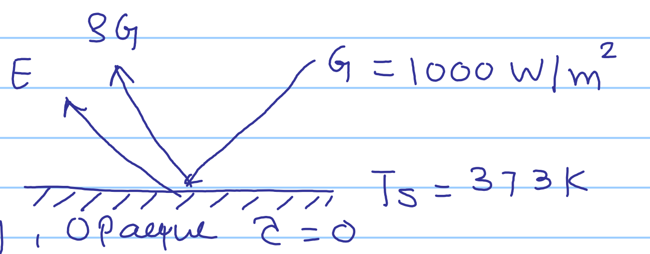
Note Title 10/14/2020

Q.1 A gray, diffuse opaque surface (Absorptivity $\alpha = 0.8$) is at 100ºC and receives an irradiation 1000 W/m2. If the surface area is 0.1 m2, calculate

i. Radiosity of the surface

ii. Net radiative heat transfer rate from the surface

iii. Calculate above quantities if surface is black.



given Data

$\tau = 0$

$\alpha = 0.8$ $\quad \alpha + \rho + \tau = 1$

$\rho = 0.2$

$T = 100 + 273 = 373\ K$

$G = 1000\ W/m^2$

$A = 0.1\ m^2$

1) Radiosity

$J = E + \rho G$

$= \varepsilon E_b + \rho G$

$= 0.8 \times 5.67 \times 10^{-8} \times 373^4 + 0.2 \times 1000$

$J = 1079.57\ W/m^2$

$\varepsilon = \frac{E}{E_b}$ $\quad E_b = \sigma T^4$

$E = \varepsilon E_b$

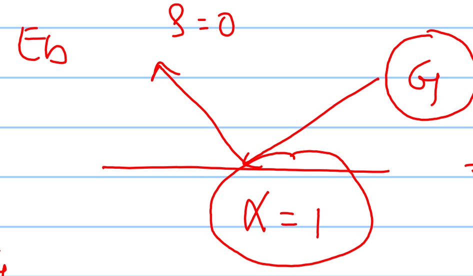
$\alpha = \varepsilon = 0.8$

(2) Net Radiative heat Transfer

$\frac{\phi_{1-2}}{A} = J - G \Rightarrow \phi_{1-2} = (J - G) A$

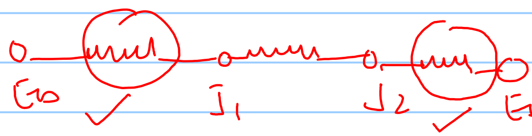
$= (1079.57 - 1000) \times 0.1$

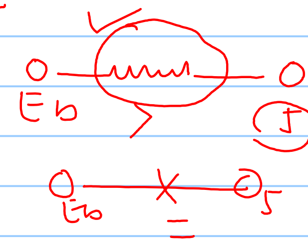
black surface



T = C

$$J = E_b = \sigma T_s^4 = 5.67 \times 10^{-8} \times 373^4 = \underline{1097.53} \ W/m^2$$





$$q_{net} = (J - G) A = (1097.53 - 1000) \times 0.1$$

$$= 9.75 \ W \Rightarrow 7.8 \ W$$

Surface property

Case-I → Non black

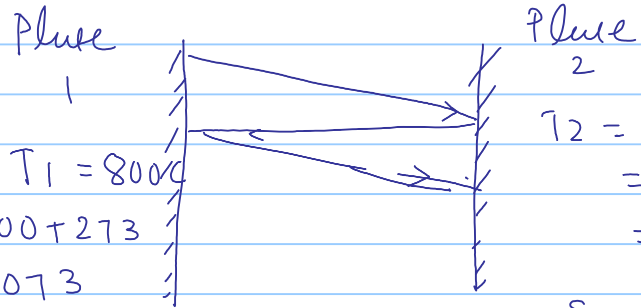
Case-II → black surface

Q.2 Emissivity of two large parallel plates maintained at 800 °C and 300 °C are 0.3 and 0.5 respectively. Find the net radiant heat exchange per square meter for these plates. (4)

given condition

$A_1 = A_2$

$F_{1-2} = F_{2-1} = 1$



$T_1 = 800 °C = 800 + 273 = 1073$

$\varepsilon_1 = 0.3$

$T_2 = 300 = 300 + 273 = 573\ K$

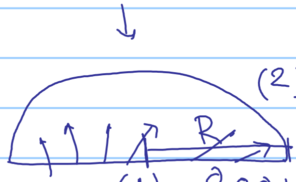
$\varepsilon_2 = 0.5$

$$\Phi_{1-2} = \frac{A_1 \sigma (T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

$$\frac{\Phi_{1-2}}{A_1} = \frac{\sigma (T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} = \frac{5.67 \times 10^{-8} (1073^4 - 573^4)}{\frac{1}{0.3} + \frac{1}{0.5} - 1} = 15933.90\ W/m^2$$

$$= 15.93\ kW/m^2$$

Q.3 The flat floor of hemispherical furnace is at 800K and has an emissivity of 0.5. The corresponding values of hemispherical roof are 1200K and 0.25. Calculate net heat transfer between roof and floor.



