Final term Summer-20

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ID — 7807

Subject — Adv. Fluid Mechanics

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Q: 1 | Part A |

Define Drage & its component:-

Drage:-

Any object moving through a fluid will experience a drag, a net force in the direction of flow due to the pressure and shear forces on the surface of the object. This net force a combination of flow direction component of the normal and tengential forces on the body.

Component of Drags—

There are two component of Drag.

1. Friction Drag
2. Pressure Drag.

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1) Friction Drag:- F_D :-

This is the part of the drag that is due directly to the Shear stress τ on the object. It is a function of not only the magnitude of the wall shear stress but also of the orientation of the surface on which it acts.

OR

It is equal to integration of component of shear stress along to surface of the body in direction of motion.

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

where C_f = Coefficent of friction drag which is depend on viscosity.

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2) Pressure Drag :- F_p :-

This is the part of the Drag that is due directly to the pressure on an object. It is often reffered to as form drag because of its strong dependancy on the Shape or form of the 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.

OR

It is equal to the integration of Component in the direction of motion of all pressure force external on Surface of the body.

$$F_p = C_p \rho \frac{V^2}{2} A.$$

⇒ C_p = Co-ffecient of pressure drag. Depend on Shap.

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Equations:-

Equ: of Friction Drage Co-efficent in Laminar boundary Layer:-

i) Thickness of Boundary layer:-

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

ii) Maxi: Shear stress:-

$$\tau_o = 0.332 \cdot \frac{\mu U}{x} \sqrt{R_x}$$

iii) Coefficient of Friction drage:-

$$C_f = \frac{1.328}{\sqrt{R_x}} \quad \because R \leq 500000$$

iv) Friction Drag:-

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

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

5 (a)

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Equations of Co-efficient of Friction Drag. in Turbulent Boundary Layer.

i) Thickness of Boundary Layer:-

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

ii) Maxi: shear Stress:-

$$\tau_0 = 0.0587 \rho \frac{V^2}{2} \left(\frac{\nu}{U x}\right)^{1/5}$$

iii) Coefficient of Friction drag:-

$$C_f = \frac{0.0735}{R^{1/5}} \quad \therefore 500000 < R < 10^7$$

$$C_f = \frac{0.455}{(\log R)^{2.58}} \quad \therefore 10^7 < R$$

iv) Friction Drag:-

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

5 b

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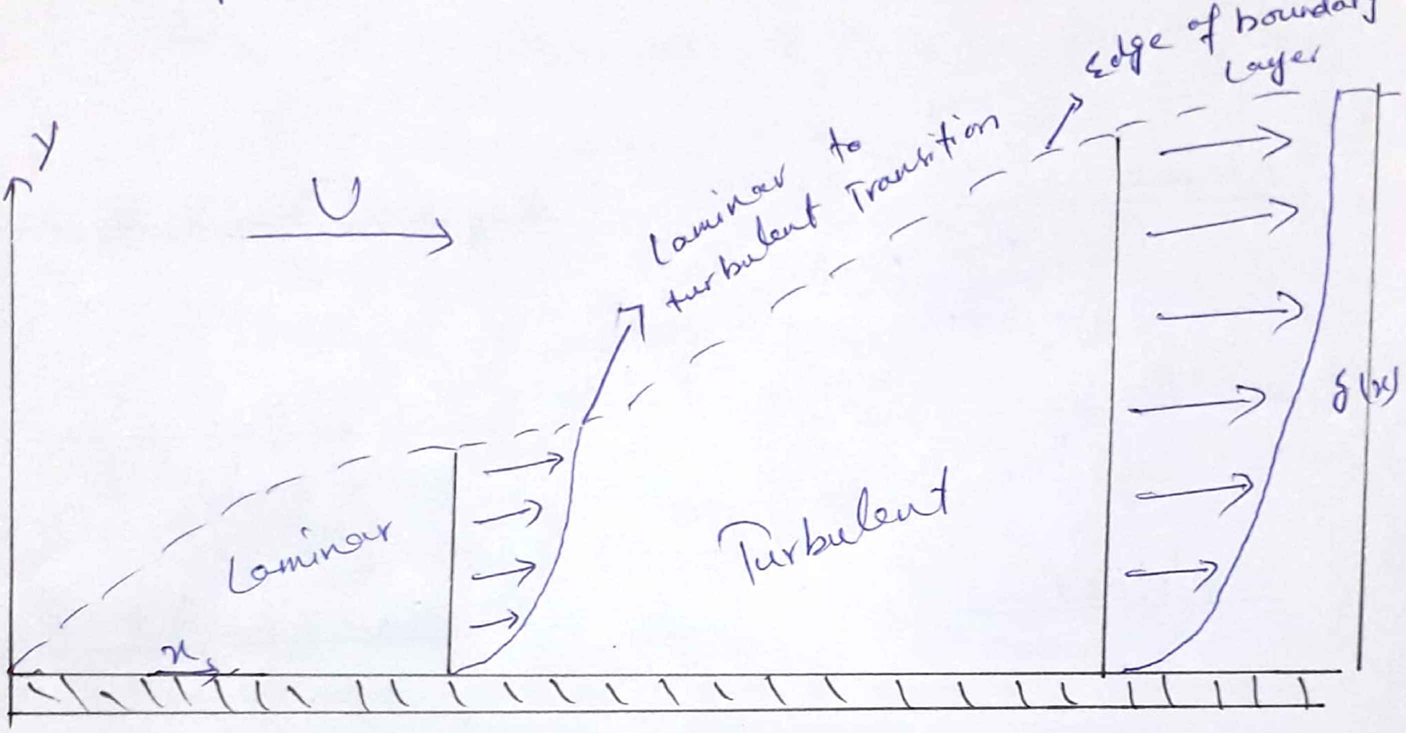

