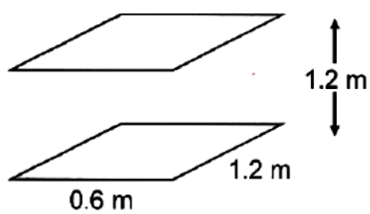
Example

Two blackbody rectangles, 0.6 m by 1.2 m, are parallel and directly opposed. 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.

(a) Find the view factors $F_{1\to2}$ and $F_{2\to1}$.
(b) Find the radiant exchange *between* the two surfaces.
(c) Find the rate at which the bottom rectangle is losing energy if the surroundings (other than the top rectangle) are considered to be a blackbody at 300 K.

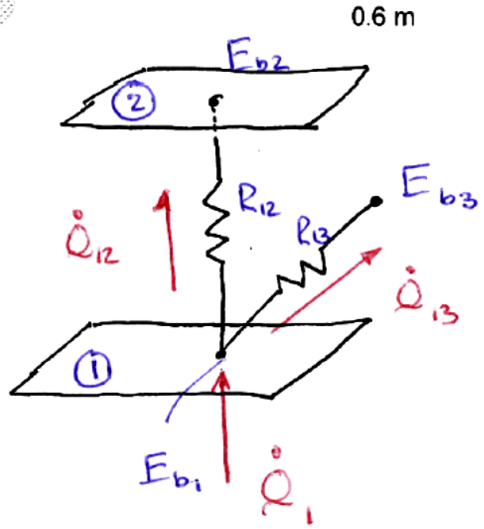
For the heat transfer calculations, you are strongly encouraged to draw all relevant resistors and currents (heat transfer rates).



(a) From figures in text...

$$F_{12} = F_{21} = 0.12$$

(b) Use resistance network.



$$\dot{Q}_{12} = \frac{E_{b1} - E_{b2}}{R_{12}} \qquad R_{12} = \frac{1}{A_1 F_{12}}$$

$$= \frac{1}{(0.6\,m)(1.2\,m)(0.12)}$$

$$= 11.57\ m^{-2}$$

$$\dot{Q}_{12} = \frac{\sigma[T_1^4 - T_2^4]}{R_{12}}$$

$$= \frac{5.67\times10^{-8}\ \frac{W}{m^2\cdot K^4}\left[500^4 K^4 - 900^4 K^4\right]}{11.57\ \frac{1}{m^2}}$$

$$= \boxed{-2907\ W}$$

(c) $\dot{Q}_1 = \dot{Q}_{12} + \dot{Q}_{13}$ (This is like Kirchof's current law on the bottom node.)

$$\dot{Q}_{13} = \frac{E_{b1} - E_{b3}}{R_{13}}$$

$$R_{13} = \frac{1}{A_1 F_{13}} = \frac{1}{(0.6m)(1.2m)(0.88)} = 1.58\ m^{-2}$$

Summation rule

$F_{12} + F_{13} = 1$

$F_{13} = 1 - F_{12}$

$= 1 - 0.12$

$= 0.88$

$$\dot{Q}_{13} = \frac{\sigma(T_1^4 - T_3^4)}{R_{13}} = \frac{5.67\times10^{-8} \frac{W}{m^2\text{-}K^4}\left(500^4 K^4 - 300^4 K^4\right)}{1.58 \frac{1}{m^2}}$$

$= 1954\ W$

$\dot{Q}_1 = -2907\ W + 1954W = \boxed{-953\ W}$