Table of Contents

David Luby

```
ME 603
Project deliverable 1
4-6-2022
```

```
clear;clc;
```

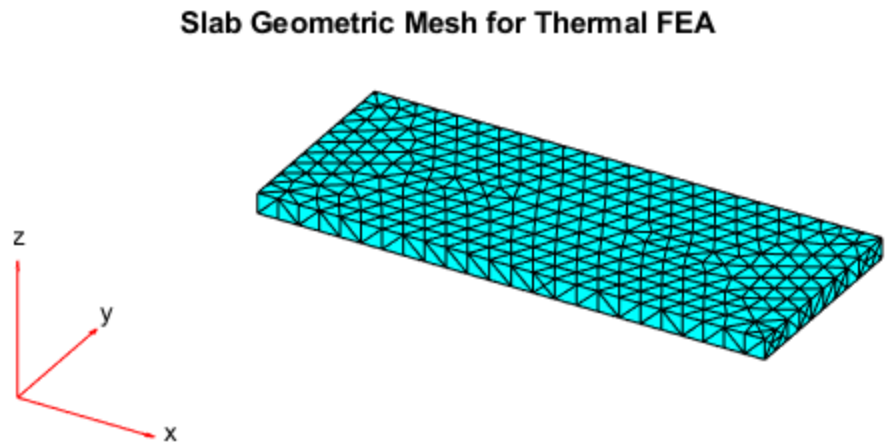
Initializing variables, etc.

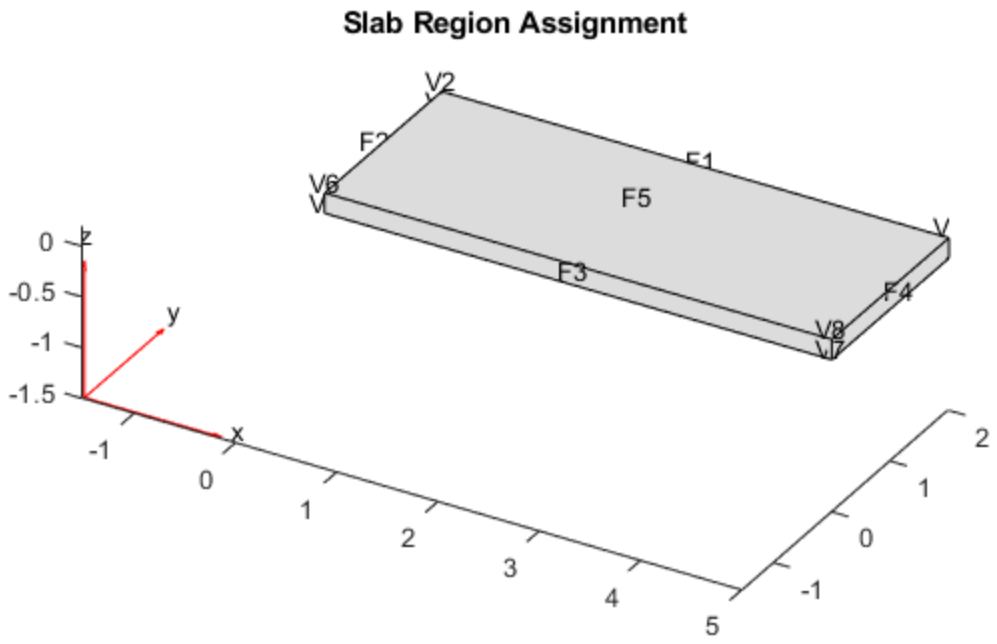
```
tI = 0+273.15; % degrees C; t inside
tO = 15+273.15; % degrees C; t infinity

k = 60; % steel thermal conductivity w/(m*k)
rho = 7.8*100^3/1000;  %kg/m^3; % steel density (kg/m^3)
C = .49*1000;  % steel specific heat j/(kg*k)
h = 60; % air convection coefficient w/(k*m^2)
```

Interfacing with PDE toolbox

```
tModel = createpde('thermal','transient'); % initialize model
gm = importGeometry(tModel,'slabFront.stl'); % import geometry

thermalProperties(tModel,'ThermalConductivity',k,'MassDensity',rho,...
    'SpecificHeat',C); % set thermal properties

thermalBC(tModel,'Face',6,'Temperature',tI); % boundary condition
thermalBC(tModel,'Face',[1 2 3 4 5],'ConvectionCoefficient',h,...
    'AmbientTemperature',tO); % boundary condition

thermalIC(tModel,tI); % initial temperature for slab
generateMesh(tModel); % creating mesh for the slab
```

