How do we quantify radiation heat xport?

EMIT

(ABSORPTION
REFLECTION
EMISSION)

ε = emissivity

$$= \frac{q_{emitted}}{q_{black\ body}}$$

ABSORB

$$\alpha = \frac{q_{absorbed}}{q_{incident}}$$

$\alpha = 1$ for black body

$\alpha < 1$ for grey body (indep of λ)

Kirchhoff's Law

$$\boxed{\alpha = \varepsilon}$$

Stefan Boltzmann Law

$$\frac{q_{\text{emitted blackbody}}}{A} = \sigma T^4$$

(σ ← universal constant)

Non Black Body?

$$\underbrace{\epsilon\, q_{\text{emi blackbody}}}_{q_{\text{emitted non black body}}} = \underbrace{A \sigma T_4}\, \epsilon$$

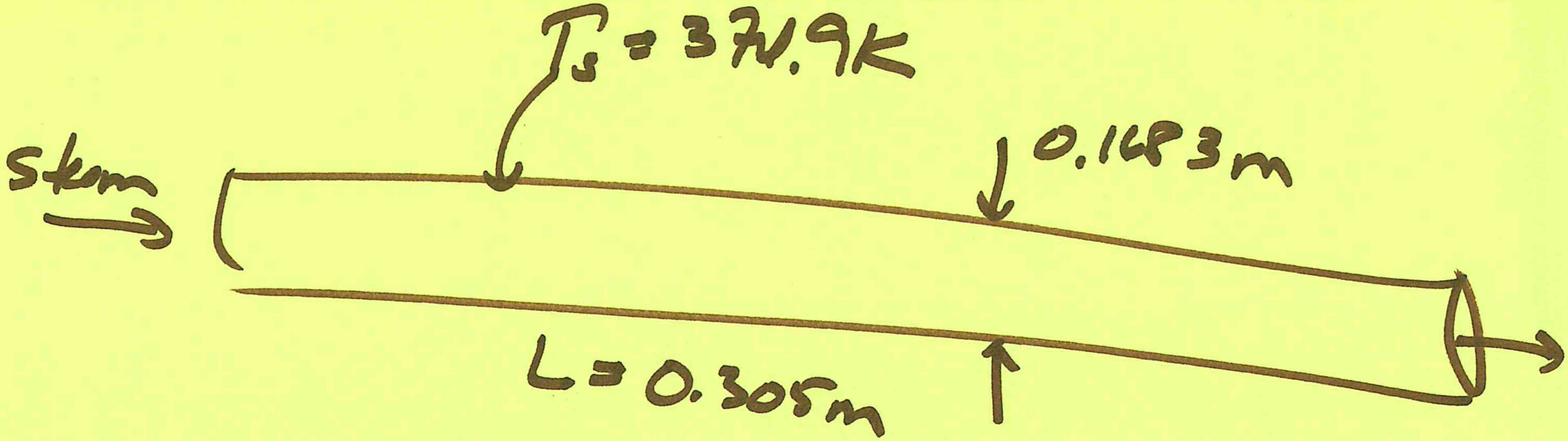
q emitted
non
black body

$$\frac{q_{net}}{A} = \varepsilon|_{T_s} \sigma \left(T_s^4 - T_{body}^4\right)$$

$$= \left(\frac{T_s - T_{body}}{T_s - T_{body}}\right) \varepsilon\sigma \left(T_s^4 - T_b^4\right)$$

$$\frac{q_{net}}{A} = \underbrace{\left(\frac{\varepsilon|_{T_s}\sigma\left(T_s^4 - T_b^4\right)}{T_s - T_b}\right)}_{h_{rad}} \left(T_s - T_b\right)$$

EXAMPLE



$T_{bulk} = 297.1K$

What is q/A ?

$$q = (h_{rad} + h_{nat'l\ conv})(T_s - T_{bulk})$$

$$Sum = \sum_{n=0}^{\infty} x^n$$

$$Sum = 1 + x + x^2 + x^3 + \dots$$

multiply by x

$$x(Sum) = x + x^2 + x^3 + \dots$$

$$(Sum) - x(Sum) = 1$$

$$Sum(1-x) = 1$$

$$Sum = \frac{1}{1-x}$$

$$X = (1-\varepsilon_1)(1-\varepsilon_2)$$

$$q_{1-2} = \varepsilon_1 \varepsilon_2 A \sigma T_1^4 \left(\frac{1}{1-(1-\varepsilon_1)(1-\varepsilon_2)} \right)$$

$$1 - (1 - \varepsilon_1 - \varepsilon_2 + \varepsilon_1 \varepsilon_2)$$

$$\cancel{1} - \cancel{1} + \varepsilon_1 + \varepsilon_2 - \varepsilon_1 \varepsilon_2$$

$$\frac{1}{1-(1-\varepsilon_1)(1-\varepsilon_2)} = \frac{\frac{1}{\varepsilon_1 \varepsilon_2}}{\frac{1}{\varepsilon_1 \varepsilon_2}(\varepsilon_1 + \varepsilon_2 - \varepsilon_1 \varepsilon_2)}$$

$$\frac{1}{1-(1-\varepsilon_1)(1-\varepsilon_2)} = \frac{\frac{1}{\varepsilon_1 \varepsilon_2}}{\left(\frac{1}{\varepsilon_2} + \frac{1}{\varepsilon_1} - 1\right)}$$

$$q_{12} = A \sigma T^4 \left(\frac{1}{\frac{1}{\varepsilon_2} + \frac{1}{\varepsilon_1} - 1} \right)$$