VTU Question Paper Solution

Scheme	2022
Month & Year	June/July 2025
Branch	CIVIL ENGINEERING
Semester	IV
Subject	Fluid Mechanics and Hydraulics
Subject Code	BCV402
Max Marks	100
Faculty Name	Prof. Seema R Basarikatti

Modified

CBCS SCHEME

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BCV402

Fourth Semester B.E./B.Tech. Degree Examination, June/July 2025
Fluid Mechanics and Hydraulics

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Define the following and mention their units: i) Capillarity ii) Surface tension (iii) Viscosity	06	L2	CO1
	b.	Calculate the density, specific weight and weight of one litre of petrol of specify gravity = 0.7	06	L3	CO1
	c.	The space between two square flat parallel plates is filled with oil. Each side of the plate is 60 cm. The thickness of the oil film is 12.5 mm. The upper plate, which moves at 2.5 meter per sec requires a force of 98.1 N to maintain the speed. Determine (i) The dynamic viscosity of the oil in poise (ii) The kinematic viscosity of the oil in stokes if the specific gravity of the oil is 0.95.	08	L3	CO1
		OR			
Q.2	a.	State and prove Pascal's law.	06	L2	CO1
	b.	An open tank contains water upto a depth of 2 m and above if an oil of sp. gr. 0.9 for a depth of 1 m. Find the pressure intensity (i) at the interface of the two liquids (ii) at the bottom of the tank.	06	L3	CO1
	c.	A differential manometer is connected the two points A and B of two pipes as shown in Fig.Q2(c). The pipe A contains a liquid of sp.gr. = 1.5. While pipe B contains a liquid of sp. gr. = 0.9. The pressure at A and B are 1 kgf/cm^2 and 1.80 kgf/cm^2 respectively. Find the difference in mercury level in the differential manometer.	08	L3	CO1

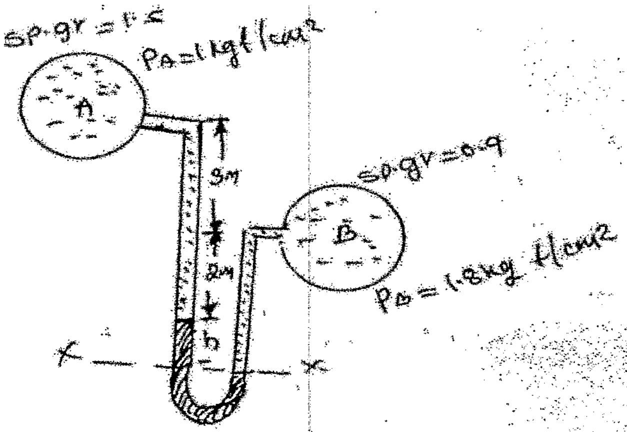

Fig.Q2(c)

Module – 2

Q.3	a.	Derive the expression for Euler's equation of motion.	08	L2	CO2
	b.	Water is flowing through a pipe having diameter 300 mm and 200 mm at the bottom and upper end respectively. The intensity of pressure at the bottom end is 24.525 N/cm^2 and pressure at the upper end is 9.81 N/cm^2. Determine the difference in datum head if the rate of flow through pipe is 40 lt/s.	08	L4	CO2
	c.	List the assumption made in the derivation of Bernoulli's equation.	04	L2	CO2

OR

Q.4	a.	Derive the equation for discharge through venturimeter. Explain with neat sketch.	08	L2	CO2
	b.	An orifice meter with orifie diameter 10 cm is inserted in a pipe of 20 cm diameter. The pressure gauge fitted upstream and downstream of the orifice meter gives reading of 19.62 N/cm^2 and 9.81 N/cm^2 respectively. Coefficient of discharge for the meter is given as 0.6. Find the discharge of water through pipe.	06	L4	CO2
	c.	A pitot-static tube placed in the centre of a 300 mm pipeline has one orifice pointing upstream and other perpendicular to it. The mean velocity in the pipe is 0.80 of the central velocity. Find the discharge through the pipe if the pressure difference between the two orifices is 60 mm of water. Take the coefficient of pitot tube as $C_v = 0.98$.	06	L4	CO2

Module – 3

Q.5	a.	Define hydraulic coefficients for an orifice and give the relation between them.	06	L2	CO3
	b.	Find the discharge from a 100 mm diameter external mouth piece, fitted to a side of a large vessel if the head over the mouth piece is 4 meters.	06	L4	CO3
	c.	Derive the expression for discharge through a triangular notch.	08	L2	CO3

OR

Q.6	a.	Derive Darcy – Weisbach equation for head loss due to friction in a pipe.	08	L2	CO3
	b.	List the any four minor losses in a pipe flow with expression.	06	L2	CO3
	c.	Write the short notes on the following : i) Pipes in series ii) Equivalent pipe iii) Pipes in parallel	06	L2	CO3

Module – 4

Q.7	a.	Distinguish between (i) Gradually varied flow and rapidly varied flow (ii) Total energy and specific energy (iii) Subcritical and super critical flow	06	L2	CO4

