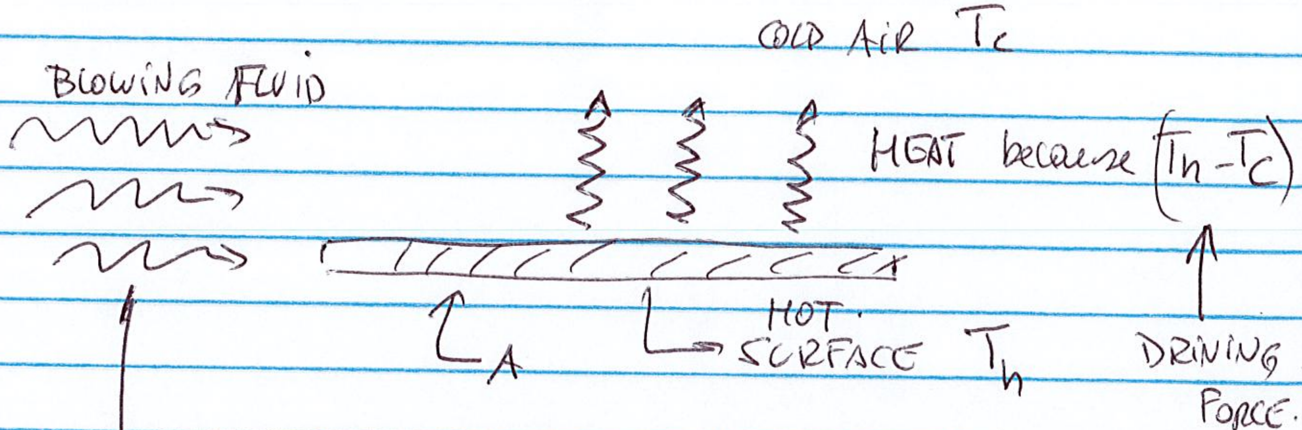
NOTES CLASS 3-22-18

CONCEPT OF BOUNDARY LAYER



$$Q = h A [T_h - T_c]$$

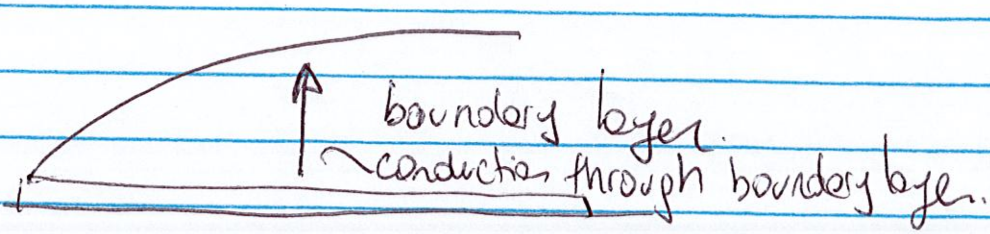
[THIS IS NOT A LAW PHYSICAL LAW]

DRIVING FORCE

Area

PARAMETER THAT DEPENDS ON THE FLOW OF THE FLUID

In order to get h (which is an empirical parameter, let's use what we know about conduction [Reynolds, Nusselt, Prandt]



CONDUCTION THROUGH BOUNDARY LAYER ≡ CONVECTION

MAIN CONCLUSION is (2)

$$\boxed{Nu = f[Re, Pr]} \qquad Pr = \frac{c_p k}{\mu}$$

To know how is the flow governing the boundary layer

FUNCTION HAS MANY FORMS DEPEND ON THE GEOMETRY ["MANY"]

