QUESTION WISE ANALYSIS:SET-1

COURSE: HYDRAULICS COURSE CODE:4011
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COURSE CODE : 4011

Qn No	Specific outcome (as per syllabus)	Module	Content Details	Score	Time in Minutes
I			PART A		
1	1.1.1	1	a) Specific Weight is defined as the weight per unit volume. b) Specific Gravity of a liquid may be defined as the ratio of specific weight or density of liquid to specific weight or density of pure water at 4^0 C.	2	3
2	2.1.12	2	Different types of Mouth pieces. a)External cylindrical Mouthpiece b)Internal mouthpiece running free c)Convergent mouthpiece d) Convergent divergent mouthpiece	2	3
3	3.11	2	a) Depending on the shape of opening Rectangular and triangular notches are named. b) Both Notches are often used in water supply, waste water and sewage systems. c) Head of Rectangular Notch is parabolic and that of V notch is linear. d) Triangular notches gives more accurate results for low discharge than rectangular notches.	2	3
4	3.22	4	a) Surge tank The major function of the "surge tank" is to minimize the hammering effects of water. It is placed as close to the turbine as possible . b) Penstock. The penstock is used to drain the water from the source to the hydro turbine in the powerhouse. This is the main part of the micro hydro as it converts the potential energy of the water into kinetic energy.	2	3
5	4.22	3	Uniform flow: If the flow velocity is the same magnitude and direction at every. point in the fluid it is said to be uniform. Non-uniform flow: If at a given instant, the velocity is not the same at every point the flow is non-uniform.	2	3
II			PART B		
1	1.2.3	1	**Atmospheric** pressure is the force exerted by the air on a surface above it as gravity pulls it to Earth. It is commonly measured with a barometer. **Gauge pressure** is the pressure relative to atmospheric pressure.	6	10

			Gauge pressure is positive for pressures above atmospheric pressure, and negative for pressures below it.. It is commonly measured by instruments called gauges. The gauges are caliberated to read atmospheric pressure at zero mark. Absolute pressure = Gauge pressure + Atmospheric pressure.		
2	1.2.5	1	The pressure of the fluid can be measured by certain devices and they are broadly classified in to (a) Manometers (b) Mechanical gauges. **Manometers:** Manometers are the pressure measuring devices which are based on the principle of balancing the column of the liquid (whose pressure is to be found) by the same or another column of liquid. The manometers are further classified as (a) Simple Manometers (b) Differential manometers Simple manometers are those which measure the pressure at a point in a fluid contained in a pipe or vessel. A simple manometer consists of a glass tube one end connected to the gauge point where the pressure is to be measured and the other end exposed to the atmosphere. (1) Piezometer. (2) U tube Manometer. (3) Single column Manometer. Simple manometers are those which measure the pressure at a point in a fluid contained in a pipe or vessel. (1) Piezometer. (2) U tube Manometer. (3) Single column Manometer. **Piezometer:** This is the simplest form of manometer for measuring moderate pressures. It consists of a glass tube in which the liquid can rise without over flowing. The tube is inserted in the pipe or a vessel whose pressure is to be measured. The pressure head is indicated by the height of the liquid in the end the tube above that point which can be read on the scale attached to it. The piezometer is meant for measuring gauge pressures only as the surface of liquid is exposed to the atmosphere. As the air will be entering through the tube, piezometer tube is not suitable for measuring negative pressures. The size of the tube should not be less than 10 mm to avoid error due to a water is capillarity action.	6	10
3	2.1.2	2	**An orifice** is an opening made in the side or bottom of tank, having a closed perimeter, through which the fluid may be discharged in such a way that the liquid surface is always above the top edge of the opening . The orifice is one of the devices to	6	10

measure the rate of flow of liquid.

TYPES OF ORIFICES

Generally the orifices are classified according to their **(1) size**
(2) shape **(3) According to shape of the edge**
(4) According to the nature of the discharge

Under the conception of size, they are divided as small and large orifices.

(2) According to shape:
(a) Circular (b) Rectangular (c) Triangular.

(3) According to shape of the edge:

(a) Sharp edged (b) Square edged
(c) Bell mouthed
(4) According to the nature of the discharge:

(a) Fully submerged(b) Partially submerged.