Q.7	b.	A rectangular channel is 2.5 m wide and has a uniform bed slope of 1 in 500. If the depth of flow is constant 1.7 m. Calculate (i) The hydraulic mean depth (ii) The velocity of flow (iii) The volume rate of flow Assume that the value of the coefficient C in Chezy's formula is 50.	06	L3	CO4
	c.	Determine the most efficient section of a trapezoidal channel with side slope of 1 vertical to 2 horizontal. The channel carries a discharge of 11.25 m^3/s with a velocity of 0.75 m/s. What should be the bed slope of the channel? Take Mannings n = 0.025 .	08	L3	CO4
		OR			
Q.8	a.	Derive Chezy's equation for uniform rate of flow in a channel.	08	L2	CO4
	b.	For most economical rectangular channel prove that half of the width equal to depth of flow in channel.	06	L3	CO4
	c.	Explain critical depth and critical velocity.	06	L2	CO4
		Module – 5			
Q.9	a.	State Impulse - Momentum equation. Give its application.	06	L2	CO5
	b.	A 75 mm diameter water jet having a velocity of 30 m/s strikes a flat plate, the normal of which is inclined at 45° to the axis of the jet. Find the normal pressure on the plate, when the plate is moving with a velocity of 15 m/s and away from the jet, the normal force on the plate.	06	L4	CO5
	c.	A jet of water of diameter 7.5 cm strikes a curved plate at its centre with a velocity of 20 m/s. The curved plate is moving with a velocity of 8 m/s in the direction of jet. The jet is deflected through an angle of 165°. Assuming the plate smooth find: (i) Force exerted on the plate in the direction of jet. (ii) Power of the jet (iii) Efficiency of the jet	08	L4	CO5
		OR			
Q.10	a.	Explain various efficiency of centrifugal pump.	06	L2	CO5
	b.	List the difference between Impulse and Reaction turbine.	06	L2	CO5
	c.	Explain classification and types of turbines.	08	L2	CO5

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Fourth Semester B.E. Degree Examination, June/July 2025

FLUID MECHANICS AND HYDRAULICS

Q.No	SOLUTION	MARKS
1a	i) Capillarity :- Capillarity is defined as a phenomenon of rise or fall of a liquid surface in a small tube relative to the adjacent general level of liquid when the tube is held vertically in the liquid. $\boxed{h = \frac{4\sigma}{\rho g d}}$	02
	ii) Surface tension : Surface tension is defined as the tensile force acting on the surface of a liquid in contact with a gas or on the surface between two immiscible liquids such that the contact surface behaves like a membrane under tension. $\boxed{P = \frac{4\sigma}{d}}$	02
	iii) Viscosity :- Viscosity is defined as the property of a fluid which offers resistance to the movement of one layer of fluid over another adjacent layer of the fluid. $\boxed{\mu = \frac{\tau}{(du/dy)}}$	02
1b.	Density (ρ) $= 0.7 \times 1000$ Kg/m^3 $= 700$ Kg/m^3	02
	Specific weight (w) $= \rho \times g = 700 \times 9.81 = 6867$ N/m^3	02
	Weight (W) $=$ Specific weight $\times$ Volume	02
	$= \underline{6.867\ N.}$	

1c. i) Dynamic Viscosity of the oil in Poise :-

$$\tau = \mu \times \frac{du}{dy} = 1.3635 \ Ns/m^2.$$

$$= 13.635 \ \text{Poise}$$ 04

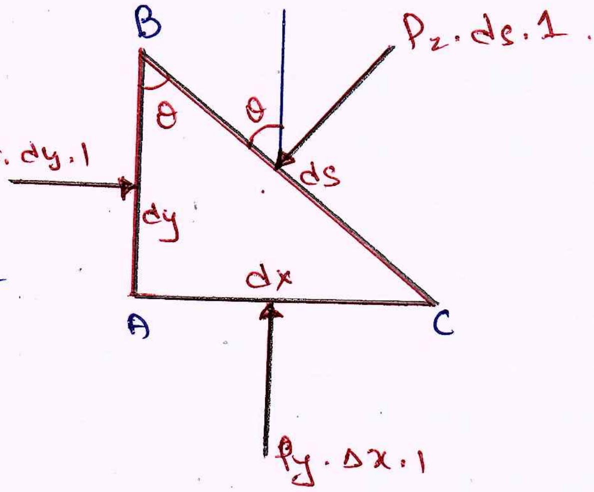
ii) Kinematic Viscosity of oil

$$\nu = \frac{\mu}{\rho} = 0.001435 \times 10^4 \ cm^2/s$$ 04

$$= 14.35 \ \text{Stokes}$$

2a. PASCAL'S LAW

Statement :- It states that the pressure or intensity of pressure at a point in a static fluid is equal in all direction.



Let the width of the element perpendicular to the plane of paper is unity and P_x, P_y & P_z are the pressures or intensity of pressure acting on the face AB, AC & BC respectively.

Let ∠ABC = θ.

The force acting on the element are :

1). Pressure forces normal to the surfaces and
2). Weight of element in the vertical direction.

Force on the face AB = $P_x \times$ Area of face AB

$= P_x \times dy \times 1$.

" " " " AC $= P_y \times dx \times 1$

" " " " BC $= P_z \times ds \times 1$

Weight of the element = (Mass of element) $\times g$

$= (\text{Volume} \times \rho) \times g = \left(\frac{AB \times AC}{2} \times 1\right) \times \rho \times g$

Resolving the forces in x-direction, we have

$$P_x \times dy \times 1 - P_z (ds \times 1) \sin(90° - \theta) = 0$$

or $P_x \times dy \times 1 - P_z ds \times 1 \cos\theta = 0$. But $ds\cos\theta = AB = dy$

$\therefore$ $P_x \times dy \times 1 - P_z \times dy \times 1 = 0$.

or $\boxed{P_x = P_z}$ —— (1)

Similarly, resolving the forces in y-direction, we get.

$$P_y \times dx \times 1 - P_z \times ds \times 1 \cos(90° - \theta) - \frac{dx \times dy}{2} \times 1 \times \rho \times g = 0.$$

or $P_y \times dx - P_z ds \sin\theta - \frac{dx dy}{2} \times \rho \times g = 0$.