NATURAL CONVECTION

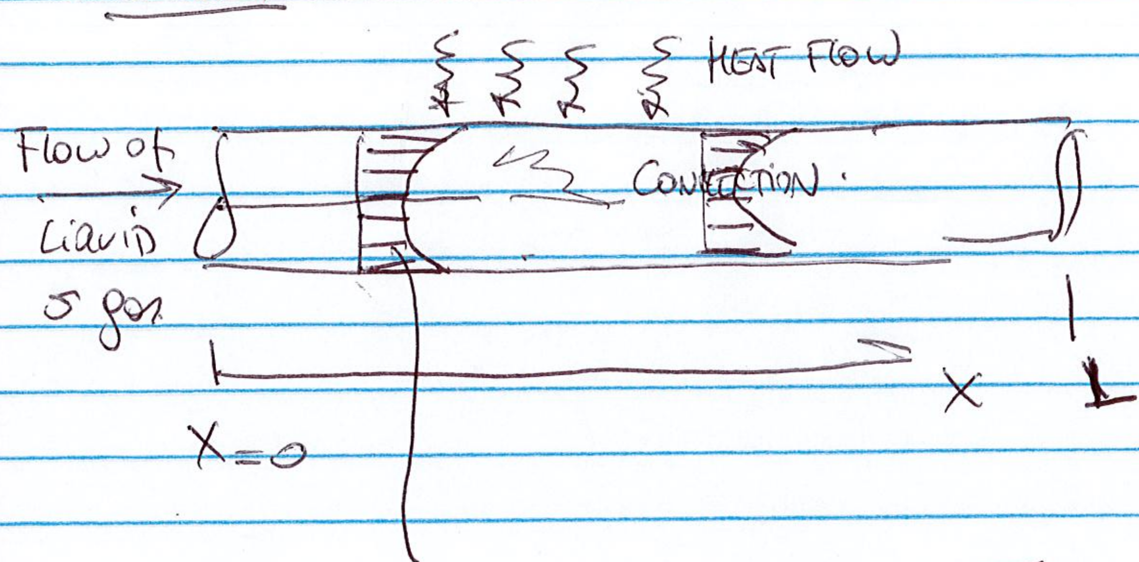
WE HAVE THE RALEIGHT NUMBER Ra

$$Ra = Gr\,Pr$$

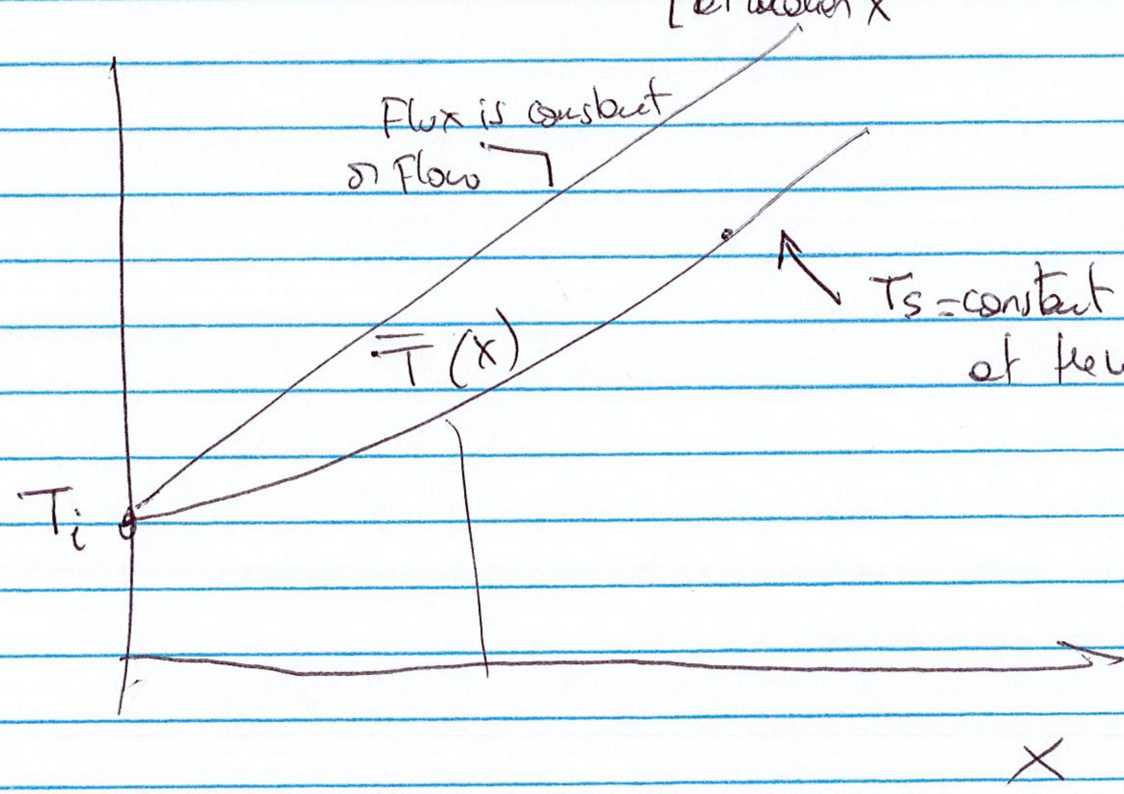
$$\hookrightarrow \beta = -\frac{1}{\rho}\left(\frac{d\rho}{dT}\right)$$

For an ideal gas $\beta = \frac{1}{T}$

Internal Convection



$$T(r,x) \xrightarrow[\text{IN A SECTION [at location } x]]{\text{AVERAGE}} \bar{T}(x)$$



