# Radiation Study Aid

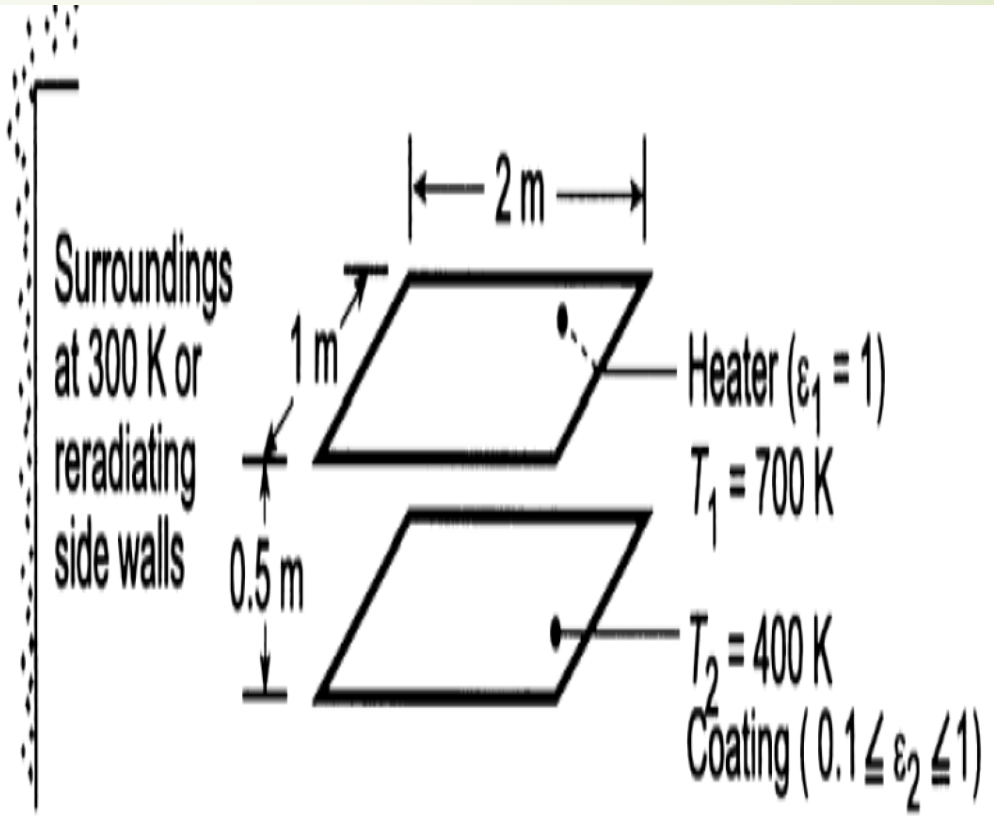
**ME-420 HEAT TRANSFER**

**Dr. K. J. Berry**

Heater exposed to large surrounding. Both surfaces are black.

A. Electrical power for heater for BB wall.

B. Electrical power w/insulated sidewall.



# CASE A: COMPLETE surroundings at 300K and Surrounding Behaves as BLACK BODY.

SHAPE FACTORS: FIG. 13.4

Y/L=1/0.5=2

X/L=2/0.5=4

$F_{12}=0.5=F_{21}$

$F_{13}=\cancel{F_{11}}+F_{12}+F_{13}=1$

$F_{13}=1-F_{12}=0.5$

$F_{23}=F_{21}+\cancel{F_{22}}+F_{23}=1$

$F_{23}=1-F_{21}=0.5$

$q_{elec}$ = is the net energy lost to the plate and to the BLACK BODY Surroundings

