NEWTON'S LAW OF COOLING

the heat transferred by convection, $\dot{Q}_{conv}$ can be ~~determined~~ determined using Newton's law of cooling, given by

$$\dot{Q}_{conv} = h A_s (T_s - T_\infty) \quad (W \text{ or } kW)$$

where

h: convection heat transfer coefficient $\left(\frac{W}{m^2 \cdot K}\right)$
A_s: surface area with temp T_s (m^3)
T_s: surface temp in (°C)
T_∞: bulk fluid temp.

EX. a heated surface at $T = 120°C$ was exposed to convection of air at $T_\infty = 25°C$. The area of the surface exposed to convection is $7cm \times 8cm$, and the convection heat transfer coeffient is estimated to be $150 \, W/m^2 \cdot °C$

SCHEMATIC

REQUIRED: determine the amount of heat transferred away from the chip.

ANALYSIS: we use Newton's law of cooling.

$$\dot{Q} = h A (T_s - T_\infty)$$

$$\dot{Q} = (150)(0.0056)(120 - 25)$$

$$\dot{Q} = 79.8 \ W.$$

HEAT TRANSFERED BY RADIATION.

Radiation is the transfer of energy by virtue of electromagnetic waves (or photons), which takes place over all wavelegths. It is the energy emitted by matter in the form of electromagnetic waves as a result of the electromagnetic configuration at the atoms or molecules.

In heat transfer studies, we talk about thermal radiation, a form of radiation emitted by bodies b/c of the temperature.

REMARK: Emissions of energy depend on the surface temperature as well as the surface thermal characteristics.

STEFEN - BOLTZMAN LAW OF RADIATION.

$$\dot{Q}_{emitted} = \sigma A_S T_s^4 (\epsilon) \qquad (w \text{ or } kW)$$

T_S: absolute temperture of surface. (K)

A_S: surface area (m^2)

σ: $5.67051 \times 10^{-8} \left(\frac{W}{m^2 \cdot K}\right)$

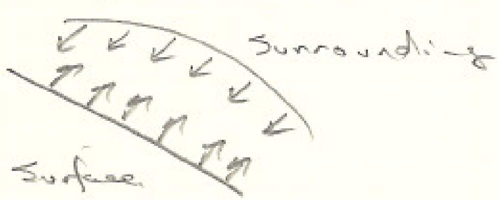
REMARK: ϵ is 1.0 a a perfectly black body
Any real surface emitts an amount of thermal energy that is a fraction of the ideal blackbody radiation; this fraction is ϵ; $(0 \leq \epsilon \leq 1)$

NET THERMAL RADIATION

the net thermal radiation is the difference between the emitted radiation rate and absorbed.

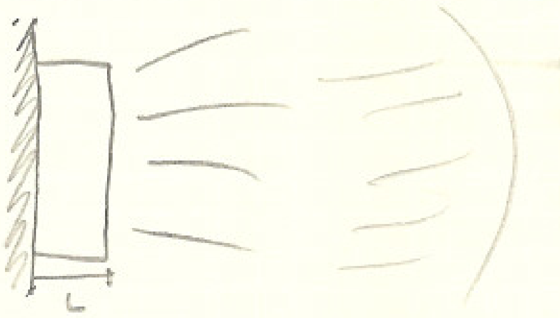
ratiation rate on a surface Consider the surface with A_S & A_T exchanging thermal radiation with it's large surroundindings the net thermal energy is given by

$$\dot{Q} = \epsilon \sigma A(T_s^4 - T_{SURR}^4)$$



note: temp need to be in K

EX. An electric circuit is exposed to blackbody thermal radiation with the surrounding walls at an encloser which is at 25°C, as shown in fig



L = 14 cm
H = 28 cm
Z = 38 cm

REQUIRED: Determine the net thermal radiation rate if the cabinet temp is 135°C

ANALYSIS:

$$\dot{Q} = \varepsilon \sigma A_s (T_s^4 - T_{surr}^4)$$
$$= (5.67)(10^{-8})(0.2912)(+19.85)(10^9)$$
$$= 327 \text{ w.}$$

H/W # 4 { CH 4 83, 87 ; CH 13 14, 26 } DUE FRIDAY AUG 18.

COMBINED MODES OF HEAT TRANSFER

In practice, many heat transfer processes involve combinations of conduction, convection and thermal radiation. In this course the analysis discussed will be discussed using "thermal resistance analogy"

There exists an analogy between heat transfer systems and DC electric circuits. The practical equations for convection, conduction and thermal radiation. Heat transfer by those equations can be expressed by

$$\dot{Q} = \frac{\Delta T}{R_{th}}$$ R_{th}: thermal resistance $\left(\frac{°C}{W}\right)$

this is similar to ohms law which relates

$$I = \frac{V}{R}$$

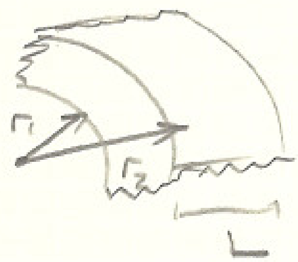
THERMAL RESISTANCE TYPES.

the conduction in a plane wall,

$$\dot{Q} = \frac{\Delta T}{\left(\frac{L}{kA}\right)} = \frac{\Delta T}{R}$$

$$\therefore R = \frac{L}{kA} \left({}^\circ C/W\right)$$

note that for cylinder



$$R = \frac{\ln(r_2/r_1)}{2\pi k L}$$

the convection heat transfer.

$$\dot{Q} = \frac{\Delta T}{\left(\frac{1}{hA}\right)} = \frac{\Delta T}{R}$$

$$\therefore R = \frac{1}{hA} \left(\frac{{}^\circ C}{W}\right)$$

the radiation heat transfer.

$$\dot{Q} = \epsilon \sigma A_s \left(T_s^4 - T_{surr}^4\right)$$
$$= \epsilon \sigma A_s \left[\left(T_s^2 - T_{surr}^2\right)\left(T_s^2 + T_{surr}^2\right)\right]$$
$$= \epsilon \sigma A_s \left[(\Delta T)\left(T_s + T_{surr}\right)\left(T_s^2 + T_{surr}^2\right)\right]$$

$$\dot{Q} = \frac{\Delta T}{\left(\frac{1}{\epsilon \sigma A_s \left[\left(T_s + T_{surr}\right)\left(T_s^2 + T_{surr}^2\right)\right]}\right)} = \frac{\Delta T}{R}$$

$$\therefore R = \frac{1}{\epsilon \sigma A_s \left[\left(T_s + T_{sur}\right)\left(T_s^2 + T_{sur}^2\right)\right]}$$