SNS COLLEGE OF TECHNOLOGY

COIMBATORE

Department of Civil Engineering

Question Bank

19CEB203 – MECHANICS OF FLUIDS AND MACHINERY

UNIT – 1: FLUID PROPERTIES

2 MARK QUESTIONS AND ANSWERS

1. Define fluid mechanics.

It is the branch of science, which deals with the behavior of the fluids (liquids orgases) at rest as well as in motion.

2. Define Mass Density.

Mass Density or Density is defined as ratio of mass of the fluid to its volume (V)
Density of water = 1 gm/cm^3 or 1000 kg / m^3.

$$p = \frac{Mass\ of\ fluid}{Volume of\ fluid}$$

3. Define Specific Weight.

It is the ratio between weight of a fluid to its volume.

$$w = p \times g$$

Unit: N / m^3

4. Define Viscosity.

Viscosity is defined as the property of fluid, which offers resistance to the movement of one layer of fluid over another adjacent layer of fluid.

5. Define Specific Volume.

Volume per unit mass of a fluid is called specific volume. Unit: m^3 / kg.

$$Sp.volume = \left(\frac{Volume\ of\ a\ fluid}{Mass\ of\ fluid} \right) = \frac{1}{p} = \frac{1}{(mass\ of\ fluid / volume)}$$

6. Define Specific Gravity

Specific gravity is the ratio of the weight density or density of a fluid to theweight density or density of standard fluid. It is also called as relative density.

Unit : Dimension less. Denoted as: 'S'

7. State Newton's Law of Viscosity.

It states that the shear stress (τ) on a fluid element layer is directly proportional to the rate of shear strain. The constant of proportionality is called the co-efficient of viscosity

$$\tau = \mu \frac{du}{dy}$$

8. Name the Types of fluids.

1. Ideal fluid
2. Real fluid
3. Newtonian fluid
4. Non-Newtonian fluid.
5. Ideal plastic fluid

9. Define Kinematic Viscosity.

It is defined as the ratio between the dynamic viscosity and density of fluid.

Unit: m^2 / sec

12. Define Compressibility.

Compressibility is the reciprocal of the bulk modulus of elasticity, K which is defined as the ratio of compressive stress to volumetric strain.

13. Define 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 membrance under tension.

Unit: N / m.

14. Define Capillarity:

Capillary is defined as a phenomenon of rise of a liquid surface is a small tube relative to adjacent general level of liquid when the tube is held vertically in the liquid. The resistance of liquid surface is known as capillary rise while the fall of the liquid surface is known as capillary depression. It is expressed in terms of cm or mm of liquid.

15. Define Real fluid and Ideal fluid.

Real Fluid:

A fluid, which possesses viscosity, is known as real fluid. All fluids, in actual practice, are real fluids.

Ideal Fluid:

A fluid, which is incompressible and is having no viscosity, is known as an ideal fluid. Ideal fluid is only an imaginary fluid as all the fluids, which exist, have some viscosity.

8 <u>MARK QUESTIONS AND ANSWERS</u>

1. **Calculate the specific weight, density of 1 litre of liquid which weighs 7 N.**

Solution:

Given $V = 1 ltre = \frac{1}{1000} m^3$

W = 7 N

i. Sp. Weight (w) $= \frac{weight}{volume} = \frac{7N}{\left(\frac{1}{1000}\right) m^3} = 7000\ N/m^3$

ii. Density (p) $= \frac{w}{G} = \frac{7000}{9.81} \frac{N}{m^3}\ kg/m^3 = 713..5\ Kg/m^3$

2. **Find the Kinematic viscosity of an oil having density 981 kg/m. The shear stressaa point in oil is 0.2452 N/m^2 and velocity gradient at that point is 0.2 /sec.**

Mass density p = 981 kg/m^3, Shear stress $\tau = 0.2452 N/m^2$

Velocity gradient $\frac{du}{dy} = 0.2$

$$\tau = \mu \frac{du}{dy}$$

$$0.2452 = \mu \times 0.2 \quad \Rightarrow \mu = \frac{0.2452}{0.2} = 1.226 Ns/m^2.$$

$$kinematic viscosity(\upsilon) = \frac{\mu}{p} = \frac{1.226}{981}$$

$$= 0.125 \times 10^{-2} m^2/s.$$

$$= 0.125 \times 10^{-2} \times 10^4 cm^2/S$$

$$= 12.5 stoke.$$

3. **Determine the specific gravity of a fluid having viscosity 0.05 poise and Kinematic viscosity 0.035 stokes.**

Given: Viscosity, μ = 0.05 poise = (0.05 / 10) Ns / m^2.

