Part - A

1. Fourier's law states that "the negative gradient of temperature and the time rate of heat transfer is proportional to the area at right angles of that gradient through which the heat flows."

2. Law of Thermal conductivity states "that the rate at which heat is transferred through a material is proportional to the negative of the temperature gradient and is proportional to the area through which the heat flows."

3. Newton's law of cooling states that the rate at which an object cools is proportional to the difference in temperature between the objects and the object's surroundings.

. When convection takes place due to buoyan force as there is a difference in densities caused by the difference in temperature it i knowns as natural convection
Eg: Oceanic winds.

5. (i) The Reynolds number is the ratio of inertial forces to viscous forces.

(ii) The Prandtl number is a dimensionless quantity that puts the viscosity of a fluid in correlation with the thermal conductivity.

Part - B.

a) Given :

fluid temperature, $T = 20°c$,

Velocity, $U = 3 m/s$.

wide, $W = 1m$.

Surface temperature, $T_w = 80°c$.

Distance, $x = 300mm, = 0.3 m$.

Solution,

w.k.t.

film temperature, $T_f = \frac{T_w + T_\infty}{2}$

$= 80+20/2$

$T_f = 50°c$.

Properties of air at 50° c.

Density $\rho = 1.093 \ kg/m^3$.

Kinematic viscosity, $\nu = 17.95 \times 10^{-6}\ m^2/s$.
Prandtl number, $Pr = 0.698$.
Thermal conductivity, $k = 28.96 \times 10^{-3}\ W/m\text{-}K$.

W.K.T.

Reynolds number $Re = VL/\nu$

$$= \frac{3 \times 0.3}{17.95 \times 10^{-6}}$$

$$Re = 5.01 \times 10^{4} < 5 \times 10^{5}$$

Since $Re < 5 \times 10^5$, flow is laminar.

for flat plate, laminar flow,

1. Hydrodynamic boundary layer thickness:

$$\delta_{hx} = 5 \times x \times (Re)^{-0.5}$$

$$= 5 \times 0.3 \times (5.01 \times 10^{4})^{-0.5}$$

$$\delta_{hx} = 6.7 \times 10^{-3}\ m.$$

2. Thermal boundary layer thickness:

$$\delta_{tx} = \delta_{hx} (Pr)^{-0.333}.$$

$$= \delta_{Tx} = (6.7 \times 10^{-3})(0.698)^{-0.333}$$

$$\delta_{tx} = 7.5 \times 10^{-3}\ m.$$

3. Local friction coefficient:

$$C_{fx} = 0.664 (Re)^{-0.5}$$

$$= 0.664 (5.01 \times 10^{4})^{-0.5}$$

$C_{fx} = 2.96 \times 10^{3}$

4. Average friction co-efficient

$\overline{C_{fL}} = 1.328\,(Re)^{-0.5}$

$= 1.328\,(5.01 \times 10^{4})^{-0.5}$

$= 5.9 \times 10^{-3}$

$\overline{C_{fL}} = 5.9 \times 10^{-3}$

5. Local heat transfer coefficient (h_x):

Local Nusselt Number.

$Nu_x = 0.332\,(Re)^{0.5}\,(Pr)^{0.333}$.

$Nu_x = 0.332\,(Re)^{0.5}\,(Pr)^{0.333}$.

$= 0.332\,(5.01 \times 10^{4})\,(0.698)^{0.333}$

$Nu_x = 65.9$.

W.K.T,

Local Nusselt Number

$Nu_x = h_x \times L / k$.

$65.9 = \dfrac{h_x \times 0.3}{23.26 \times 10^{-3}}$ $[\because x = L = 0.3m]$

$h_x = 6.20\ W/m^2K$.

Local heat transfer co-efficient $h_x = 6.20\ W/m^2K$

6. Average heat transfer co-efficient (h)

$h = 2 \times h_x = 2$ $h = 2 \times h_x = 2 \times 6.20$.

