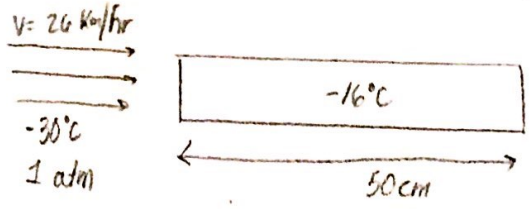
Nusselt Number → Nu Reynold's Number → Re Prandtl Number → Pr

$Nu = \frac{Q_{convection}}{Q_{conduction}} = \frac{hL}{K} > 1$ $Re_x = \frac{\rho V_\infty x}{\mu} = \frac{V_\infty x}{\nu}$ $Pr = \frac{\nu}{\alpha} = \frac{C_p \mu}{K}$

Example

Air at -30°C and 1 atm flows 26km/hr over plate 1 m wide, -16°C. Heat transferred in first 50 cm?



local $Nu_x = 0.332 Re_x^{1/2} Pr^{1/3}$ $Re < 5 \times 10^5$ $0.6 < Pr < 50$

$T_{film} = \frac{T_{wall} + T_\infty}{2}$

$\bar{Nu} = 0.664 Re_L^{1/2} Pr^{1/3}$

T_{film} is average temp used to calculate fluid properties,

$T_{film} = \frac{-16-30}{2} = -23°C = 250K$ → find ν, ρ, K.

$Re_{x=L} = \frac{V_\infty L}{\nu} = \frac{26 km/hr \times \frac{1}{3600} \times 0.5}{11.31 \times 10^{-6}} = 31820$

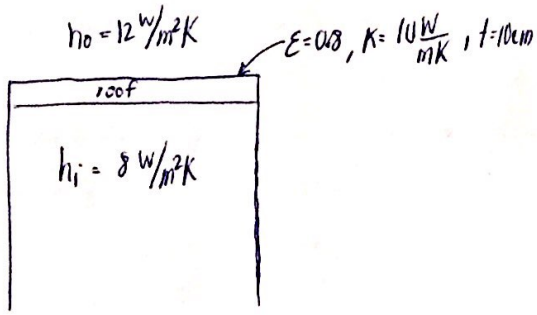
$Pr = 0.722$, ∴ fits limit

$\bar{Nu} = 337$

$\bar{Nu} = \frac{\bar{h}L}{K}$, $\bar{h} = \bar{Nu}\frac{K}{L} = 15 W/m^2K$

$\dot{Q} = 105W$ using $\bar{h}A(T_s - T_\infty)$

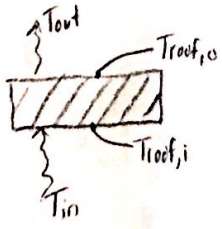
Heat Transfer Example (used on final exam)



Part a) $T_i = 20°C$, $T_{inner\ roof} = 10.74°C$. Effective $T_{out} = 0°C$, what is the temperature of the outside air?

Part b) What is the rate of heat loss due to convection? $Q_{convection} = ?$

Part c) Temperature distribution?

a) 

$h_i(T_{in} - T_{roof,i}) = \frac{K}{t}(T_{roof,i} - T_{roof,o}) = h_o A(T_{roof,o} - T_{out}) + \varepsilon A\sigma(T_{roof,o}^4 - T_{sky}^4)$

$8(20 - 10.74) = \frac{10}{0.1}(10.74 - T_{roof,o})$, $T_{roof,o} = 10°C$

$74.1 = 12(10 - T_{out}) + 0.8\sigma(10^4 - 0^4)$, $\sigma = 5.67 \times 10^{-8}$

$74.1 = 120 - 12T_{out} + 4.536 \times 10^{-8}(\ldots)$

$T_{out} = 7.08°C$

b) $\frac{\dot{Q}}{A} = h_i(T_{in} - T_{roof,i})$

$= 8(20 - 10.74)$