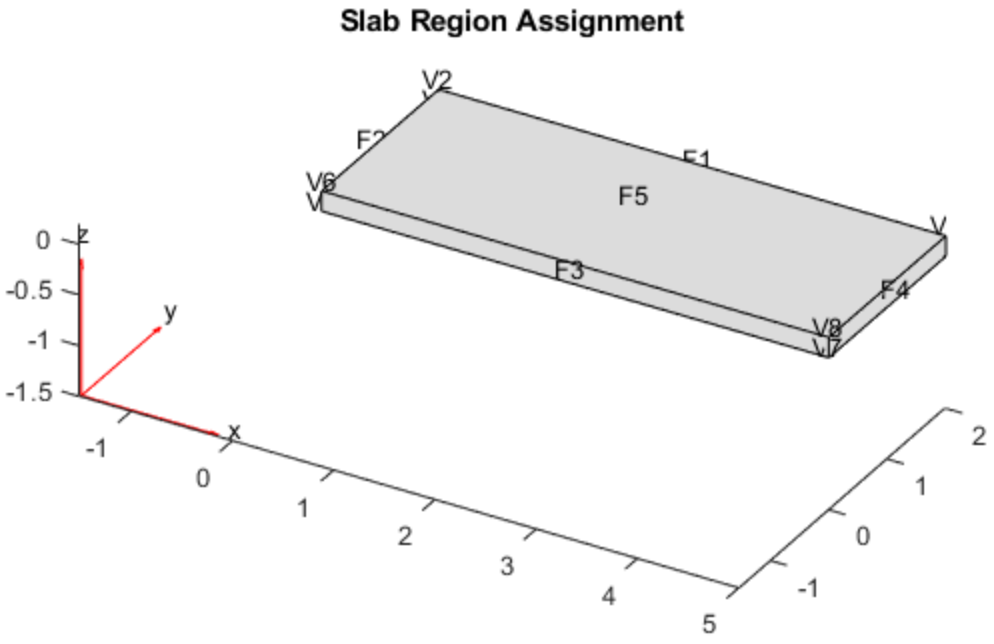
```
t = linspace(0,7000,500);% time vector (s)
results = solve(tModel,t); % evaluation of system over given t vector

figure
pdemesh(tModel)
title('Slab Geometric Mesh for Thermal FEA')
figure
pdegplot(tModel,'VertexLabels','on','FaceLabels','on')
title('Slab Region Assignment')
```

