220 09/11/23 12 Nov 23

Scoring Indicators

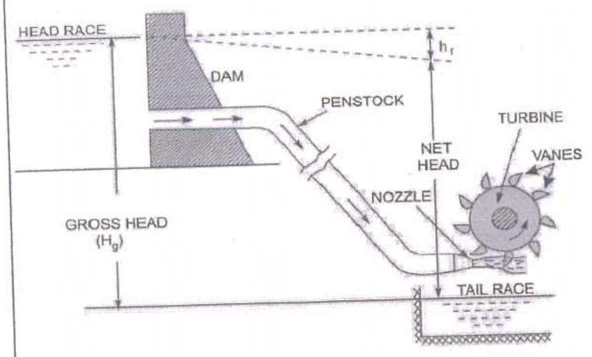
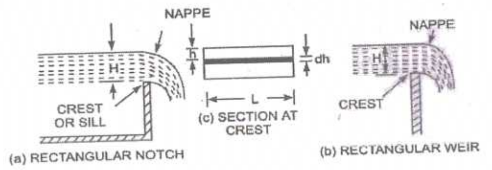
COURSE NAME:HYDRAULICS

COURSE CODE :4011 QID :1

Q No	Scoring Indicators	Split score	Sub Total	Total score
	PART A			**10**
I.1	**Surface Tension**: Surface tension is defined as the tensile force acting on the surface of a liquid in contact with the gas or on the surface between two immersible liquids such that the contact surface behaves like a membrane under tension **Capillarity:** Define the phenomenon of rise or fall of any liquid surface in a small tube relative to the adjacent general level of liquid when the tube is held vertically in the liquid		2	
I.2.	**Vena Contracta** : This term refers to a point within a fluid stream where the velocity of the fluid is at its maximum and the cross-sectional area is at its minimum		2	
I.3	a) Orifice: An orifice is a small, typically circular opening or hole in a surface, barrier, or device that allows fluids (liquids or gases) to pass through. Orifices are commonly used in engineering and fluid dynamics to control the flow of fluids or to measure the rate of flow b) Notch: A notch, refers to a specially shaped or configured opening or groove, often provided on the side of a container or channel, to allow the controlled discharge of fluid.	1 1	2	
I.4	The total energy line (TEL) is a graphical or mathematical representation used to represent the total energy of a fluid at various points along a flow path within a system. It shows the different forms of energy that a fluid possesses in a pipeline or open channel. Total Energy (TE) = Kinetic Energy (KE) + Potential Energy (PE) + Pressure Energy (PE)	2	2	
I.5	The hydraulic mean depth is defined as the ratio of the cross-sectional area of flow (A) to the wetted perimeter (P). Mathematically, it is expressed as: Hydraulic Mean Depth (HMD) = A / P Where: • A - the cross-sectional area of the flow (the area of the water surface).	2	2	

	• P - the wetted perimeter, which is the length of the channel bottom and sides that is in contact with the flowing liquid.			
	PART B			30
II.1	Atmospheric Pressure: • Atmospheric pressure, also known as barometric pressure, is the pressure exerted by the Earth's atmosphere on any given point on the Earth's surface. It is the force per unit area exerted by the weight of the air above a particular location Gauge Pressure: • Gauge pressure is the pressure measured relative to atmospheric pressure. It represents the pressure difference between the measured pressure and atmospheric pressure.Gauge pressure can be positive or negative, depending on whether the measured pressure is greater than or less than atmospheric pressure. Absolute Pressure: • Absolute pressure is the pressure measured relative to a perfect vacuum (zero pressure). It includes the pressure of the fluid or gas itself and any additional pressure from the atmosphere.To calculate absolute pressure from gauge pressure, you add atmospheric pressure to the gauge pressure.	2 2 2	6	
II.2.	Vacuum pressure, p_{vacuum} = 650mm of Hg Atm pressure, p_{atm} = 1.01325 bar 1 mm of Hg = 133.416N/m^2 and 1 bar = 10^5N/m2 Hence, 1 mm oh Hg = 133.416 x 10^{-5} bar The vacuum pressure in bar as p_{vacuum} = 650 x 133.416 x 10^{-5} bar = .8672 bars Using the relation, absolute pressure, $p_{abs} = p_{atm} - p_{vacuum}$ = 1.01325-0.8672 = 0.14605 bar	2 2 2		

