv	rity Gas 1:	2.43e-2		W/(m⋅K	0		
					Heat Capa	city Pane	2:	703		J/(kg·K)			
					Density Ma	aterial Pa	ne 2:	2203		kg/m³			
=					Thermal C	onductiv	ity Pane 2:	1.38		W/(m⋅K	0		
ompute					Temperatu	re Initial		273.15		к			
					Heat Flux I	nside:		15		W/(m²·ł	K)		
					Heat Flux (Outside:		15		W/(m²·ł	K)		
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Outside: 19 10 0 0.1 0.2 0.3 0.4</td> <td>Properture: 70 *F Heat Capacity Pane1: emperature: 0 *F Density Material Pane 1: ickness: 5e-3 m Thermal Conductivity Pane 1: Thickness: 15e-3 m Heat Capacity Gas1: ickness: 5e-3 m Density Material Gas 1: Thickness: 5e-3 m Density Material Gas 1: ickness: 5e-3 m Density Material Gas 1: Thermal Conductivity Gas 1: Heat Capacity Pane 2: Density Material Pane 2: Density Material Pane 2: Thermal Conductivity Pane 2: Temperature Initial: Heat Flux Inside: Heat Flux Outside: Heat Flux Outside: *** *** *** *** 0 0.1 0.2 0.3 0.4 0.5</td> <td>Thermperature: 70 "F Heat Capacity Pane1: 703 emperature: 0 "F Density Material Pane 1: 2203 ickness: 5e-3 m Thermal Conductivity Pane 1: 1.38 Thickness: 15e-3 m Heat Capacity Gas1: 1005 ickness: 5e-3 m Density Material Gas 1: 1.293 Thermal Conductivity Gas 1: 2.43e-2 Heat Capacity Pane 2: 703 Density Material Pane 2: 2203 Thermal Conductivity Pane 2: 1.38 Temperature Initial: 273.15 Heat Flux Inside: 15 mperature Initial: 15 Heat Flux Outside: 15</td> <td>amperature: 70 *F Heat Capacity Pane1: 703 amperature: 0 *F Density Material Pane 1: 2203 ickness: 5e-3 m Thermal Conductivity Pane 1: 1.38 Thickness: 15e-3 m Heat Capacity Gas1: 1005 ickness: 5e-3 m Density Material Gas 1: 1.293 Thickness: 5e-3 m Density Material Gas 1: 1.293 Thermal Conductivity Gas 1: 2.43e-2 Heat Capacity Pane 2: 703 Density Material Pane 2: 2203 Thermal Conductivity Pane 2: 1.38 Temperature Initial: 273.15 Heat Flux Inside: 15 Heat Flux Outside: 15 15 15 *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** **** *** *** *** *** **** *** *** *** ***<td>To *F Heat Capacity Pane1: 703 J/(kg·k) emperature: 0 *F Density Material Pane 1: 2203 kg/m³ ickness: 5e-3 m Thermal Conductivity Pane 1: 1.38 W/(m.K eThickness: 15e-3 m Heat Capacity Gas1: 1005 J/(kg·k) ickness: 5e-3 m Density Material Gas 1: 1.293 kg/m³ Thermal Conductivity Gas 1: 1.243e-2 W/(m.K Heat Capacity Pane 2: 703 J/(kg·k) Density Material Pane 2: 703 J/(kg·k) Density Material Pane 2: 203 kg/m³ Thermal Conductivity Pane 2: 1.38 W/(m.K Temperature Initial: 273.15 K Heat Flux Outside: 15 W/(m²-1) @@ @ @ @ 60 0 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0</td><td>mperature: 70 *F Heat Capacity Pane1: 703 J/(kg.K) emperature: 0 *F Density Material Pane 1: 2203 kg/m³ ickness: 5e-3 m Thermal Conductivity Pane 1: 1.38 W/(m-k) : Thickness: 15e-3 m Heat Capacity Gas 1: 1005 J/(kg.K) : ickness: 5e-3 m Density Material Gas 1: 1.293 kg/m³ : ickness: 5e-3 m Density Material Gas 1: 1.293 kg/m³ : ickness: 5e-3 m Density Material Gas 1: 1.293 kg/m³ : Thermal Conductivity Gas 1: 2.43e-2 W/(m·k) Heat Capacity Pane 2: 703 J/(kg.K) : Density Material Pane 2: 138 W/(m·k) Temperature Initial: 273.15 K : Heat Flux Inside: 15 W/(m².K) Heat Flux Outside: 15 W/(m².K) : : : : : : : : : : : : :<td>Importature: 70 *F Heat Capacity Pane1: 703 J/(kg·k) Importature: 0 *F Density Material Pane 1: 2203 kg/m³ ickness: 5e-3 m Thermal Conductivity Pane 1: 1.38 W/(m·k) 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Interior Temper	ature:	70		۴F	Heat Capacity Pane1:	703	J/(kg⋅K)		
Exterior Temper	ature	0		۴F	Density Material Pane 1:	2203	kg/m ³		
Pane 1 Thicknes	55:	5e-3		m	Thermal Conductivity Pane	1.38	W/(m·K)		
Gas Space Thick	ness:	15e-3		m	Heat Capacity Gas1:	1005	J/(kg·K)		
Pane 2 Thicknes	55:	5e-3		m	Density Material Gas 1:	1.293	kg/m ³		
					Thermal Conductivity Gas 1:	2.43e-2	W/(m·K)		
					Heat Capacity Pane 2:	703	J/(kg·K)		
					Density Material Pane 2:	2203	kg/m ³		
					Thermal Conductivity Pane 2	2: 1.38	W/(m·K)		
					Temperature Initial:	273.15	к		
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le									
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Exterior T	emperature:	0			°F Density Material Pane 1:	2203	kg/m ³		
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Gas Spac	e Thickness:	15e-3			m Heat Capacity Gas1:	1005	J/(kg·K)		
Pane 2 TI	hickness:	5e-3			m Density Material Gas 1:	1.293	kg/m³		
					Thermal Conductivity Gas 1:	2.43e-2	W/(m·K)		
					Heat Capacity Pane 2:	703	J/(kg·K)		
		=			Density Material Pane 2:	2203	kg/m³		
		Compu	te		Thermal Conductivity Pane 2	: 1.38	W/(m·K)		
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Q Q	: ₽ , ⊕		10		Heat Flux Outside:	15	W/(m²·K)		
mperature (K)	:9						104020000		(E
Temperature (K)	290 - 285 - 280 - 275 - 270 -						104020000		C

References:

1. R.E.White, Personal Communication, 2017

References:

- 1. R.E.White, Personal Communication, 2017
- 2. COMSOL, HeatTransferModuleUsersGuide, V. 5.3, p. 143

References:

- 1. R.E.White, Personal Communication, 2017
- 2. COMSOL, HeatTransferModuleUsersGuide, V. 5.3, p. 143
- 3. R.W. Pryor, Multiphysics Modeling Using COMSOL 5 and MATLAB, p. 37

The END

Thank You!