But $ds \sin\theta = dx$

$\therefore$ $P_y dx - P_z dx = 0$.

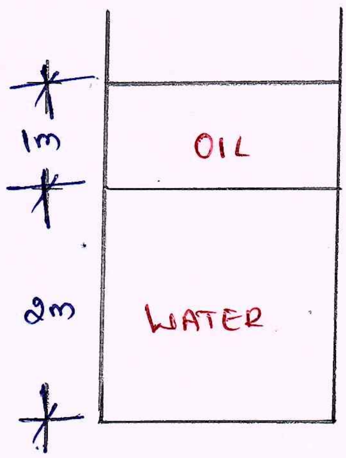
or $\boxed{P_y = P_z}$ —— (2)

From equation (1) & (2) we have

$$\boxed{P_x = P_y = P_z}$$

2b

i) at the interface of the two liquids 01



$p = \rho_2 \times g \times 1.0$ 2½

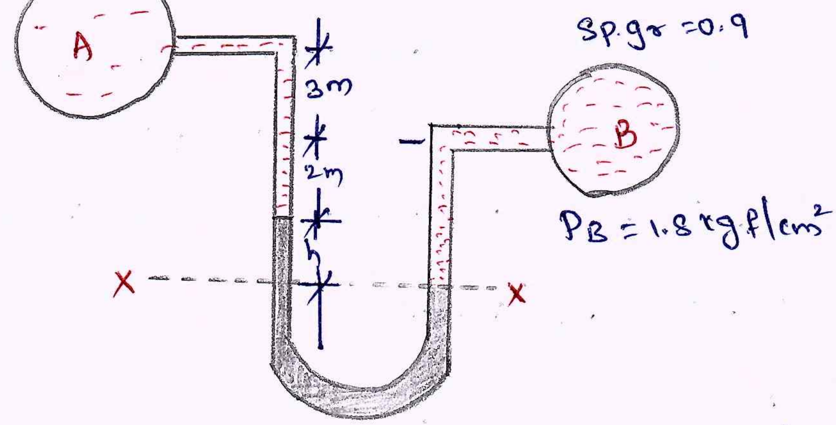
$= 0.8829 \ N/cm^2$

ii) at the bottom of the tank.

$P = \rho_2 \times g z_2 + \rho_1 \times g z_1$ 2½

$= 2.8449 \ N/cm^2$.

2c.



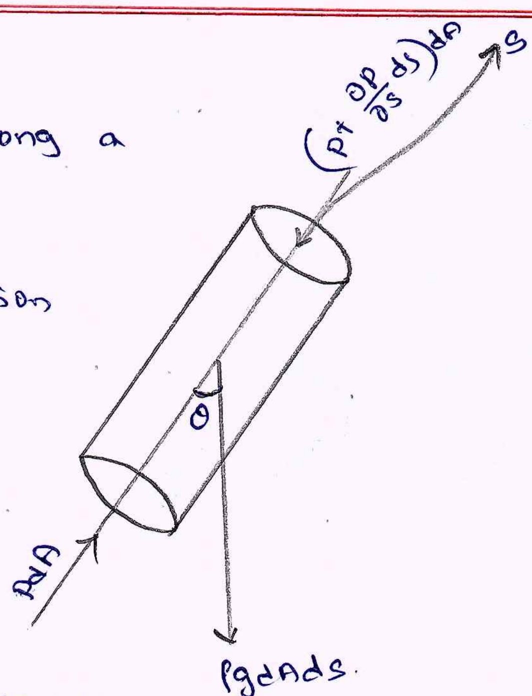
02

Pressure above X-X axis in the left limb. 06

$$= 13.6 \times 1000 \times 9.81 \times h + 7500 \times 9.81 + 9.81 \times 10^4$$

$$\therefore \boxed{h = 18.1\,cm}$$

3a. Euler's equation of Motion:-



The motion of a fluid element along a streamline as:- 02

1). Pressure force pdA in the direction of flow

2) pressure force $\left(p + \frac{\partial p}{\partial s} ds\right) dA$ opposite to the direction of flow 02

3). Weight of element ρgdA.ds.

Let θ is the angle between the direction of flow and the line of action of the weight of element

The resultant force on the fluid element in the direction of S must be equal to the mass of fluid element × acceleration in the direction S.

04

$$pdA - \left(p + \frac{\partial p}{\partial s} ds\right) dA - \rho g dA ds \cos\theta$$

$$= \rho dA ds \times a_s.$$

$$= \frac{\partial v}{\partial s}\frac{ds}{dt} + \frac{\partial v}{\partial t} = \frac{v\partial v}{\partial s} + \frac{\partial v}{\partial t} \qquad \left(\because \frac{ds}{dt} = v\right)$$

If the flow is steady $\frac{\partial v}{\partial t} = 0$.

$$\therefore a_s = \frac{v\partial v}{\partial s}$$

$$\therefore -\frac{\partial p}{\partial s} ds dA - \rho g dA ds \cos\theta = \rho dA ds \times \frac{\partial v}{\partial s}$$

Dividing by $\rho ds dA$, $\frac{-\partial p}{\rho \partial s} - g\cos\theta = \frac{v\partial v}{\partial s}$