A mouthpiece is a short tube fitted to a circular orifice provided in the vessel such that it projects towards outside or inside.
By fitting the mouthpiece of length, about two to three time the diameter the discharge through the orifice may be increased.
The mouthpiece may have different shapes like cylindrical, convergent and divergent which is attached externally to an orifice.

TYPES OF MOUTHPIECES:

1. They can be classified according to the position of the mouth-pieces.

(a) External mouthpiece. (b) Internal mouthpiece.

II. According to the shape of the mouthpiece.

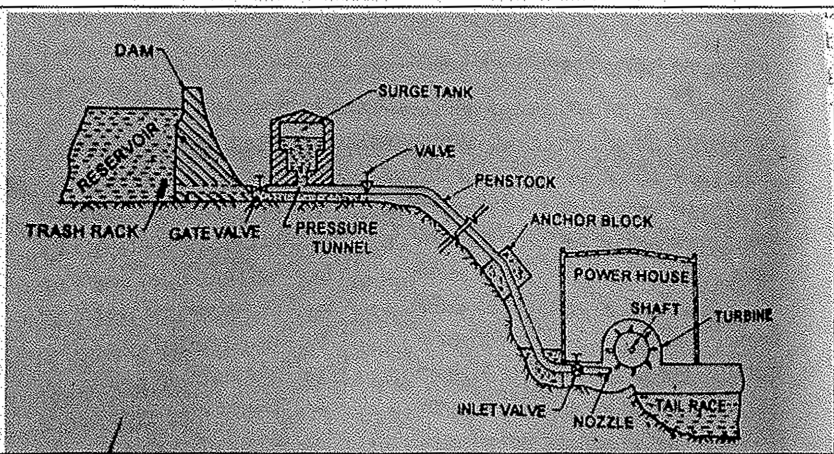
(a) Cylindrical mouthpiece.
(b) Convergent mouthpiece.
(c) Convergent, divergent mouthpiece.
(d) Divergent mouthpiece.

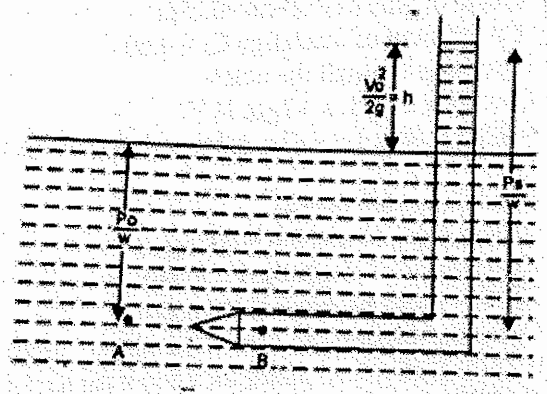
III. According to the discharge condition.

(a) Mouthpiece running full.
(b) Mouthpiece running free.

If the diameter of jet of the liquid from the mouthpiece is of same diameter as that of mouth piece it is said to be Mouth piece

			running full. If the jet emerging from the mouthpiece does not touch the sides of the mouth piece it is said to be mouthpiece running free. (a) External Mouthpiece: When the tube is fixed externally to the orifice it is called External mouth piece. (b) Internal mouth piece: If the tube is fixed internally inside the tank it is known as internal mouth piece. It is also called Re entrant or Borda's mouth piece. (c) Convergent mouth piece: A convergent mouth piece is one which is made to conform to the shape of the jet upto vena contracta. This is in the shape of a frustum of a cone. (d) Convergent, divergent mouth piece: The mouth piece is made convergent upto vena contracta and beyond vena contracta it is made divergent. Such a mouth piece is called convergent, divergent mouth piece. (e) Divergent mouth piece: In this, mouth piece is gradually diverging to eliminate loss of energy.		
4	2.3.1	2	**a)Turbines** are machines which convert hydraulic energy into mechanical energy. According to hydraulic action, **the turbines are mainly classified as** (a) Impulse turbines (b) Reaction turbines (a) The Impulse Turbine is one in which the available potential head is converted into kinetic energy by passing water through a nozzle under atmospheric pressure The jet of water coming through the nozzle strikes the blades of the runner. After water doing its work, it is discharged into open tail race. In this type of turbine water flows only on some part of the periphery of the turbine and that is why the pressure in the turbine is only atmospheric. Example of Impulse Turbine: Pelton wheel. (b) Reaction turbines. The water'is supplied to the turbine in large quantity under pressure with some velocity. The pressure at the inlet to the turbine is more than the atmospheric pressure. The pressure and velocity energies of water are converted into mechanical energy by the turbine. Since the flow from inlet to tail race is under pressure an air tight casing is absolutely necessary to enclose the turbine. Vacuum pressure is created in these turbines due to which it is not possible to leave the water into tailrace directly. For releasing the water into tail race, a suitable draft tube is necessary which gradually increases the pressure to the required level.	6	10