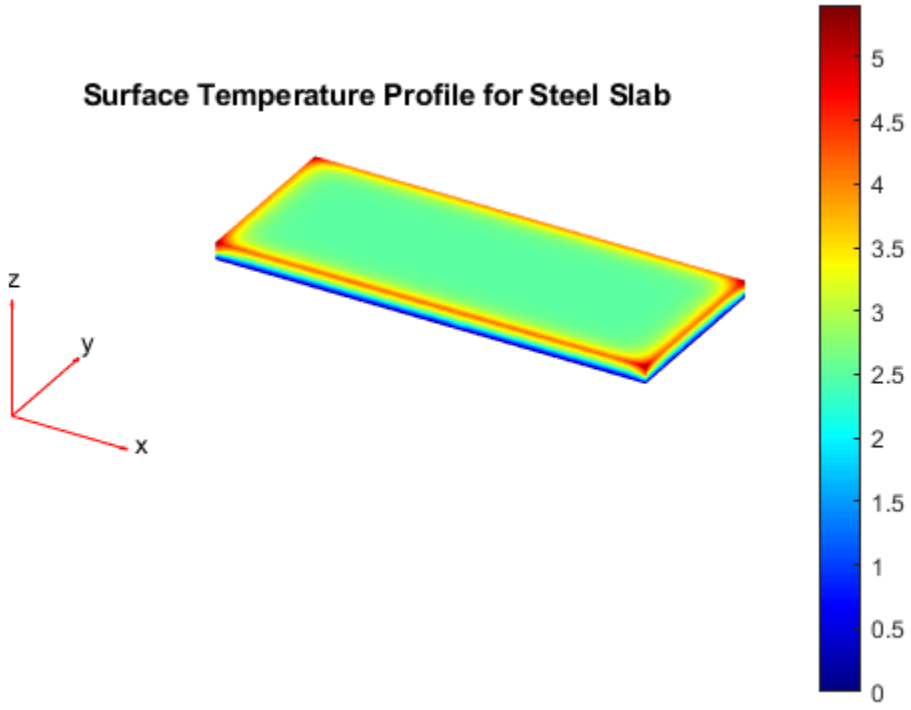




Creating color map

```
figure
pdeplot3D(tModel,"ColorMapData",results.Temperature(:,end)-273.15);
title('Surface Temperature Profile for Steel Slab')
```


Slab Region Assignment
V2
F2
F1
V6
F5
F3
F4
V8
0
-0.5
-1
-1.5
z
y
x
-1
0
1
2
3
4
5
2
1
0
-1


Surface Temperature Profile for Steel Slab
z
y
x
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

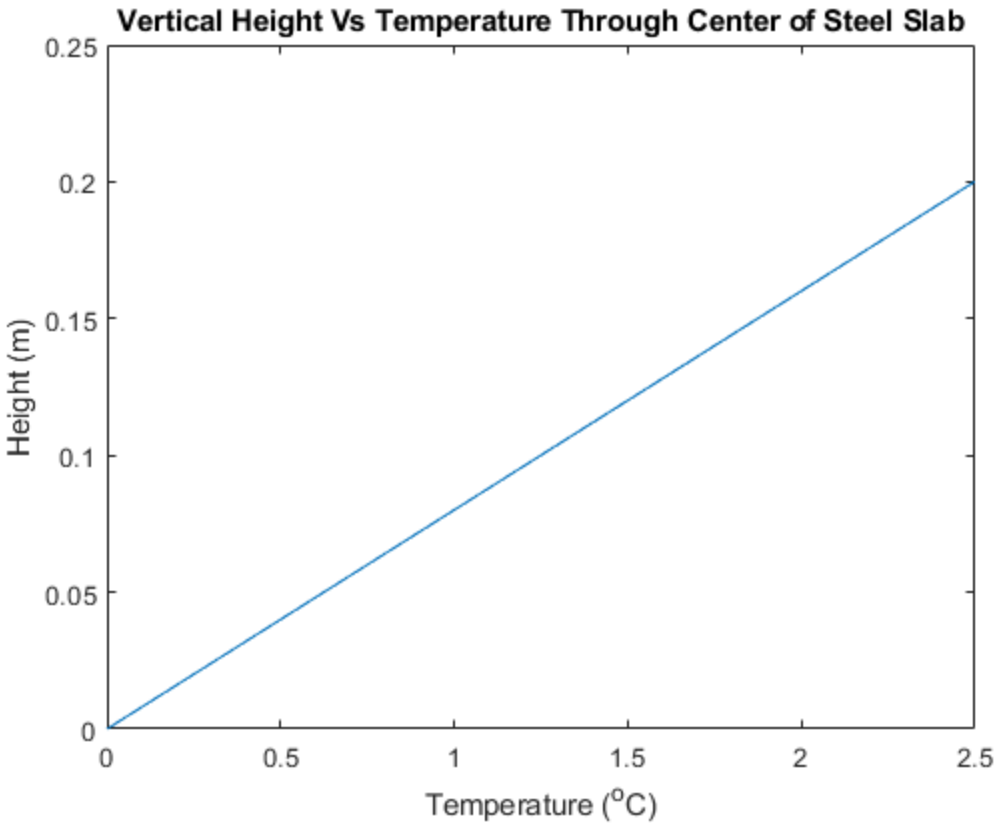
Below is an animation I made before realizing we only needed steady

state slab profile

```
% k =0;
% space = 2;
% for i = 1:length(t)
%     if i/space == floor(i/space)
%         k = k+1;
%
 pdeplot3D(tModel,"ColorMapData",results.Temperature(:,i)-273.15);
%         %plot(t,Temperature(caxis([tI tO-11]);
%         %title(['T(t = ',num2str(t(i)),')']);
%         frame(i+k-space*k) = getframe;
%     end
% end
% figure
% movie(frame,3,30)
```