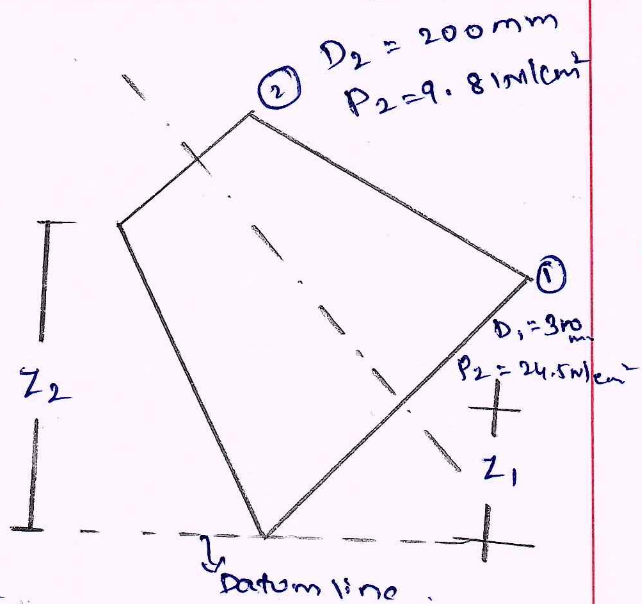
or $\frac{\partial p}{\rho \partial s} + g\cos\theta + v\frac{\partial v}{\partial s} = 0$

we have $\cos\theta = \frac{dz}{ds}$

$\therefore \frac{1}{\rho}\frac{dp}{ds} + g\frac{dz}{ds} + \frac{vdv}{ds} = 0$ or $\frac{dp}{\rho} + gdz + vdv = 0$.

or $\boxed{\frac{dp}{\rho} + gdz + vdv = 0.}$

3b. Given:-



$D_1 = 300mm = 0.3m$

$D_2 = 200mm = 0.2m$

$P_1 = 24.5 N/cm^2$

$P_2 = 9.81 N/cm^2$

$\therefore Z_2 - Z_1 = 9$

$Q = 40 lit/s = 0.04 m^3/s$.

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2$$ 03

$A_1V_1 = A_2V_2 =$ rate of flow $= 0.04$.

$$\therefore V_1 = \frac{0.04}{A_1} = \frac{0.04}{\pi/4 (D_1)^2} = \frac{0.04}{\pi/4(0.3)^2} = 0.5658 \text{ m/s}.$$

$\therefore \boxed{V_1 = 0.566 \text{ m/s}.}$ 05

$$V_2 = \frac{0.04}{A_2} = \frac{0.04}{\pi/4\,(0.2)^2} = 1.274 \text{ m/s}.$$

$$\therefore \frac{24.525\times10^4}{1000\times9.81} + \frac{0.566\times0.566}{2\times9.81} + Z_1 = \frac{9.81\times10^4}{1000\times9.81} + \frac{(1.274)^2}{2\times9.81} + Z_2$$

$$25 + 0.32 + Z_1 = 10 + 1.623 + Z_2$$

$$\therefore \boxed{Z_2 - Z_1 = 13.70\text{m}.}$$

3C Assumptions:-

i) The fluid is ideal

ii) The flow is steady

iii) The flow is incompressible 04

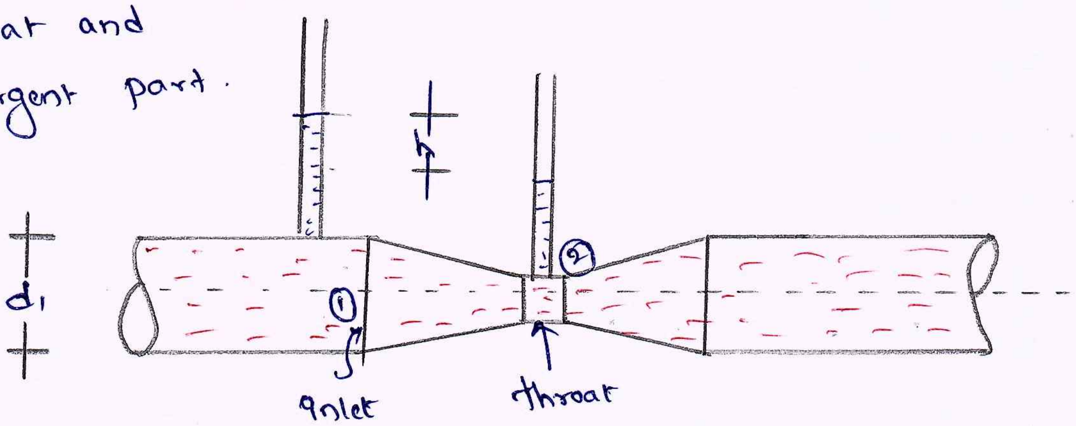
iv) The flow is irrotational

4a. A Venturimeter is a device used for measuring the rate of flow of a fluid flowing through a pipe. It consists of three parts:- 01

i) A short converging part.

ii) throat and

iii) Divergent part.



02

Let d_1, P_1, V_1, be the diameter, pressure & velocity at section 1

d_2, P_2, V_2, be the diameter, pressure & velocity at section 2.

Applying Bernoulli's equation.

