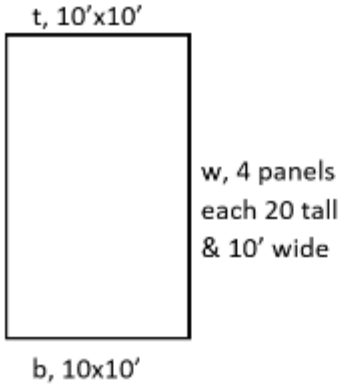
A soaking pit 20-ft deep with 10-ft wide walls has a no net flux floor. When the top is rolled back, the furnace walls are at 1000 °C. The emissivity of all interior surfaces is 2/3rds.

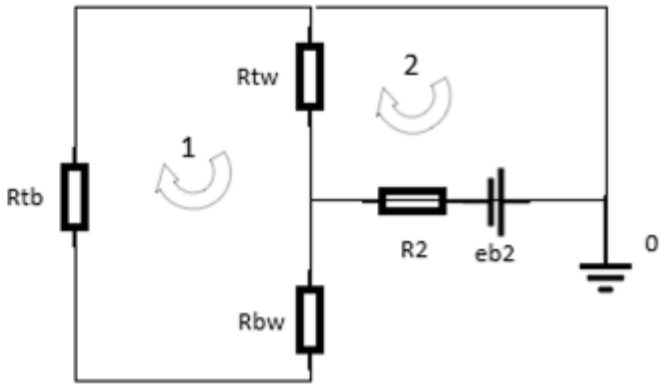
a) What is the net heat flux from the pit and

b) What is the equilibrium temperature of the floor?

Hint: treat the four walls as one surface and the open top as a 0 K black surface.

F_{tb} = 0.09 $F_{tw} = F_{bw} = 0.91$





$$\sigma = \left(5.67 \cdot 10^{-8}\right) \frac{W}{m^2 \cdot K^4}$$

$At := 100 \cdot ft^2$ $Ab := 100 \cdot ft^2$ $Aw := 800 \cdot ft^2$ $Ftb := 0.09$ $Ftw := (1 - Ftb) = 0.91$

$Fbw := Ftw = 0.91$ $Tw := 1273 \cdot K$ $\varepsilon 2 := \frac{2}{3}$ $eb2 := \sigma \cdot Tw^4 = \left(1.489 \cdot 10^5\right) \frac{W}{m^2}$

$Rtb := \frac{1}{At \cdot Ftb} = 1.196 \frac{1}{m^2}$ $Rtw := \frac{1}{At \cdot Ftw} = 0.118 \frac{1}{m^2}$ $Rbw := Rtw$

$R2 := \frac{1 - \varepsilon 2}{Aw \cdot \varepsilon 2} = 0.007 \frac{1}{m^2}$ Note: reset origin to 1 so subscripts start at 1, not 0

$$I := \begin{bmatrix} -Rbw - Rtb - Rtw & Rtw \\ Rtw & -Rtw - R2 \end{bmatrix} = \begin{bmatrix} -1.433 & 0.118 \\ 0.118 & -0.125 \end{bmatrix} \frac{1}{m^2} \qquad RHS := \begin{bmatrix} 0 \\ -eb2 \end{bmatrix}$$

$$E := I^{-1} \cdot RHS = \begin{bmatrix} 1.067 \cdot 10^5 \\ 1.292 \cdot 10^6 \end{bmatrix} W$$

$Qtop := -E_2 = -1.292 \cdot 10^6 \ W$ $Tb := \left(\frac{E_1 \cdot Rtb}{\sigma}\right)^{0.25} = \left(1.2247805 \cdot 10^3\right) K$

$TB2 := \left(\frac{eb2 - R2 \cdot E_2 - Rbw \cdot E_1}{\sigma}\right)^{0.25} = \left(1.225 \cdot 10^3\right) K$ check $\frac{Tb}{K} - 273 = 951.78$ C