Kinematic viscosity ν = 0.035 stokes = 0.035 cm^2 / s

= 0.035 x 10^{-4} m^2 / s

$$\boxed{\upsilon = \frac{\mu}{p}}$$

$$0.035 \times 10^{-4} = \frac{0.05}{10} \times \frac{1}{p} \Rightarrow p = 1428.5 kg/m^3$$

$$\text{Specific gravity of liquid} = \frac{\text{Density of liquid}}{\text{Density of water}} = \frac{1428.5}{1000} = 1.428 = 1.43$$

4. **The Capillary rise in the glass tube is not to exceed 0.2 mm of water. Determineits minimum size, given that surface tension of water in contact with air = 0.0725 N/m**

Solution:

Capillary rise, h = 0.2 mm = 0.2 x 10^3 m

Surface tension $\sigma = 0.0725\ N/m$

Let, Diameter of tube = d

Angel θ for water = 0

Density for water = 1000 kg / m^2

$$h = 4\sigma/\rho g d$$

$$0.0002 = (4x0.0725)/(1000x9.81xd)$$

$$d = 0.143\ m$$

5. **Two horizontal plates are placed 1.25 cm apart. The space between them being filled with oil of viscosity 14 poises. Calculate the shear stress in oil if upper plate is moved with a velocity of 2.5 m/s.**

Solution:

Distance between the plates, dy = 1.25 cm = 0.0125m.

Viscosity μ = 14 poise = 14 / 10 Ns / m^2

Velocity of upper plate, u = 2.5 m/Sec.

Shear stress is given by equation as τ = μ (du / dy).

Where du = change of velocity between the plates = u – 0 = u = 2.5 m/sec.

dy = 0.0125m.

τ = (14 /10) X (2.5 / 0.0125) = 280 N/m^2.

6. **Calculate the capillary effect in millimeters a glass tube of 4mm diameter, when immersed in (a) water (b) mercury. The temperature of the liquid is 20^0 C and the values of the surface tension of water and mercury at 20^0 C in contact with air are 0.073575 and 0.51 N/m respectively. The angle of contact for water is zero that for mercury 130^0. Take specific weight of water as 9790 N / m^3**

Given:

Diameter of tube ⇒ d = 4 mm = $4 \times 10^{-3}\, m$

Capillary effect (rise or depression) ⇒ $h = \dfrac{4\sigma \cos\theta}{p \times g \times d}$

$\sigma =$ Surface tension in kg f/m

$\theta =$ Angle of contact and p = density

i. Capillary effect for water

$\sigma = 0.073575\ N/m,\ \theta = 0^0$

$p = 998\ kg/m^3\ @\ 20^0 c$

$$h = \frac{4 \times 0.73575 \times Cos 0^0}{998 \times 9.81 \times 4 \times 10^{-3}} = 7.51 \times 10^{-3}\ m$$

= 7.51 mm.

ii. Capillary effect for mercury:

$\sigma = 0.51\ N/m,\ \theta = 130^0$

$p = sp\ gr \times 1000 = 13.6 \times 1000 = 13600\ kg/m^3$

$$h = \frac{4 \times 0.51 \times Cos 130^0}{13600 \times 9.81 \times 4 \times 10^{-3}}$$

$= -2.46 \times 10^{-3}$ m

= - 2.46 mm.

-Ve indicates capillary depression.