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 .$$

As pipe is horizontal $z_1 = z_2$

$$\therefore \frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} \quad \text{or} \quad \frac{P_1 - P_2}{\rho g} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

$$h = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

continuity equation $a_1 V_1 = a_2 V_2$ or $V_1 = \frac{a_2 V_2}{a_1}$.

$$h = \frac{V_2^2}{2g} - \frac{\left(\frac{a_2 V_2}{a_1}\right)^2}{2g} = \frac{V_2^2}{2g}\left[1 - \frac{a_2^2}{a_1^2}\right] = \frac{V_2^2}{2g}\left[\frac{a_1^2 - a_2^2}{a_1^2}\right]$$ 05

$$V_2^2 = 2gh \frac{a_1^2}{a_1^2 - a_2^2}$$

$$V_2 = \sqrt{2gh \frac{a_1^2}{a_1^2 - a_2^2}} = \frac{a_1}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}.$$

Discharge $Q = a_2 V_2$

$$= a_2 \frac{a_1}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh} = \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}.$$

Actual discharge $\boxed{Q_{act} = Cd \times \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}}$

4b Given:-

$d_0 = 10cm$ (dia of orifice)

$a_0 = \frac{\pi}{4}(10)^2 = 78.54 cm^2$.

$d_1 = 20cm$ 01

$a_1 = \frac{\pi}{4}(20)^2 = 314.16 cm^2$

$P_1 = 19.62 \, N/cm^2 = 19.62 \times 10^4 \, N/m^2$

$$\frac{P_1}{\rho g} = \frac{19.62\times10^4}{1000\times9.81} = 20m \text{ of water}$$

$$\frac{P_2}{\rho g} = \frac{9.81\times10^4}{1000\times9.81} = 10 \text{ m of water}.$$ 02

$$h = \frac{P_1}{\rho g} - \frac{P_2}{\rho g} = 20-10 = 10m \text{ of water} = 1000cm \text{ of water}$$

$Cd = 0.6$ 03

$$\therefore Q = Cd \times \frac{a_0 a_1}{\sqrt{a_1^2 - a_0^2}} \times \sqrt{2gh}$$

$$= 0.6 \times \frac{78.54\times314.16}{\sqrt{(314.16)^2-(78.54)^2}} \times \sqrt{2\times9.81\times1000}.$$

$\boxed{Q = 68.21 \text{ litres/sec}}$

4c Given:-

$d = 300mm = 0.30m$

$h = 60mm$ of water $= 0.06m$ of water. 01

$Cv = 0.98$

$\bar{V} = 0.80 \times$ central Velocity

$= Cv \times \sqrt{2gh} = 0.98 \times \sqrt{2\times9.81\times0.06}$

$= 1.063$ m/s. 02

$\bar{V} = 0.80 \times 1.063 = 0.8504$ m/s.

Discharge Q = Area of pipe $\times \bar{V}$

$= \frac{\pi}{4}(0.30)^2 \times 0.8504$ 03

$\boxed{Q = 0.06 \ m^3/s}$

5a. Hydraulic coefficients :-

1) Co-efficient of Velocity (C_v) = It is defined as the ratio between the actual velocity of a jet of liquid at vena-contracta and the theoretical velocity of jet 02

$$\therefore \boxed{C_v = \frac{V}{\sqrt{2gH}}}$$

2) Co-efficient of Contraction (C_c) :- It is defined as the ratio of the area of the jet at vena-contracta to the area of the orifice

$$\boxed{C_c = \frac{a_c}{a}}$$ 02

3) Co-efficient of discharge (C_d) :- It is the ratio of the actual discharge from an orifice to the theoretical discharge from the orifice

$$\boxed{C_d = \frac{Q}{Q_{th}}} = \frac{\text{Actual velocity} \times \text{Actual area}}{\text{theoretical velocity} \times \text{theoretical area}}$$

02

$$\therefore \boxed{C_d = C_v \times C_c}$$

5b. Given :-

Dia. of mouthpiece = 100m = 0.1m

$\therefore$ Area $a = \pi/4 (0.1)^2 = 0.007854 \, m^2$ 02

Head $H = 4.0m$

$C_d = 0.855$

Discharge = C_d × Area × Velocity = $0.855 \times a \times \sqrt{2gH}$ 02

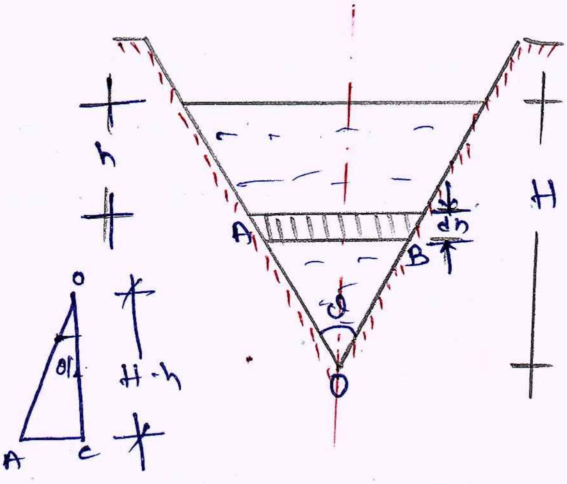
$= 0.855 \times 0.007854 \times \sqrt{2 \times 9.81 \times 4.0}$

$\boxed{Q = 0.05948 \, m^3/s}$ 02

5C.

$\tan\frac{\theta}{2} = \frac{AC}{OC} = \frac{AC}{(H-h)}$

$AC = (H-h)\tan\frac{\theta}{2}$



03

Width of strip

$AB = 2AC = 2(H-h)\tan\theta/2$

Area of strip

$= 2(H-h)\tan\theta/2 \times dh$

Discharge through the strip.

