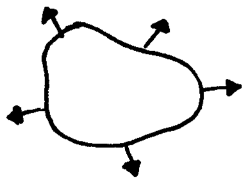
Oct. 26/17
THERMAL

Chapter 1 : Heat Transfer

Introduction and basic concepts

Radiation : electromagnetic waves → 1) thermal radiation
2) non-thermal (x-ray, radiowaves, microwaves)



($T > 0K$, then radiation exists)

1) + 2) Conduction and convection → material medium

3) Rad → do not require medium
↳ max in vacuum

Stefan - Boltzmann :

Black body ← $\dot{Q}_{emit,max} = \sigma (A_s)(T_s)^4$ absolute

Stefan-boltzman constant

$\sigma = 5.67 \times 10^{-8}\ W/m^2 \cdot K^4$

For real surfaces :

$\dot{Q}_{emit} = \epsilon \sigma A_s T_s^4$
↳ emissivity

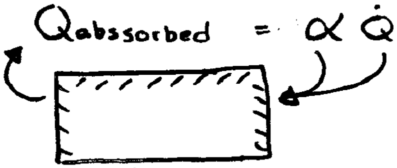
For black body $\epsilon = 1$
For others : $0 \leq \epsilon \leq 1$

T1-6	ϵ
Aluminum Foil	0.07
Black Paint	0.98
White paper	0.92 → 0.97
Human skin	0.95

$$\boxed{\dot{Q}_{emit} = \epsilon \sigma A_s T_s^4}$$

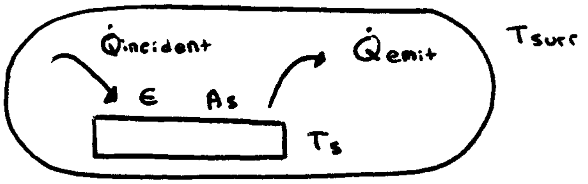
Kirchoff's Law : ϵ, α
emissivity absorptivity

$\dot{Q}_{abssorbed} = \alpha \dot{Q}_{incident}$



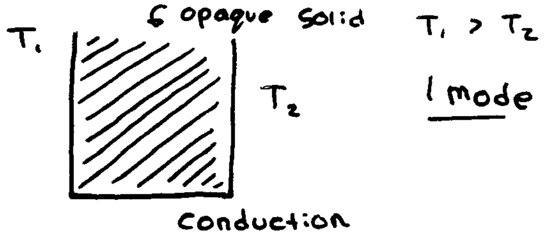
- At same temperature + wavelength

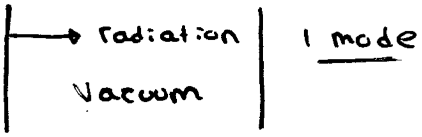
$$\boxed{\epsilon = \alpha}$$

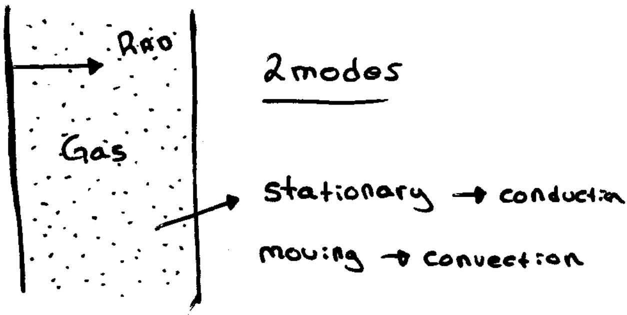


$$\dot{Q}_{rad} = \epsilon \sigma A_s (T_s^4 - T_{surr}^4)$$

Simultaneous heat transfer mechanisms







Example 1.9 (2nd textbook)

$\epsilon_{skin} = 0.95$

$\sigma = 5.67 \times 10^{-8} \frac{W}{m^2 \cdot K^4}$

$\dot{Q}_{rad,\ summer} = 40.9\ W$

$\dot{Q}_{rad,\ winter} = 152\ W$

Example 1.10 (2nd textbook)

$\epsilon_{skin} = 0.95$

$\sigma = 5.67 \times 10^{-8} \frac{W}{m^2 K^4}$

$T_{s_1} = 29°C + 273K = 302K$

$A_s = 1.6\ m^2$

$T_{surr} = 20°C + 273K$

$$\dot{Q}_{radiation} = (0.95)(5.67 \times 10^{-8} \frac{W}{m^2 K})((302)^4 - (293)^4)(1.6)$$

$$\dot{Q}_{radiation} = 81.7\ W$$

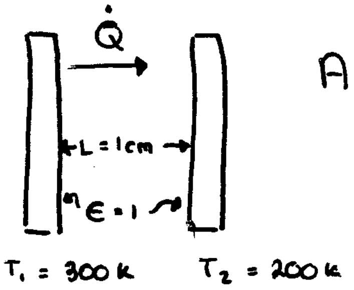
$$\dot{Q}_{convection} = \underset{\text{conv. coeff.}}{h} \underset{\text{surface area}}{A_s} (\overset{\text{surface}}{T_s} - \underset{\text{fluid temp}}{T_\alpha})$$

$$\dot{Q}_{convection} = (6)(16)(29 - 20)$$

$$= 86.4\ W$$

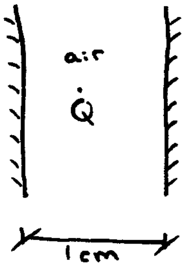
$$\dot{Q}_{total} = 51.07\ W + 86.4\ W = 168.1\ W$$

Example 1-11 (second textbook)

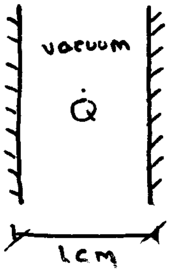


$A_s = 1 m^2$

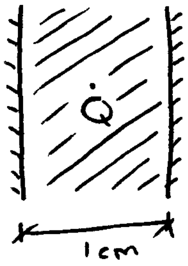
a) atmos. air



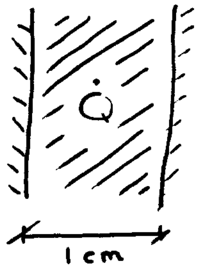
b) vacuum



c) urethane



d) superinsulation



From TA-15 : Air Property Table

① $K_{air} = 0.0219$ W/m.K

② ~ vacuum

③ $K_{urethane} \Rightarrow K = 0.026$ W/m·K (A-6)

④ $K_{superinsulation} \Rightarrow K = 0.000002$ W/m.K

a) $\dot{Q}_{conduction} = kA\left(\frac{T_1 - T_2}{L}\right) = 219 W$
$\dot{Q}_{radiation} = \epsilon \sigma A (T_1^4 - T_2^4) = 369 W$ $\Big\}$ $\dot{Q} = 588 W$

b) $\dot{Q}_{radiation} = \epsilon \sigma A (T_1^4 - T_2^4) = 369 W$

c) $\dot{Q}_{conduction} = kA\left(\frac{T_1 - T_2}{L}\right) = 260 W$

d) $\dot{Q}_{conduction} = kA\left(\frac{T_1 - T_2}{L}\right) = 0.2 W$