Creating vertical temperature profile

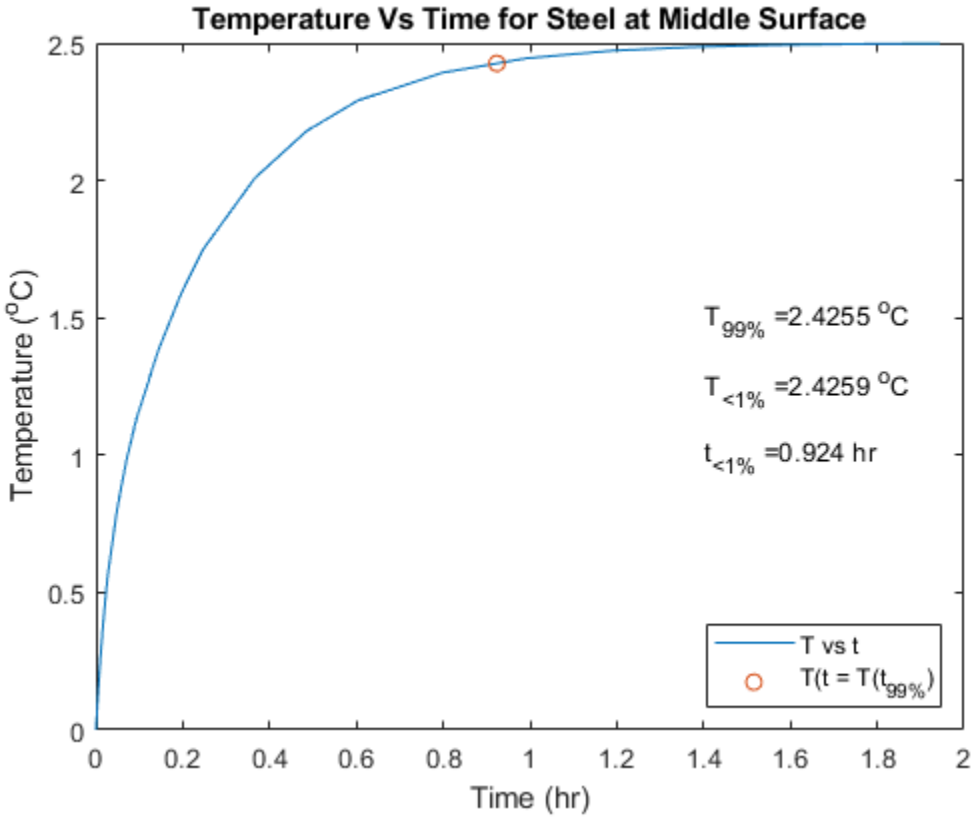
```
x = results.Mesh.Nodes(1,:);
y = results.Mesh.Nodes(2,:);
z = results.Mesh.Nodes(3,:);
T = results.Temperature(:,end);

tol = .05;
inds = abs(x-2.5)<tol & abs(y-1)<tol;

figure
plot(T(inds)-273.15,z(inds))
title('Vertical Height Vs Temperature Through Center of Steel Slab')
xlabel('Temperature (^oC)')
ylabel('Height (m)')
```



Generating temperature vs time for top middle

```
tol2 = 1e-5;
indsZ = abs(z(inds)-.2) < tol2;

xN = x(inds);
xNN = xN(indsZ);
yN = y(inds);
yNN = yN(indsZ);
zN = z(indsZ);

tN = T(inds);
tNN = tN(indsZ);

for i = 1:length(T)
    for j = 1:length(t)
        if results.Temperature(i,j) == tNN
            column = j;
            row = i;
            break
        end
    end
end

for i = 1:length(results.Temperature(row,:))
```

```
    if (results.Temperature(row,i)-273.15) > (.99*(275.6-273.15))
        tempOnePercent = results.Temperature(row,i)-273.15;
        timeOnePercent = t(i);
        break
    else
        tempOnePercent = results.Temperature(row,i)-273.15;
        timeOnePercent = t(i);
    end
end

figure
plot(t/3600,results.Temperature(row,:)-273.15,timeOnePercent/3600,...
    tempOnePercent,'o')
title('Temperature Vs Time for Steel at Middle Surface')
xlabel('Time (hr)')
ylabel('Temperature (^oC)')
legend('T vs t','T(t = T(t_{99%})','location','Southeast')
text(1.4,1.5,strcat('T_{99%} = ',num2str((275.6-273.15)*.99,5),'
 ^oC'))
text(1.4,1.25,strcat('T_{<1%} = ',num2str(tempOnePercent,5),' ^oC'))
text(1.4,1,strcat('t_{<1%} = ',num2str(timeOnePercent/3600,3),' hr'))
```



