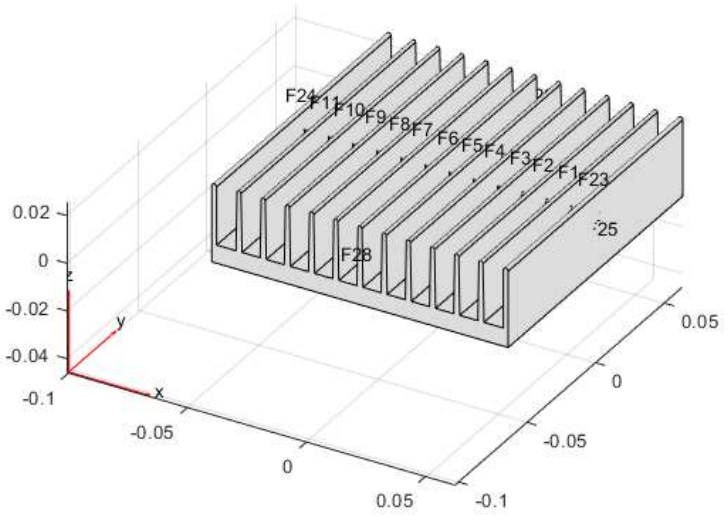
Heat Sink Simulation

ME-495, Group G2

Simulating steady-state results of heat sink experiment.

Create PDE model, import STL, plot

```
thermalmodel = createpde('thermal','steadystate');
importGeometry(thermalmodel, 'ME495_ProjFin_5in.STL');
rotate(thermalmodel.Geometry, 90, [0 0 0], [1 0 0]);
scale(thermalmodel.Geometry, 0.001);
translate(thermalmodel.Geometry, [-0.06223 0.0635 -0.00762]);
pdegplot(thermalmodel, 'FaceLabels','on', 'FaceAlpha', 1)
grid on
```



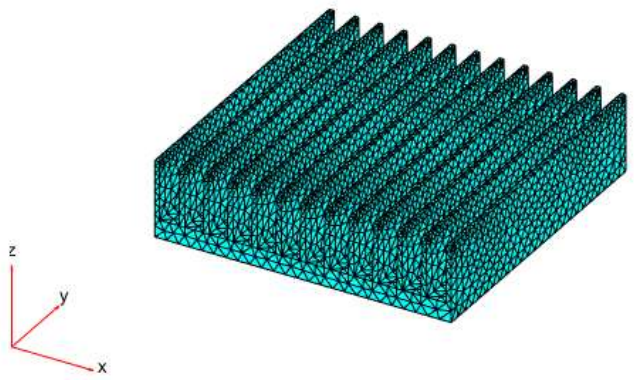
Generate mesh

```
generateMesh(thermalmodel, 'Hmax', 0.005)       % Limit max edge size to 5mm
```

```
ans =
  FEMesh with properties:

            Nodes: [3×45196 double]
         Elements: [10×23698 double]
    MaxElementSize: 0.0050
    MinElementSize: 0.0025
     MeshGradation: 1.5000
    GeometricOrder: 'quadratic'
```

```
thermalmodel.Mesh;
pdemesh(thermalmodel)
```



Material properties: Aluminum 6063-T6

k_aluminum ~ 200 W/mK

```
tc = 200;
thermalProperties(thermalmodel, 'Cell',1,'ThermalConductivity',tc);
```

Set up boundary conditions

Assume h_max = 20 W/m^2K (semi-forced convection)