7. **The pressure inside a soap bubble of 50 mm diameter is 2.5 N/m² above the atmosphere. Estimate the surface tension of the soap film.**

Given

d = 50mm=0.050

P = 2.5N/M^2

Solution

$P_i - P_o = (8\sigma)/d$

$2.5 = (8\sigma)/ 0.050$

$\sigma = 0.01562$ N/m

8. **Air is introduced through a nozzle into a tank of water to form a stream of bubbles. If the bubbles are intended to have a diameter of 2mm. Calculate by how much the pressure of the air at the nozzle must exceed that of the surrounding water. Assume that surface tension of water is 0.073 N/m. What would be the absolute pressure inside the bubble if the surrounding water is at 100 kPa.**

Given

d = 2 mm=0.002

$\sigma = 0.073$ N/m

$P_o = 100$ kPa = 100000 N/m^2

Solution

$P_i - P_o = (4σ)/d$

$= (4 \times 0.073)/0.002$

$= 146\ N/m^2$

$P_i - 100000 = 146$

$P_i = 100146\ N/m^2$

$P_i = 100.146\ kPa$

9. In measuring the unit energy of a mineral of a mineral oil (specific gravity = 0.85) by the bubble method having an internal diameter of 1.5mm is immersed to a depth of 1.25cm in the oil. Air is forced through the tube forming a bubble at the lower end. What magnitude of the unit surface energy will be indicated by a maximum bubble pressure intensity of 150 N/m^2?

Given

$ρ = 0.85$

$d = 1.5\ mm = 0.0015\ m$

$h = 1.25cm = 0.0125\ m$

$P_i = 150\ N/m^2$

Solution

(i) $P_o = Wh$

$P_o = (0.85 \times 9810) \times 0.0125 = 104.3\ N/m^2$

(ii) $P = P_i - P_o$

$P = 150 - 104.3 = 45.7\ N/m^2$

(iii) $P_i - P_o = (4σ)/d$

$45.7 = (4σ)/0.0015$

$σ = 0.0172\ N/m$

10. When the pressure of a liquid is increased from 3.5 MN/m^2 to 6.5 MN/m^2. Its volume is found to decrease by 0.08%. What is the bulk modulus of elasticity of liquid?

Given

$σ_i = 3.5\ MN/m^2$

$σ_f = 6.5\ MN/m^2$

Solution

$dp = 6.5 - 3.5 = 3\ MN/m^2$

$dv = 0.08$

$K = -dp/(dv/v)$

$= -(3 \times 10^6 \times 100)/0.08$

$= 3.75 \times 10^9\ N/m^2$

$K = 3.75\ GN/m^2$

Unit – 2: Fluid Statics and Dynamics

Two Mark Questions and Answers

1. Define "Pascal's Law":

It stats that the pressure or intensity of pressure at a point in a static fluid is equal in all directions.

2. What is mean by Absolute pressure and Gauge pressure?

Absolute Pressure:

It is defined as the pressure which is measured with the reference to absolute vacuum pressure.

Gauge Pressure:

It is defined as the pressure which is measured with the help of a pressure measuring instrument, in which the atmospheric pressure is taken as datum. The atmospheric pressure on the scale is marked as zero.

3. Define Manometers.

Manometers are defined as the devices used for measuring the pressure at a point in a fluid by balancing measuring the column of fluid by the same or another column of fluid.

1. Simple M
2. Differential M

4. A differential manometer is connected at the two points A and B . At B pr is 9.81 N/cm² (abs), find the absolute pr at A.

Pr above X – X in right limb = $1000\times9.81\times0.6+p_B$

Pr above X – X in left limb = $13.6\times1000\times9.81\times0.1+900\times9.81\times0.2+P_A$

Equating the two pr head

Absolute pr at P_A = 8.887 N/cm²

5. Define Buoyancy.

When a body is immersed in a fluid, an upward force is exerted by the fluid on the body. This upward force is equal to the weight of the fluid displaced by the body and is called the force of buoyancy or simply buoyancy.

6. Define META – CENTRE

It is defined as the point about which a body starts oscillating when the body is fitted by a small angle. The meta – centre may also be defined as the poit at which the line of action of the force of buoyancy wil meet the normal axis of the body when the body is given a small angular displacement.

7. Write a short notes on " Differential Manometers"

.

Differential manometers are the devices used for measuring the difference of pressures between two points in a pipe or in two different pipes/ a differential manometer consists of a U – tube containing a heavy liquid, whose two ends are connected to the points, whose difference of pressure is to be measured. Most commonly types of differential manometers are:

1. U – tube differential manometer.
2. Inverted U – tube differential manometers.

8. Define Centre of pressure.

Is defined as the point of application of the total pressure on the surface.The submerged surfaces may be:

1. Vertical plane surface
2. Horizontal plane surface
3. Inclined plane surface
4. Curved surface

9. What is mean by Rate flow or Discharge?

It is defined as the quantity of a fluid flowing per second through a section of a pipe or channel. For an incompressible fluid(or liquid) the rate of flow or discharge is expressed as volume of fluid flowing across the section per section. For compressible fluids, the rate of flow is usually expressed as the weight of fluid flowing across the section.

