

**DIPLOMA EXAMINATION IN ENGINEERING/TECHNOLOGY/  
MANAGEMENT/COMMERCIAL PRACTICE — OCTOBER, 2019**

**HYDRAULICS**

[Time : 3 hours

(Maximum marks : 100)

PART — A

(Maximum marks : 10)

Marks

I Answer *all* questions in one or two sentences. Each question carries 2 marks.

1. What is coefficient of discharge ?
2. Define compressibility.
3. What is laminar and turbulent flow ?
4. What is vena contracta ?
5. Define weirs.

(5×2 = 10)

PART — B

(Maximum marks : 30)

II Answer any *five* of the following questions. Each question carries 6 marks.

1. State Pascal's law.
2. Explain the experimental determination of  $C_v$ .
3. Differentiate between uniform and non-uniform flow.
4. Distinguish among atmosphere pressure, gauge pressure and absolute pressure.
5. State the use of foot valve and strainer in centrifugal pump.
6. Differentiate between sharp crested and broad crested weir.
7. Explain the effect of water hammer.

(5×6 = 30)

PART — C

(Maximum marks : 60)

(Answer *one* full question from each unit. Each full question carries 15 marks.)

UNIT — I

III (a) A pipe of uniform diameter 400mm carries a water at a velocity 20 m/s.

The data pertaining to two points P and Q.

Point P → Pressure intensity = 4 kg/cm<sup>2</sup>      Elevation = 28m

Point Q → Pressure intensity = 3 kg/cm<sup>2</sup>      Elevation = 31m

For a steady flow, find the loss of head between P and Q.

8

(b) Describe the working of Pitot tube.

7

OR

	Marks
IV (a) State and prove Bernoulli's theorem.	8
(b) Describe pressure measuring instrument.	7
UNIT — II	
V (a) Explain Kaplan turbine with neat sketches.	8
(b) What is orifice ? Describe the types of orifice.	7
OR	
VI (a) Explain Francis turbine.	8
(b) A head of water over an orifice of diameter 10 cm is 10 m. The water coming out from the orifice is collected in a circular tank of diameter 1.5 m. The rise of water level in this tank is 0.1 in 25 seconds. Also the coordinates of a point on the jet measured from vena contracta are 4.3 m horizontal and 0.5 m vertical. Find Cd, Cv, Cc.	7
UNIT — III	
VII (a) Advantages of triangular notch over rectangular notch.	6
(b) Derive the formulae for the discharge over rectangular notches.	9
OR	
VIII (a) Explain the function of surge tank, penstock and anchor block.	7
(b) Derive the formulae for the discharge over broad crested weirs.	8
UNIT — IV	
IX (a) Water flows through a pipe 15 cm dia & 300m long with a velocity of 2.4 m/s. Find the head lost in friction. (i) Using Darcy's formulae (ii) using Chezy's formulae. Take the pipe as old one.	8
(b) Explain hydraulic gradient line and total energy line.	7
OR	
X (a) A trapezoidal channel has side slopes 2 vertical to 3 horizontal. The discharge in the channel is 20 cumecs with a bed slope of 1 in 2000. Design the channel for its best form. Use Manning's formulae. Take $N = 0.01$	8
(b) Derive the conditions for most economical section of rectangular channels.	7

(12) 8

1

REVISION:15		COURSE CODE :4011		
COURSE TITLE:				
Qt No	Scoring indicator	Split up	Sub total	Total mark
<b>PART A</b>				
1.	Ratio between the actual discharge issued and the theoretical discharge	2	2	10
2.	Property of the substance by which it changes its volume when the compressive force is applied	1	2	
	Inverse of bulk modulus of elasticity	1		
3.	Laminar :when various fluid particles moves in layers with one layer of liquid sliding smooth over an adjacent layer	1	2	
	Turbulent : when the path of the individual particles cross each other	1		
4.	When water flows through an orifice the jet of water contracts from the mouth of orifice up to a distance of about 1.5times the diameter of the orifice	1	2	
	This section of jet beyond which no further contraction takes place and the stream lines first become parallel is known as vena contracta	1		
5.	It is a structure of concrete or masonry built across a stream or river to store water on the upstream side and allow excess water to downstream side	2	2	
<b>PART B</b>				
1	When the fluid is at rest, pressure at all points on the same horizontal plane in a continuous homogeneous liquid is same	3	6	30
	Total pressure = avg intensity of pressure *area $(0+wh)/2 * (h*1) = wh^2/2$ per length	3		