Initializing variables FOR WOOD

```
clear;clc;
```

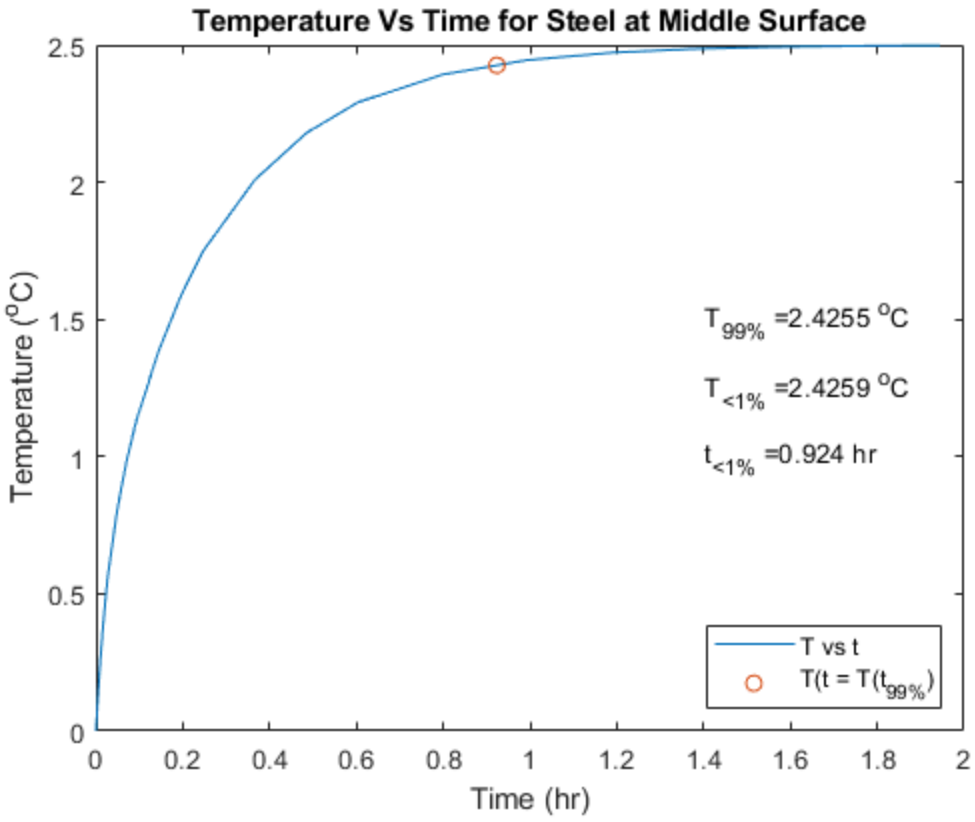
```
tI = 0+273.15; % degrees C; t inside
tO = 15+273.15; % degrees C; t infinity

k = .12; % wood thermal conductivity w/(m*k)
rho = .660*100^3/1000;  %kg/m^3; % cuban mahogany wood density (kg/
m^3)
C = 2.38*1000;  % wood specific heat j/(kg*k)
h = 60; % air convection coefficient w/(k*m^2)
```