The discharge (Q) = A X V

Where, A = Cross – sectional area of pipe.

V = Average velocity of fluid across the section.

10. What do you understand by Continuity Equation?

The equation based on the principle of conservation of mass is called continuity equation. Thus for a fluid flowing through the pipe at all the cross-section, the quantity of fluid per second is constant.

$$A_1V_1 = A_2V_{2..}$$

8 mark Questions and Answers

1. **Water is flowing through two different pipes, to which an inverted differential manometer having an oil of sp. Gr 0.8 is connected the pressure head in the pipe A is 2 m of water, find the pressure in the pipe B for the manometer readings.**

Pr heat at $A = \dfrac{p_A}{pg} = 2m$ of water.

$$p_A = p \times g \times 2 = 1000 \times 9.81 \times 2$$

= 19620 N/ m^2

Pr below X – X in left limb

= $P_A - p_1 gh_1$ = 19620 - 1000 x 781 x 0.3
= 16677 N/m^2

P_r below X–X in right limb

$$p_B - 1000 \times 9.81 \times 0.1 - 800 \times 9.81 \times 0.12 = P_B - 1922.76$$

Equating two pressure, we get,

$$P_B = 16677 + 1922.76 = 18599.76 \quad N/m^2 = 1.8599 \quad N/cm^2$$

2. **A differential manometer is connected at the two points A and B . At B pr is 9.81 N/cm^2 (abs), find the absolute pr at A.**

Pr above X – X in right limb = $1000 \times 9.81 \times 0.6 + p_B$

Pr above X – X in left limb = $13.6 \times 1000 \times 9.81 \times 0.1 + 900 \times 9.81 \times 0.2 + P_A$

Equating the two pr head Absolute pr at P_A = 8.887 N/cm^2.

3. **The diameters of a pipe at the sections 1 and 2 are 10 cm and 15 cm respectively. Find the discharge through the pipe if the velocity of water flowing through the pipe section 1 is 5 m/s. determine also the velocity at section 2.**

Given

D_1 = 10 cm = 0.1 m.

$A_1 = (\pi / 4) \text{ X } D_1^2 = (\pi / 4) \text{ X } (0.1)^2 = 0.007854 \text{ m}^2$.

$V_1 = 5$ m/s.

$D_2 = 15$ cm = 0.15 m.

$A_2 = (\pi / 4) X (0.15)^2 = 0.01767$ m^2.

Solution

Discharge through pipe is given by equation

$$Q = A_1 X V_1$$

$$= 0.007544 X 5 = 0.03927 m^3/ s.$$

We have $A_1V_1 = A_2V_2$..

$$V_2 = (A_1V_1 / A_1) = (0.007854 /0.01767) X 5 = 2.22 m/s.$$

4. **A differential manometer is connected at the two points A and B of two pipes a shown in figure. The pipe A contains a liquid of sp. Gr = 1.5 while pipe b contains a liquid of sp . gr = 0.9 . The pressures at A and B are 1 kgf / cm^2 respectively. Find the difference in mercury level in the differential manometer.**

Given

Pr at A, $P_A = 10^4 \times 9.81 N / m^2$

Pr at B, $P_B = 1.8$ kgf / cm^2 (1 kgf= 9.81 N)

$$= 1.8 \times 10^4 \times 9.81\ N / m^2$$

Density of mercury $= 13.6 \times 1000 kg / m^3$

Solution

Pr above X – X in left limb = $13.6 \times 1000 \times 9.81 \times h + 1500 \times 9.81 \times (2+3) + P_A$