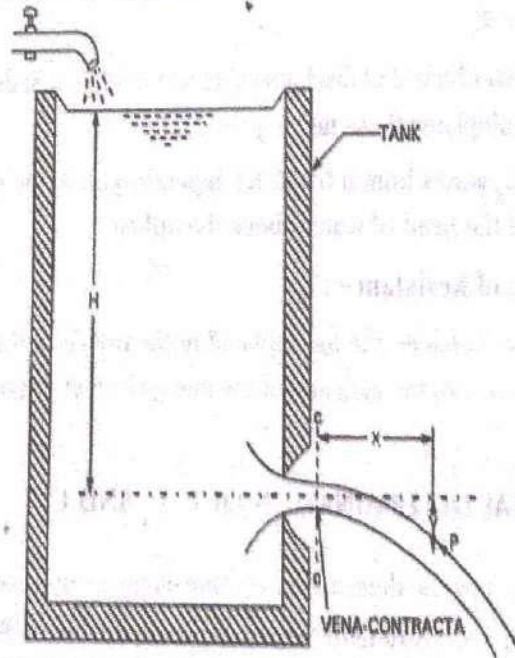
2.

**DETERMINATION OF CO-EFFICIENT OF VELOCITY ( $C_v$ ) BY METHODS OF CO-ORDINATES :**

6

The free liquid jet in the air will describe a trajectory path under the action of gravity. Consequently the path followed by the particle will be parabolic.

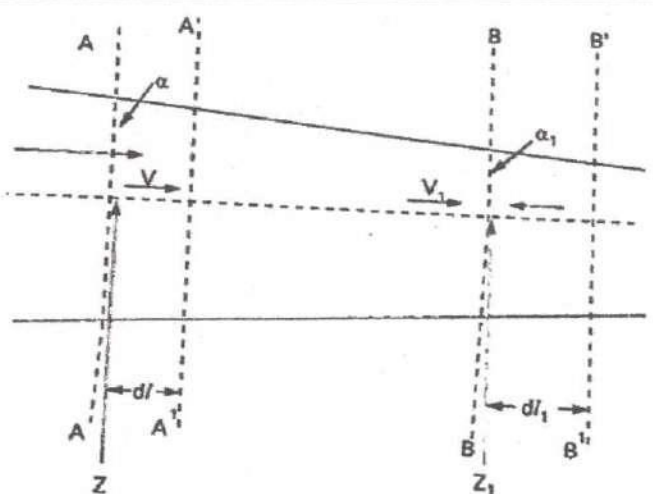
By measuring  $x$  (horizontal),  $y$  (vertical) co-ordinates of the path of the jet  $C_v$  of the orifice can be determined.