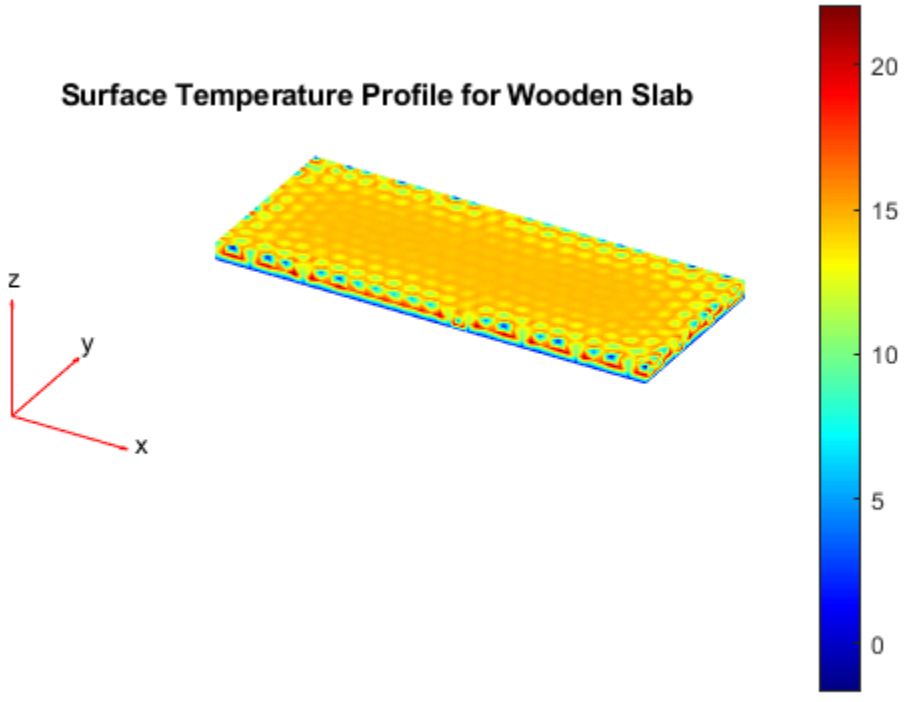
Interfacing with PDE toolbox FOR WOOD

```
tModel = createpde('thermal','transient'); % initialize model
gm = importGeometry(tModel,'slabFront.stl'); % import geometry

thermalProperties(tModel,'ThermalConductivity',k,'MassDensity',rho,...
    'SpecificHeat',C); % set thermal properties

thermalBC(tModel,'Face',6,'Temperature',tI); % boundary condition
thermalBC(tModel,'Face',[1 2 3 4 5],'ConvectionCoefficient',h,...
    'AmbientTemperature',tO); % boundary condition

thermalIC(tModel,tI); % initial temperature for slab
generateMesh(tModel); % creating mesh for the slab

t = linspace(0,25000,200);% time vector (s)
results = solve(tModel,t); % evaluation of system over given t vector
```

Creating color map FOR WOOD

```
figure
pdeplot3D(tModel,"ColorMapData",results.Temperature(:,end)-273.15);
title('Surface Temperature Profile for Wooden Slab')
```


Temperature Vs Time for Steel at Middle Surface
Temperature (°C)
Time (hr)
T99% =2.4255 °C
T<1% =2.4259 °C
t<1% =0.924 hr
T vs t
T(t = T(t99%)
0
0.5
1
1.5
2
2.5
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2


Surface Temperature Profile for Wooden Slab
z
y
x
20
15
10
5
0

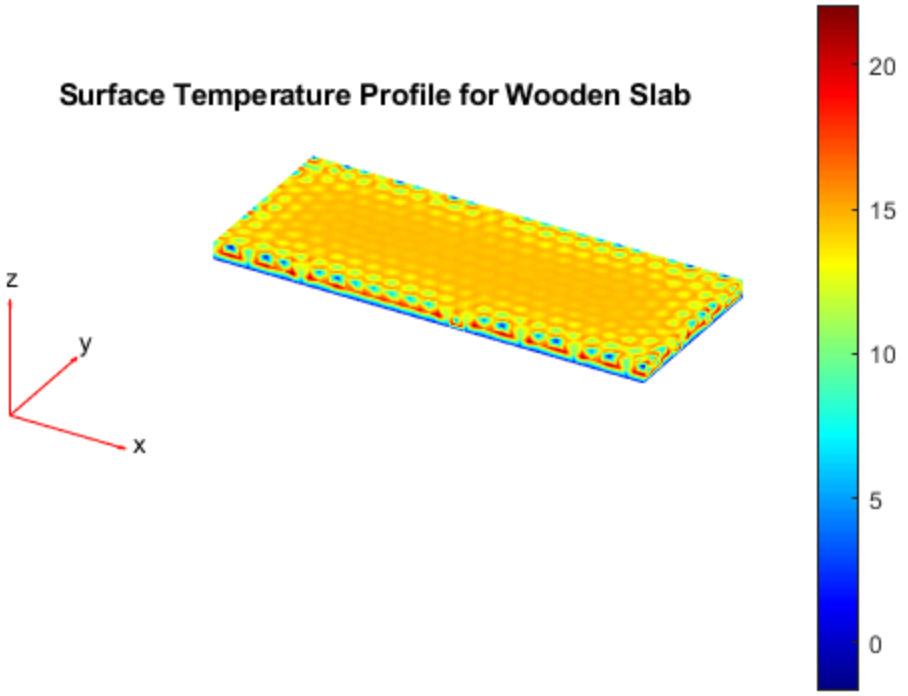
Below is an animation I made before realizing we only needed steady