			Example: Francis Turbine, Kaplan turbine		
5	3.1.1	3	**For rectangular notch:** Length of the notch L = 1m Depth of water H=25cm=0.25m Co-efficient of discharge C_d = 0.60 Discharge through the notch $Q = 2/3 \times C_d \times L \times \sqrt{2g}) \times H^{3/2}$ $= 2/3 \times 0.60 \times 1 \times (\sqrt{(2 \times 9.81)}) \times (0.25)^{3/2} = 0.221\ m^3/sec.$ **For triangular notch:** Given angle of notch θ = 90degree Coefficient -of discharge C_d = 0.55 Let H = depth of water in the notch Using the relation $Q = 8/15 \times C_d \times \sqrt{2g} \times \tan(\theta/2) \times H^{5/2}$ $0.221 = 8/15 \times 0.55 \times sqrt(2 \times 9.81) \times \tan 45^0 \times H^{(5/2)}$ or $H^{(5/2)} = 0.171$ H = .4937m = 49.37cm	3+3=6	10
6	3.2.1	3	 	6	10
7	4.2.0	4	**An open channel** is the passage through which water is flowing and the free surface of water is having contact with atmosphere. Open channels may either be natural like streams and rivers or artificial channels built for some specific purpose like navigation, irrigation and power generation. Flowing water is subjected to frictional resistance at the wetted surface. As the pressure throughout is atmospheric the head causing flow will be entirely due to the slope of the channel. Hence the head due to the slope of the channel will be lost in overcoming the frictional resistance of the side. (a) Depth of flow (y): It is the vertical distance between the lowest point of the channel section and the free surface. (b) Wetted perimeter (P) :I t is the perimeter in contact with the liquid. (c) Wetted area (A): It is the cross-sectional area of the channel normal to the direction of the flow. (d) Top width (T): It is the width of the channel section at the free surface.	6	10

			(e) Hydraulic depth (D): It is the ratio of wetted area to top width. D = A/T		
			PART C		
III.	1.3.9	1	 A simple **Pitot tube** is a glass tube bent at right angles at one end. The bent end is placed in the flowing liquid such that it faces the motion of the stream. The Pitot tube is used for measurement of velocity in open channels, streams and rivers. Consider a point A on any stream line where the velocity is v. As the liquid strikes the point B in Pitot tube nose. The liquid enters the tube and rises to a height Ps/w. All the kinetic energy W of the flow is converted into pressure head. The pressure at B is called stagnation pressure. It can be understood from the figure that the height of the liquid above the free surface is equal to the velocity head in the stream approaching the tube. $V_0 = \sqrt{2gh}$ **Orifice meter** is another device to measure discharge through a pipe. This meter also works on the same principle as Venturi meter. The loss of head is more than that of Venturi meter. The device consists of a plate with an orifice which is fixed between the flanges in a pipe line. The pressure difference is measured between two sections, one upstream of the plate and the other downstream of the plate. The ratio of orifice to the pipe diameter is between 0.4 and 0.8 and is usually it is kept at 0.5.	5	10
	1.3.10	1	<u>discharge of a flowing liquid using pitot tube</u> Let Po= static pressure in the un-disturbed flow at A Vo= velocity at A Ps = stagnation pressure at B Applying Bernoulli's equation to the points A and B which are in the same line. $(P_o/w)+(V_0^2/2g)+0=(P_s/w)+0+0$ (as $z_1 = 2_2 = 0$). $(V_0^2/2g) = (P_s/w) - (P_o/w)$ $V_0 = \sqrt{2g}\ x\ ((P_s/w) - (P_o/w))$ If $(P_s/w) = (P_o/w) = h$	10	15

