FORCED CONV. | characteristic length | ALGORITHM | NATURAL CONV.

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

FORCED CONV.

① $Re = \frac{u_\infty L \rho}{\mu}$

L ← characteristic length

ρ, μ ← film (Tables) → physical and thermal properties (Pr, μ, ρ, α, etc)

We know: $Nu = \frac{hD}{k}$

D ← characteristic "length"

Re, Pr (tables)

↓

② $Nu = f(Re, Pr)$

↓

③ $h = \frac{k \cdot Nu}{D}$

NATURAL CONV.

① Grasof #

↓

② $Ra = f(Gr, Pr)$

↓

Ra, Pr (tables)

↓

③ $Nu = f(Ra, Pr)$

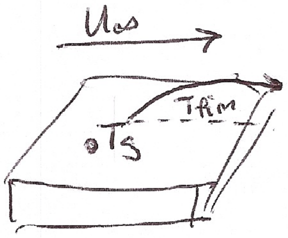
↓

④ $h = \frac{k \cdot Nu}{D}$

$q = h A (T_s - T_\infty)$

↑ h: we have solved for this, the heat (convective) transfer coefficient!

QUESTION ONE



□ Flat plate, forced

$$Re = \frac{u_\infty L \rho}{\mu}$$ $\sqrt{2}$

watch units (ft and m)

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

$$T_{film} = \frac{95+80}{2} = 87.5^\circ F \approx 300K$$

Air properties table =
$\left\{ Pr, \mu, \rho \right.$ @ 300K

Compare laminar or turbulent

(if laminar)

$$Nu_L = 0.664 Re_L^{\frac{1}{2}} Pr^{\frac{1}{3}}$$

$(Re < 2400)$ * could be turbulent, I did not calc. Re.

$$Nu_L = \frac{h_{air} L}{K_{air}}$$

→ solve for h_{air}

~~$q = h_{air} A (T_s - T_\infty)$~~ only asked for h

QUESTION TWO

↑ see above, similar solution

$q = h_{air} A (T_s - T_\infty)$ = heat flow [watts]

REMEMBER:

$q'' = \text{flux} = \frac{q}{A} \left[\frac{\text{watts}}{m^2}\right]$

$q'' = h_{air} (T_s - T_\infty)$

If you have start and end temp. → Log mean $\Delta T = \dfrac{\Delta T_{out} - \Delta T_{in}}{\ln\left(\frac{T_{out}}{T_{in}}\right)}$ QUESTION THREE

We have T_s and T_w, so use T_{film}. → $\dfrac{T_s + T_w}{2}$

T_{film} → Thermal and physical properties of water
Pr, ρ, μ

$$Re = \frac{(0.2\frac{kg}{s})(0.02m)(\rho)}{\mu}$$

This case heating
$n = 0.4$

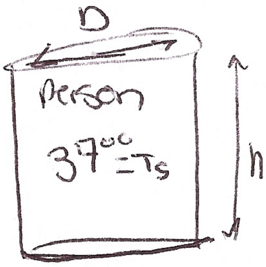
Re → turbulent or laminar
if ~~turbulent~~ (guessing) *did not actually check Re #

$$Nu_{,D} = 0.023 Re_D^{\frac{4}{5}} Pr^{n} \leftarrow 0.4$$

$$Nu_{,D} = \frac{hD}{k}$$

$$q'' = h(T_s - T_{water})$$

QUESTION FOUR



a) Forced, over cylinder

Use $T_{film} = \frac{T_s + T_\infty}{2}$ → tables

$$Nu_{,D} = B\, Re_{,D}^{\,n} Pr^{\frac{1}{3}}$$

Driving force, notice no T_{film}!

$$q = hA\underbrace{(T_s - T_\infty)}_{(T_H - T_C)}$$

b) Natural convection, over cylinder

$$\beta \equiv \frac{1}{T_{film}}$$

defined in slides! also in book; book is very helpful.

- Be careful about characteristic length.