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

Pr above X – X in right limb $= 900 \times 9.81 \times (h+2) + P_B$

$$= 900 \times 9.81 \times (h+2) + 1.8 \times 10^4 \times 9.8$$

Equating two pressure, we get,

$$13.6 \times 1000 \times 9.81 h + 7500 \times 93.81 + 9.81 \times 10^4$$

$$= 900 \times 9.81 \times (h+2) + 1.8 \times 10^4 \times 9.81$$

Dividing by 1000×9.81, we get

$$13.6h + 7.5 + 10 = (h + 2.0) \times 0.9 + 18$$

$$13.6h + 17.5 = 0.9h + 1.8 + 18 = 0.9h + 19.8$$

$$(13.6 - 0.9)h = 19.8 - 17.5$$

$12.7\ h = 2.3$

$h = 2.3/12.7$

$h = 0.181\ m = 1.81cm$

5. **Water flows through a pipe AB 1.2m diameter at 3 m/s and then passes through a pipe BC 1.5 m diameter at C, the pipe branches. Branch CD is 0.8m in diameter and carries one third of the flow in AB. The flow velocity in branch CE is 2.5 m/s. find the volume rate of flow in AB, the velocity in BC, the velocity in CD and the diameter of CE.**

Given

Diameter of pipe CE = D_{CE}

Then flow rate through CD = Q / 3

And flow rate through CE = Q – Q/3 = 2Q/3

Solution.

(i). Now the flow rate through AB = Q = V_{AB} X Area of AB

$= 3 \times (\pi / 4) \times (D_{AB})^2 = 3 \times (\pi / 4) \times (1.2)^2$

$= 3.393\ m^3/s.$

(ii). Applying the continuity equation to pipe AB and pipe BC,

V_{AB} X Area of pipe AB = V_{BC} X Area of Pipe BC

$3 \times (\pi / 4) \times (D_{AB})^2 = V_{BC} \times (\pi / 4) \times (D_{BC})^2$

$3 \times (1.2)^2 = V_{BC} \times (1.5)^2$

$V_{BC} = (3 \times 1.2^2)/ 1.5^2 = 1.92\ m/s.$

(iii). The flow rate through pipe

$CD = Q_1 = Q/3 = 3.393 /3 = 1.131\ m^3/s.$

$Q_1 = V_{CD}$ X Area of pipe $C_D \times (\pi / 4) (C_{CD})^2$

$1.131 = V_{CD} \times (\pi / 4) \times (0.8)^2$

$V_{CD} = 1.131 / 0.5026 = 2.25\ m/s.$

(iv). Flow through CE,

$Q_2 = Q - Q_1 = 3.393 - 1.131 = 2.262\ m^3/s.$

$Q_2 = V_{CE}$ X Area of pipe CE = $V_{CE} \times (\pi / 4) (D_{CE})^2$

$2.263 = 2.5 \times (\pi / 4) (D_{CE})^2$

$$D_{CE} = \sqrt{(2.263 \times 4) / (2.5 \times \pi)} = 1.0735 \text{ m}$$

Diameter of pipe CE = 1.0735m.

6. **The diameter of a pipe at the section 1 and 2 are 10cm and 15cm. Find the discharge through the pipe if the velocity of water flowing through the pipe at section 1 is 5 m/s. Determine the velocity of the section 2.**

Given

D_1 = 10cm = 0.1m

D_2 = 15 cm = 0.15m

Solution

$Q = A_1 V_1$

$= (\pi \times D_1^2 \times V_1)/4$

$= (\pi \times 0.1^2 \times 5)/4$

$= 0.03925 \text{ m}^3/\text{sec}$

$V_2 = 0.1^2 \times 5/0.15^2$

$= 2.22$ m/sec

7. **In a smooth inclined pipe of uniform diameter 250mm, a pressure of 50 kPa was observed at section 1 which was at elevation 10m. At another section 2 at elevation 12m, the pressure was 20 kPa and velocity was 1.25 m/sec. Determine the direction of flow and the head loss between these two sections. The fluid in the pipe is water. The density of water at 20°C and 760mm of Hg is 998 kg/m^3.**

