Subject	Advance Fluid
Name	Yaseen Kamal
ID	7794
Instructor Name	Sir Engr Waheed Khan

QNO.1):

(a)

Ans:→ A body which is wholy immersed in a homogenous fluid may be subjected two kind of forces araising from relative motion b/w body & fluid. These forces are termed as drag and lift depending on forces parallel or right angle to motion

→ Drag force are submerged body can have 2 components.

1) Pressure Drag: It is equal to the integration of components in direction of motion of all pressure forces exerted on surface of body.

$$F_P = C_P \cdot \rho \frac{V^2}{2} \cdot A$$

(where C_P depend on shape)

2) Friction Drag: It is equal to integration of component of all shear stresses along the surface in direction of motion.

$$F_P = C_F \cdot \rho \frac{V^2}{2} (Bc)$$

(C_F depends on velocity).

Friction Drag of Boundary Layer:

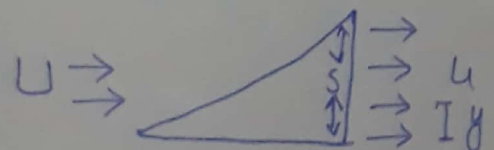
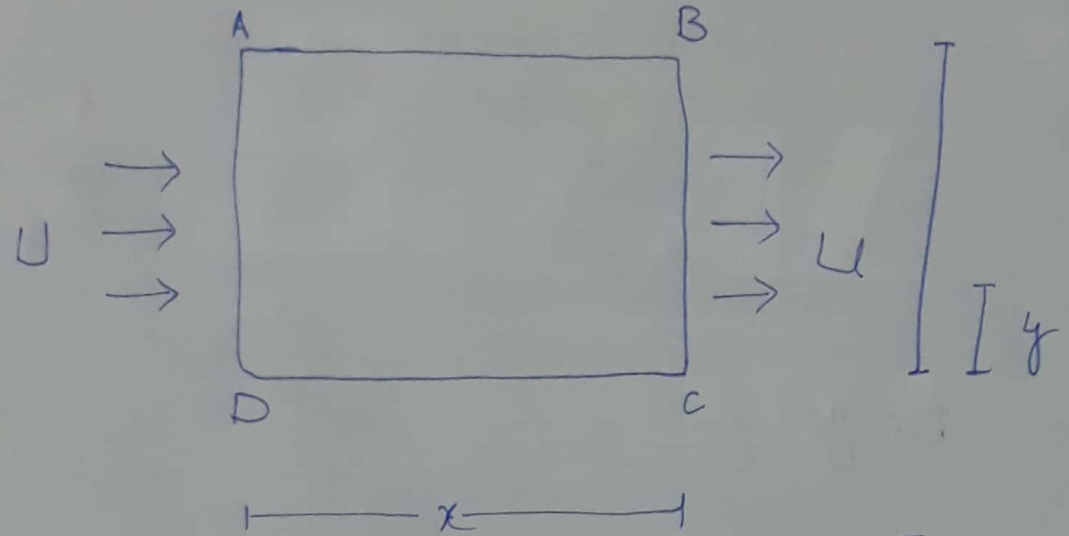


Figure shows growth of Boundary layer along one side of smooth plate in steady flow of incompressible fluid consider volume where δ is the thickness of boundary layer and U is the undisturbed velocity.



As we have $\sum F_x = 0$

where

$$F_x = \frac{\Delta P}{\Delta t} = \frac{\Delta m v}{\Delta t} \qquad \therefore m = \rho v$$

$$F_x = \frac{\Delta \rho \cdot vol. \cdot v}{\Delta t} = \Delta \rho Q v$$

$$\boxed{F_x = \Delta \rho Q v}$$

$-F_x =$ rate of change of BC + AB − AD

$AD = \rho U (U \delta B)$

$BC = \rho B (u^2 dy)$

$AB = \rho U (UB\delta) - B \int_0^{\delta} u\, dy$

$F_x = \rho B \int_0^{\delta} u (U - u) dy$

integration on b/s — ①

$Fx = \int B\ u^2 \delta d$

Where a is a function of boundary layer velocity distribution

Now to find Shear stress

$$\tau = \frac{Fx}{A} = \frac{d\ Fx}{B dx} = \frac{d Fx}{B dx}$$

$$\bar{\tau}_o = \int \cancel{B} u^2 d \frac{d\delta}{\cancel{B} dx}$$

$$= \int u^2 \alpha \frac{d\delta}{du}$$

$$\bar{\tau}_o = \int u^2 \alpha \frac{d\delta}{dx}$$

Laminar Boundary Layer:

$$\frac{u}{U} = f\left(\frac{y}{\delta}\right) \quad — ①$$

$$\frac{y}{\delta} = n$$

$$y = \delta n$$

$$dy = \delta dn \quad — ②$$

$$\frac{u}{U} = f(n)$$

$$du = u df(n) \quad — ③$$

For laminar flow

$$\bar{\tau}_o = u \frac{du}{dy} \quad — ④$$

Scanned with CamScanner

$$\tau_o = \frac{\mu u\, d\, f(n)}{\delta\, d(n)}$$

$$\overline{\tau}_o = \frac{\mu U B}{\delta} \quad \text{—— (5)}$$

As we have $\tau_o = \delta u^2 \alpha \frac{d\delta}{dx}$

Compare both

$$\delta u^2 \alpha \frac{d\delta}{dx} = \frac{\mu U B}{\delta}$$

$$\delta\, d\delta = \frac{\mu B\, dx}{\delta U \alpha}$$

Int on b/s

$$\frac{\delta^2}{2} = \frac{\mu B x}{\delta U \alpha} + c \qquad \because c = 0$$

$$\delta = \sqrt{\frac{2B}{d}} \cdot \sqrt{\frac{\mu U}{\delta U}}$$

$$\because R_x = \frac{U x \delta}{\mu}$$

$B = 1.63$, $d = 0.135$

$$\delta = \frac{4.91 x}{\sqrt{R_x}} \quad \text{—— (6)}$$

where (R_x) is local Reynold no.

As we have

$$\overline{\tau}_o = \frac{\mu U B}{\delta}$$

put eq (6) in (5)

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

Scanned with CamScanner

eq ① & ②

$x = 0 \quad , \delta = 0$

$$\delta = \left(\frac{0.0287}{\alpha}\right)^{4/5}\left(\frac{\nu}{Ux}\right)^{1/5} x$$

$\alpha = 0.0972$

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

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

Now

$$F_f = B \int_0^{l} \tau_0 \, dx$$

$$F_f = 0.0735 \rho \frac{U^2}{2}\left(\frac{\nu}{UL}\right)^{1/5} \cdot BL$$

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

equationg b/s

$$C_F = \frac{0.0735}{(R)^{1/5}} \qquad (50{,}00{,}00 < R < 10^7)$$

For $R > 10^7$

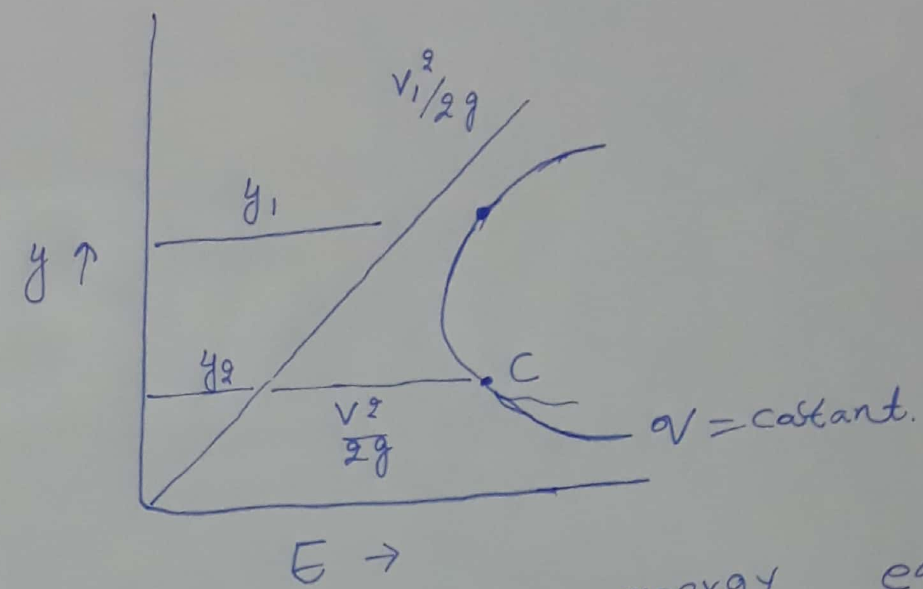
$$\boxed{C_F = \frac{0.455}{(\log R)^{2.52}}}$$

