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Section	A
Paper	Advance Fluid Mechanics

QNo.1): (a)

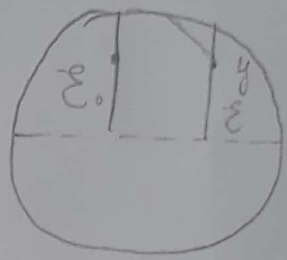
Ans: velocity profile For laminar Flow:

As we have

$$h_L = \frac{\tau . 2L}{\varepsilon \gamma}$$

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

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



Thus $y = \varepsilon_0 - \varepsilon$

$$dy = \cancel{d\varepsilon_0}^{\,0} - d\varepsilon$$

$$dy = -d\varepsilon$$

$\because d\varepsilon_u$ is constant value.

putting value in (x)

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

Now $h_L = \frac{\tau . 2 . L}{\varepsilon \gamma} . \varepsilon d\gamma$

Integration on both side

$$\int du = \int -\frac{h_L \gamma}{2\mu L} . \varepsilon . d\varepsilon$$

$$u = \frac{-h_L \gamma}{2\mu L} . \frac{\varepsilon^2}{2} + c$$

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

putting values

$$u = \frac{-h_L \gamma}{2\mu L} . \frac{\varepsilon^2}{2} + c$$

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

$C = u_{max}$

Thus $u = u_{max} - \frac{hL\gamma}{2\mu L} \cdot \frac{\varepsilon^2}{2}$

(velocity at any point)

Assume $K = \frac{hL \cdot \gamma}{4\mu L} \cancel{= \frac{hL\gamma D^2}{16\mu L}}$ ∴ $u = u_{max} - K\varepsilon^2$

As for $\varepsilon = \varepsilon_0$, $u = 0$

$0 = u_{max} - K\varepsilon_0^2$ or

$u_{max} = K\varepsilon_0^2 = \frac{hL\gamma}{4\mu L} \cdot \varepsilon_0^2 = \frac{hc\gamma \cdot D^2}{16\mu L}$

(It is also know as critical velocity.)

$V_{av} = \frac{V_c\varepsilon + 0}{2} = 0.5\, V_c\varepsilon$

↓

average velocity

$= \frac{hL\gamma \cdot D^2}{32\mu L}$ As $\gamma = \rho g$, $\mu/\rho = \nu$

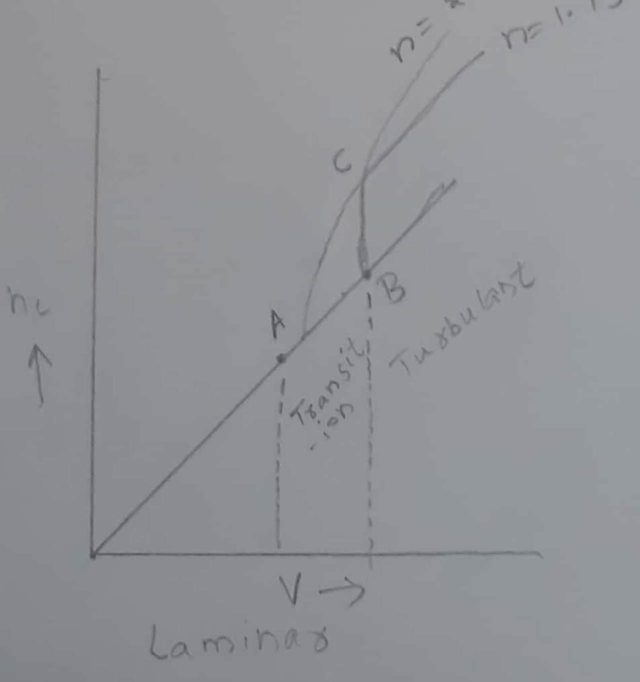
$\Rightarrow \frac{32\mu L V}{\rho g \cdot D^2} = \frac{32\nu L}{gD^2} V$

QNo. 1):

(b):

Ans): Critical Reynold Number: If head loss in given length of uniform pipe is measured at different values 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 turbulant cause change in head loss. Thus if values are plotted, lines obtained with slop ranging 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 reynolds number corresponding to point B is indeterminate and depend upon case taken to prevent initial disturbance. Its value is 4000. But normally, its impossible for flow to be in straight after R is at 2000. Thus lower value is mush more definite than higher one and is dividing point. Thus lower value is true critical Reynold number.

$$\boxed{R = \frac{D V_{cr}}{\nu}}$$

QNO.2):

Solution:

Specific Gravity (s) = 0.7

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

Dia of pipe = 150mm = 0.15 m

Flow = 0.5 L/sec = 0.0005 m^3/sec

First we check flow is laminer or Turbulent

$$R = \frac{DV}{\nu} \quad \text{—— (1)}$$

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

$$V = 0.028\ m/sec$$

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

$$R = 233.33 < 2000 \text{ (laminar}$$

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

$$V_{cr} = 0.056\ m/sec$$

AS

$$u = u_{max} - Kr^2$$

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

Thus $\cancel{u}^{0} = u_{max} - Kr^2$

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$U_{max} = K r^2$

$K = \dfrac{U_{max}}{r^2} = \dfrac{0.056}{(0.075)^2}$

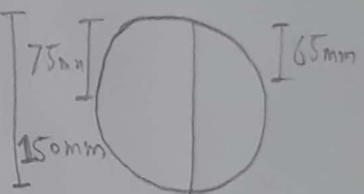
$K = 9.96$

we get an equation

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

velocity at 10mm from edge

$r = 0.065m$



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

$V = 0.014\ m/sec$

velocity at edge;

$r = 0.075m$

$V = 0.056 - 9.96(0.075)$

$V = -0.0002\ m/sec$ Say $V = 0$

Similarly

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

$f = 0.27$

Shear stress at wall;

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

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

$\tau = 0.074\ N/m^2$

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