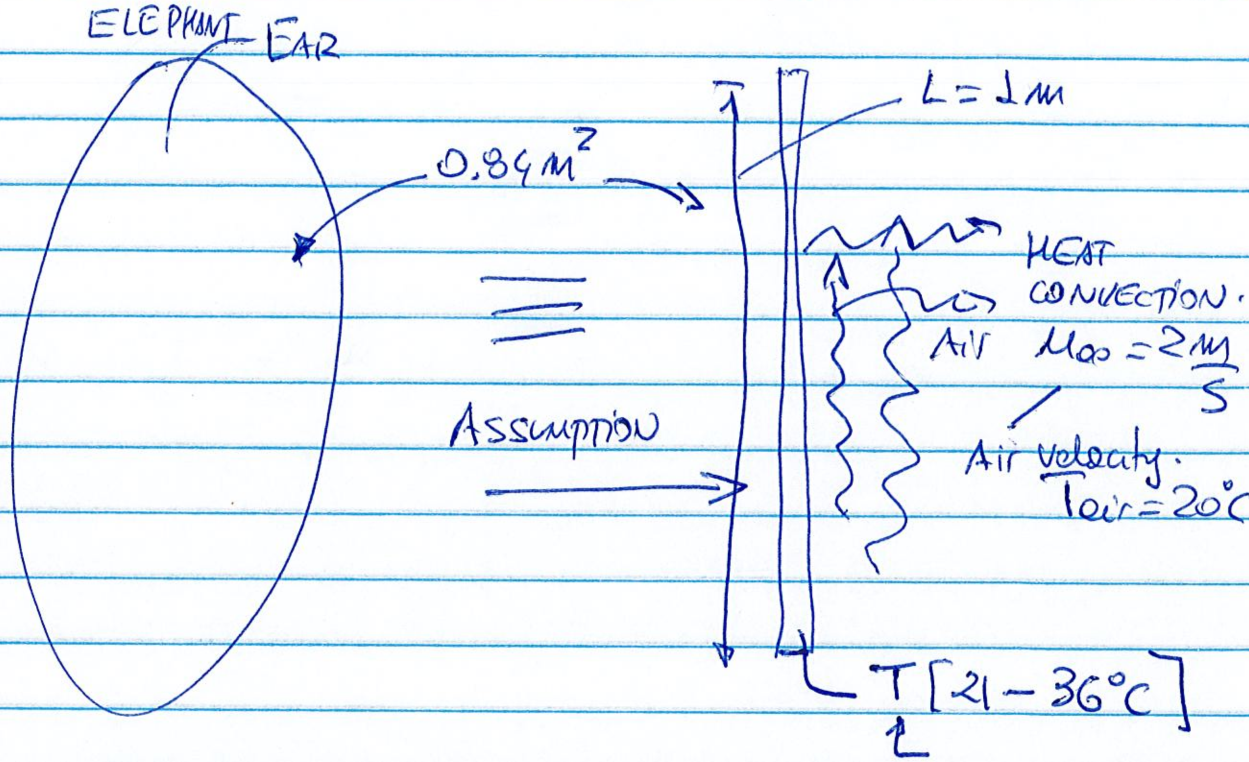
LECTURE NOTES CLASS 3-6-18



(1) Convective heat from the ear to the air. between 21°C to 36°C

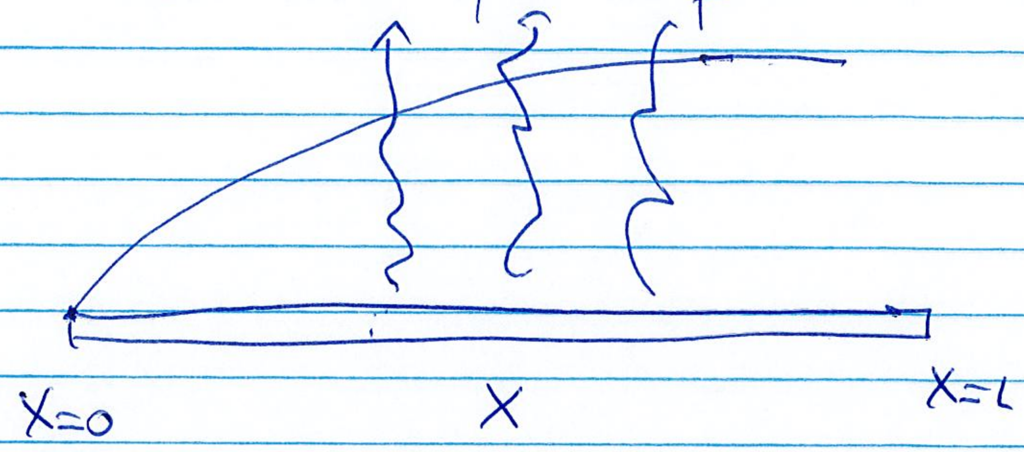
$$Q = 2hA\,[T - T_{air})$$

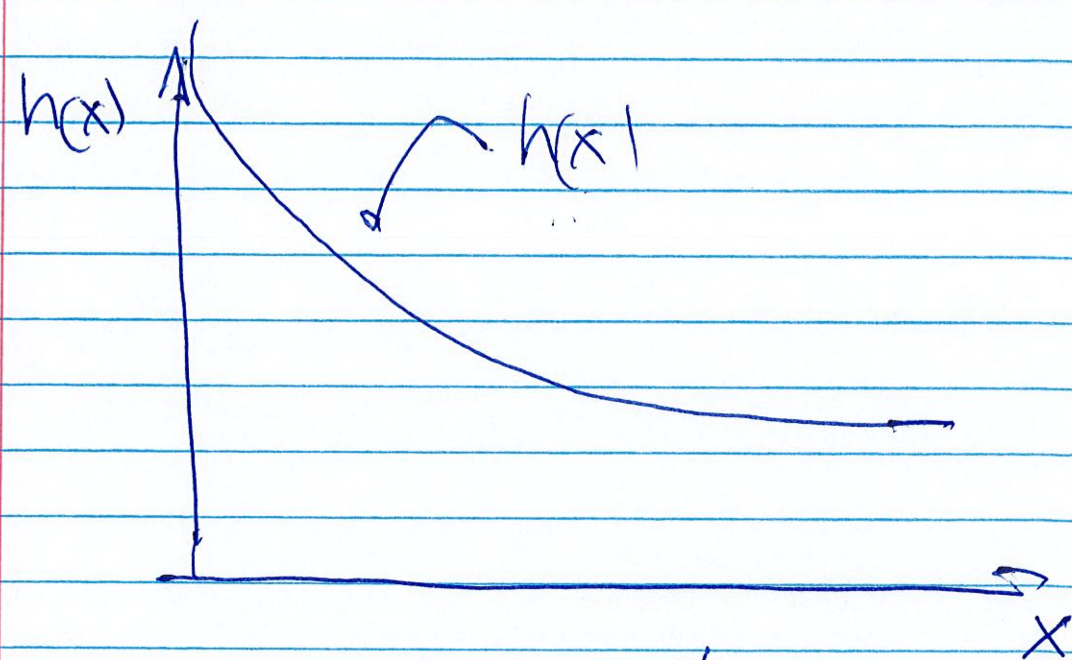
h ??

<u>Question</u> why the coefficient changes when we move from the local Nusselt Number [Nu_x] to the <u>average Nu_L</u> [Preferred h to be used]

$$Nu_L = \frac{h_L L}{k_f} \qquad Nu_x = \frac{h(x)\,x}{k_f}$$

h(x) is a function of h (2)





$$h_L = \frac{1}{L}\int_0^L h(x)\,dX$$

average value.

what equation to use out of the two (3)

We need to know if we have laminar or turbulent flow.

air velocity 2 m/s

1 m

$$Re_L = \frac{u_\infty L \rho}{\mu}$$

density of the air. 1.22 kg/m³

1.80×10^{-5} $\frac{kg}{m.s}$

Pa.s.

