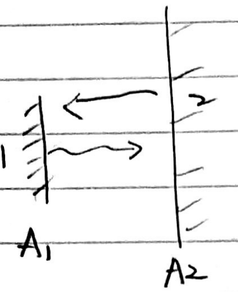
view factor



$Q_{1-2} = A_1 \sigma T_1^4 \cdot F_{1-2}$

$Q_{2-1} = A_2 \sigma T_2^4 \cdot F_{2-1}$

net heat exchange : $Q_{net} = A_1 \sigma T_1^4 F_{1-2} - A_2 \sigma T_2^4 \cdot F_{2-1}$

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

$= A_2 F_{2-1} (\sigma T_1^4 - \sigma T_2^4)$

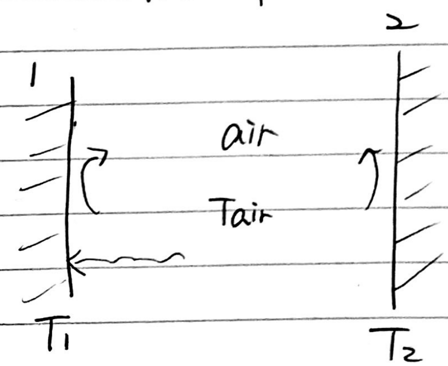
reciprocal rule : $A_1 F_{1-2} = A_2 F_{2-1}$

some discussions :

<1> radiation heat transfer between black bodies

regardless of surface area and view factor, radiative energy is always flowing from T_{high} to T_{low}.

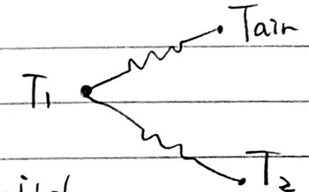
<2> multiple - modes of heat transfer



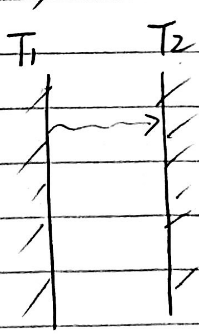
$T_{air} < T_1 < T_2$

convective heat transfer $q_c = \bar{h} (T_1 - T_{air})$

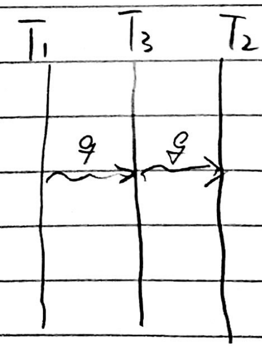
radiative heat transfer $q_r = A_1 F_{12} (\sigma T_1^4 - \sigma T_2^4)$



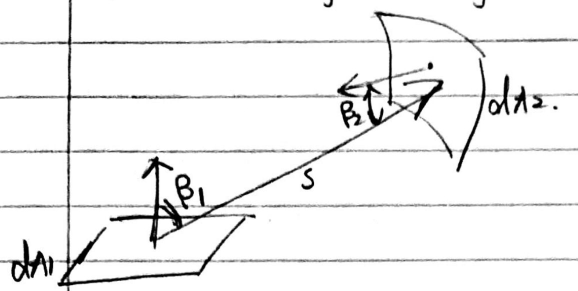
<3> black-body radiation sheild



← $q_{1-2} = \sigma (T_1^4 - T_2^4)$



General form of view factor



$$dQ_{net} = dQ_{1-2} - dQ_{2-1}$$

$$dQ_{1-2} = \frac{\sigma T_1^4}{\pi} \cdot \left(\frac{\cos\beta_1 \cdot \cos\beta_2 \, dA_1 \, dA_2}{S^2} \right)$$

$$dQ_{2-1} = \frac{\sigma T_2^4}{\pi} \left(\frac{\cos\beta_2 \cdot \cos\beta_1 \, dA_2 \, dA_1}{S^2} \right)$$