Given

Z_1 = 10m

Z_2 = 12m

D = 250mm = 0.25m

P_1 = 50 kPa = 50000 N/m^2

P_2 = 20 kPa = 20000 N/m^2

ρ = 998 kg/m^3

$V_1 = V_2$ = 1.25 m/sec

Solution

$E_1 = (P_1/w) + (V_1^2/2g) + Z_1$

$E_1 = (50000/(9.81 \times 998)) + (1.25^2/(2 \times 9.81)) + 10$

$E_1 = 15.87m$

$E_2 = (P_2/w) + (V_2^2/2g) + Z_2$

$E_2 = (20000/(9.81 \times 998)) + (1.25^2/(2 \times 9.81)) + 12$

$E_2 = 14.122m$

Head loss

$h_L = 15.187 – 14.122$

$h_L = 1.065m$

Direction of flow

$E_1 > E_2$. The flow is from section 1 to section 2

8. **An isosceles triangular plate of base 3m and altitude 3m is immersed vertically in an oil of specific gravity 0.8. The base of the plate coincides with the free surface of oil. Determine total pressure on the plate and position of centre of pressure.**

Given

b = 3m

h = 3m

Solution

x = h/3 = 3/3 = 1m

Total Pressure

P = WAx

P = 0.8 x 9.81 x 3 x 3/2

P = 35.3 kN

Centre of Pressure

$h_0 = (I_G/Ax) + x$

$h_0 = (3x33x2)/(3x3x36) + 1$

$h_0 = 1.5m$

9. **Find the density of a metallic body which floats at the interface of mercury of sp. Gr 13.6 and water such that 40% of its volume is sub-merged in mercury and 60% in water.**

Given

Let the volume of the body = V m^3

Then volume of body sub-merged in mercury

= (40/100)V = 0.4V m^3

Volume of body sub-merged I water

$= (60/100)V = 0.6V \text{ m}^3$

Solution

Total buoyant force = Force of buoyancy due to water+ Force of buyancy due to mercury.

Force of buoyancy due to water = Weight of water displaced by body.

= Density of water x g x Volume of water displaced.

$= 1000 \times g \times$ volume of body in water.

$= 1000 \times g \times 0.6 \times V$ N

Force of buoyancy due to mercury = Weight of mercury displaced by body.

$= g \times \textit{Density of mercury} \times \textit{Volume of mercury displaced}.$

$= g \times 13.6 \times 1000 \times \textit{Volume of body in mercury}$

$= g \times 13.6 \times 1000 \times 0.4V$ N.

Weight of the body = Density x g x volume of body

$= p \times g \times V$

Where, p is the density of the bodyFor equilibrium,

Total buoyant force = Weight of the body

$$1000 \times g \times 0.6 \times V + 13.6 \times 1000 \times g \times 0.4V = p \times g \times V$$

$$p = 600 + 13600 \times 0.4 = 600 + 54400$$

$$p = 6040.00 \text{ kg / m}^3$$

$\therefore$ Density of the body $= 6040.00 \text{ kg / m}^3$

10. A solid cylinder of diameter 4.0 m has a height of 3m. Find the meta – centric height of the cylinder when it is floating in water with its axis vertical.The sp gr of the cylinder – 0.6 .

Given

Dia of cylinder , D = 4.0 m

Height of cyinder, h = 3.0 m

Sp, gr of cylinder = 0.6

Depth of immersion of cylinder = 0.6 x 3.0

= 1.8 m

$$AB = \frac{1.8}{2} = 0.9m$$

$$AG = \frac{3}{2} = 1.5m$$

BG = AG - AB

= 1.5 – 0.9 = 0.6 m.

V = volume of cylinder in water.

$$= \frac{\pi}{4} D^4 \times \text{Depth of immersion}$$

$$= \frac{\pi}{4} (4)^2 \times 1.8m^3$$

$$GM = \frac{\frac{\pi}{64} \times (4.0)^4}{\frac{\pi}{4} \times (4.0)^4 \times 1.8} - 0.6$$

$$= \frac{1}{1.8} \times \frac{4.0^2}{16} - 0.6 = \frac{1}{18} - 0.6 = 0.55 - 0.6$$

= - 0.05 m.