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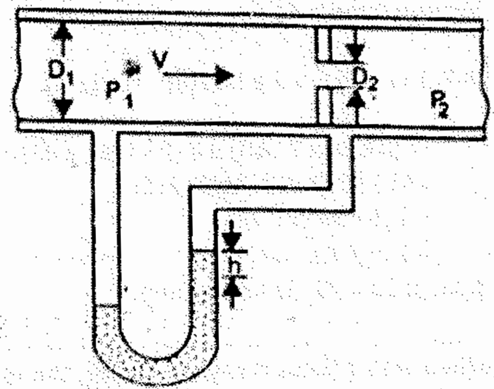
$V_0 = \sqrt{2gh}$

<u>discharge of a flowing liquid using orifice meter</u>



Let a_1 = area of the pipe as section 1
v_1= velocity of liquid at section 1
p_1 = pressure at section 1

Let a_2,V_2 and P_2 are corresponding values at section (2) in orifice.

Applying Bernoulli's equation at sections 1 and 2

$(p_1/w) + (v_1^2/2g) + z_1 = (p_2/w) + (v_2^2/2g) + z_2$
or
$((p_1/w) + z_1) - ((p_2/w) + z_2) = (v_2^2/2g) - (v_1^2/2g) = h$

If Q is the discharge. $Q = K.\ (a_1.\ a2/\sqrt{(a_1^2 - a_2^2)}) \times \sqrt{2gh}$

where K is the co-efficient of the meter.

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<tr><td>IV.</td><td>1.3.5</td><td>1</td><td>

The Bernoulli's theorem can be stated that for steady flow of frictionless incompressible liquid the total energy of a particle remains constant at every point in its path of flow.

The following **assumptions** have been made in the derivation of Flow of Liquids Bernoulli's equation.
(1) The fluid is ideal and incompressible.
(2) The flow is steady and continuous.
(3) The flow is along a stream line (i.e.) it is one dimensional.
(4) The velocity is uniform over the section and is equal to mean velocity.
(5)No external force except the gravitational force is acting on the liquid.