Since we need to calculate the heat convection in a range of temperature we will use air temperature [No film temperature]

$$T_{air} = 20°C = 293K$$

let's assume $293K \approx 290K$

$$Re_L = 1.35 \times 10^5$$

Flow is laminar.

$$Nu = \frac{h_L L}{K} = 0.664 \times (1.35 \times 10^5)^{1/2} \, P_r^{1/3}$$

K = 0.0255 W/m.K

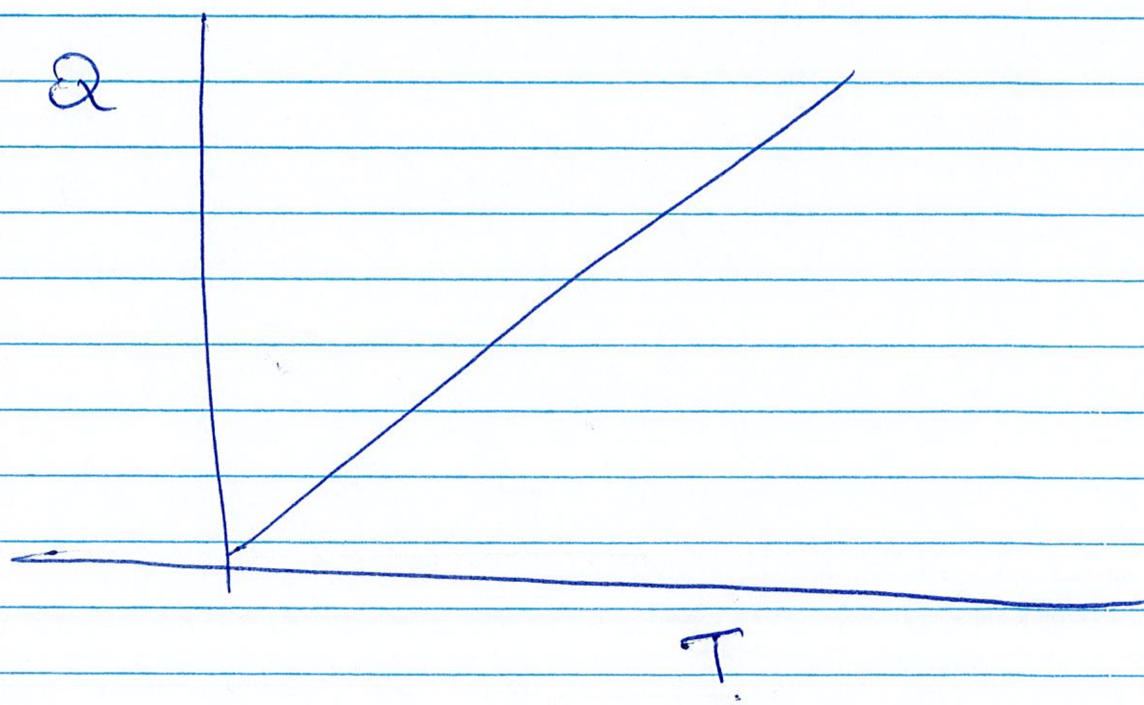
P_r = 0.71

$$\frac{h_L L}{k} = 218$$

$$h_L = \frac{218 \times \overset{0.0255}{k}}{L} = \frac{218 \times 0.0255}{1\,m} \; W/m.K$$

$$\boxed{h_L = 5.6 \frac{W}{m^2 K}}$$

$$Q = 5.6 \frac{W}{m^2K} \times 0.84\,m^2 \times 2 \left[T - T_{air}\right]$$



temperature of the air.