- Ve sign indicates meta- centre (M) below the centre of gravity (G)

UNIT III FLOW THROUGH PIPES

Part A- 2 Mark Questions and Answers

1. List the types of fluid flow.

Steady and unsteady flow Uniform

and non-uniform flowLaminar and

Turbulent flow

Compressible and incompressible flow

Rotational and ir-rotational flow

One, Two and Three dimensional flow

2. Define Steady and Unsteady flow.

Steady flow

Fluid flow is said to be steady if at any point in the flowing fluid various characteristics such as velocity, density, pressure, etc do not change with time.

$$\partial V/\partial t = 0 \quad \partial p/\partial t = 0 \quad \partial \rho/\partial t = 0$$

Unsteady flow

Fluid flow is said to be unsteady if at any point flowing fluid any one or all characteristics which describe the behaviour of the fluid in motion change withtime.

$$\partial V/\partial t \neq 0 \quad \partial p/\partial t \neq 0 \quad \partial \rho/\partial t \neq 0$$

3. Define Uniform and Non-uniform flow.

Uniform flow

When the velocity of flow of fluid does not change both in direction and magnitude from point to point in the flowing fluid for any given instant of time, the flow is said to be uniform.

$$\partial V/\partial s = 0 \quad \partial p/\partial s = 0 \quad \partial \rho/\partial s = 0$$

Non-uniform flow

If the velocity of flow of fluid changes from point to point in the flowing fluid at any instant, the flow is said to be non-uniform flow.

$$\partial V/\partial s \neq 0 \quad \partial p/\partial s \neq 0 \quad \partial \rho/\partial s \neq 0$$

4. Define One, Two and Three dimensional flow.

One dimensional flow

The flow parameter such as velocity is a function of time and one space co-ordinate only.

$\mathbf{u = f(x), v = 0}$ & $w = 0$.

Two dimensional flow

The velocity is a function of time and two rectangular Space co-ordinates.

$$u = f_1(x,y),\ v = f_2(x,y)\ \&\ w = 0.$$

Three dimensional flow

The velocity is a function of time and three mutually perpendicular directions.

$$u = f_1(x,y,z),\ v = f_2(x,y,z)\ \&\ w = f_3(x,y,z).$$

5. Write the Bernoulli's equation applied between two sections

$$p_1/\rho g + v^2{}_1/2g + Z_1 = p_2/\rho g + v^2{}_2/2g + Z_2$$

Where, $p/\rho g$ = pressure head

$v^2/2g$ = kinetic head

Z = datum head

6. State the assumptions used in deriving Bernoulli's equation

Flow is steady;

Flow is laminar;

Flow is irrotational;

Flow is incompressible;

Fluid is ideal.

7. Write the Bernoulli's equation applied between two sections with losses.

$$p_1/\rho g + v^2{}_1/2g + Z_1 = p_2/\rho g + v^2{}_2/2g + Z_2 + h_{loss}$$

8. List the instruments works on the basis of Bernoulli's equation.

Venturi meter

Orifice meter

Pitot tube.

9. Define Impulse Momentum Equation (or) Momentum Equation.

The total force acting on fluid is equal to rate of change of momentum. According toNewton's second law of motion,

F =ma F

dt = d(mv)

10. Mention the range of Reynold's number for laminar and turbulent flow in a pipe.

If the Reynolds number is less than 2000, the flow is laminar. But if the Reynold's number is greater than 4000, the flow is turbulent flow.

11. What does Haigen-Poiseulle equation refer to?

The equation refers to the value of loss of head in a pipe of length 'L' due toviscosity in a laminar flow.

12. What is Hagen poiseuille's formula?

$$(P_1-P_2) / \rho g = h_f = 32\ \mu \bar{U} L / \rho g D^2$$

The expression is known as Hagen poiseuille formula.

Where $P_1-P_2 / \rho g$ = Loss of pressure head,
$\bar{U}$= Average velocity,
μ = Coefficient of viscosity,
D = Diameter of pipe,
L = Length of pipe

13. Write the expression for shear stress?

$$\text{Shear stress } \zeta = - (\partial p/\partial x)\ (r/2)$$
$$\zeta_{max} = - (\partial p/\partial x)\ (R/2)$$

14. Give the formula for velocity distribution: -

The formula for velocity distribution is given as

$$u = - (¼\ \mu)\ (\partial p/\partial x)\ (R^2-r^2)$$

Where R = Radius of the pipe,

r = Radius of the fluid element

15. Give the equation for average velocity: -

The equation for average velocity is given as

$$\bar{U} = - (1/8\mu)\ (\partial p/\partial x)\ R^2$$

Where R = Radius of the pipe

Part B : 8 Mark Questions and Answers

1. **A pipe 1 m diameter and 15 km long transmits water of velocity of 1 m/sec.The friction coefficient of pipe is 0.005. Calculate the head loss due to friction?**

