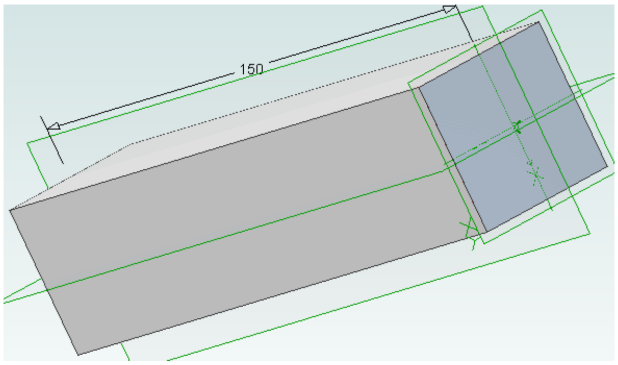
FEMdesigner Accuracy Verification Examples

Thermal Analysis

1. Square bar with convection end, fixed temperature end, adiabatic sides



Length = 150mm
Width = 30mm = Thickness
Thermal conductivity, k = 0.9e-3

Left face = fixed temperature of 850, applied as convection with htc=100 and fluid temperature of 850.

Right face heat transfer coefficient, h= 35e-6, fluid temperature of 10.

Theoretical Results:

Overall heat transfer, U from (1/U)=(1/h)+(x/k), where x=150

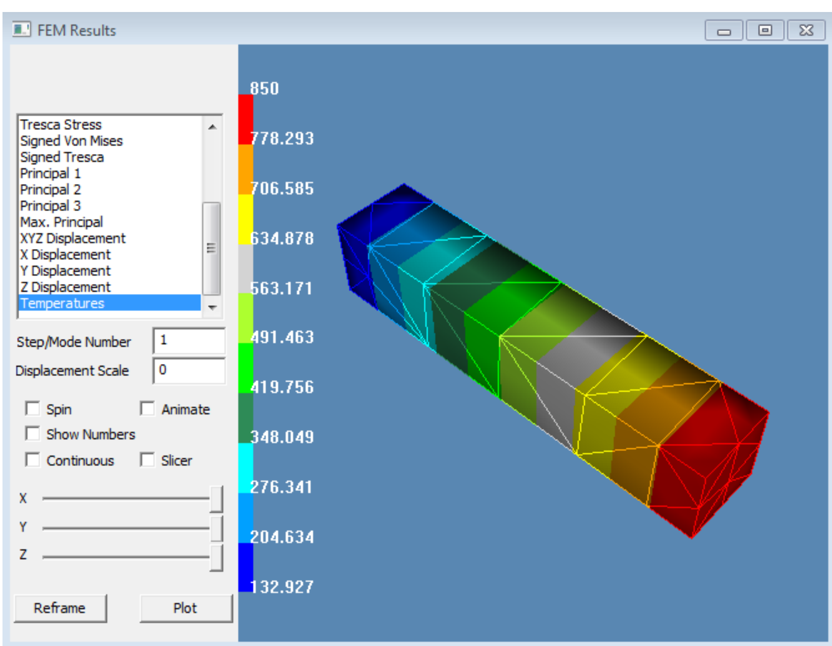
So U = 5.121e-6

Heat flux, q=U(T1-T3) = 5.121e-6(850-10) = 4.3e-3

q=h(Tw-T3)

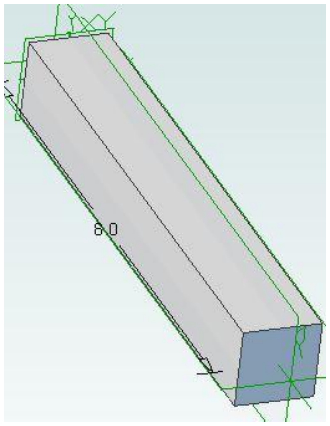
So wall temperature, Tw = q/h + T3 = [(4.3e-3)/(35e-6)] + 10 = 132.8

FEMdesigner AD results (default mesh): T=132.9, **error = 0.08%**



2. Cooling spine, fixed temp on one end, insulated on other, convection on sides

Refer to Kreith F: Principles of Heat Transfer; Harper and Row, 3rd edition, Page 60



Length =8”, Width = 1.2”, Thickness=1.2”

Thermal conductivity, k = 9.71 e-3 BTU/(s.ft.F)

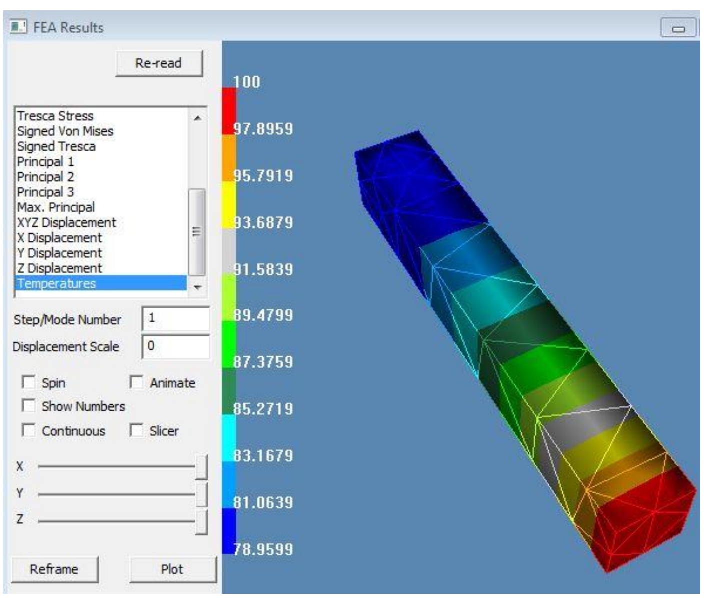
Left face fixed temperature of 100, applied as convection with htc=100 and fluid temperature of 100.

Right face adiabatic.

Sides, heat transfer coefficient, h= .778e-4 BTU/(s.ft2.F), fluid temperature of 0F.

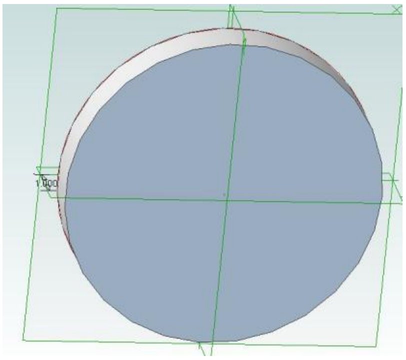
Solve for temperature of adiabatic face. Theoretical result (from Kreith) = 79.03F

FEMdesigner AD result (default mesh): T=78.96F, **error = 0.09%**



3. Water is boiled using the front face of a flat electric heating plate

Reference: Arpaci, Conduction Heat Transfer, Addison Wesley 1966, Page 130



Radius of disk = 3.937”, thickness=1”

Internal heat generation = 10 BTU/(s.in^3)

k = 0.01375(1 + 0.001T) = 0.0203 BTU/(s.in.F)

FEMdesigner problem setup:

Front face fixed temp of 212F applied as fluid temp of 212F with htc of 100. Other face insulated (adiabatic)

Theoretical result: maximum temperature = 476F

FEMdesigner AD result, maximum temp = 458.4, **error = 3.7%**

Slightly larger error due to nonlinearity of k, but still well within acceptable norms, and the heat generation load is proven.