Questions about the Equation in internal Flow

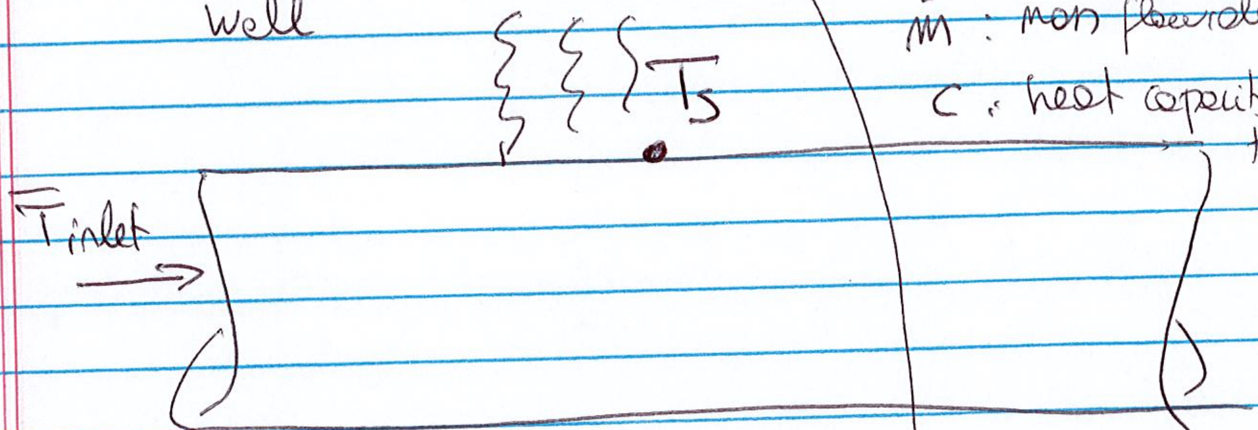
$$\frac{T_s - \bar{T}(x)}{T_s - \bar{T}_{inlet}} = \exp\left[-\frac{P\,x\,U}{\dot{m}\,c}\right]$$

temperature of the well

P: Perimeter of the pipe πD

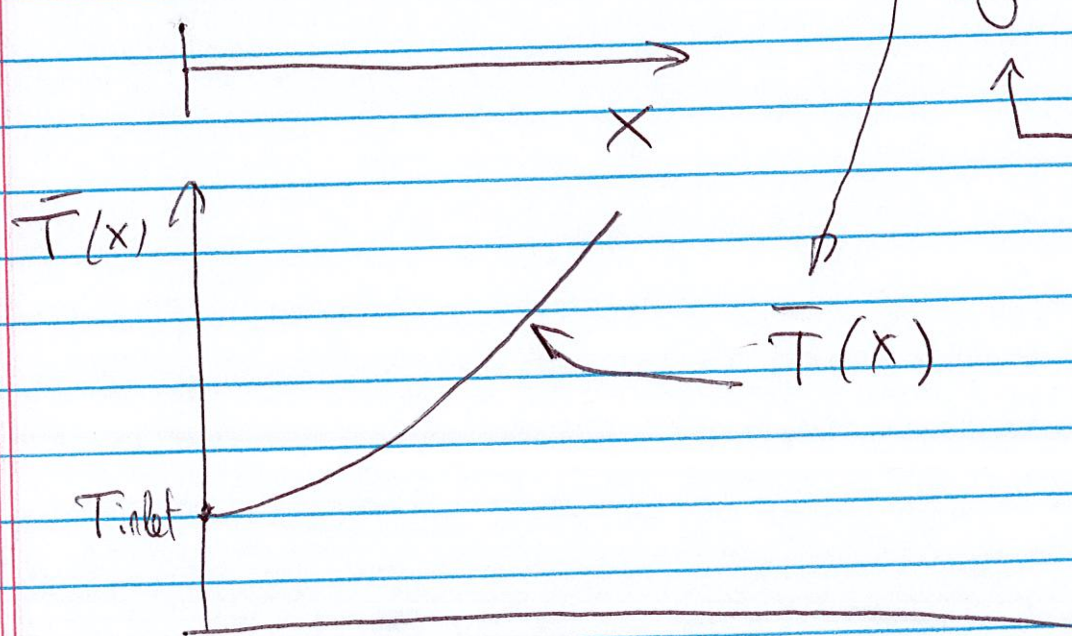
$\dot{m}$: mass flowrate $\left(\frac{kg}{s}\right)$

c: heat capacity of the inside flow



U ?

overall heat transfer coefficient.

