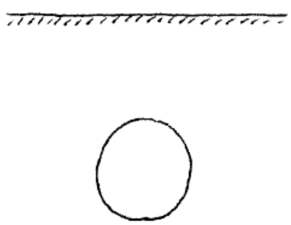
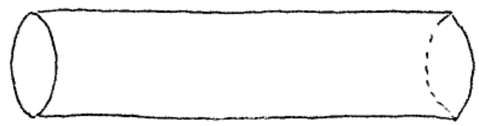
**NOTES: Internal convection**

TWO TYPES OF Flow :
- EXTERNAL ______________________
- INTERNAL ______________________

EXTERNAL



INTERNAL



## INTERNAL FLOW

¿ How does internal flow differ from external flow in terms of boundary layers ?

<u>VELOCITY (MOMENTUM) BOUND. LAYER</u>


<u>THERMAL BOUNDARY LAYER</u>

Do you expect $C_f$ (or $f$) & $Nu$ to be higher in the developing region or the fully developed region? Why?

YOU CAN SEE THAT $V = V(r)$ & $T_{\text{FLUID}} = T(r)_{\text{FLUID}}$ IN THE INTERNAL FLOW CASE. LET US DEFINE, THEN

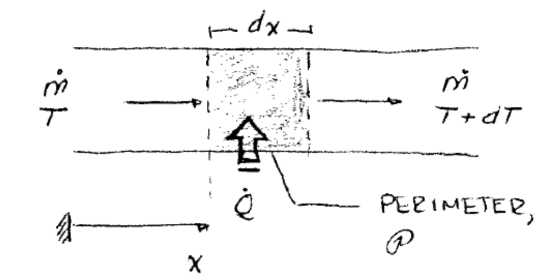
$$\boxed{\dot{m} = \rho V_m A}$$

$$\boxed{\dot{m} c_p T_m = \quad}$$

OUR **GOAL** IS TO FIND $\dot{Q} = hA(T_s - T_m)$

¿ WHAT $T_s - T_m$ DO I USE ?

TAKE A SMALL SLICE of PIPE




Cons of Energy →

$$\frac{dE}{dt} = \dot{Q}_{IN} + \dot{W}_{in} + \sum_{in} \dot{m}(h + \ldots) - \sum_{OUT} \dot{m}(h + \ldots)$$

[EQN 1]

$\dot{q}$ ALSO ⇒ $\dot{q} =$ [EQN 2]

COMBINING [1] & [2]

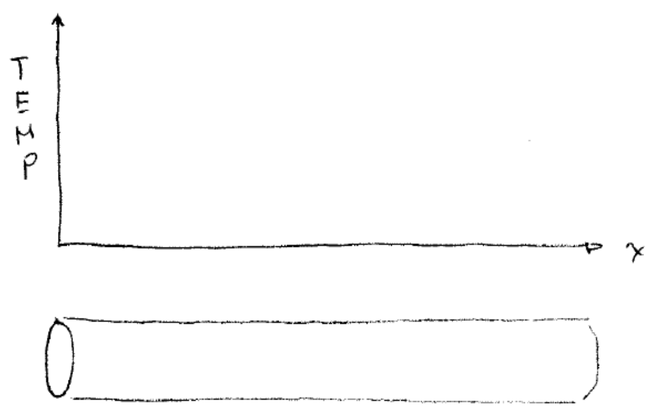
[EQN 3]

$\boxed{\text{CASE 1}}$ $\dot{q} =$ CONST

[1] SAYS

[2] SAYS
(IF $h =$ CONST)

∴




$\dot{q} =$

$\dot{Q} =$

$\dot{q} =$ CONST
BOUNDARY CONDITION

## NOTES: Internal convection

CASE 2 $T_s$ = CONST

[3] SAYS

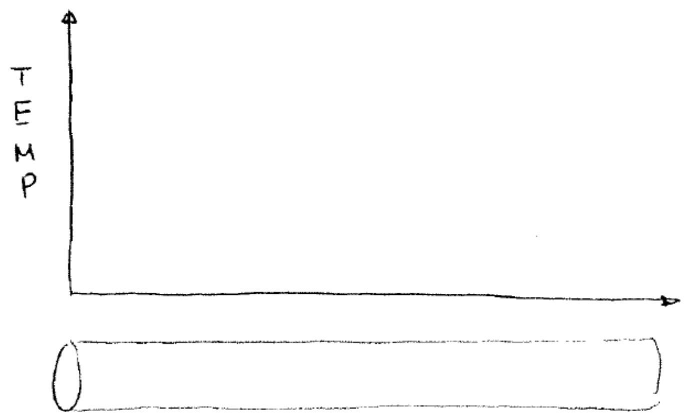
A LITTLE TRICK $dT_m = -\,d(T_s - T_m)$

SO

$\Rightarrow T_m(x) =$

[EQN 5]

$\therefore$

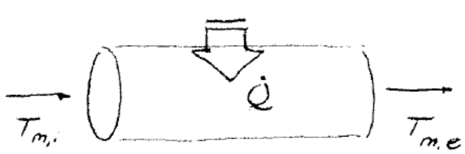



WE SEE THAT $\dot{Q} = hA(T_s - T_m)$ IS A PROBLEM.

LET'S USE $\dot{Q} = hA\,\Delta T_{AVG}$

¿ What is $\Delta T_{AVG}$?

Cons. of Energy on whole tube →




$\dot{Q} =$ [EQN 6]

[5] FOR THE TUBE EXIT (@ X = L) GIVES

[EQN 7]

COMBINE [6] & [7] TO ELIMINATE $\dot{m} c_p$

$$\boxed{\dot{Q} = hA \frac{[(T_s - T_{m,e}) - (T_s - T_{m,i})]}{\ln \dfrac{T_s - T_{m,e}}{T_s - T_{m,i}}}}$$

$$\dot{Q} = hA$$