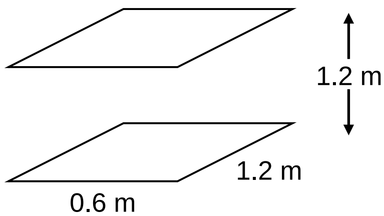
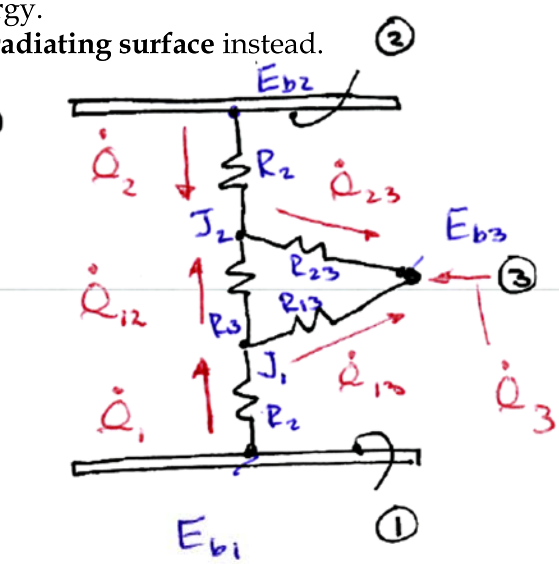
Example

Reconsider the last example, but this time assume the surfaces are both diffuse and gray with $\varepsilon_1 = \varepsilon_2 = 0.7$. Otherwise, the conditions are the same. (The bottom rectangle is at T_1 = 500 K and the top rectangle is at T_2 = 900 K. The two rectangles are 1.2 m apart. The surroundings can be considered a blackbody at 300 K.)

(a) Draw a resistance network showing all the relevant heat transfer rates and resistances.
(b) Find the net radiant exchange *between* the two surfaces.
(c) Find the rate at which the bottom rectangle is losing energy.
(d) Repeat (b) and (c) if the surroundings are treated as a **reradiating surface** instead.



(a)



(b) & (c)

Surface 1

$$\dot{Q}_1 = \frac{E_{b1} - J_1}{R_{sur,1}} \quad (1) \qquad R_{sur,1} = \frac{1-\epsilon_1}{A_1\epsilon_1}$$

Surface 2

$$\dot{Q}_2 = \frac{E_{b,2} - J_2}{R_{sur,2}} \quad (2) \qquad R_{sur,2} = \frac{1-\epsilon_2}{A_2\epsilon_2}$$

"V = IR" for ① → ②

$$\dot{Q}_{12} = \frac{J_1 - J_2}{R_{SPACE,12}} \quad (3) \qquad R_{SPACE,12} = \frac{1}{A_1F_{12}}$$

② → ③

$$\dot{Q}_{23}^{?} = \frac{J_2 - E_{b,3}}{R_{SPACE,23}^{\checkmark}} \quad (4) \qquad R_{SPACE,23} = \frac{1}{A_2 F_{23}}$$

① → ③

$$\dot{Q}_{13}^{?} = \frac{J_1 - E_{b,3}}{R_{SPACE,13}^{\checkmark}} \quad (5) \qquad R_{SPACE,13} = \frac{1}{A_1 F_{13}}$$

So far we have 7 eqn's w/ 5 unknowns. Extra eqn's come from applying KCL to the three nodes:

$$\dot{Q}_1 = \dot{Q}_{12} + \dot{Q}_{13} \quad (6)$$

$$\dot{Q}_2 + \dot{Q}_{12} = \dot{Q}_{23} \quad (7)$$

$$\dot{Q}_{13} + \dot{Q}_{23} + \dot{Q}_3^{?} = 0 \quad (8)$$

Eight eqn's with eight unknowns. Let EES do the hard work. (See code for details.)

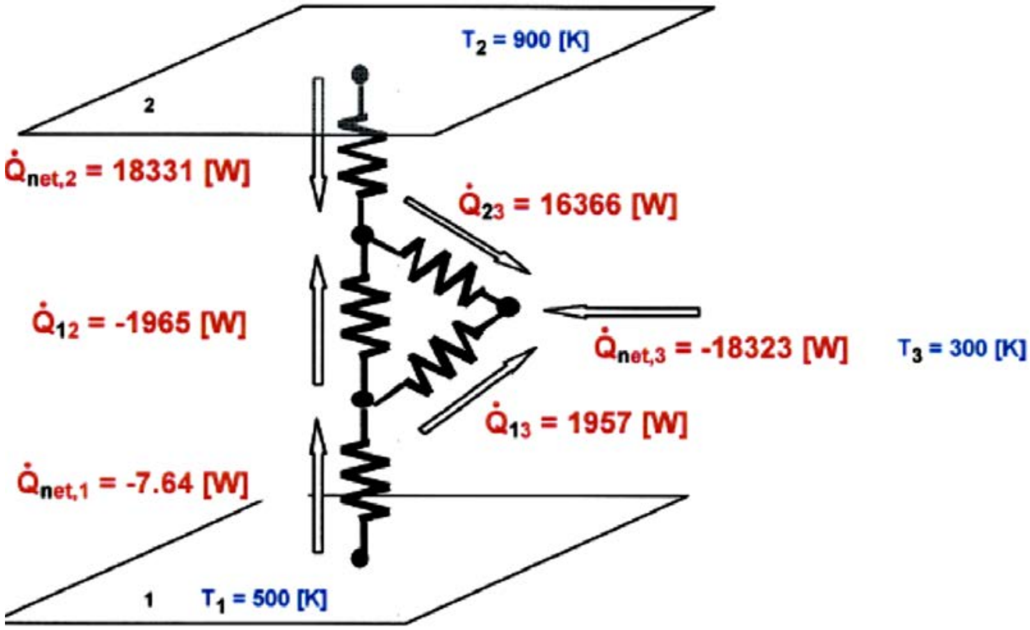
(d) For part (d) we must add

$$\dot{Q}_3 = 0 \quad (9)$$

But now the equation set it is overconstrained! We must now make T_3 an unknown.

~~$T_3 = 300\text{ K}$~~ ⇨ $T_3 = ?$

Again, let EES do the hard work.



Calculate

Results for parts (b) & (c)