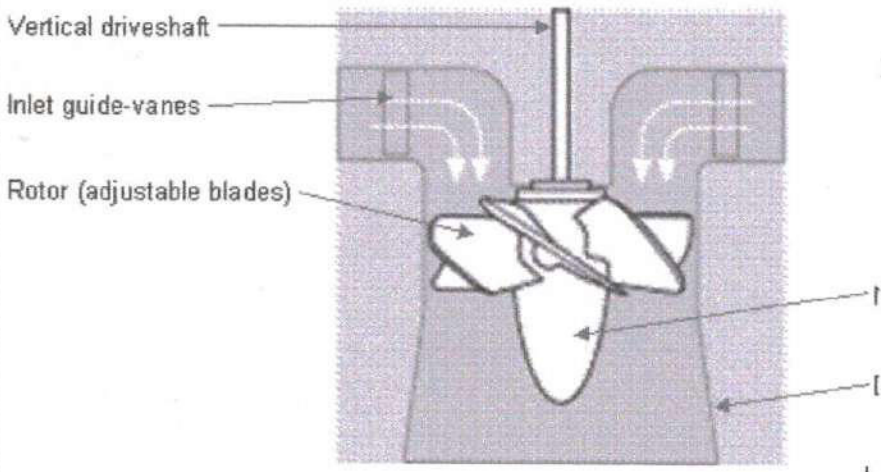
	<p>Let the water flow through an orifice fitted in one of the tank. Consider a particle of water in the jet at P. Let the section C-C represent the point of vena contracta.</p> <p>Let <math>H</math> = constant water head  <math>x</math> = horizontal distance between C-C and P  <math>y</math> = vertical distance between C-C and P  <math>v</math> = velocity of the jet  <math>t</math> = time taken in seconds by the particle to reach from C-C to P</p> <p>As the particle falls in 't' seconds a vertical distance 'y'.</p> <p>Then <math>y = \frac{1}{2} g t^2</math> where <math>g</math> is the gravitational acceleration.  and <math>x = v \times t</math>  <math>\therefore t = \frac{x}{v}</math></p> <p>Substituting the value of <math>t</math> in eqn. (i)</p> $y = \frac{1}{2} g \left( \frac{x}{v} \right)^2$ $\frac{2y}{g} = \left( \frac{x}{v} \right)^2$ $v = \sqrt{\frac{g x^2}{2y}}$ <p>Theoretical velocity of the particle  <math>v_{\text{theo}} = \sqrt{2gH}</math>  <math>\therefore</math> Co-efficient of velocity,</p> $C_v = \frac{v_{\text{actual}}}{v_{\text{theoretical}}} = \frac{\sqrt{\frac{g x^2}{2y}}}{\sqrt{2gH}}$ $C_v = \sqrt{\frac{x^2}{4yH}}$			
3.	<p><b>Uniform Flow</b></p> <p>The flow is defined as uniform flow when in the flow field the <b>velocity and other hydrodynamic parameters do not change from point to point at any instant of time.</b></p> <p>For a uniform flow, the velocity is a function of time only, which can be expressed in Eulerian description as  <math>\therefore dV / dS = 0</math></p>	3	6	

	<p><b>Non-Uniform Flow</b></p> <p>When the <b>velocity and other hydrodynamic parameters changes from one point to another</b> the flow is defined as <b>non-uniform</b></p> <p>For a non-uniform flow, the changes with position may be found either in the direction of flow or in directions perpendicular to it.</p> <p><math>dV / ds \neq 0</math></p>	3		
4	<p>Atmospheric pressure : The air exerts normal pressure upon all surfaces which is in contact and it is known as atmospheric pressure</p> <p>101.33KN/m<sup>2</sup></p> <p>10.33 of water in terms of equivalent water column</p> <p>76cm of mercury in terms of equivalent mercury column</p> <p>GAUGE PRESSURE: When the pressure measured either above or below atmospheric pressure</p> <p>Absolute pressure : algebraic sum of gauge pressure and atmospheric pressure</p>	2	6	
5	<p>Foot valve: it keeps the suction pipe filled with water when the pump is stopped and automatically cuts out the delivery pipe from the pump in case the pump stops and may not permit water to flow back to the pump</p> <p>Strainer :To prevent the solid bodies and debris from entering the pump</p>	4	6	
6	<p><b>Sharp-crested</b> weirs are typically constructed by placing a thin, rust resistant metal plate, with a notch in the top of it, perpendicular to the flow of water (concrete and timber can also be used to construct). Water will flow through the notch and the depth of water that flows through it will correlate to the discharge in the channel</p> <p><b>Broad-crested</b> weirs typically are constructed out of reinforced concrete and span the width of the channel. Their rating curves rely on flow over the crest of the weir passing through critical depth, <math>y_c</math>. When the weir is constructed to a height large enough to ensure that critical depth occurs over the crest, a rating curve can be calculated based on the geometry of the critical section. This rating curve allows for simplified determination of discharge by only looking at the depth of the water surface</p>	3	6	
7.	<p>Water hammer occurs in installations where sudden closure of a valve causes water to surge back and forth at supersonic speeds. Due to this phenomenon, the reservoir end of the pipe reflects negatively whereas the valve end reflects positively causing pressure to fluctuate rapidly. Immediately after valve closure, a steam column is generated and an air pocket forms behind the moving water. As the water hits the closed valve, the water reverses its direction and quickly fills the</p>	6	6	