$dQ = C_d \times \text{Area of Strip} \times \text{Velocity}$

$= C_d \times 2(H-h)\tan\frac{\theta}{2} \times dh \times \sqrt{2gh}$

$= 2C_d(H-h)\tan\frac{\theta}{2} \times \sqrt{2gh} \times dh.$

Total discharge $Q = \int_0^H 2C_d(H-h)\tan\frac{\theta}{2} \times \sqrt{2gh} \times dh.$

$= 2C_d \times \tan\frac{\theta}{2} \times \sqrt{2g}\int_0^H (H-h)\,h^{1/2}\,dh$

$= 2 \times C_d \times \tan\frac{\theta}{2} \times \sqrt{2g}\left[\frac{H h^{3/2}}{3/2} - \frac{h^{5/2}}{5/2}\right]_0^H$

$= 2 \times C_d \times \tan\frac{\theta}{2} \times \sqrt{2g}\left[\frac{2}{3}H^{5/2} - \frac{2}{5}H^{5/2}\right]$ 05

$= 2 \times C_d \times \tan\frac{\theta}{2} \times \sqrt{2g}\left[\frac{4}{15}H^{5/2}\right]$

$= \frac{8}{15}C_d \times \tan\frac{\theta}{2} \times \sqrt{2g} \times H^{5/2}$

if $C_d = 0.6$, $\theta = 90°$ $\therefore \tan\frac{\theta}{2} = 1.$

Discharge $Q = \frac{8}{15} \times 0.6 \times 1 \times \sqrt{2 \times 9.81} \times H^{5/2}$

$\boxed{Q = 1.417\,H^{5/2}}$

6a	Applying Bernoullis equation between two Section 1 & 2	
	$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + h_f$	02
	Frictional resistance per unit area @ unit velocity.	
	Velocity $= f' \times PW \times V^n$	01
	Pressure force at 1 & 2	
	$P_1A = P_2A$ + frictional resistance.	
	$\therefore \boxed{h_f = \frac{f'}{\omega} + \frac{P}{A} + LV^n.}$	03
6b.	**Minor losses:-**	
	i) Loss of head due to Sudden enlargement.	
	Applying bernoullis equation.	
	$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$ + loss of head due to enlargement.	
	$Z_1 = Z_2$ as pipe is horizontal.	
	$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_e$	02½
	$\therefore h_e = \left(\frac{P_1}{\rho g} - \frac{P_2}{\rho g}\right) + \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right)$	
	$\boxed{h_e = \frac{(V_1 - V_2)^2}{2g}}$	
	ii) Loss of head due to Sudden contraction:-	
	$\boxed{h_c = 0.5\frac{V_2^2}{2g}}$ or $0.5\frac{V_2^2}{2g}$.	02½

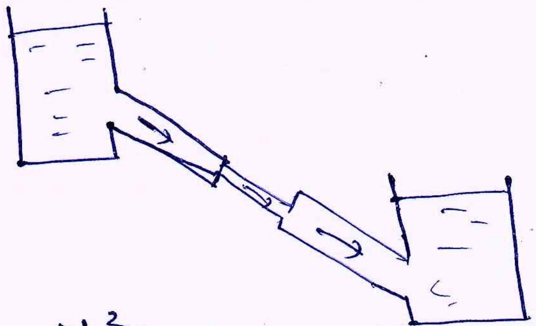
iii) Loss of head at the entrance of a pipe :-

$$\boxed{h_i = 0.5\frac{V^2}{2g}}$$ 01½

iv) Loss of head at the exit of pipe

$$\boxed{h_0 = \frac{V^2}{2g}}$$ 01½

6c i) Pipe in Series :-



$$Q = A_1V_1 = A_2V_2 = A_3V_3$$

$$H = \frac{0.5V_1^2}{2g} + \frac{4f_1L_1V_1^2}{d_1\times 2g} + \frac{0.5V_2^2}{2g} + \frac{4f_2L_2V_2^2}{d_2\times 2g} + \frac{(V_2-V_3)^2}{2g} + \frac{4f_3L_3V_3^2}{d_3\times 2g} + \frac{V_3^2}{2g}.$$ 02

$$f_1 = f_2 = f_3.$$

$$\boxed{H = \frac{4f}{2g}\left[\frac{L_1V_1^2}{d_1} + \frac{L_2V_2^2}{d_2} + \frac{L_3V_3^2}{d_3}\right]}$$

ii) Equivalent pipe :-

$$H = \frac{4f_1L_1V_1^2}{d_1\times 2g} + \frac{4f_2L_2V_2^2}{d_2\times 2g} + \frac{4f_3L_3V_3^2}{d_3\times 2g}.$$

$$Q = A_1V_1 = A_2V_2 = A_3V_3 = \frac{\pi}{4}(d_1)^2V_1 = \frac{\pi}{4}d_2^2V_2 = \frac{\pi}{4}d_3^2V_3.$$ 02

$$H = \frac{4fL_1\left(4Q/\pi d_1^2\right)^2}{d_1\times 2g} + \frac{4fL_2\left(4Q/\pi d_2^2\right)^2}{d_2\times 2g} + \frac{4fL_3\left(4Q/\pi d_3^2\right)^2}{d_3\times 2g}.$$

$$\therefore \boxed{H = \frac{4f\cdot L\left(4Q/\pi d^2\right)^2}{d\times 2g} = \frac{4\times 16Q^2f}{\pi^2\times 2g}\left[\frac{L}{d^5}\right]}$$

iii) Pipes in parallel :-

$$Q = Q_1 + Q_2$$

$$\frac{4 f_1 L_1 V_1^2}{d_1 \times 2g} = \frac{4 f_2 L_2 V_2^2}{d_2 \times 2g}$$ 02

if $f_1 = f_2$

then $$\boxed{\frac{L_1 V_1^2}{d_1 \times 2g} = \frac{L_2 V_2^2}{d_2 \times 2g}}$$

7a. i) Gradually Varied flow & rapidly Varied flow :-

i) Gradually Varied flow : If a depth in a channel changes gradually over a length of a Channel. 02

Rapidly Varied flow :- flow changes abruptly over a small length of the Channel.

ii) Total energy : It is sum of the kinetic head, potential head & datum head.

