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Summer final Term Exam

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Question No 01

Part A:-

Drag:-

Drag force exerted by a fluid stream on any obstacle in its path or felt by an object moving through a fluid. Its magnitude and it may be reduced are important to designers of moving vehicles, ships, suspension bridges and other structures. Drag force are conventially described by a drag co-efficient. Dimensional analysis reveals that the drag co-efficient depends on the reynolds number.

Components of Drage:

There are two components:

1) pressure Drag:-

Is the part of the Drag that is due directly to the pressure on an object. pressure drag is a function of the magnitude of the pressure and the orientation of the surface element on which the pressure force acts. For example the pressure force on either side of a flat plate parallel to the flow may be very large, but it doesnot contribute to the drag because it acts in the direction normal to the upstream velocity, thus the pressure force on a flat ~~parallel~~ normal to the flow provides the entire drag.

Friction Drag

friction Drag is that part of the drag that is due directly to the shear stress on the object. It is a function of not only the magnitude of the wall shear stress but also of the orientation of the surfaces on which it acts. The friction drag on a flat plate of width 'b' and length 'l' oriented parallel to the upstream flow.

$$D_f = \frac{1}{2} \rho v^2 b l \, C_{Df}$$

where

C_{Df} is the friction drag coefficient

Most objects are not flate plates parallel to the flow, instead they have curved surfaces along which the pressure varies.

Laminar flow:

The type of fluid flow in which the fluid travels smoothly or in regular paths, in which the fluid undergoes irregular fluctuations and mining. The Laminar flow sometime called stream line flow. The velocity, pressure and other flow properties at each point in the fluid remain constant.

Equation for friction Drag coefficient laminar-

$$\delta = \frac{4.91}{\sqrt{R_x}} \cdot x$$

$$\tau_0 = 0.332 \frac{\mu V}{x} \sqrt{R_x}$$

~~$C_f = 1.328 \sqrt{\quad}$~~

$$C_f = \frac{1.328}{\sqrt{R_x}}$$

$$F_f = C_f \cdot \rho \frac{U^2}{2} \times BL$$

$\therefore R \leq 500,000$ for Laminar Boundry Layer.

$$F_f = 0.664\, B \sqrt{\rho \mu L v^3}$$

where

F_f = friction drag or friction force.

C_f = coefficient of friction.

δ = thickness of boundry layer

τ_0 = Maximum shear stress.

Turbulent flow:

The type of fluid flow in which the fluid undergoes irregular fluctuation, or ~~undergoes~~ mixing. in contrast to Laminar flow in which the fluid moves in smooth paths or layer. In turbulent flow the speed of the fluid at a point is continiously under going changes in both magnitude and direction.