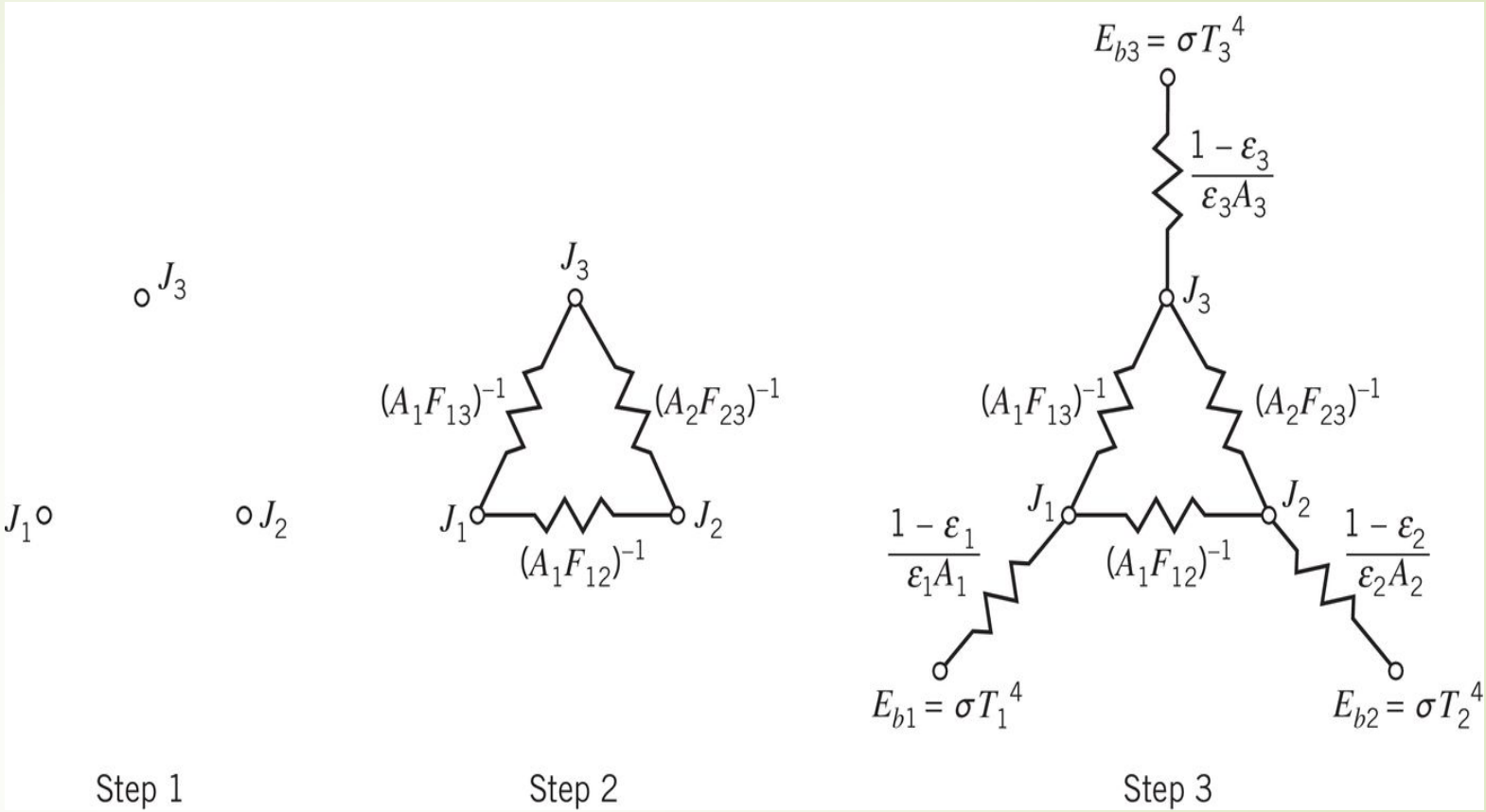
$$q_{elec}=A_1F_{12}\sigma(T_1^4-T_2^4)+A_1F_{13}\sigma(T_1^4-T_3^4)$$

$$=(2m^2)x0.5x5.67E-8\frac{W}{m^{2-}-K^4}(2(700K)^4-(400)K^4-(300K)^4)$$

$$=25.32kW$$

$$\sum_i F_{ij}=1\rightarrow \text{CONSERVATION}$$

# CASE B: PLATES are Surrounded by INSULATED (RE-RADIATING) Walls.




$$E_{b_1} = J_1 = \sigma T_1^4 \rightarrow \text{BLACK BODY}$$

$$E_{b_2} = J_2 = \sigma T_2^4 \rightarrow \text{BLACK BODY}$$

$$J_3 = \sigma T_3^4 \rightarrow q_{wall} = 0 \rightarrow RE - RADIATING$$

# NODAL BALANCE

$NODE:3$

$$0 = q_{wall} = \frac{J_3 - J_1}{\frac{1}{A_3F_{31}}} + \frac{J_3 - J_2}{\frac{1}{A_3F_{32}}}$$

$$0 = J_3\left(\frac{1}{\frac{1}{A_3F_{31}}} + \frac{1}{\frac{1}{A_3F_{32}}}\right) - \frac{J_1}{\frac{1}{A_3F_{31}}} - \frac{J_2}{\frac{1}{A_3F_{32}}}$$

$$0 = J_3\left(\frac{1}{\frac{1}{A_1F_{13}}} + \frac{1}{\frac{1}{A_2F_{23}}}\right) - \frac{J_1}{\frac{1}{A_1F_{13}}} - \frac{J_2}{\frac{1}{A_2F_{23}}}$$

$A_1 = A_2$

$F_{13} = F_{23}$

$$J_3 = \frac{J_1 + J_2}{2} = \frac{\sigma(T_1^4 + T_2^4)}{2}\frac{W}{m^2}$$

$$J_3 = \frac{J_1 + J_2}{2} = \frac{\sigma(T_1^4 + T_2^4)}{2}\frac{W}{m^2}$$

$J_1 = 13,614W/m2$

$J_2 = 1,452W/m2$

$$J_3 = 7,533W/m2 \rightarrow T_{3wall} = \left(\frac{J_3}{\sigma}\right)^{1/4} = 604K$$

$$q_1 = \frac{J_1 - J_2}{\frac{1}{A_1F_{12}}} + \frac{J_1 - J_3}{\frac{1}{A_1F_{13}}} = A_1F_{12}\left(J_1 - J_2 + J_1 - \left(\frac{J_1 + J_2}{2}\right)\right)$$

$$= A_1xF_{12}x1.5x(J_1 - J_2)$$

$$= A_1 \bullet \sigma \bullet 1.5 \bullet 0.5(T_1^4 - T_2^4)$$

$$= 18,243W(= -q_2)$$

Lower HEATER REQUIREMENT DUE TO HIGH TEMPERATURE RE-RADIATING WALLS

$$q_2 = \frac{J_2 - J_1}{\frac{1}{A_2 F_{21}}} + \frac{J_2 - J_2}{\frac{1}{A_2 F_{22}}} + \frac{J_2 - J_3}{\frac{1}{A_2 F_{23}}}$$