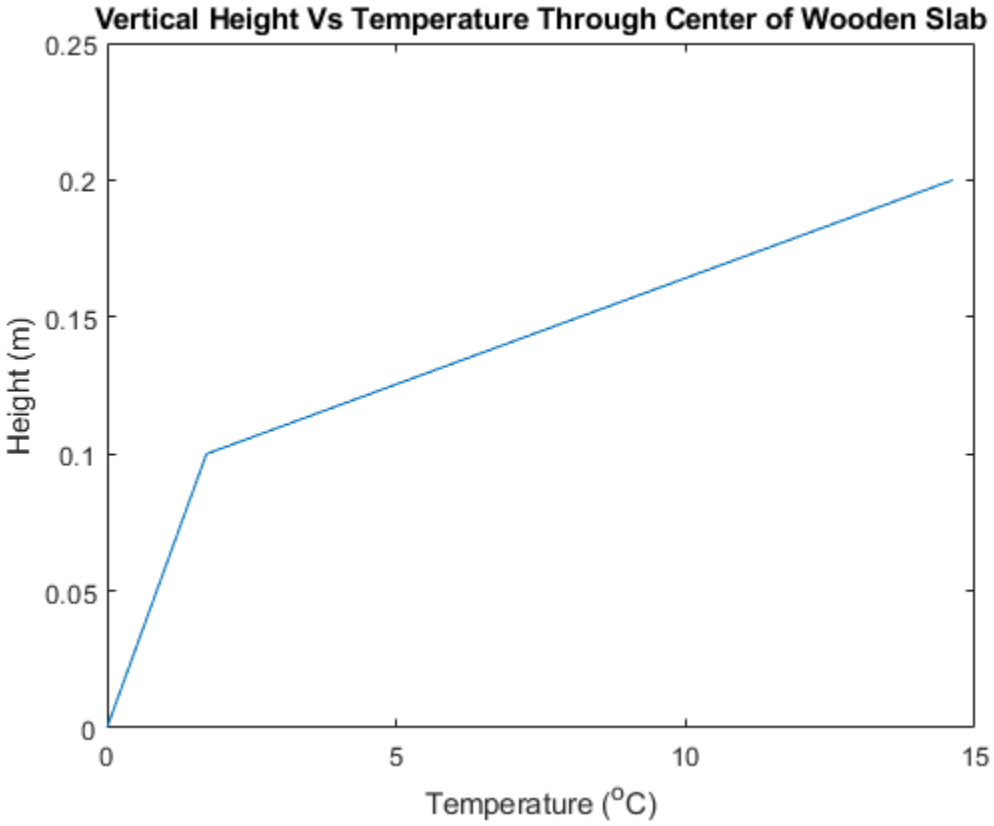
state slab profile

```
% k =0;
% space = 2;
% for i = 1:length(t)
%     if i/space == floor(i/space)
%         k = k+1;
%
 pdeplot3D(tModel,"ColorMapData",results.Temperature(:,i)-273.15);
%         %plot(t,Temperature(caxis([tI tO-11]);
%         %title(['T(t = ',num2str(t(i)),')']);
%         frame(i+k-space*k) = getframe;
%     end
% end
% figure
% movie(frame,3,30)
```