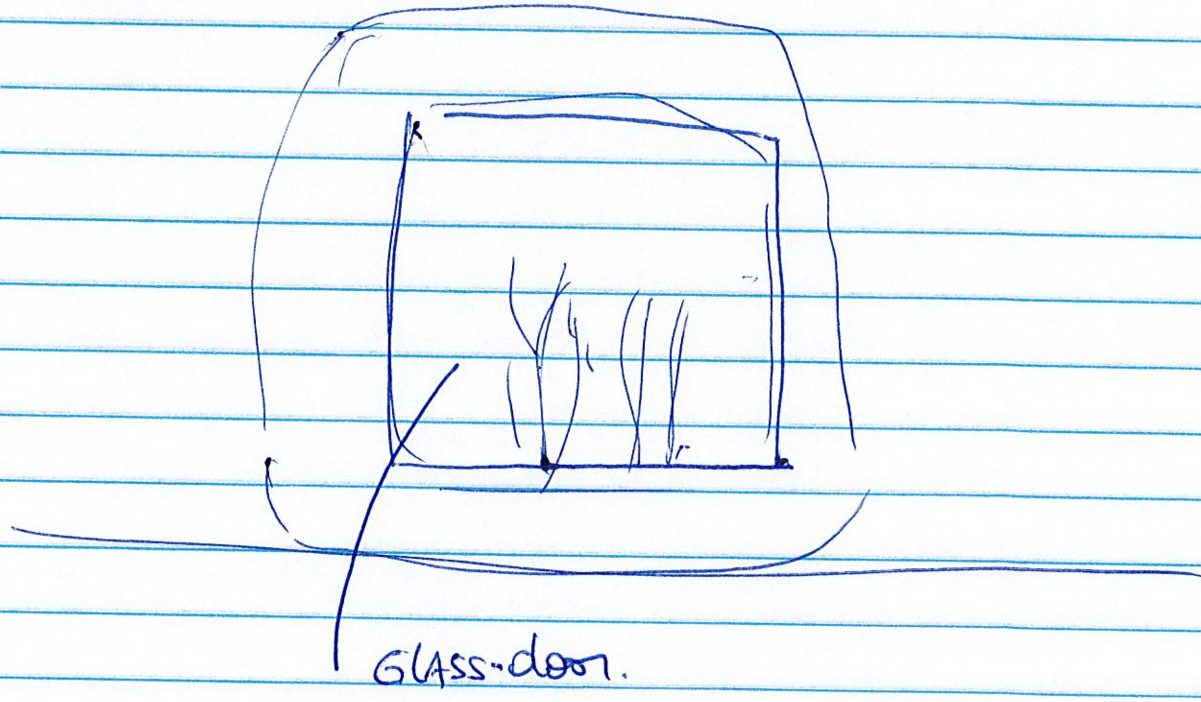
HEAT PRODUCTION = 1650 W (5)