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Q:1/ |Part b/

Specific Energy:-

It is defined as the energy head reffered to channel bed

Thus $E = y + \frac{v^2}{2g}$

Flow q per unit width b of can be expressed as $q = Q/b$.

Now average velocity will be

$$U = \frac{Q}{A} = \frac{qb}{by} = \frac{q}{y}$$

Thus

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

Let consider how E will vary with y if q remain constant.

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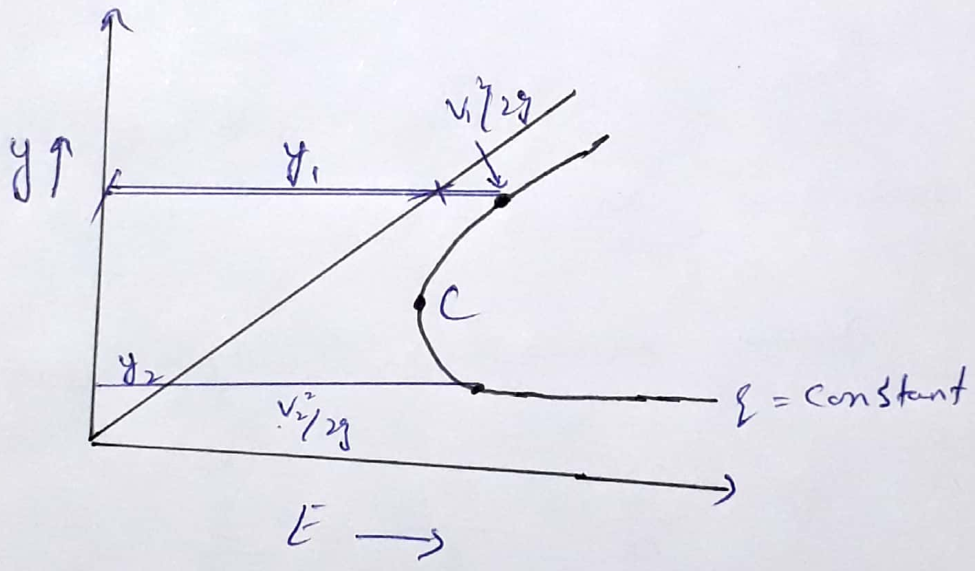
Thus

$$(E-y) = \frac{q^2}{2g(y^2)}$$

$$(E-y)y^2 = \frac{q^2}{2g} = \text{Constant}$$

Now plot E vs y is parabola.



Specific Energy diagram.

For particular q, There will be two kind of possible value of y, for given E.