II.3.	Orifice is a small opening of any cross-section (such as circular, triangular, rectangular etc.) on the side or at the bottom of a tank, through which a fluid is flowing. A mouthpiece is a short length of a pipe which is two to three times its diameter in length, fitted in a tank or vessel containing the fluid. Orifices as well as mouthpieces are used for measuring the rate of flow of fluid.	2		
	CLASSIFICATIONS OF ORIFICES The orifices are classified on the basis of their size, shape, nature of discharge and shape of the upstream edge. The following are the important classifications : 1. The orifices are classified as **small orifice** or **large orifice** depending upon the size of orifice and head of liquid from the centre of the orifice. If the head of liquid from the centre of orifice is more than five times the depth of orifice, the orifice is called small orifice. And if the head of liquids is less than five times the depth of orifice, it is known as large orifice. 2. The orifices are classified as (*i*) Circular orifice, (*ii*) Triangular orifice, (*iii*) Rectangular orifice and (*iv*) Square orifice depending upon their cross-sectional areas. 3. The orifices are classified as (*i*) Sharp-edged orifice and (*ii*) Bell-mouthed orifice depending upon the shape of upstream edge of the orifices. 4. The orifices are classified as (*i*) Free discharging orifices and (*ii*) Drowned or sub-merged orifices depending upon the nature of discharge. The sub-merged orifices are further classified as (*a*) Fully sub-merged orifices and (*b*) Partially sub-merged orifices.	4	6	
II.4	**▶ 7.4 HYL IC CO-EFFICIENTS** The hydraulic co-efficients are 1. Co-efficient of velocity, C_v 2. Co-efficient of contraction, C_c 3. Co-efficient of discharge, C_d. **Coefficient of velocity** is the ratio of actual velocity of the jet at veena contractor to the theoretical velocity of jet. It is usually denoted by C_V $Cv = \frac{v}{\sqrt{2gH}}$ **Coefficient of contraction:** it is the ratio of area of jet at win a contractor to the area of the orifice especially denoted using Cc $Cc = \frac{a_c}{a}$ **Coefficient of discharge** is the ratio of actual discharge from an orifice to the theoretical discharge from the orifice $Cd = \frac{Q}{Qth}$ $C_d = \frac{Q}{Q_{th}} = \frac{\text{Actual velocity} \times \text{Actual area}}{\text{Theoretical velocity} \times \text{Theoretical area}}$ $= \frac{\text{Actual velocity}}{\text{Theoretical velocity}} \times \frac{\text{Actual area}}{\text{Theoretical area}}$ $C_d = C_v \times C_c$	3 x 2 marks ech	6	

II. 5	 *Layout of a hydroelectric power plant.* A hydroelectric power plant converts the energy of flowing water into electricity. The layout of a typical hydroelectric power plant consists of several key components and structures. Dam: Reservoir: Intake Structure: Penstock: Turbines:	3 3			
II.6	The expression for discharge over a rectangular notch or weir is the same.  Fig. 8.1 *Rectangular notch and weir.* Consider a rectangular notch or weir provided in a channel carrying water as shown in Fig. 8.1. Let H = Head of water over the crest L = Length of the notch or weir For finding the discharge of water flowing over the weir or notch, consider an elementary horizontal strip of water of thickness dh and length L at a depth h from the free surface of water as shown in Fig. 8.1(c). The area of strip $= L \times dh$ and theoretical velocity of water flowing through strip = $\sqrt{2gh}$ The discharge dQ, through strip is $dQ = C_d \times$ Area of strip $\times$ Theoretical velocity $= C_d \times L \times dh \times \sqrt{2gh}$ ...(i) where C_d = Co-efficient of discharge. The total discharge, Q, for the whole notch or weir is determined by integrating equation (i) between the limits 0 and H. $\therefore \quad Q = \int_0^H C_d \cdot L \cdot \sqrt{2gh} \cdot dh = C_d \times L \times \sqrt{2g} \int_0^H h^{1/2}\, dh$ $= C_d \times L \times \sqrt{2g} \left[\frac{h^{1/2+1}}{\frac{1}{2}+1} \right]_0^H = C_d \times L \times \sqrt{2g} \left[\frac{h^{3/2}}{3/2} \right]_0^H$ $= \frac{2}{3} C_d \times L \times \sqrt{2g}\, [H]^{3/2}$. ...(8.1)			6	