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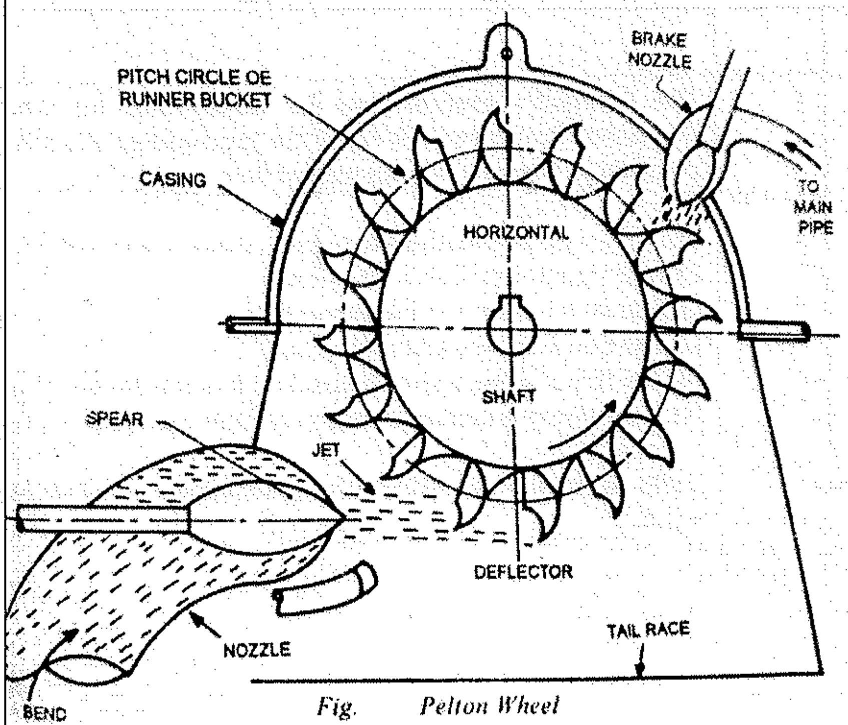
	1.3.8	1	Solution: Area at the inlet $a1 = \pi /4 \times 7.5^2 = 44.18\ cm^2$ Area at the throat $a2 = \pi /4 \times 3^2 = 7.065\ cm^2$ Venturi head = 42 cm. $Q = K. (a_1. a2) \times \sqrt{2 g h} / \sqrt{(a_1^2 - a_2^2)})$ $= ((44.18 \times 7.065) \times \sqrt{(2 \times 9.81 \times 42)}) / \sqrt{(44.18^2 - 7.065^2)})$ $= 312.1317 \times 28.70/(7.065)$ $= 1267.96\ cm^3 /sec$ = 1.267 lts./sec. or 1.267 x 60 = 76. 02 lts./minute.	8	15
V.	2.1.3	2	When water flows throw an orifice, the jet of water contracts from the mouth of orifice upto a distance of about one half of the orifice diameter. This section of the jet beyond which no further contraction takes place and the stream lines first become parallel is known as **vena contracta.** The velocity at the vena contracta has reached the maximum and hence there will be no further contraction. The cross sectional area of the jet at vena contracta is less than the area of the cross section of the orifice. The fluid particles before they reach the orifice have the velocity components parallel to the plane of the orifice. They cannot make abrupt changes in the direction because of inertia. They take curvilinear paths and this causes the contraction of the jet at vena contracta.	5	10
	2.3.2	2	 *Fig. Pelton Wheel* PELTON WHEEL	10	15

			This is the most popular impulse turbine. It works under high heads and require small quantity of water. Water is taken to the turbine through penstock pipe fitted with a nozzle at the end water 'comes out of the nozzle in the form of a jet. The jet of water issuing from the nozzle strikes the buckets in the direction tangential to the wheel. The impact of water imparts a dynamic force to the wheel and the wheel starts moving. Usually one jet is used. The over all efficiency of the turbine is about 84%. The buckets are divided into hemispherical cups by a sharp central edge which divides the jet into two parts. The pelton wheel is kept above the tailrace so that the buckets do not splash the tail race water. The water coming out of the wheel is discharged into tail race. A casing made of cast iron is provided for pelton wheel to prevent splashing of water and to act as a protection against accidents. Main Component Parts of a Pelton Wheel: (1) Nozzle with flow regulating mechanism : (2) Buckets and runner (3) Casing (4) Hydraulic brake (5) Deflector		
VI.	2.1.4	2	The ratio of the actual discharge to the theoretical discharge is known as the co-efficient of discharge. If Cd= Co-efficient of discharge Q_{act} = actual discharge Q_{theo} =theoretical discharge a_0 =area of the orifice $C_d = Q_{act} / Q_{theo}$ $Q_{theo} = a_0 \times (\sqrt{2gH})$ Actual discharge (Q_{act})= actual area at vena contracta x actual velocity of the jet. (Q_{act})= $Cc \times a_0 \times Cv \ \sqrt{(2gH)}$ $C_d = (Cc \times a_0 \times Cv) \sqrt{2gH})/(a_o \times \sqrt{(2gH)}$ $\mathbf{C_d = C_c . C_v}$ The value of Cd varies from 0.6 to 0.62 depending up on the size and shape of orifice and the head of water above the orifice.	7	10
	2.1.9	2	Q= 250/ (1000x50) = 5×10^{-3} m^3 /sec. x = 8.2m y = 3m H = 6 m $Cv = \sqrt{((x^2)/(4yH))}$ $= \sqrt{((8.2)^2)/(4 \times 3 \times 6.0))} = \sqrt{(67.24/72)}$ = 0.965	8	15

