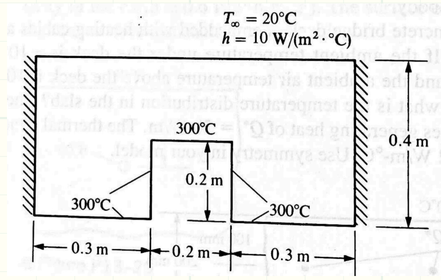
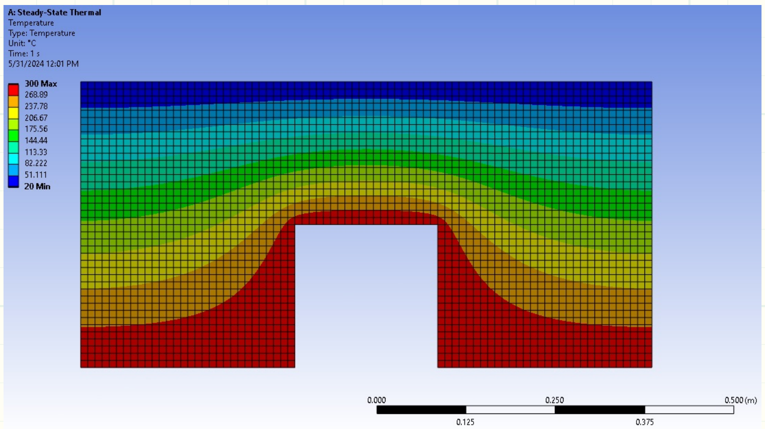
Problem 1

The geometry & end conditions shown in the figure to the right was created. This geometry was modeled as a 2D surface w/ Øm thickness. A quadratic, 10^{-2}m element size mesh was created. I also assumed:

- Structural steel
- Steady state



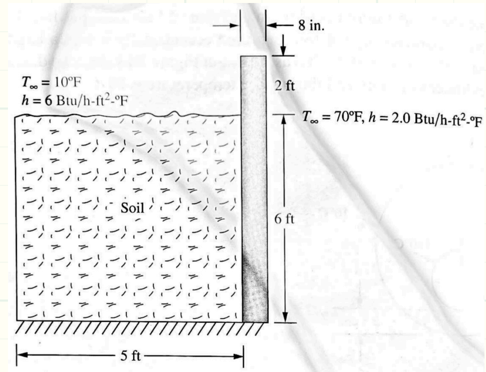
This resulted in the thermal distribution below:



Note that at the left & right edges, the thermal gradient is nearly constant, showing the far-field, 1D conduction behavior. The middle also shows 1D conduction behavior with a larger thermal gradient. Near the internal channel corners, the largest thermal gradient occurs, likely due to containing two free surfaces for convection to occur.

Problem 2

Two new materials (concrete & soil) were created w/ thermal conductivities of $1.0 \frac{BTU}{hr \cdot ft \cdot °F}$ & $0.85 \frac{BTU}{hr \cdot ft \cdot °F}$. The geometry to the right was created as 2D surfaces, with the concrete wall split in two to allow multiple convectivities. Temperatures & convective coefficient were applied as show. Note that convection occures on both sides of the concrete wall above the soil. Adiabatic conditions were applied on all other surfaces. A quadratic, 2 in element size mesh was created. The convectivities were converted from $\frac{BTU}{hr \cdot ft \cdot °F}$ to $\frac{BTU}{s \cdot ft \cdot °F}$ as follows:

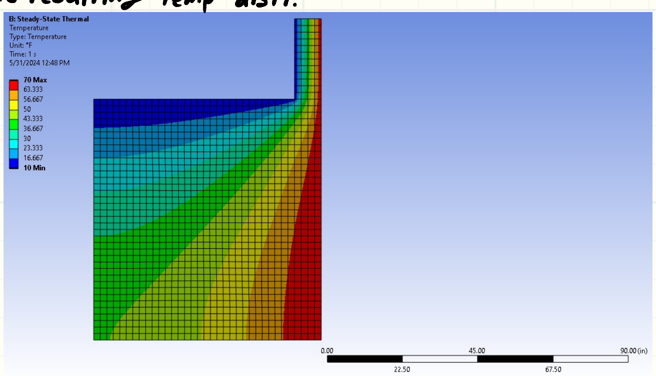


- $h_{inner} = 6 \frac{BTU}{hr \cdot ft \cdot °F} \left(\frac{1 hr}{3600 s}\right) = \frac{1}{600} \frac{BTU}{s \cdot ft \cdot °F}$
- $h_{outer} = 2 \frac{BTU}{hr \cdot ft \cdot °F} \left(\frac{1 hr}{3600 s}\right) = \frac{1}{1800} \frac{BTU}{s \cdot ft \cdot °F}$

The following assumptions were made:

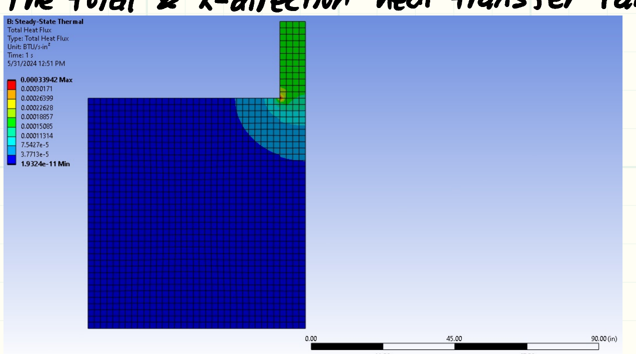
- constant isotropic material properties
- Leftmost soil & top of wall experience no heat transfer (perfectly insulated)
- Steady state

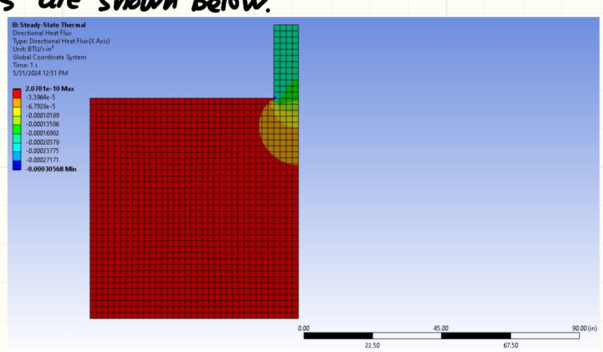
The resulting temp distr.



A high temp. gradient is at the concrete wall above soil as expected. The highest gradient occurs at the corner due to two convective surfaces as in the previous problem. The temp is not constant along the left soil edge in the horizontal direction, indicating that it is not far enough to be uneffected by the concrete wall, so assuming adiabatic on that end is not valid.

The total & x-direction heat transfer rates are shown below.





There was little heat transfer in the soil & concrete except near the surface of the soil-concrete interface. The corner had the largest rate due to its two convective faces. This indicates that the soil is a negligible heat transfer medium, & when designing houses, the wall properties should be higher priority.