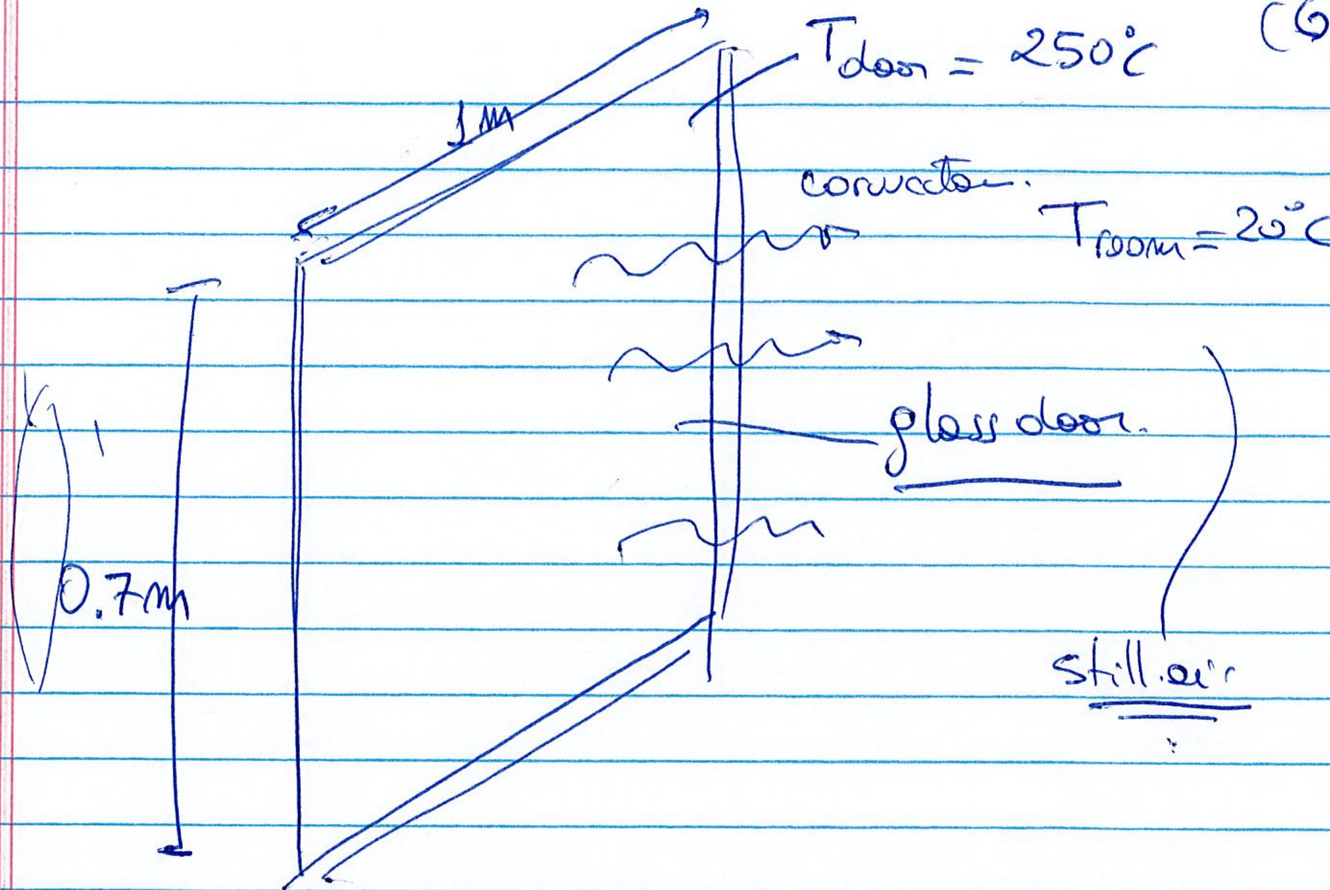
if we assume ear temperature of 37°C

$$\frac{Q}{\text{HEAT PRODUCTION}} = \frac{5.6 \times 2 \times 0.84 [37-20] \cancel{W}}{1650 \cancel{W}} = 0.19$$

19% Energy generated by metabolic heat is being lost by the elephant ears

Problem 2





(a) Natural or forced convection? Natural.

(b) Calculate heat transferred to the room

$$Q = hA[250 - 20]$$

A ← 1m x 0.7m

h? → can be calculated with the correlation

$$Nu_L = \left[0.825 + \frac{0.387\, Ra_L^{1/6}}{\left[1 + \left(\frac{0.492}{Pr}\right)^{9/16}\right]^{8/27}} \right]^2$$

$$Gr = \frac{\beta g L^3 \Delta T}{\nu^2}$$

$\beta \cancel{=} \cancel{\frac{1}{}} \left(\frac{d\rho}{dT}\right)$ For an ideal gas $\beta = \frac{1}{T}$

$$\boxed{\beta = -\frac{1}{\rho}\left(\frac{d\rho}{dT}\right)_{\cancel{P}}}$$

$PV = nRT = \frac{m}{M} RT$

$$\frac{PM}{RT} = \frac{m}{V} = \rho$$

$$T = T_{film} = \frac{20+250}{2} = 135°C = 408K$$

To avoid interpolation let's assume $T = 400K$.

$$\rho = \frac{PM}{RT} \Rightarrow$$

$$\beta = -\frac{d\rho}{dT} = -\left(-\frac{PM}{RT^2}\right) = \frac{PM}{RT^2}$$

$$\beta = \frac{1}{\cancel{\rho}} \frac{PM}{RT} \frac{1}{T}$$

$\cancel{\rho}$

$$\nu = \frac{\mu}{\rho} = \frac{2.29 \times 10^{-5}\ Kg/m.s}{0.882\ Kg/m^3}$$

$Gr = 2.83 \times 10^9$ $\quad$ $Pr = 0.689$ at 400K (8) for air.