$h = 12.41\ W/m^2K$

7\. Heat transfer,

W.K.T,

$$Q = hA(T_w - T_\infty)$$

$$= 12.41 (1 \times 0.3)(80-20)$$

$$Q = 223.38 \text{ Watts.}$$

8\. ~~overall drag co-efficient~~

$$\cancel{\overline{C_n} = 1.328 \times (Re)^{-0.5}}$$

$$\cancel{5.9 \times 10^{-3} = 1.328 \times (5.01 \times 10^4)^{-0.5}}$$

$$\cancel{= 0.0059 - 5.9 \times 10^{-3}}$$

$$\cancel{= 0.}$$

8\. Dracy force

$$F_D = A \times \bar{\tau}$$

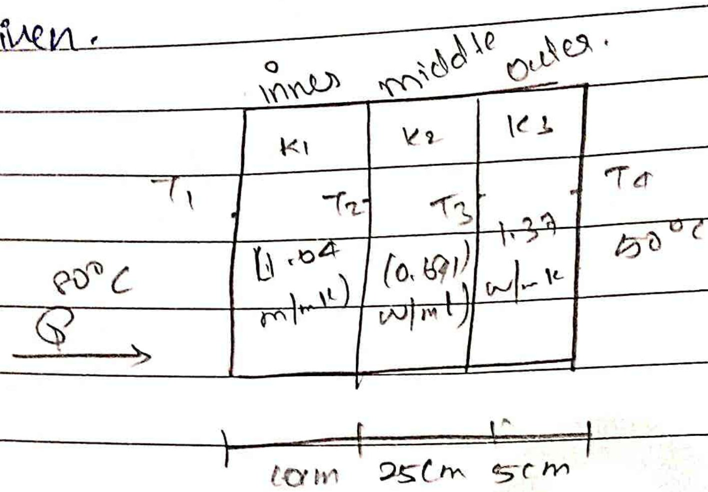
$$= 0.3 \times 0.028.$$

$$F_D = 8.4 \times 10^{-3}\ N$$

Part-C.

13. Given.

(a)



$K_1 = 1.04$ W/mK

$K_2 = 0.09$ W/mK

$K_3 = 1.37$ W/mK

$L_1 = 10cm$

$L_2 = 25$ cm.

$L_3 = \cancel{25}\,5$ cm.

$T_1 = 800 + 273 = 1073$ K

$T_4 = 50 + 273 = 323$K.

To find

1) Thermal resistance

2) Heat flow.

3) Inner face temperature

Solution:

$$Q = \Delta T / R$$

$$R = \frac{1}{A}\left[\frac{1}{h_a} + \frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{L_2}{k_3} + \frac{1}{h_b}\right]$$

$$Q = \frac{\Delta T}{R} = \frac{(T_1 - T_4)}{\frac{1}{A}\left[\frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{L_3}{k_3}\right]}$$

$$\frac{Q}{A} = \frac{T_1 - T_4}{\frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{L_3}{k_3}}.$$

$$= \frac{1073 - 323}{\frac{0.1}{1.04} + \frac{0.25}{0.69} + \frac{0.05}{1.37}}$$

$$= \frac{750}{0.0962 + 0.36 + 0.0365}$$

$$\boxed{\frac{Q}{A} = 1522.22 \ W/m^2}$$

Thermal Resistance (R)

$$R = R_1 + R_2 + R_3$$

C_A = per meter^2 (so A = 1m^2)

$$R = \frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{L_3}{k_3}.$$

$$R = \frac{0.1}{1.04} + \frac{0.25}{0.69} + \frac{0.05}{4.57}$$

$$= 0.0962 + 0.36 + 0.0365$$

$$\boxed{R = 0.4927 \ K/W}$$

Inner face temperature

($T_2 = ?$, $T_3 = ?$)

$$Q/A = \frac{\Delta T}{R} = \frac{T_1 - T_4}{R} = \frac{T_1 - T_2}{R_1} = \frac{T_2 - T_3}{R_2} = \frac{T_3 - T_4}{R_3}$$

$$Q/A = \frac{T_1 - T_2}{R_1} = \frac{T_1 - T_2}{[L_1/k_1]}$$

$\cancel{15.22}$ $1522.22 = \frac{1073 - T_2}{0.0962}$

$T_2 = (1522.22 \times 0.0962) - 1073$

$T_2 = 926.56k$

$Q/A = T_2 - T_3 / R_2$

$1522.22 = 926.56 - T_3 / L_1/k_2$

$1522.22 = 926.56 - T_3 / 0.36$

$T_3 = 378.56k.$