<table>
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<td>II.7</td>
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Definition of open channel and pipe flow

Open Channel Flow:
Open channel flow refers to the flow of a liquid (typically water) in an open, unconstrained channel or conduit with a free surface exposed to the atmosphere
Pipe Flow:
Pipe flow, on the other hand, refers to the flow of fluid (liquid or gas) within enclosed, pressurized conduits, such as pipes, tubes, or ducts. In pipe flow, the fluid is confined within a closed cross-sectional area, and the shape and dimensions of the conduit remain relatively constant along its length.

<table>
<tr><td></td><td>Pipe flow</td><td>Open channel flow</td></tr>
<tr><td>Cross section</td><td>Pipe flow occurs within closed</td><td>Occurs in open unconfined systems such as rivers & canals</td></tr>
<tr><td>boundary</td><td>with a defined boundary And a well defined cross section shape</td><td>Fluid is exposed to the atmosphere and free surfaces not constrained by rigid boundary</td></tr>
<tr><td>Flow driven by</td><td>The flow is typically pressurized</td><td>Governed by the principles of gravity driven</td></tr>
<tr><td>Governing pricpile</td><td>Can can be described using darcy weisbasch equation</td><td>Can be described using equations like Mannings and chezys</td></tr>
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Each point 1mark (4x1 =4)</td>
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<tr><td></td><td>PART C</td><td></td><td></td><td>42</td></tr>
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<td>III.a
.</td>
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ᴧEASUREMENT OF PRESSURE

The pressure of a fluid is measured by the following devices :
1 Manometers 2. Mechanical Gauges.
.ᴧanometers. Manometers are defined as the devices used for measuring the pressure at a point in a fluid by balancing the column of fluid by the same or another column of the fluid. They are classified as :
(a) Simple Manometers, (b) Differential Manometers.

2.5.2 Mechanical Gauges. Mechanical gauges are defined as the devices used for measurin the pressure by balancing the fluid column by the spring or dead weight. The commonly used mechan cal pressure gauges are :
(a) Diaphragm pressure gauge, (b) Bourdon tube pressure gauge,
(c) Dead-weight pressure gauge, and (d) Bellows pressure gauge.
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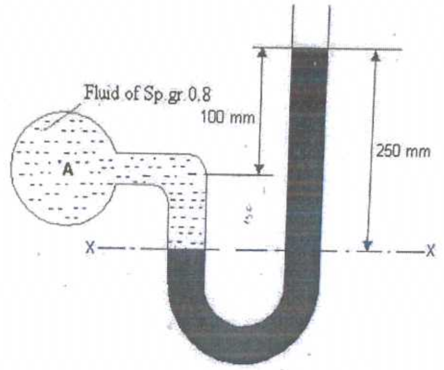
III.b.	Specific gravity of fluid in the pipe, $S_1 = 0.8$ $\therefore$ Density of the fluid, $\rho_1 = S_1 \times 1000 = 0.8 \times 1000 = 800 \text{ kg/m}^3$ Specific gravity of mercury, $S_2 = 13.6$ (Assumed data) $\therefore$ Density of mercury, $\rho_2 = S_2 \times 1000 = 13.6 \times 1000 = 13600 \text{ kg/m}^3$	3	9	9
	Height of mercury level in the right limb above XX or Difference of mercury level, $h_2 = 250 \text{ mm} = 0.25 \text{ m}$ Height of liquid in the left limb from X-X, $= 250 - 100 = 150 \text{ mm} = 0.15 \text{ m}$	1		
		2		
	Let p be the intensity pressure of fluid flowing in pipe Equating the pressure at the left and right limb above the datum X-X, we get $p + \rho_1 g h_1 = \rho_2 g h_2$ Substituting the values in the above equation $p + 800 \times 9.81 \times 0.15 = 13600 \times 9.81 \times 0.25$ $p + 1177.2 = 33354$ $p = 33354 - 1177.2 = 32176.8 \text{ N/m}^2 = \mathbf{32.176 \text{ kN/m}^2}$	3		
IV. a.	1. Steady and Unsteady Flow: - Steady Flow:In a steady flow, the velocity and other flow characteristics at any given point in the fluid do not change with time. - Unsteady Flow: In unsteady flow, the fluid properties at a particular point change over time.. 2. Uniform and Non-Uniform Flow: - Uniform Flow: Uniform flow occurs when the fluid properties (e.g., velocity and pressure) are the same at all points within a particular cross-section of the flow. In other words, the flow does not vary along the direction of flow.	(2each x 3 = 6)	6	6