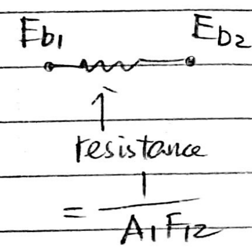
$$Q_{net\,1-2} = \sigma (T_1^4 - T_2^4) \int_{A_1}\int_{A_2} \frac{\cos\beta_1 \cos\beta_2}{\pi S^2} dA_1 \, dA_2 = A_1 F_{1-2} (\sigma T_1^4 - \sigma T_2^4)$$

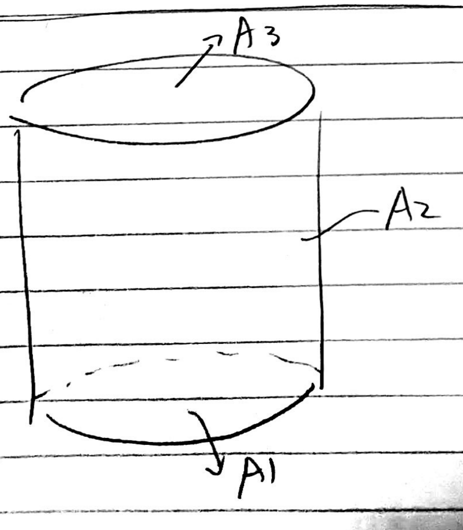
So $F_{1-2} = \frac{1}{A_1} \int_{A_1}\int_{A_2} \frac{\cos\beta_1 \cos\beta_2}{\pi S^2} dA_1 \, dA_2$

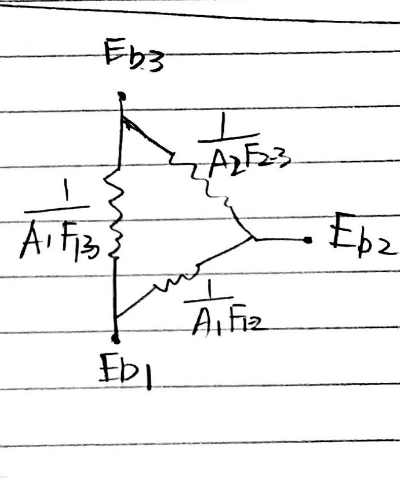
view factor tables <<Lienhard>> Table 10.2.

Black-body electrical network analogy

$$E_{b1} = \sigma T_1^4$$
$$E_{b2} = \sigma T_2^4$$
$$\Rightarrow Q_{12} = \frac{E_{b1} - E_{b2}}{\frac{1}{A_1 F_{12}}}$$







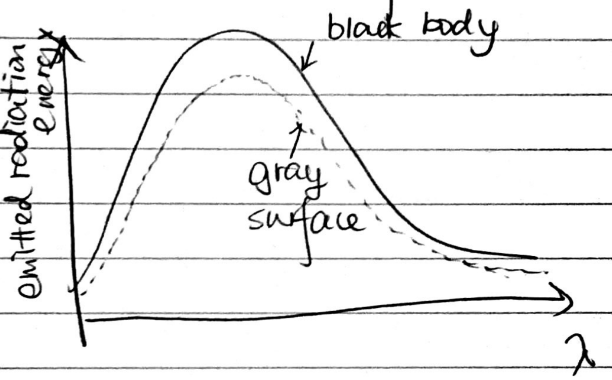
Non-Ideal surface.

emissivity $\varepsilon = \frac{\text{Actual radiation emitted}}{\text{black body radiation}} < 1$

$\varepsilon_\lambda = \frac{\text{actual radiation for wavelength } \lambda}{\text{black body radiation for wavelength } \lambda} < 1$

gray surface

ε_λ is the same for all λ, $\varepsilon_\lambda = \varepsilon$



Kirchhoff's Law.

$\varepsilon_\lambda = \alpha_\lambda$ (diffuse form)

$\varepsilon = \alpha$ (diffuse and gray form)