Specific energy :- Energy per unit weight of the fluid at particular section. 02

iii) Subcritical flow :- Froude number $F_r < 1$ (tranquil or Streaming)

Super critical flow :- If $F_r > 1$ 02

(Rapid | shortly | Torrential)

7b. Given:-

Width of Channel $b = 2.5m$

Slope $i = 1 in 500$

depth of Channel $d = 1.7m$. 02

a) Hydraulic mean depth : $R = A/P$.

$$\boxed{R = 0.72m}$$

b) Velocity of flow $V = C\sqrt{RS}$.

$$= 50 \times \sqrt{0.72 \times 1/500}$$ 02

$$\boxed{V = 1.897 \ m/s.}$$

c) Volume rate of flow.. $Q = A \times V$ 02

$$\boxed{Q = 8.064 \ m^3/s.}$$

7c

$$\frac{B + 2zy}{2} = y\sqrt{1+z^2}$$ 02

$$B/y = 0.472$$

$Q = AV$.

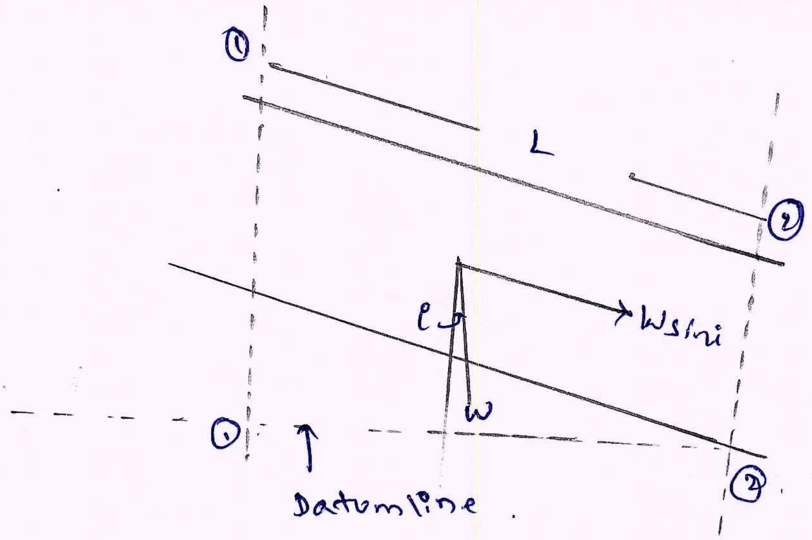
Area $A = 2.42y^2$ 03

$y = 2.463m$

$\therefore V = 1/n \, R^{2/3} S^{1/2}$

$\therefore S = 0.000266$ 03

8a.



Let L = length of channel. 01
A = Area of flow of water
i = slope of the bed
V = mean velocity of flow.
P = wetted perimeter
f = Frictional resistance per unit velocity per unit area.

component of W along distance of flow = $W \times \sin i$

$= WAL\sin i$. —①

Frictional resistance against motion = $f \times P \times L \times V^2$. —② 02

Resolving all forces in the direction of flow, we get.

$$WAL\sin i - f \times P \times L \times V^2 = 0.$$

$$WAL\sin i = f \times P \times L \times V^2.$$

$$V^2 = \frac{WAL\sin i}{f \times P \times L} = \frac{W}{f} \times \frac{A}{P} \times \sin i$$ 02

$$V = \sqrt{\frac{W}{f}} \times \sqrt{\frac{A}{P}\sin i}$$

$$\frac{A}{P} = m.$$ 01

$$\sqrt{W/f} = C.$$

$$\boxed{Q = A \times C\sqrt{mi}}$$

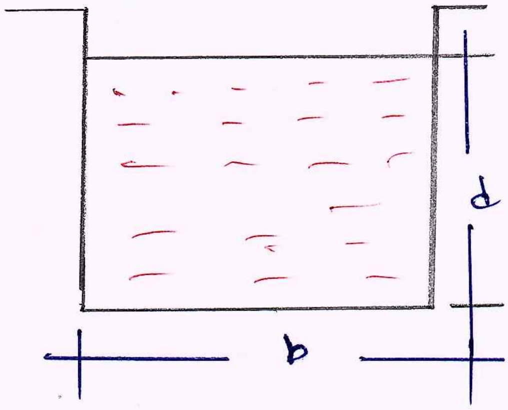
8b. Let b = width of channel

d = depth of flow

$A = b \times d$

$P = b + d + d = b + 2d$.