	- Non-Uniform Flow: Non-uniform flow is characterized by variations in fluid properties across the cross-section of the flow. The velocity and pressure may vary spatially, indicating that the flow is not the same at all points within the flow domain. 3. Laminar and Turbulent Flow: - Laminar Flow:Laminar flow is a smooth, orderly flow pattern in which fluid moves in parallel layers or streamlines. The fluid particles move in a predictable manner, with minimal mixing. Laminar flow typically occurs at low velocities and is characterized by a low Reynolds number. - Turbulent Flow: Turbulent flow is characterized by chaotic and irregular motion of fluid particles. The fluid undergoes intense mixing and eddying, leading to fluctuations in velocity and pressure. Turbulent flow typically occurs at high velocities and is characterized by a high Reynolds number.			
IV . b.	Larger diameter of tapered pipe, $d_1 = 200\text{ mm} = 0.2\text{ m}$ Smaller diameter of tapered pipe, $d_2 = 100\text{ mm} = 0.1\text{m}$ Velocity of flow at larger end, $v_1 = 4.5\text{ m/sec}$ Larger cross sectional area, $a_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} \times (0.2)^2 = 0.0314\text{ m}^2$ Smaller cross sectional area, $a_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4} \times (0.1)^2 = 0.00785\text{ m}^2$ Discharge through the pipe, $Q = a_1 v_1 = 0.0314 \times 4.5 = \mathbf{0.1413\text{ m}^3/s}$ Using continuity equation, *i.e.*, $a_1 v_1 = a_2 v_2$ $\therefore$ Velocity at the smaller end of the pipe, $v_2 = \frac{a_1 v_1}{a_2} = \frac{0.1413}{0.00785} = \mathbf{18\text{ m/s}}$	4.5 4.5	9	
V.a.	Diameter of orifice, $d = 40\text{ mm} = 0.04\text{ m}$ Head, $H = 10\text{ m}$ Actual discharge, $Q = 10.75\text{ litres/s} = 0.01075\text{ m}^3/s$ Cross sectional area of the orifice, $a = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times (0.04)^2 = 1.26 \times 10^{-3}\text{ m}^2$ Theoretical discharge through the orifice, $Q_{th} = a\sqrt{2gH} = 1.26 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 10}$ $= 0.0176\text{ m}^3/s.$ $\therefore$ Coefficient of discharge, $C_d = \frac{Q}{Q_{th}} = \frac{0.01075}{0.0176} = \mathbf{0.61}$ ***(Ans)***	1 1 1 1 2 1	7	
V.b.	Mouthpieces are fluid flow control devices that are typically used to discharge or control the flow of fluids, especially liquids, from one location to another. ▶ **LASSIFICATION OF MOUTHPIECES** 1. The mouthpieces are classified as (*i*) External mouthpiece or (*ii*) Internal mouthpiece depending upon their position with respect to the tank or vessel to which they are fitted. 2. The mouthpiece are classified as (*i*) Cylindrical mouthpiece or (*ii*) Convergent mouthpiece or (*iii*) Convergent-divergent mouthpiece depending upon their shapes. 3. The mouthpieces are classified as (*i*) Mouthpieces running full or (*ii*) Mouthpieces running free depending upon the nature of discharge at the outlet of the mouthpiece. This classification is only for internal mouthpieces which are known Borda's or Re-entrant mouthpieces. A mouthpiece is said to be running free if the jet of liquid after contraction does not touch the sides of the mouthpiece. But if the jet after contraction expands and fills the whole mouthpiece it is known as running full.	3 5	8	

VI.a (7)