Scanned with CamScanner

Q.NO. 1):

(b):

Ans:



This is specific energy equation For particular q, there will be two Kind of possible values of y For given E. The equ is Cubic with three roots 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 between two regima of flow. Thus for given "q" value of E is minimum & flow at this

Point is critical flow Depth of flow at this point is critical depth b/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 min specific energy

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

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

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

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

$$\Rightarrow q^2 = gy^3$$

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

AS $q = Vy$, $Vc^2 = gy^3$

OR $\boxed{V_c = \sqrt{g y_c}}$ critical velocity

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

Scanned with CamScanner

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 $y_{cr} = \frac{2}{3}$ Combine both

	Suberinal	Critical	Super critical
Depth of Flow	$y > y_c$	$y = y_c$	$y < y_c$
velocity Slop	$V < V_c$ mild Slop $S_o < S_c$	$V = V_c$ Critical Slop	$V > V_c$

QNO. 2):

Given Data:

Depth of Rectangular Channel (d) = ?

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

Slop of Bed (S_o) = 0.0008

$n = 0.0219$

Width of bed = 7821 mm

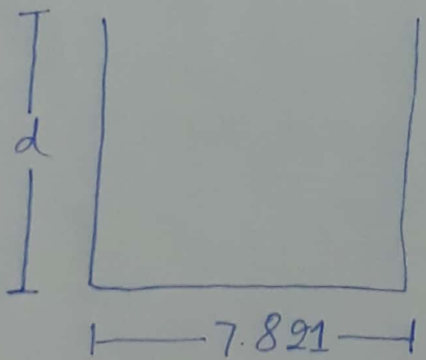
= 7.821 m

Find:

Critical depth = ?

Flow subcritical or supercritical = ?

Solution:



Area = 7.821 × d

= 7.821 d

Parameter = d + 7.821 + d

= 7.821 + 2d

Hydraulic Radius (R_h) = A/p

minimum

$\tau_o = 0.332$

$$A/P = \frac{7.821d}{7.821+2d}$$

By using manning equ

$$Q = \frac{1}{n} A R_h^{2/3} \cdot (S_o)^{1/2} \quad - \star$$

putting values

$$3.5 = \frac{0}{0.0219} \times 7.821d \times \left(\frac{7.821d}{2d+7.821}\right) \times (0.008)^{1/2}$$

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

Area $= 7.821(0.55)$
$= 4.30 m^2$

Parameter $= 7.821 + 2(0.55)$
$= 8.921m$

Hydraulic Radius $(R_h) = \frac{4.37}{8.921}$
$= 0.489 m$

AS Critical Depth

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

AS $q = Q/B$

Scanned with CamScanner

$= 3.5/7.821$

$= 0.447\ m^2/sec$

$$y_{cr} = \left(\frac{(0.447)^2}{9.81} \right)^{1/3}$$

$= 0.27$

$y > y_{cr}$ So flow is sub critical

$0.55 > 0.27$

Q NO. 3):
Solution:

Friction Drag (FD) = ?

Width (B) = 200 mm = 0.2 m

Length (L) = 800 mm = 0.8 m

undisturbed velocity (v) = 5 m/sec

specific gravity (S) = 0.89

kinematic velocity (ν) = 0.98×10^{-4} m²/sec

Check whether Flow is laminar or not By Reynold number

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

For smooth plate

D = L , V = U

so

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

$$= \frac{0.8 \times 5}{0.93 \times 10^{-4}} = 43010$$

43010 < 500,000 → laminar

By using formula

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

where

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

$$C_f = 0.0064$$

$$S = \frac{\rho_{oil}}{\rho_{water}}$$

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

$$\rho_{oil} = 0.39 \times 1000$$

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

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

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

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