			Q_{theo} =area x velocity $= (\pi/4) \times (0.04)^2 \times \sqrt{(2 \times 9.81 \times 6.0)}$ =0.00125 x 10.849 $= 13.5 \times 10^{-3}\ m^3/sec$. Cd = actual discharge /theo. discharge $=(5 \times 10^{-3}) / (13.5 \times 10^{-3}) = 0.370$ Cc= Coefficient of discharge/ Coefficient of velocity = 0.370/0.965 = 0.383 Hydraulic co-efficients Cc = 0.383 Cv= 0.965 Cd= 0.370		
VII.	3.1.1	3	WEIR: A weir is a concrete or masonry structure built across a stream or river to raise water level on the upstream side and allow excess water to flow to the downstream side. The conditions of flow in case of weir are practically same as those of a rectangular notch. Hence there is no difference between a notch and a weir except the notch is of small size; but the weir is of bigger one. A notch is usually made in plate where as weir is made of masonry or concrete. CLASSIFICATION OF WEIRS **The Weirs are Classified as According to Shape:** (a) Rectangular weir (b) Cippolettic weir **According to Nature of Discharge :** (a) Freely discharging weir (b) Submerged or drowned weir **According to the Shape of the Crest:** (a) Sharp crested weir (b) Broad crested weir (c) Narrow crested weir If the liquid level on the downstream side of the weir is lower than the crest level, the weir is called Freely Discharging Weir. When the liquid level on the downstream side is higher than the crest level, the weir is called Submerged Weir.	8	15

	3.1.5	3	Given length of the weir L = 12 m Qmax = 10 m^3/sec. Cd= 0.65 Let H = head of water on the upstream side of the weir for maximum discharge. $Q = 1.705\ C_d.\ L.\ H^{3/2}$ $10 = 1.705 \times 0.65 \times 12\times H^{3/2}$ H=0.826m	7	10
VIII.	3.2.1	3	**Turbines** are machines which convert hydraulic energy into mechanical energy, They are usually coupled to electric generators. CLASSIFICATION OF HYDRAULIC TURBINES: Hydraulic turbines may be classified according to the following factors. (1) According to Hydraulic action (2) According to Direction of flow of water (3) According to Direction of shaft (4) According to Head (5) According to Specific speed.	7	10
	3.2.1	3	**According to Hydraulic Action:** According to hydraulic action, the turbines are mainly classified as (a) Impulse turbines (b) Reaction turbines (a) The Impulse Turbine is one in which the available potential head is converted into kinetic energy by passing water through a nozzle under atmospheric pressure. The jet of water coming through the nozzle strikes the blades of the runner. After water doing its work, it is discharged into open tail race. In this type of turbine water flows only on some part of the periphery of the turbine and that is why the pressure in the turbine is only atmospheric. Example of Impulse Turbine: Pelton wheel (b) Reaction turbines / The water is supplied to the turbine in large quantity under pressure with some velocity. The pressure at the inlet to the turbine is more than the atmospheric pressure. The pressure and velocity energies of water are converted into	8	15

mechanical energy by the turbine. Since the flow from inlet to tail race is under pressure an air tight casing is absolutely necessary to enclose the turbine. Vacuum pressure is created in these turbines due to which it is not possible to leave the water into tail race directly. For releasing the water into tail race, a suitable draft tube is necessary which gradually increases the pressure to the required level.

Example: Francis Turbine, Kaplan turbine

According to Direction of Flow of Water:

(a) **Tangential flow turbine:** In this turbine the flow strikes the radially buckets of the runner tangentially to the path of rotation. Example: Pelton Wheel

(b) **Radial flow turbines:** In a radial flow turbine the water strikes in the radial direction.

The radial flow may be (1) inward radial flow and (2) out ward radial flow

(1) In ward radial flow: If water flows from out wards to in-wards radially the turbine is known as inward radial flow turbine

Example: Old Francis turbine

(2)Out ward radial flow: If water flows radially from inwards to outwards the turbine is known as outward flow turbine. Water from the centre, enters the turbine blades through guide blades and leaves radially.

Example: Fourneyron turbine

(c) Axial flow turbines: In this type the water flows in the direction parallel to the axis of the shaft

Example: Kaplan and propellor turbines

(d) Mixed flow turbines: In a mixed flow turbine the water enters the runner in radial direction and leaves in axial direction. Ex. (1) Modern Francis turbine (2) Dariaz turbine. The Dariaz turbine is similar to Francis turbine except the blade angles can be changed according to guide blade position.