Creating vertical temperature profile FOR WOOD

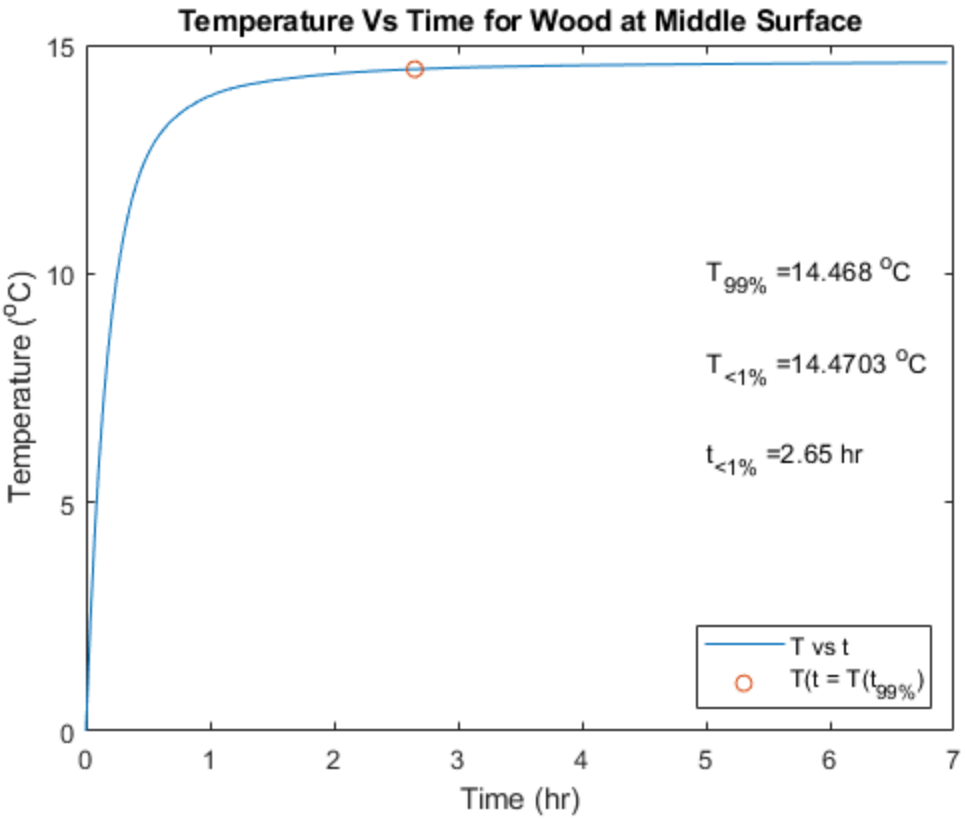
```
x = results.Mesh.Nodes(1,:);
y = results.Mesh.Nodes(2,:);
z = results.Mesh.Nodes(3,:);
T = results.Temperature(:,end);

tol = .05;
inds = abs(x-2.5)<tol & abs(y-1)<tol;

figure
plot(sort(T(inds))-273.15,sort(z(inds)))
title('Vertical Height Vs Temperature Through Center of Wooden Slab')
xlabel('Temperature (^oC)')
ylabel('Height (m)')
```


Surface Temperature Profile for Wooden Slab
z
y
x
20
15
10
5
0


Vertical Height Vs Temperature Through Center of Wooden Slab
Height (m)
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
Temperature (°C)

Generating temperature vs time for top middle FOR WOOD

```
tol2 = 1e-5;
indsZ = abs(z(inds)-.2) < tol2;

xN = x(inds);
xNN = xN(indsZ);
yN = y(inds);
yNN = yN(indsZ);
zN = z(indsZ);

tN = T(inds);
tNN = tN(indsZ);

for i = 1:length(T)
    for j = 1:length(t)
        if results.Temperature(i,j) == tNN
            column = j;
            row = i;
            break
        end
    end
end

for i = 1:length(results.Temperature(row,:))
    if results.Temperature(row,i)-273.15 > ...
            .99*(results.Temperature(row,end)-273.15)
        tempOnePercentW = results.Temperature(row,i)-273.15;
        timeOnePercentW = t(i);
        break
    else
        tempOnePercentW = results.Temperature(row,i)-273.15;
        timeOnePercentW = t(i);
    end
end

figure
plot(t/3600,results.Temperature(row,:)-273.15,timeOnePercentW/3600,...
    tempOnePercentW,'o')
title('Temperature Vs Time for Wood at Middle Surface')
legend('T vs t','T(t = T(t_{99%})','location','Southeast')
xlabel('Time (hr)')
ylabel('Temperature (^oC)')
text(5,10,strcat('T_{99%} = ',...
    num2str(.99*(results.Temperature(row,end)-273.15),5),' ^oC'))
text(5,8,strcat('T_{<1%} = ',num2str(tempOnePercentW,6),' ^oC'))
text(5,6,strcat('t_{<1%} = ',num2str(timeOnePercentW/3600,3),' hr'))
```



Published with MATLAB® R2021a