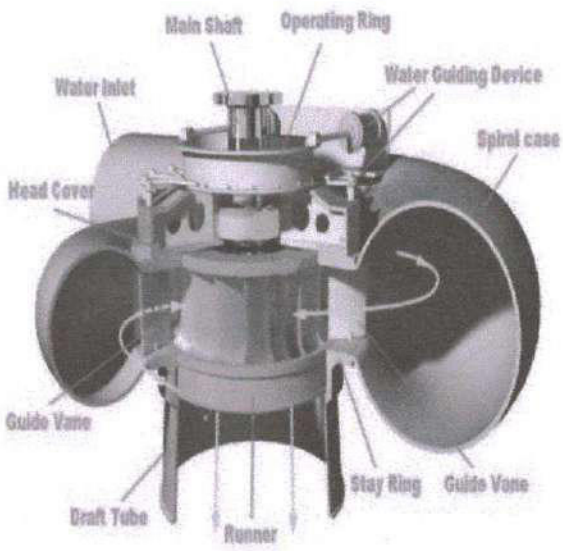
	void where the air pocket had formed. The waters change in direction causes massive forces back through the pipe			
<b>PART C</b>				
III.a	<p>Point P</p> <p>Datum head <math>Z_1 = 28</math> m</p> <p>Velocity head <math>v_1^2 / 2g = 20^2 / (2 \cdot 9.81) = 20.387</math> m</p> <p>Pressure head, <math>p_1 / w = 4 \cdot 10^4 / 1000 = 40</math> m</p> <p>Point Q</p> <p>Datum head <math>Z_2 = 31</math> m</p> <p>Velocity head <math>v_2^2 / 2g = v_1^2 / 2g = 20^2 / (2 \cdot 9.81) = 20.387</math> m</p> <p>Pressure head, <math>p_2 / 2g = 3 \cdot 10^4 / 1000 = 30</math> m</p> <p>Total head at point P = 88.387</p> <p>Total head at point Q = 81.387</p> <p>Total head at point P = Total head at point Q + <math>h_L</math></p> <p><math>88.387 = 81.387 + h_L</math></p> <p><math>h_L = 7</math> m</p>	3	3	2
III.b	<p>The pitot tube installed in the flow stream measures the direct pressure at the contact pitot tube hole and a second measurement is required, being of static pressure. The difference between the two measurements gives a value for dynamic pressure. The flow rate, like other devices, is calculated from the square_root_extractor of the pressure.</p> <p>The pitot meter consists of a tube pointing directly toward the flow. The fluid enters through the impact hole and there can one or two other holes in the pitot tube, which are the static pressure source.</p> <p>For a simple pitot tube (shown in fig:1) we should arrange one another pressure sensing element to measure the static pressure. The axis of tube measuring the static pressure should be perpendicular to the boundary and free from burrs so that the boundary is smooth.</p> <p>A pitot tube is a simple round cylinder with one end opened with a small hole and other end enclosed. The fluid flowing through the pipeline enters the pitot tube and rest there. There is another chamber within the pitot tube filled with fluid with static pressure. A diaphragm separates both the chambers.</p> <p>The differential pressure is measured between both the pressures gives the dynamic pressure. The difference in level between the liquid in the tube and the free surface becomes the measure of dynamic pressure. The flow rate, like other devices, is calculated from the square root of the pressure.</p>	7	7	