According to the Direction of the Shaft:

Depending upon the disposition of the shaft, a turbine may be **(1) Vertical shaft turbine (2) Horizontal shaft turbine.**

In the case of vertical shaft turbine, the shaft is vertical and runner horizontal. In the case of horizontal shaft turbine the shaft is horizontal and the runner is vertical. Generally a vertical shaft turbine is adopted for large units.

According to Head:

The turbines can be classified according to the head under which

			they work. They are **1) High head turbine:** When the net head varies from 150 m to 2000 m or more, it is known as high head turbine. Example: Pelton wheel. **(2) Medium head turbine :** When the head varies 30m to 150 m it is enste known as medium head turbine. Example: Francis turbine **(3) Low head turbine :** When the head is less than 30 m it is known ne j as low head turbine. Example: Kaplan turbine <u>According to Specific Speed :</u> Specific Speed: Specific speed of a turbine is the speed at which turbine runs under unit head and develops unit power. According to the specific speed of the turbine **(a) Low specific speed turbine:** When the specific speed is less than 60, it is known as low specific speed turbine Example: Pelton wheel **(b) Medium specific speed turbine:** When the specific speed lies between 60 and 400 it is known as medium specific speed Example: Francis turbine **(c)High specific speed turbine** : When the specific is greater than hich 100 it is known as high specific speed turbine Example: Kaplan turbine		
IX.	4.1.2	4	$h_f = 4 f l v^2/2gd$ where h_f = head loss due to friction f= co.efficient of friction l= length of the pipe V= velocity of flow g= gravitational constant d= diameter of the pipe	5	10
	4.1.6	4	Solution: Given data d = 0.15m l = 500 m $h_f = 4f l v^2/2gd$ $30 = (4 \times 0.01 \times 500 \times v^2)/(2 \times 9.81 \times 0.15)$ $30 = (20 \times v^2)/(2.943)$	10	15

			$v^2 = 4.41$ $v = 2.10$ m /sec. Discharge Q = AV $= (3.14 X .15^2 / 4) X 2.10$ $= 0.037 m^3/sec$		
X.	4.1.1	4	MOST ECONOMICAL RECTANGULAR CHANNEL: The most economical section for a channel is the one which gives the maximum discharge for a given quantity of excavation. The discharge proportional to the velocity and area, where as the excavation is proportional to the area. The proportions of the most economical section are found by assuming the area to be constant and finding the depth for maximum velocity. Q = Av For a given area 'Q' is maximum when 'v' is maximum. $v = C x\sqrt{(mi)}$ v is maximum when m is maximum. m = A/p m is maximum when P is minimum. Discharge is maximum when P is minimum. Consider a rectangular channel. Let b =breadth, d =depth. b = A/d Discharge $Q = AV = A C x\sqrt{(mi)} = AC \sqrt{(A/P)}$. Now assuming section is constant, the discharge is maximum when P is minimum. P = b + 2d = A/d + 2d $= A . d^{-1} + 2d$ For P to be minimum (d(P))/(d(d)) should be zero. (i.e.) $(d(P))/(d(d)) = - A . d^{-2} + 2$ $A = 2d^2$ $bd = 2d^2$ or d = b / 2 For maximum discharge in rectangular channel d = b / 2 m= A/P = (bd)/(b + 2d) $m = (2d^2)/(2d + 2d)$ m = d/2 d = b/2	6	10
	4.2.1	4	Given data d = 3.6m b= 6m $A = 3.6 X 6 = 21.6 m^2$ P = b + (2 X 3.6) = 6 +(2 X 3.6)= 13.2 m Slope of bed i = 1/1000 Chezy's constant = C = 50 Let Q= discharge through the channel , hydraulic mean depth m= A/P = 21.6/13.2 = 1.63 Q=AreaX velocity= $AC \sqrt{(mi)} = 21.6 X 50\sqrt{((1.63) X (1/1000))}$ $=43.68 m^3 /sec.$	9	15
Total Time 285 Minutes					