(2) 1200 K $\varepsilon_2 = 0.25$

(1) 800 K $\varepsilon_1 = 0.5$

Given Data

$T_1 = 800K$

$T_2 = 1200K$

$\varepsilon_1 = 0.5$

$\varepsilon_2 = 0.25$

$A_1 = \pi R^2$

$A_2 = \frac{4\pi R^2}{2} = 2\pi R^2$

$F_{1-2} = 1$

$F_{1-1} + F_{1-2} = 1$

$F_{1-1} = 0 \Rightarrow F_{1-2} = 1$

$\Phi_{1-2} = (fg)_{1-2} A_1 \sigma (T_1^4 - T_2^4)$

$$(fg)_{1-2} = \frac{1}{\frac{1-\varepsilon_1}{\varepsilon_1} + \frac{1}{F_{1-2}} + \frac{1-\varepsilon_2}{\varepsilon_2} \cdot \frac{A_1}{A_2}}$$

$$= \frac{1}{\frac{1}{\varepsilon_1} - 1 + 1 + \left(\frac{1-\varepsilon_2}{\varepsilon_2}\right)\frac{A_1}{A_2}} = \frac{1}{\frac{1}{0.5} + \left(\frac{1-0.25}{0.25}\right) \times 0.5} = 0.2857$$

$$\frac{\Phi_{1-2}}{A} = (fg)_{1-2}\, \sigma (T_1^4 - T_2^4)$$

$$= 0.2857 \times 5.67 \times 10^{-8} \times (800^4 - 1200^4)$$

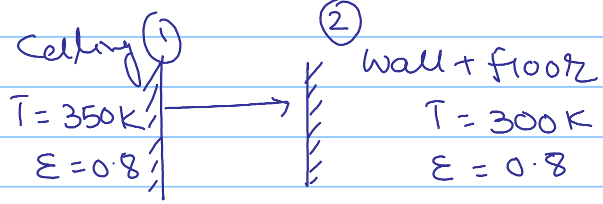
$$\frac{A_1}{A_2} = \frac{\pi R^2}{2\pi R^2} = 0.5$$

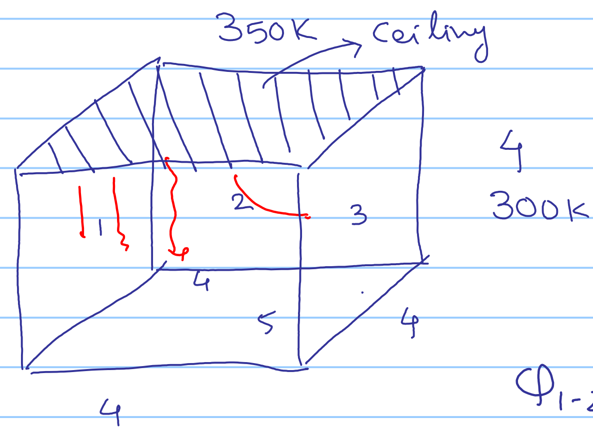
$$\frac{Q_{1-2}}{A} = 0.2857 \times 5.67 \times 10^{-8} \times (800^4 - 1200^4)$$

$$= -26955.8 \ W/m^2$$

− sign indreate that heat is Transfer from Roof to floor

Q.4 A cubical room 4 m × 4 m × 4 m is heated through the ceiling by maintaining it at uniform temperature of 350 K, while walls and the floor are at 300 K. Assuming that the all surfaces have an emissivity of 0.8, determine the rate of heat loss from ceiling by radiation.



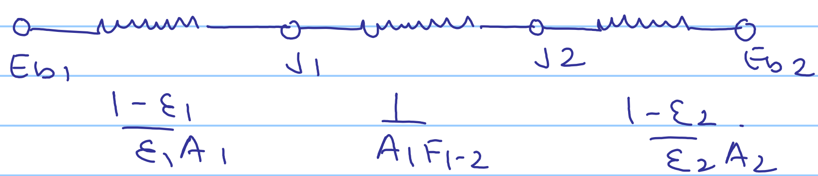


$\varepsilon_1 = \dots = \varepsilon_6 = 0.8$

$F_{1-1} + F_{1-2} + F_{1-3} + F_{1-4} + F_{1-5} + F_{1-6} = 1$

$F_{1-1} + F_{1-2} = 1$

$F_{1-2} = 1$



$$Q_{1-2} = \frac{(E_{b1} - E_{b2})}{R_1 + R_2 + R_3}$$

$$\phi_{1-2} = \frac{E_{b1} - E_{b2}}{\frac{1-\varepsilon_1}{\varepsilon_1 A_1} + \frac{1}{A_1 F_{12}} + \frac{1-\varepsilon_2}{\varepsilon_2 A_2}}$$

$A_1 = 4 \times 4 = 16\ m^2$

$A_2 = 4(4 \times 4) + (4 \times 4)$

$= 64 + 16 = 80\ m^2$

$\varepsilon_1 = \varepsilon_2 = 0.8$

$$= \frac{5.67 \times 10^{-8} (350^4 - 300^4)}{\frac{1-0.8}{0.8 \times 16} + \frac{1}{16 \times 1} + \frac{1-0.8}{0.8 \times 80}}$$

$= 4815.6\ W = 4.8\ kW$