<p>IV.a</p>	 <p>Let distance between AA and A'A = <math>d l</math>          Let distance between BB and B'B = <math>d l_1</math>          ... <math>a d l = a_1 d l_1</math>  <math>W = w a d l = w a_1 d l_1</math>          Workdone by pressure at AA in moving the liquid to AA  <math>= P a d l \dots (1)</math>          Workdone by pressure at BB in moving the liquid to BB  <math>= - P_1 a_1 d l_1 \dots (2)</math>          total work done by pressure <math>= (1) - (2)</math>  <math>= W/w</math>          Loss of potential energy <math>= W(z - z_1)</math>          Gain in kinetic energy <math>= W(V_1^2 - V^2) / 2g</math>          Loss of potential energy + Workdone by pressure = Gain in kinetic energy  <math>Z + P/w + v^2 / 2g = Z_1 + P_1/w + v_1^2 / 2g</math></p>	<p>2</p> <p>6</p>	<p>8</p>	<p>15</p>
<p>IV.b</p>	<p><b>Piezometer</b> is a simple manometric device which measures pressure at a point in a fluid, without balancing any other fluid column. Consider a cylindrical vessel having a fluid filled in it and is open to atmosphere. Connect a piezometer glass tube, at the point where pressure is to be measured, such that the other end of the piezometer tube is open to the atmosphere. As soon as the piezometer glass tube is connected to the cylindrical tank, some amount of the fluid rushes into the tube, due to atmospheric pressure outside the cylindrical tank. But as the other end of the piezometer glass tube is exposed to atmosphere, atmospheric pressure acts at that open end also and hence fluid raises up to some level in the glass tube and does not overflow from the tube</p> <p><b>U-tube manometer</b> is a simple manometric device used to measure pressure at a point in a fluid, by balancing the fluid column by the same or another column of fluid. It has a glass tube bent in "U" shape</p>	<p>7</p>	<p>7</p>	

	<p>with some amount of same or other type of fluid, called manometric fluid like mercury,</p> <p>Consider a pipe carrying a fluid called "fluid 1" with specific weight <math>\gamma_1</math> and let pressure <math>P_A</math> to be measured at a point "A" in the pipe. Let the manometric fluid have specific weight <math>\gamma_2</math> - As the U-tube manometer is connected to the pipe, the "fluid 1" rushes into the U-tube and pushes the manometric fluid upwards in the other limb of the U-tube, due to which the initial manometric fluid level as shown in Figure 2.8a is disturbed and lowers in the left limb and raised up with a pressure head "<math>h_2</math>" in the right limb of U-tube. Let the fluid 1 in pipe occupy the U-tube column in the left limb, of height "<math>h_1</math>" and let the manometric fluid in U-tube be raised up to a height "<math>h_2</math>", in the right limb. Due to the push given by the fluid 1 onto the manometric fluid, the manometric fluid may overflow but it does not happen due to the reason that the atmospheric pressure acts on the open end of the U-tube</p> <p><b>Single column/micro-manometers</b> are just similar to the U-tube manometer, only with a difference of having a small reservoir in the tube, Micro-manometer has a glass tube bent in "U" shape or inclined and has a small reservoir in the tube, having some amount of same or other type of fluid called manometric fluid.</p> <p><b>Inverted differential U-tube manometer</b> is a device just as same that of U-tube differential manometer but is inverted in construction. It measures pressure difference <math>\Delta P</math> at two different points "A" and "B" in a single pipe or different pipes, carrying two fluids of same or different kinds</p>			
V.a	<p>Kaplan Turbine is an axial flow reaction turbine with adjustable blades. This turbine was developed in the year 1913 by Viktor Kaplan, who was a Austrian Professor. In his design, he combined automatically adjusted propeller blades and automatically adjusted wicket gates to obtain efficiency over a wide range of water flow and level.</p> <p>It is also called as propeller turbine and evolved from the Francis Turbine. It is capable of working at low head and high flow rates very efficiently which is impossible with <u>Francis turbine</u>. The working range of head at which the Kaplan turbine works more efficiently is 10 to 70 m.</p> <p>Since it is a <u>reaction turbine</u>, so the reaction force of leaving water is used to turn the runner of the Kaplan turbine, As the water flows through the twisted blades a lift force is generated in the opposite direction of the leaving water and that lift force causes the blades to rotate.</p>	6	8	15