Equation for tubulent flow: Boundry Layer

$$F_f = C_f \cdot \rho \cdot \frac{V^2}{2} \times BL$$

$$C_f = \frac{0.0735}{R^{1/5}}$$

$$C_f = \frac{0.455}{(\log R)^{2.58}}$$

$$\delta = \frac{0.377}{(Rx)^{1/5}} \cdot x$$

$$\tau_0 = 0.0587 \rho \frac{v^2}{2} \left(\frac{\gamma}{vx}\right)^{1/5}$$

$\therefore$ $(500000 < R < 10^7)$

$(10^7 < R)$

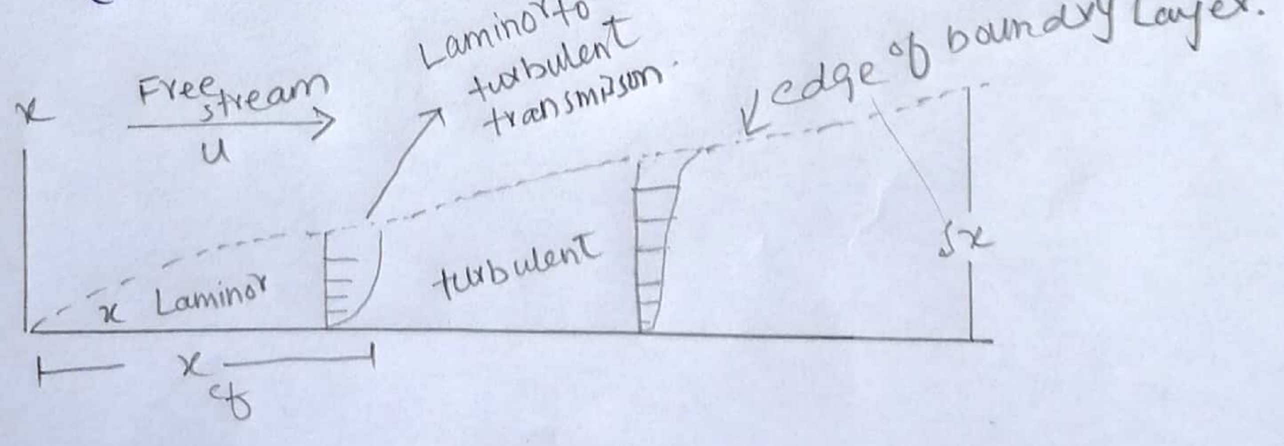
where

F_f = friction drag

c_f = co-efficient of friction

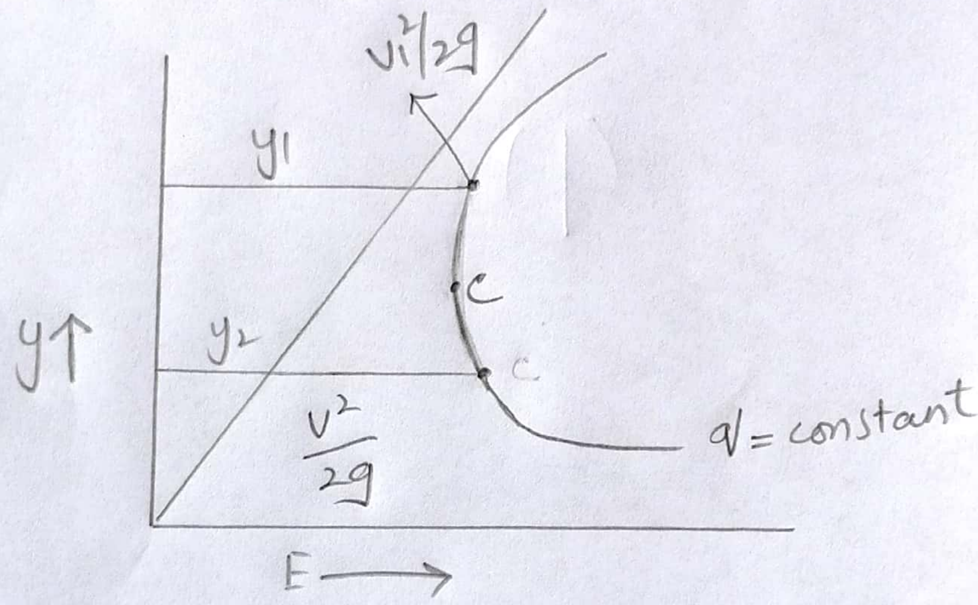
δ = thicknes of boundry layer

τ_0 = Maximum shear stress.



Question No 1 (part B)

Derive equation for critical depth critical velocity of rectangular section of a channel.



So this is the specific energy equation diagram,

For particular q, there will be two kind of possible values of 'y' for given 'E'. The equation is cubic with three rods with third being negative giving no values.

Thus two alternative depths represents two totally different flow regimes- slow & deep on upper portion & Fast and Shallow on lower portion.

Point represent dividing point b/w two regima of flow thus for given 'q' value 'E' is minimum and flow at this point is critical flow. Depth of flow at this point is critical depth y_c and velocity at this point is critical velocity.

Thus relation of critical depth can be found as.

$$E = y + \frac{1}{2g}\left(\frac{q^2}{y^2}\right)$$

For minimum specific energy

$$\frac{dE}{dy} = 0$$

$$\frac{dE}{dy} = 1 - \frac{2}{2g}\left(\frac{q^2}{y^3}\right)$$

$$\frac{dE}{dy} = 1 - \frac{q^2}{gy^3}$$

$$1 = \frac{q^2}{gy^3} = q^2 = gy^3$$

$$y_{cr} = \left(\frac{q^2}{g}\right)^{1/3} \text{ critical depth}$$

As $q = vy$, $v_c^2 = gy^3$

OR $\boxed{v_c = gy_c}$ → critical velocity

$$y_c = \frac{v_c^2}{g}$$

Now $$\frac{y_c}{2} = \frac{v_c^2}{2g}$$

$$E_{min} = y_c + \frac{v_c^2}{2g} = y_c + \frac{y_c}{2}$$

$\frac{3}{2} y_c$ OR $y_{cR} = \frac{2}{3}$ cons.