k_air = 0.03 W/mK

Pr = 0.69

v_air = 24 * 10^-6 m^2/s

```
htc = 20;

thermalBC(thermalmodel,'Face',[26, 28],...
    'ConvectionCoefficient', htc,'AmbientTemperature',293);     % Front and back surfaces (y-direction)
thermalBC(thermalmodel,'Face', 29,...
    'ConvectionCoefficient',0,'AmbientTemperature',293);        % Bottom surface (against hot plate)
thermalBC(thermalmodel,'Face', [1:11, 23, 24],...
    'ConvectionCoefficient',htc,'AmbientTemperature',293);      % Fin tips

hfun = @(location, state) (0.332 * ((2 - cos(location.x * pi / 0.063))*((0.075 - abs(location.y)) + max(location.z - (abs(location.y)), 0))/(24*10^-6))^0.5 * ...
    (0.69^0.333) * (30*10^-3)) / ((0.075 - abs(location.y)) + max((location.z - abs(location.y)), 0));
hfun2 = @(location, state) (0.332 * ((2 - cos(location.x * pi / 0.063))*((0.075 - abs(location.y))))/(24*10^-6))^0.5 * (0.69^0.333) * (30*10^-3)) / (0.075 - abs(location.y));

thermalBC(thermalmodel,'Face', [25, 27, 31:54],...
    'ConvectionCoefficient',hfun,'AmbientTemperature',293);     % Fin surfaces
thermalBC(thermalmodel,'Face', [12:22, 30],...
    'ConvectionCoefficient',hfun2,'AmbientTemperature',293);    % Channel bottom surfaces
```

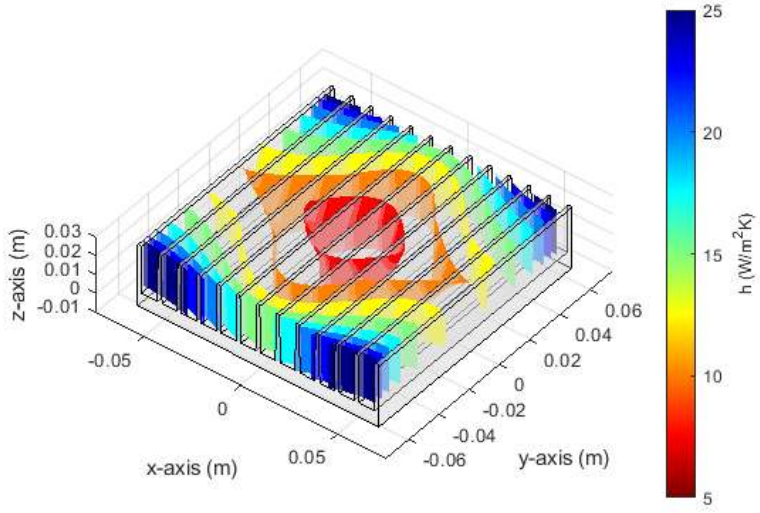
Assume bottom face has 365K fixed temperature BC

```
thermalBC(thermalmodel,'Face',29,'Temperature', 365);
```

Plot h isosurfaces

```
[x_range, y_range, z_range] = meshgrid(-0.06223:0.005:0.06223, -0.0635:0.005:0.0635, 0:0.001:0.0244);
hfun_plot = (0.332 * ((2 - cos(x_range .* pi / 0.063)).*((0.075 - abs(y_range)) + max(z_range - (abs(y_range)), 0))/(24*10^-6)).^0.5 * ...
    (0.69^0.333) * (30*10^-3)) ./ ((0.075 - abs(y_range)) + max((z_range - abs(y_range)), 0));
pdegplot(thermalmodel,'FaceAlpha',0.35);

hold on
for i = 5:2.5:25
    isosurface(x_range, y_range, z_range, hfun_plot, i);
end
colormap(flipud(jet));
grid on
c = colorbar;
c.Label.String = 'h (W/m^2K)';
xlim([-0.075, 0.075]);
ylim([-0.075, 0.075]);
zlim([-0.01, 0.03]);
xlabel('x-axis (m)')
ylabel('y-axis (m)')
zlabel('z-axis (m)')
hold off
view([38 40])
```




```
%hold on
%pdegplot(thermalmodel, 'FaceAlpha', 0.1);
```

Solve FEA

Calculate max and bulk body temps, time to see how long solution takes

```
tic
results = solve(thermalmodel);
time = toc
```

```
time = 22.0149
```

Plot results

```
pdeplot3D(thermalmodel, 'ColorMapData', results.Temperature)
```