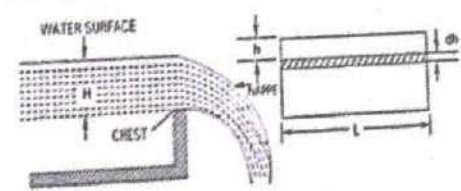
	 <p>Vertical driveshaft</p> <p>Inlet guide-vanes</p> <p>Rotor (adjustable blades)</p>	2		
V.b	<p>Orifice is defined as the small opening on side or bottom of a tank through which any kind of <u>fluid</u> is flowing. The opening can be of circular, triangular or rectangular in cross section and they are named on the basis of shape accordingly. Orifices are mainly used for measuring the rate of fluid flow.</p> <p>Orifices are classified on the basis of many criteria such as:</p> <ol style="list-style-type: none"> <li>1. Size</li> <li>2. Shape</li> <li>3. Nature of discharge</li> <li>4. Nature of upstream edge etc</li> </ol>	7	7	
VI.a	<p>Francis Turbine is a combination of both impulse and reaction turbine, where the blades rotate using both reaction and impulse force of water flowing through them producing electricity more efficiently. Francis turbine is used for the production of electricity in hydro power stations.</p> <p>Majorly there are 2 turbines flow patterns on which they work, namely radial and axial flow concepts. An American civil engineer by name, James B. Francis in Lowell, Massachusetts comes up with an idea of combining both impulse and reaction turbine where water enters the turbine radially and exits axially.</p> <p>The main reason of higher efficiency of Francis turbine lies in the design of blades, these blades rotate using both reaction and</p>	7 Fig =1	8	15

impulse force of water flowing through them. Due the use of this type of turbines the main problem faced due to the water head availability is eliminated as the turbine uses both the kinetic and potential energy to produce power



**Francis Turbine**

<p>VI.b</p>	$Q_{act} = \frac{\text{Area of measuring tank} \times \text{Height of water in measuring tank}}{\text{time}}$ $= \frac{\pi \times (0.75)^2 \times 1}{25} = 0.707 \text{ m}^3 / \text{sec}$ $Q_{theo} = \text{Area of orifice} \times \sqrt{(2gH)} = \pi \times (0.505)^2 \times \sqrt{(2 \times 9.81 \times 10)}$ $= 0.11 \text{ m}^3 / \text{sec}$ $C_d = 0.707 / 0.11 = 0.643$ $C_v = \sqrt{(x^2 / 4 y H)} = \sqrt{(4.3)^2 / (4 \times 0.5 \times 10)} = 0.9615$ $C_d = C_d / C_v = 0.669$	<p>7</p>	<p>7</p>	
<p>VII. a</p>	<p>A <b>triangular notch</b> gives much more accurate results in low discharge conditions, as compared to the conventional <b>rectangular notch</b>. Also, only one reading (the head) is required to calculate the discharge rate, making calculations much easier. However, it cannot handle large volumes of flow rate accurately</p>	<p>6</p>	<p>6</p>	<p>15</p>

<p>VII. b</p>	<p>Consider a rectangular notch in one side of a tank over which water is flowing as shown in Fig. 6.5.</p>  <p>Fig. 6.5 Rectangular Weir</p> <p>Let <math>H</math> = Height of water above the sill of the notch  <math>L</math> = Width or length of the notch</p> <p>Consider a horizontal strip of water of thickness 'dh' at a depth of 'h' from the water level as shown in Fig. 6.5.      Area of the strip = <math>Ldh</math> and      Theoretical velocity of water flowing through the strip</p> $= \sqrt{2gh} \quad \dots (i)$ <p>Let <math>d_q</math> = discharge through the strip  <math>C_d</math> = co-efficient of discharge  <math>d_q = C_d \times \text{area of the strip} \times \text{theoretical velocity}</math></p> $= C_d \cdot Ldh \cdot \sqrt{2gh} \quad \dots (ii)$ <p>Total discharge over the whole notch may be found out by integrating the above equation with in the limits 0 to H.</p> $Q = \int_0^H C_d \cdot L \cdot \sqrt{2gh} \, dh = C_d \cdot L \cdot \sqrt{2g} \int_0^H h^{1/2} \, dh = \frac{2}{3} C_d \cdot L \cdot \sqrt{2g} \left[ h^{3/2} \right]_0^H$ $\dots (6.1)$ $= \frac{2}{3} C_d \cdot L \cdot \sqrt{2g} \cdot H^{3/2}$	<p>9</p>	<p>9</p>	
<p>VIII. a</p>	<p>The function of the <b>anchor block</b> is to fix the penstock and do not allow the pipe with any direction of movement. The installation site of the anchor block is usually at the connection of forebay pool and pressure pipe, connection between pressure pipe and power house, and when pressure pipe changes its direction. The change of direction can be vertical or horizontal. In either cases anchor blocks should be provided. They are designed to ensure the thrust restraint of water. The penstock between the anchors are supported by rocker supports. <b>Penstock pipes</b> are also called pressure pipes, they are used to carry water from the forebay or reservoir to the powerhouse. These pipes should be designed for the water pressure the desired levels, mostly at the anchor block. The design aspects are explained in the noted references</p>	<p>7</p>	<p>7</p>	<p>15</p>