$b = \frac{A}{d}$



02

$\therefore P = b + 2d = \frac{A}{d} + 2d$.

for most economical section, P should be minimum.

$$\frac{dP}{d(d)} = 0.$$

02

Differentiating above equation.

$$\frac{d}{d(d)}\left[\frac{A}{d} + 2d\right] = 0 \quad \text{or} \quad -\frac{A}{d^2} + 2 = 0 \quad \text{or} \quad A = 2d^2$$

$$A = b \times d \quad \therefore b \times d = 2d^2 \quad \text{or} \quad b = 2d$$

Hydraulic mean depth $m = \frac{A}{P} = \frac{b \times d}{b + 2d}$

02

$$= \frac{2d \times d}{2d + 2d} = \frac{2d^2}{4d} = \frac{d}{2}.$$

8c Critical depth :- Critical depth is defined as that depth of flow of water at which the Specific Energy is minimum.

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

03

Critical Velocity : The velocity of flow at the critical depth is known as Critical Velocity.

03

$$\boxed{V_c = \sqrt{g \times h_c}}$$

9a. It is based on the law of Conservation of momentum on the momentum principle, which states that the net force acting on a fluid mass is equal to the change in momentum of flow per unit time in that direction. 02

$$f = m \times a$$

where a is the acceleration acting in the same direction of force F. 02

$$a = \frac{dv}{dt}$$

$$f = m \cdot \frac{du}{dt}$$

$$= \frac{d(mv)}{dt}$$

$$\boxed{f = \frac{d(mv)}{dt}}$$ 02

Application:-

i) For any problems involving variable force F, velocity v and time t.

ii) Helpful for impulsive force.

iii) for problems involving force Vs, F. & t.

9b. Given:-

$d = 75mm = 0.075m$

$a = \frac{\pi}{4}(d)^2 = \frac{\pi}{4}(0.075)^2 = 0.004417 m^2$

$V = 30 m/s.$ 02

$\theta = 45°$

$f_n = \rho a v^2 \sin\theta.$ 02

$= 1000 \times 0.004417 \times (30)^2 \sin(45°)$

$$\boxed{f_n = 2811.51N.}$$ 02

9c Given:-

$d = 7.5cm = 0.075 m$

$a = \frac{\pi}{4}(0.075)^2 = 0.004417$

$V = 20 m/s.$

$u = 8 m/s.$

$\theta = 165°$

Angle made by the relative velocity at the outlet of the plate $\theta = 180° - 165° = 15°$

i) Force exerted by the jet on the plate in the direction of jet

$F_x = \rho a (V-u)^2 (1+\cos\theta)$

$= 1000 \times 0.004417 (20-8)^2 [1 + \cos 15°]$ 02

$\boxed{F_x = 1250.38N}$

ii) work done by the jet on the plate per second.

$F_x \times u = 1250.38 \times 8 = 10003.04$ Nm/s. 03

$\therefore$ Power of the jet $= \frac{10003.04}{1000}$ $\boxed{= 10 kW}$

iii) Effeciency of the jet $= \frac{Output}{Input}$

$= \frac{\text{workdone by jet/sec}}{\text{Kinetic Energy of jet/sec}} = \frac{1250.38 \times 8}{1/2(\rho a v) \times V^2}$ 03

$= \frac{1250.38 \times 8}{1/2 \times 1000 \times 0.004417 \times 20^3} = 0.564$

$\boxed{\eta = 56.4\%}$

10a i) Manometric efficiency (η_{man}) :- The ratio of the manometric head to the head imparted by the impeller to the water is known as manometric efficiency.

$$\eta_{man} = \frac{\text{Manometric head}}{\text{Head imparted by impeller to water}}$$ 02

$$\boxed{\eta_{man} = \frac{H_m}{\left(\frac{V_{w_2} u_2}{g}\right)} = \cancel{\frac{g H_m}{V_{w_2} u_2}}}$$

ii) Mechanical efficiency (η_m): the power at the shaft of the centrifugal pump is more than the power available at the impeller of the pump. the ratio of the power available at the impeller to the power at the shaft of the centrifugal pump is known as mechanical efficiency. 02

$$\eta_m = \frac{\text{Power at the impeller}}{\text{Power at the shaft.}}$$

$$\boxed{\eta_m = \frac{\frac{W}{g}\left(\frac{V_{w_2} u_2}{1000}\right)}{S.P.}}$$

iii) Overall efficiency :- It is defined as ratio of power output of the pump to the power input to the pump.

$$\eta_o = \frac{\text{Weight of water lifted} \times H_m}{1000} = \frac{W H_m}{1000}$$ 02

$$\eta_o = \frac{\left(\frac{W H_m}{1000}\right)}{SP}$$

$$\boxed{\eta_o = \eta_{man} \times \eta_m}$$

10b. Difference between impulse turbine & reaction turbine. 06

	Impulse turbine	Reaction turbine.
1.	water flows through the nozzle	water flow first through. guide mechanism
2.	The water impinges on the bucket with Kinetic Energy	The water glides over the moving Vanes.
3.	The water or may over the whole	The water must be admitted over the circumference.
4.	The blades are symmetrical	The blades are not Symmetrical

10c Classification & types. of turbines:-

1) According to the type of Energy at inlet. 02

a) Impulse turbine & b) Reaction turbine.

2) According to the direction of flow through runner.

a) Tangential flow turbine b) Radial flow turbine. 02

c) Axial flow turbine and d) Mixed flow turbine.

3) According to the head at the inlet of turbine.

a) High head turbine b) Medium head turbine and 08

c) Low head turbine.

4) According to the specific speed of the turbine. 02

a) Low specific speed turbine b) Medium specific speed.

c) High specific speed turbine.