EXPERIMENTAL DETERMINATION OF HYDRAULIC CO-EFFICIENTS

Determination of Co-efficient of Discharge (C_d). The water is allowed to flow through an orifice fitted to a tank under a constant head, *H* as shown in Fig. . The water is collected in a measuring tank for a known time, *t*. The height of water in the measuring tank is noted down. Then actual discharge through orifice, (2)

$$Q = \frac{\text{Area of measuring tank} \times \text{Height of water in measuring tank}}{\text{Time } (t)}$$

and theoretical discharge = area of orifice × $\sqrt{2gH}$

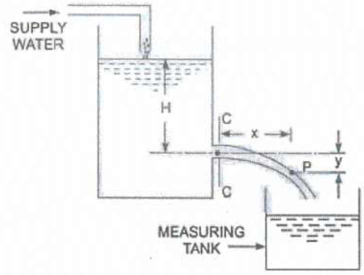


Fig. *Value of C_d.*

$$\therefore \quad C_d = \frac{Q}{a \times \sqrt{2gH}}$$

Determination of Co-efficient of Velocity (C_v). Let *C-C* represents the vena-contracta of a jet of water coming out from an orifice under constant head *H* as shown in Fig. . Consider a liquid particle which is at vena-contracta at any time and takes the position at *P* along the jet in time '*t*'.

Let x = horizontal distance travelled by the particle in time '*t*'
y = vertical distance between *P* and *C-C*
V = actual velocity of jet at vena-contracta.

Then horizontal distance, $x = V \times t$ ...(*i*)

and vertical distance, $y = \frac{1}{2} g t^2$ ...(*ii*)

From equation (*i*), $t = \frac{x}{V}$

Substituting this value of '*t*' in (*ii*), we get

$$y = \frac{1}{2} g \times \frac{x^2}{V^2}$$

$$V^2 = \frac{gx^2}{2y}$$ (3)

$$\therefore \quad V = \sqrt{\frac{gx^2}{2y}}$$

But theoretical velocity,

$$V_{th} = \sqrt{2gH}$$

$$\therefore \text{ Co-efficient of velocity, } C_v = \frac{V}{V_{th}} = \sqrt{\frac{gx^2}{2y}} \times \frac{1}{\sqrt{2gH}} = \sqrt{\frac{x^2}{4yH}}$$

$$= \frac{x}{\sqrt{4yH}}.$$

Determination of Co-efficient of Contraction (C_c). The co-efficient of contraction is determined from the equation (7.4) as (2)

$$C_d = C_v \times C_c$$

$$\therefore \quad C_c = \frac{C_d}{C_v}$$

VI.b. (1 mark each; Total: 8)

Impulse turbine	Reaction Turbine
The entire available energy of the water is first converted into kinetic energy.	The available energy of the water is not converted from one form to another.
The water flows through the nozzles and impings on the buckets, which are fixed to the outer periphery of the wheel.	The water is guided by the glide blades to flow over the moving vane.
The water impings on the buckets with KE	The water glides over the moving vanes with PE.
The pressure of the flowing water remains unchanged and is equal to the atmospheric pressure.	The pressure of the flowing water is reduced after gliding over the vane.
It is not essential that the wheel should run full.	It is essential that the wheel should always run full and kept full of water.
It is possible to regulate the flow without loss.	It is not possible to regulate the flow without loss.
Impulse Turbine has more hydraulic efficiency.	Reaction Turbine has relatively less efficiency.
Impulse Turbine operates at high water heads.	Reaction turbine operates at low and medium heads.
Example of Impulse turbine is Pelton wheel.	Examples of Reaction Turbine are Francis turbine, Kaplan and Propeller Turbine, Deriaz Turbine, Tubuler Turbine, etc.

VII. a (Marks: 7; Total: 7)

A triangular notch is prefered to a rectangular notch due to the following advantanges ver a rectangular notch.

1. In a right angled V- notch the expression for the computation of discharge is very simple to remember (i.e., $Q = 1.417$)
2. For measuring more accurate results for low discharge, triangular notch is preferred than rectangular notch
3. In case of triangular notch, only one reading i.e., head (H) is required to be taken for the computation of discharge.
4. No need for ventilation of triangular notch.
5. The same triangular notch can measure a wide range of flows accurately.
6. The head over the crest of triangular notch is independent of wetted edge. In case of rectangular notch the width or length of notch crest is constant for all heads with which the results are effected.