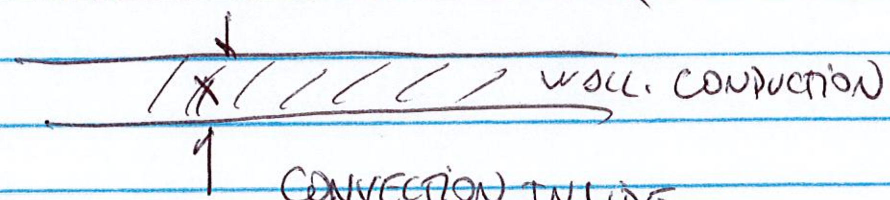


$\frac{1}{U}$ = TOTAL RESISTANCE

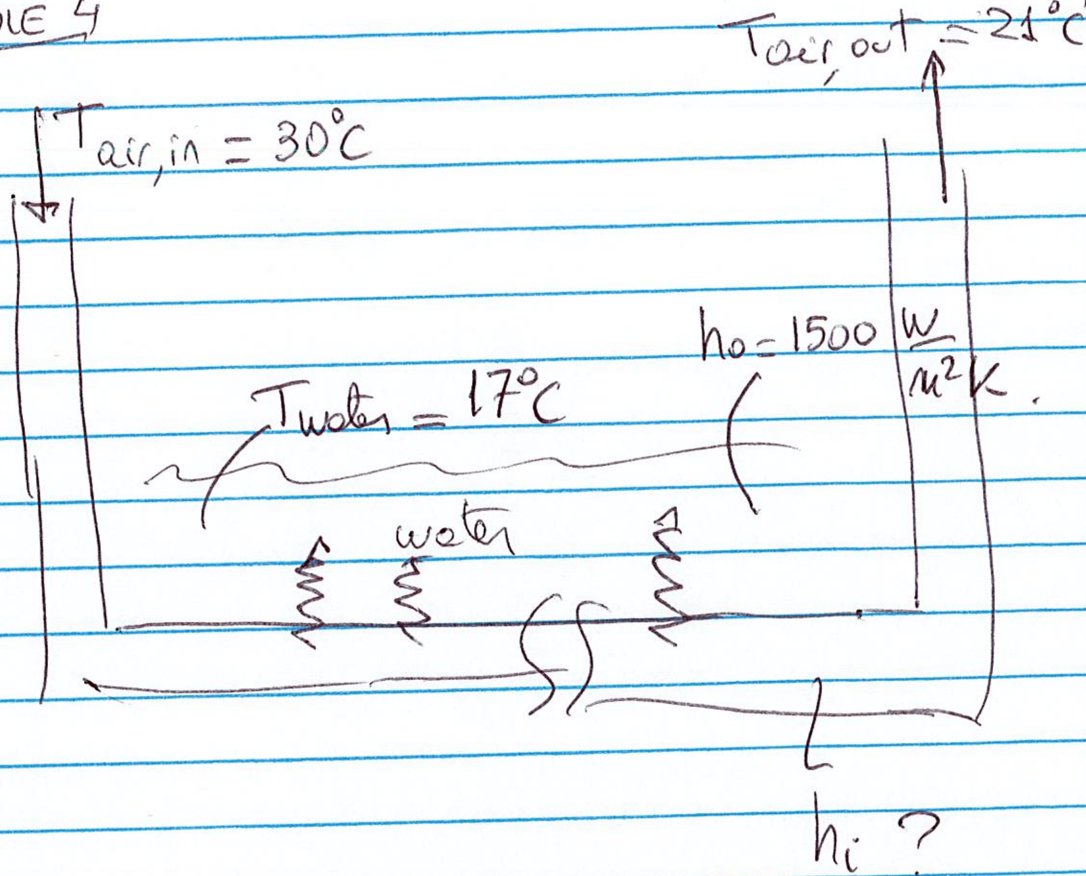
$$\frac{1}{U} = \underbrace{\text{Resistance to convection Outise}}_{\to h_o} + \underbrace{\text{Resistence to conduction through the wall}}_{\to K_{Tube}} + \underbrace{\text{Resistance to convection inside.}}_{\to h_i}$$

Resistance Conve Otis. $\propto \frac{1}{h_o}$ $\qquad \frac{x}{K_{Tube}}$ $\qquad \propto \frac{1}{h_i}$

convection outisede



Example 4



if $\bar{T}(x) = T_{air,outlet}$

$$\frac{T_w - \bar{T}(x)}{T_w - T_{air,inlet}} = \exp\left(-\frac{P \times U \times \overset{\to L}{x}}{\dot{m}c}\right)$$

$$\frac{T_w - T_{air,out}}{T_w - T_{air,inle}} = \exp\left(-\frac{\overset{\pi D}{P} \times \overset{h_i}{U} \times L}{\underset{\dot{V} \times \rho}{\dot{m}C}}\right)$$

we can get L.

to get U we need to know

$h_o = 1500\ W/m^2K$ [convection outside

K and thickness of the tube. [~~convection~~ conduction)

h_i [convection inside]

$$\frac{1}{U} = \cancel{\frac{1}{2\pi r_o L h_o}} + \cancel{\frac{\ln r_o/r_i}{2\pi k_{tube} L}} + \frac{1}{2\pi r_i L h_i}$$

L assume 1m for the time being.