	Surge tank is a water storage device used as pressure neutralizer in hydropower water conveyance system to resist excess pressure rise and pressure drop conditions.			
VIII. b	<p>Let <math>H</math> = Head of water on the upstream side of the weir  <math>h</math> = head of water on the downstream side of the weir  <math>v</math> = velocity of water on the downstream side at B  <math>L</math> = length of the weir  <math>C_d</math> = co-efficient of discharge.</p> <p>Applying Bernoulli's equation at A and B</p> $0 + 0 + H = \frac{v^2}{2g} + h \text{ or } \frac{v^2}{2g} = H - h$ $v = \sqrt{2g(H-h)} \quad \dots (i)$ <p><math>\therefore</math> Discharge over the weir <math>Q = C_d \times \text{area of flow} \times \text{velocity}</math></p> $Q = C_d \times L \times h \times v \quad \dots (ii)$ $= C_d \times L \times h \times \sqrt{2g(H-h)} \quad \dots (6.20)$ $= C_d \cdot L \cdot \sqrt{2g} \times \sqrt{Hh^2 - h^3} \quad \dots (iii)$ <p>The discharge is maximum when <math>(Hh^2 - h^3)</math> is maximum. Therefore differentiating the equation <math>(Hh^2 - h^3)</math> and equating to zero.</p> $\frac{dQ}{dh} = 0$ $\frac{d}{dh} (Hh^2 - h^3) = 0$ $2Hh - 3h^2 = 0$ $2H - 3h = 0$ $h = \frac{2}{3} H$ <p>Introducing of the above value of <math>h</math> in equation 6.20 the maximum discharge over a broad crested weir</p> $Q_{\max} = C_d \cdot L \times \frac{2}{3\sqrt{3}} \sqrt{2g} \times H^{3/2}$ $= 0.384 C_d \cdot L \cdot \sqrt{2g} \times H^{3/2} = 0.384 C_d \cdot L \times \sqrt{2 \times 9.81} \times H^{3/2}$ $Q_{\max} = 1.705 C_d \cdot L \cdot H^{3/2} \quad \dots (6.21)$	8	8	
IX.a	<p>For old pipes <math>f = 0.01</math>  <math>C = \sqrt{2g/f} = 43.75</math>  Darcy's formula <math>hf = 4fL v^2/d \cdot 2g = 24.07</math>  chezys formula <math>v = C \sqrt{mi}</math>  <math>hf = v^2 l / C^2 m = 24.07 \quad m = d/4</math></p>	8	8	15
IX.b	<p>Total energy gradient line is equal to sum of pressure head, velocity head and datum head <math>EL = H = p/W + v^2/2g + h = \text{constant}</math> along a streamline where, (EL) Energy Line Hydraulic Grade Line (HGL) Hydraulic gradient line is the sum of pressure head and datum head <math>HGL = p/W + h</math> where The hydraulic grade line lies below the energy line.</p>	7	7	

X.a	$(b+2nd)/2 = d\sqrt{n^2 + 1}$ ... $b + 3d = 2d (1.8) \dots b = 0.6d$ $A = (b+2nd) d = 2.1d^2$ $Q = A 1 \text{ m}^{2/3} \cdot (i)^{1/2}$ ... $d = 2.05\text{m}$ ... $b = 0.6 * 2.05 = 1.23\text{m}$	7	7	15
X.b	$D = b/2 \quad m = d/2$	8	8	