VII. b (Total: 8)

Discharge over the notch, $Q = 233$ litres/s $= 0.233$ m³/s — 1

Head over the notch, $H = \frac{1}{3}L$ — 1

Coefficient of discharge, $C_d = 0.62$. — 1

Using the equation for discharge, i.e., $Q = \frac{2}{3}C_d \cdot L \cdot \sqrt{2g} \cdot H^{\frac{3}{2}}$ — 2

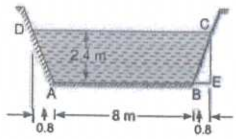
Substituting

$$0.233 = \frac{2}{3} \times 0.62 \times L \times \sqrt{2 \times 9.81} \times \left(\frac{L}{3}\right)^{\frac{3}{2}} = 0.352 \times L^{\frac{5}{2}}$$ — 2

$\therefore$ Length of the notch, $L = \left(\frac{0.233}{0.352}\right)^{\frac{2}{5}}$ **= 0.85 m** — 1

VIII a.	Head over the notch, $H = 900\text{mm} = 0.9\text{m}$ Discharge over the notch, $Q = 300 \text{ litres/s} = 0.3 \text{ m}^3/\text{s}$ Coefficient of discharge, $C_d = 0.62$ Using the equation for discharge over a rectangular notch, i.e., $Q = \frac{2}{3} C_d \cdot L \cdot \sqrt{2g} \cdot H^{\frac{3}{2}}$ or, Length of the notch, $L = \frac{3Q}{2C_d\sqrt{2g} \cdot H^{\frac{3}{2}}} = \frac{3 \times 0.3}{2 \times 0.62 \times \sqrt{2 \times 9.81} \times (0.9)^{\frac{3}{2}}}$ $= 0.1919 \text{ m} = 192 \text{ mm}$ ***(Ans)***	1 1 1 2 2	7	
VIII b.	A **notch** is a device used for measuring the rate of flow of a liquid through a small channel or a tank. It may be defined as an opening in the side of a tank or a small channel in such a way that the liquid surface in the tank or channel is below the top edge of the opening. A **weir** is a concrete or masonary structure, placed in an open channel over which the flow occurs. It is generally in the form of vertical wall, with a sharp edge at the top, running all the way across the open channel. The notch is of small size while the weir is of a bigger size. The notch is generally made of metallic plate while weir is made of concrete or masonary structure. 1. **Nappe or Vein.** The sheet of water flowing through a notch or over a weir is called Nappe or Vein. 2. **Crest or Sill.** The bottom edge of a notch or a top of a weir over which the water flows, is known as the sill or crest. **CLASSIFICATION OF NOTCHES AND WEIRS** The notches are classified as : 1. According to the shape of the opening : (*a*) Rectangular notch, (*b*) Triangular notch, (*c*) Trapezoidal notch, and (*d*) Stepped notch. 2. According to the effect of the sides on the nappe : (*a*) Notch with end contraction. (*b*) Notch without end contraction or suppressed notch. Weirs are classified according to the shape of the opening, the shape of the crest, the effect of the sides on the nappe and nature of discharge. The following are important classifications. (*a*) According to the shape of the opening : (*i*) Rectangular weir, (*ii*) Triangular weir, and (*iii*) Trapezoidal weir (Cipolletti weir) (*b*) According to the shape of the crest : (*i*) Sharp-crested weir, (*ii*) Broad-crested weir, (*iii*) Narrow-crested weir, and (*iv*) Ogee-shaped weir. (*c*) According to the effect of sides on the emerging nappe : (*i*) Weir with end contraction, and (*ii*) Weir without end contraction.	4 4	8	
IX a.	When a fluid is flowing through a pipe, the fluid experiences some resistance due to which some of the energy of fluid is lost. This loss of energy is classified as : **Energy Losses** 1. Major Energy Losses → This is due to friction and it is calculated by the following formulae : (*a*) Darcy-Weisbach Formula (*b*) Chezy's Formula 2. Minor Energy Losses → This is due to (*a*) Sudden expansion of pipe (*b*) Sudden contraction of pipe (*c*) Bend in pipe (*d*) Pipe fittings etc. (*e*) An obstruction in pipe.	5 2	7	