$Ra_L = Gr \times Pr = 2.83 \times 10^9 \times 0.689 = 1.95 \times 10^9$

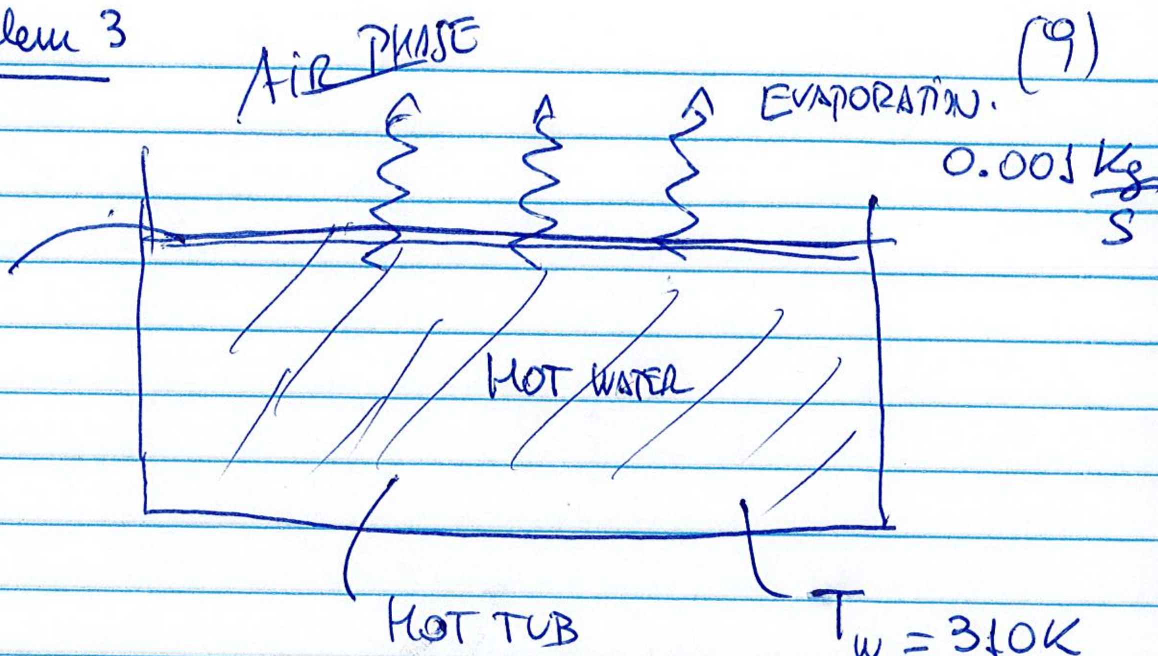
$$Nu_L = 150.5 = \frac{h_L L}{k} \Rightarrow h_L = \frac{150.5 \times 0.0337 \text{ W/m.K}}{0.7 \text{ m}}$$

$$\boxed{h_L = 7.24 \frac{W}{m^2 K}}$$

$$Q = 7.24 \frac{W}{\cancel{m^2}\cancel{K}} \times 0.7 \times 1 \cancel{m^2} [250 - 20] \cancel{K}$$

$Q = 1{,}165.6 W = 1.16 kW$

Problem 3 (9)

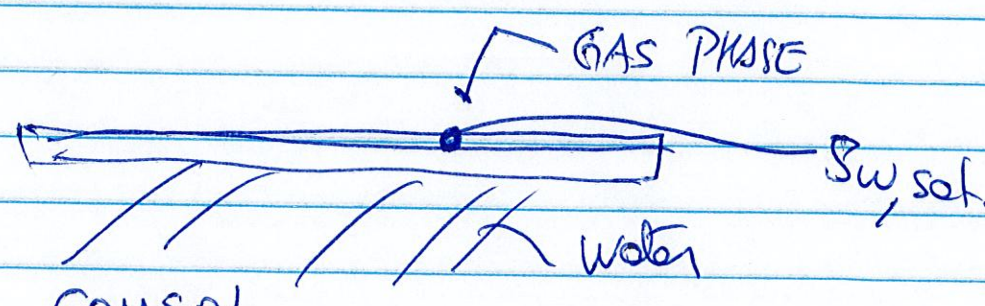


$$q_{w,evap} = h_m A (\rho_{w,sat} - \rho_{w,air})$$

convective mass transfer.

$$RH = \frac{P_w|air}{P_w|sat.}$$

$\rho_w|air.$



COMSOL

if we assume water vapor is an ideal gas.

$$\rho_w = \frac{P_w M_w}{RT}$$