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	Sub critical	Critical	Super critical
Depth of flow	$y > y_c$	$y = y_c$	$y < y_c$
Velocity	$V < V_c$	$V = V_c$	$V > V_c$
Slope	mild slope $S_o < S_c$.	critical slope	steep slope $S > S_o$

Question No 02

Given data:-

Depth of rectangular channel (d) = ?

Flow rate (Q) = $3.5\ m^3/sec$

$n = 0.0219$

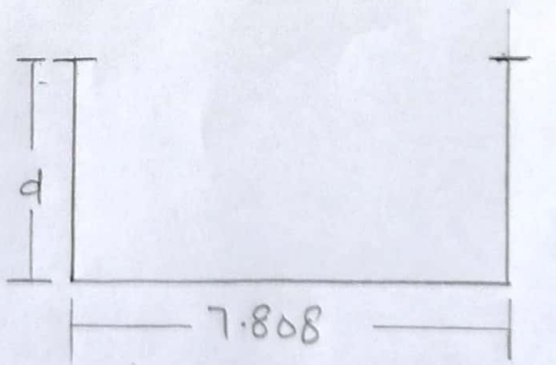
Critical depth (y_{cr}) = ?

Flow sub-critical or super-critical = ?

width of bed (B) = 7808m = 7.808 m

Slope of channel bed (S_o) = 0.0008

Solution:-



Area = $7.808 \times d$

$= 7.808\,d$

Perimeter $= d + 7.808 + d$

$$P = \boxed{2d + 7.808}$$

Now

Hydraulic Radius (R_N) $= A/P$

$$= \frac{7.808\,d}{2d + 7.808}$$

Now with the help of using Manning's Equation.

$$Q = \frac{1}{n} A \, R_h^{2/3} \cdot S_o^{1/2}$$

$$3.5 = \frac{1}{0.0219} \times 7.808\,d \times \left(\frac{7.808\,d}{2d+7.808}\right)^{2/3} \times (0.0008)^{1/2}$$

$$\boxed{d = 0.55\ m}$$

Now find area

$$\text{area} = 7.808\,(0.55)$$

$$= \boxed{4.294\ m^2}$$

(8) Perimeter $= 7.808 + 2(0.55)$

$= $ ~~[illegible]~~ $\boxed{8.91\ m^2}$

Hydraulic Radius $= \dfrac{4.294}{8.91} = \boxed{0.481 m}$

Now to find critical depth:

$$y_{cr} = \left(\frac{q^2}{g}\right)^{1/3}$$

As $q = Q/B$

$= 3.5/7.808$

$= \boxed{0.45\ m^2/sec}$

$$\Rightarrow y_{cr} = \left(\frac{(0.45)^2}{9.81}\right)^{1/3}$$

$= \boxed{0.274\ m}$

So

As we know that

As $y > y_{cr}$

$0.55 > 0.274$

So it is known as sub-critical flow.

Critical velocity:

$$V_{cr} = \sqrt{g \times h_{cr}} = \sqrt{9.81 \times 0.27}$$

$$\boxed{V_{cr} = 1.62\ m/sec}$$

Question No 03

Given data

Friction Drag $(F_D) = ?$

width $(B) = 200mm = 0.2m$

specific gravity $(S) = 0.89$

Kinematic viscosity $(\nu) = 0.93 \times 10^{-4} m^2/sec$

length $(L) = 800mm = 0.8m$

undisterbed velocity $(\nu) = 5m/sec$

Solution:

we will first to check the flow whether flow is laminour or turbulent by the help of reynold number

$$R = \frac{DV}{\nu}$$

For smooth flate plate

$D = L$, $V = U$

So

$$R = \frac{LU}{\nu}$$

$$= \frac{0.85 \times 5}{0.93 \times 10^{-4}} = \boxed{43010}$$

$43010 < 500{,}000$

So the flow is Laminar

By using formula

$$F_f = C_f \cdot \rho \cdot \frac{V^2}{2} \cdot BL$$

where

$$C_f = \frac{1.328}{\sqrt{R}} = \frac{1.328}{\sqrt{43010}} = \boxed{0.0064}$$

Now

$$S = \frac{\rho_{oil}}{\rho_{water}} \Rightarrow 0.89 = \frac{\rho_{oil}}{1000}$$

$$\rho_{oil} = 0.89 \times 1000$$

$$\rho_{oil} = 890 \ kg/m^3$$

$$\Rightarrow F_f = C_f \cdot \rho \cdot \frac{v^2}{2} \cdot BL$$

putting the values

$$= 0.0064 \times 890 \times \frac{(5)^2}{2} \times 0.2 \times 0.8$$

$$\boxed{F_f = 11.39\ N}$$