	LOSS OF ENERGY (OR HEAD) DUE TO FRICTION (*a*) **Darcy-Weisbach Formula.** The loss of head (or energy) in pipes due to friction is calculated from Darcy-Weisbach equation which has been derived and is given by $h_f = \frac{4 . f . L . V^2}{d \times 2g}$			
IX b.	Diameter of pipe, d $= 200mm = 0.2m$ Length of pipe, l $= 600m$ Loss of head, h_f $= 30m$ Pipe friction coefficient, f $= 0.01$ Using the Darcys formula for considering all minor losses. $h_f = \frac{0.5v^2}{2g} + \frac{4flv^2}{2gd} + \frac{v^2}{2g} = \frac{v^2}{2g}\left(0.5 + \frac{4fl}{d} + 1\right)$ $30 = \frac{v^2}{2\times 9.81}\left(0.5 + \frac{4\times 0.01\times 600}{0.2} + 1\right)$ $30 = \frac{v^2}{2\times 9.81}\times 121.5$ $\therefore \quad v = \sqrt{\frac{30\times 2\times 9.81}{121.5}} = 2.2 \text{ m/s}$ According to the continuity equation Discharge through the pipe, $Q = a\times v = \frac{\pi}{4}d^2\times v = \frac{\pi}{4}\times(0.2)^2\times 2.2 = 0.0691 \text{ m}^3/\text{s}$ **= 69.1 litres/s** (*An*	2 4 2	8	
X.a.	Diameter of pipe, d $= 250 \text{ mm} = 0.25m$ Length of pipe, l $= 100m$ Velocity of flow, v $= 2.5 \text{ m/s}$ Coefficient of pipe friction, f $= 0.005$ Chezy's constant, C $= 55$ Using Darcy's formula Head loss due to friction, $h_f = \frac{4flv^2}{2gd} = \frac{4\times 0.005\times 100\times (2.5)^2}{2\times 9.81\times 0.25}$ **= 2.548 m of water** (*Ans*) Hydraulic mean depth, $m = \frac{d}{4} = \frac{0.25}{4} = 0.0625 \text{ m}$ Loss of head per unit length, $i = \frac{h_f}{l} = \frac{h_f}{100}$ Using Chezy's formula for velocity of flow, $v = C\sqrt{mi}$ Substituting $2.5 = 55\times\sqrt{0.0625\times\frac{h_f}{100}}$ $\therefore \quad h_f = \left(\frac{2.5}{55}\right)^2 \times \frac{100}{0.0625}$ **= 3.306 m of water** (*Ans*)	2 2 3	7	

X.b.	Width, $b = 8$ m Side slope $= 1$ hor. to 3 vertical Depth, $d = 2.4$ m Chezy's constant, $C = 50$ Bed slope, $i = \frac{1}{4000}$  Fig. 16.3 From Fig. 16.3 when depth, $CE = 2.4$, the horizontal distance $BE = 2.4 \times \frac{1}{3} = 0.8$ m $\therefore$ Top width of the channel, $CD = AB + 2 \times BE = 8.0 + 2 \times 0.8 = 9.6$ m	2	8	
	$\therefore$ Area of trapezoidal channel, $ABCD$ is given as, $A = (AB + CD) \times \frac{CE}{2} = (8 + 9.6) \times \frac{2.4}{2} = 17.6 \times 1.2 = 21.12\ \text{m}^2$ Wetted perimeter, $P = AB + BC + AD = AB + 2BC$ $(\because\ BC = AD)$ But $BC = \sqrt{BE^2 + CE^2} = \sqrt{(0.8)^2 + (2.4)^2} = 2.529$ m $\therefore$ $P = 8.0 + 2 \times 2.529 = 13.058$ m Hydraulic mean depth, $m = \frac{A}{P} = \frac{12.12}{13.058} = 1.617$ m	4		
	The discharge, Q is given by equation (16.5) as $Q = AC\sqrt{mi} = 21.12 \times 50\sqrt{1.617 \times \frac{1}{4000}} =$ **21.23 m³/s. Ans.**	2		