The Equation is Cubic with three roots with third being negative, giving no value.

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Thus two alternative depths represent two totally diffrent flow regimes - Slow and deep on upper portion and fast & Shallow on lower portion.

Thus relation of Critical depth

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

For minimum Spc: Energy $\frac{dE}{dy} = 0$

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

$$\frac{dE}{dy} = 1 - \frac{q^2}{gy^3} = 0 \Rightarrow 1 = \frac{q^2}{gy^3}$$

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

As $V_c = \sqrt{g y_c}$ or

$$\boxed{y_c = \frac{V_c^2}{g}}$$

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Now

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

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

So

$$E_{min} = \frac{3}{2} y_c \quad \text{and} \quad \boxed{y_{cr} = \frac{2}{3} E_{min}}$$

★: Critical Depth:- (y_c):

This is the normal depth at critical flow condition for a given flow rate in a given channel (i.e, bottom slop, shape & size

★: Critical velocity:- V_c:

This is the liquid velocity for critical flow condition in a particular channel with specified flow rate.

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Q: 21 Given data:

Depth of rectangular Channel (d) = ?

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

Slope of Bed (S_o) = 0.0008

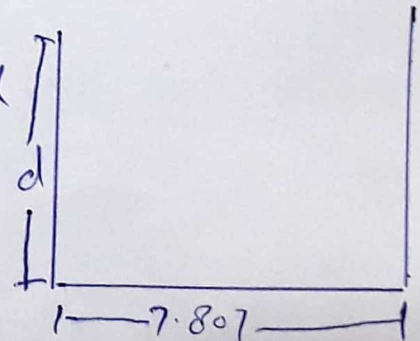
n = 0.0219

width of bed = 7807 mm = 7.807 m

Critical depth = ?

Is flow Sub critical or Super critical = ?

Soln:-



⇒ Area = 7.807 × d = 7.807d

⇒ Perimeter = d + 7.807 + d

= 7.807 + 2d

⇒ Hydraulic radius (R_h) = A/P

$$= \frac{7.807\,d}{7.807 + 2d}$$

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By using of Manning Equation.

$$Q = \frac{1}{n} A R_h^{2/3} S_o^{1/2} \quad \text{— (A)}$$

put the value in (A)

$$3.5 = \frac{1}{0.0219} \times 7.807d \times \left(\frac{7.807d}{2d + 7.807}\right)^{2/3} \times (0.0008)^{1/2}$$

We get

$$d = 0.55m$$

So

⇒ Area = $7.807(0.55)$

$$A = 4.29m^2$$

⇒ Perimeter = $7.807 + 2(0.55)$

$$P = 8.9m$$

⇒ Hydraulic Radius = $(R_h) = \frac{4.29}{8.9} = 0.482m$

$$R_h = 0.482m$$

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1) Find Critical depth:-

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

As we know that

$$q = Q/B$$

$$q = 3.5/7.807 = 0.44\ m^2/sec$$

$$q = 0.44\ m^3/sec$$

$$\Rightarrow y_{cr} = \left(\frac{(0.44)^2}{9.81}\right)^{1/3} = 0.27$$

$$y_{cr} = 0.27$$

⇒ As

$y > y_{cr}$ → So

$0.55 > 0.27$ The flow is Sub Critical.

2) Critical velocity:-

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

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

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Q: 3/ Given data :-

Friction drag (F_D) = ?

width (B) = 200mm = 0.2 m

Length (L) = 800mm = 0.8 m

Specific gravity (S) = 0.89

undisturbed velocity (V) = 5 m/sec

Kinematic viscosity (ν) = 0.93×10^{-4} m²/sec

Solution :-

Check the flow by reynold number wether flow is Laminar or turbulent.

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

For Smooth flat plate

$D = L$, $V = U$

So $R = \frac{LU}{\nu} = \frac{0.8 \times 5}{0.93 \times 10^{-4}} = 43010$

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So

43010 < 500000 ⇒ So flow is Laminar.

By using formula

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

where

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

$$\boxed{C_f = 0.0064}$$

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

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

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

$$\Rightarrow F_f = C_f \cdot \rho \cdot 890 \times \frac{(5)^2}{2} \times 0.2 \times 0.8$$

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