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Q 1

Part (a) Expression for velocity profile in laminar flow:.

As we have

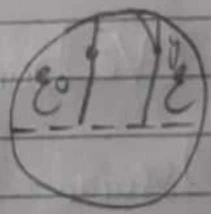
$$h_L = \frac{\tau \cdot 2L}{\xi r}$$

From viscosity $\Rightarrow \tau = \mu \frac{du}{dy}$ — ⓧ

Where "u" is velocity at distance "y" from the boundary.

Thus,

$$y = \xi_0 - \xi$$



$$dy = d\xi_0 - d\xi$$

$$dy = -d\xi$$

Putting value in ⓧ $\quad\because d\xi_0$ constant value

$$\tau = -\mu \frac{du}{d\xi}$$

Now, $h_L = \frac{\tau \cdot 2 \cdot L}{\xi r} \cdot \xi\, dr$

Integrating on b/s

$$\int du = \int -\frac{h_L r}{2\mu L} \cdot \xi \cdot d\xi$$

$$u = -\frac{hLr}{2\mu L} \cdot \frac{\xi^2}{2} + C$$

Now for $\xi = 0$, $u = u_{max}$

Putting value

$$u = -\frac{hLr}{2\mu L} \cdot \frac{\xi^2}{2} + C$$

$$u = u_{max}, \quad u_{max} = 0 + C$$

$$C = u_{max}$$

Thus, $u = u_{max} - \frac{hLr}{2\mu L} \cdot \frac{\xi^2}{2}$

(Velocity at any point)

Assume $k = \frac{hL \cdot r}{4\mu L}$ $\therefore u = u_{max} - k\xi^2$

As for $\xi = \xi_0$, $u = 0$

$$0 = u_{max} - k\xi_0^2$$

$$u_{max} = k\xi_0^2 \quad \text{or} \quad = \frac{hLr}{4\mu L} \cdot \xi_0^2$$

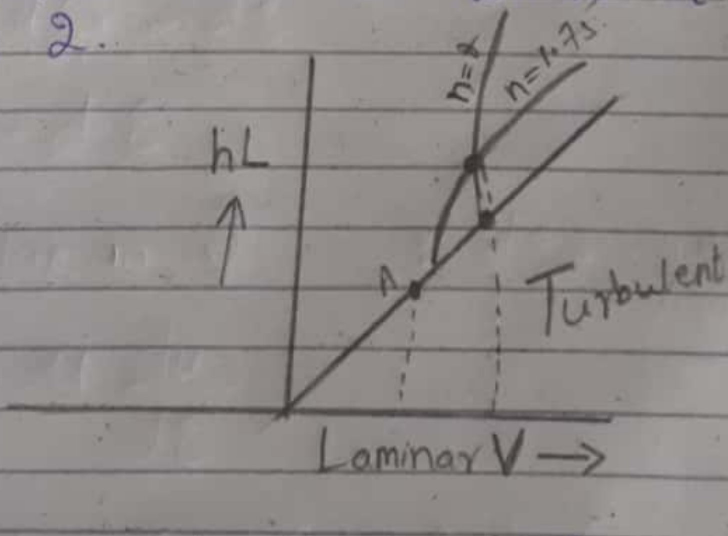
(It is also known as critical velocity)

Now,

$$V_{av} = \frac{V_c \xi + 0}{2} = \boxed{0.5 V_{c\xi}}$$

Q 1
Part B **Critical Reynold's Number:-** If head loss in given length of uniform pipe is measured at different value of velocity, It will found that as long as velocity is low enough to secure laminar flow, The head loss due to friction will be directly proportional to velocity, but increase in velocity change flow from laminar to turbulent cause change in head loss. Thus if values are plotted, lines obtained with slope changing about 1.75 to 2.

Thus for laminar, drop of energy varies as V and for turbulent, friction varies as V^n where n is 1.75 to 2.



The upper critical Reynold's number corresponding to point B is indeterminate and depends upon care taken to prevent initial disturbance. Its value is 4000 But normally, Its impossible for flow to be in

Straight line after R is at 9000. Thus lower Value is much more definite than higher one and is dividing point. Thus lower Value is true critical Reynold number.

Equation:-

$$R = \frac{D v_{cr}}{\nu}$$

Q 2

Given data:.

Oil having $S = 0.7$

Kinematic Viscosity $= 1.8 \times 10^{-5}\ m^2/sec$

Dia of pipe $= 150mm = 0.15m$

Flow $= 0.5\ L/sc = 0.0005\ m^3/sec$

Required data:-

Centerline velocity = ?
Velocity at 10mm from edge = ?
Velocity at edge of pipe = ?
Max shear stress at well = ?

Solution:-

first we will check flow is laminar or turbulent

$$R = \frac{DV}{\nu} \quad \text{— (i)}$$

$$V = Q/A = \frac{Q}{\frac{\pi}{4}d^2} = \frac{0.0005}{\frac{\pi}{4}(0.15)^2}$$

$$V = 0.028\ m/sec$$

$$R = \frac{(0.15)(0.028)}{1.8 \times 10^{-5}}$$

P#06

$R = 233.33 < 2000$ (laminar)

$V_{cr} = 2V = 2 \times 0.028$

$V_{cr} = 0.056$ m/sec

As;

$$u = u_{max} - K r^2$$

$$r = r_0 = 0.075m, \; u = 0$$

Thus,

$$u = u_{max} - K r^2$$

$$u_{max} = K r^2$$

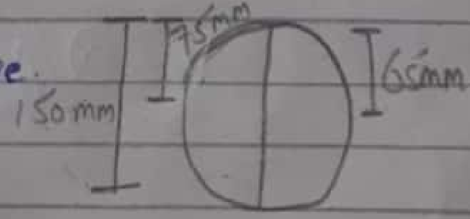
$$K = u_{max}/r^2 = \frac{0.056}{(0.075)^2}$$

$$K = 9.96 \; m^2 . sec/m$$

We get a equation;

$$u = 0.056 - 9.96 (r^2) \quad (*)$$

Velocity at 10mm from edge.



$r = 0.065m$

$V = 0.056 - 9.96 (0.065)^2$

$V = 0.014$ m/sec

P#07

Velocity at edge;

$r = 0.075\,m$

$V = 0.056 - 9.96\,(0.075^2)$

$V = -0.00002\ m/sec$ Say, $V = 0$

Similarly:-

$f = \frac{64}{R} = \frac{64}{233.33}$

$f = 0.27$

Shear stress at wall;

$\tau = \frac{f}{4}\,\rho\,\frac{V^2}{2}$

$= \frac{0.27}{4} \times (0.7 \times 1000) \times \frac{(0.056)^2}{2}$

$\boxed{\tau = 0.074\ N/m^2}$ Answer

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