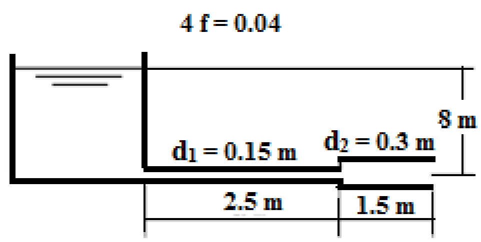
Solution

$$h_f = \frac{4\ f\ L\ v^2}{2\ g\ d}$$

$$h_f = \frac{4 \times 0.005 \times 15000 \times 1^2}{2 \times 9.81 \times 1} = 15.29\ \text{m}$$

2. **A pipe, 40 m long, is connected to a water tank at one end and flows freely in atmosphere at the other end. The diameter of pipe is 15 cm for first 25 m fromthe tank, and then the diameter is suddenly enlarged to 30 cm. Height of waterin the tank is 8 m above the centre of pipe. Darcy's coefficient is 0.01. Determine the discharge neglecting minor losses?**

Solution



Loss due to friction, $h_{Lf} = h_{f1} + h_{f2}$

$$h_f = \frac{32\, f\, L\, Q^2}{\pi^2\, g\, d^5} \qquad f = 0.01$$

Total losses,

$$h_T = Q^2 \left(\frac{32\, f\, L_1}{\pi^2 g d_1^5} + \frac{32\, f\, L_2}{\pi^2 g d_2^5} \right)$$

$$8 = Q^2 \left(\frac{(32\text{x}0.01)\text{ x }(25)}{\pi^2\, g\, (0.15)^5} + \frac{(32\text{x}0.01)\,(15)}{\pi^2\, g\,(0.3)^5} \right)$$

$\therefore Q = 0.087$ m /sec

3. **Two pipes are connected in parallel between two reservoirs that have difference in levels of 3.5 m. The length, the diameter, and friction factor (4 f) are 2400 m, 1.2 m, and 0.026 for the first pipe and 2400 m, 1 m, and 0.019 for the second pipe. Calculate the total discharge between the two reservoirs?**
Solution

$$H_L = \frac{32\, f_1\, L\, Q_1^{\,2}}{\pi^2\, g\, d_1^{\,5}} = \frac{32\, f_2\, L\, Q_2^{\,2}}{\pi^2\, g\, d_2^{\,5}}$$

$$3.5 = \frac{32\, f_1\, L\, Q_1^{\,2}}{\pi^2\, g\, d_1^{\,5}} = \frac{8\text{x}0.026\text{x}2400\text{x}Q_1^{\,2}}{\pi^2\text{x}9.81\text{ x}1.2^{\,5}}$$

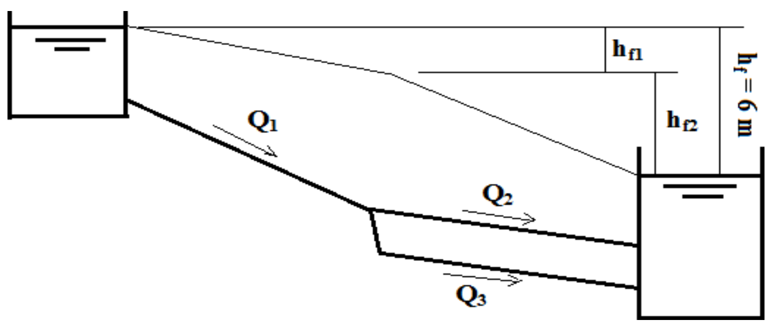
$Q_1 = 1.29\ m^3/sec$

$$3.5 = \frac{32\ f_2\ L\ Q_2^{\ 2}}{\pi^2\ g\ d_2^{\ 5}} = \frac{8x0.019x2400xQ_2^{\ 2}}{\pi^2 x9.81\ x1^{\ 5}}$$

$Q_2 = 0.96\ m^3/sec$

$\therefore\ Q = Q_1 + Q_2 = 1.29 + 0.96 = 2.25\ m^3/sec$

4. Two reservoirs have 6 m difference in water levels, and are connected by a pipe 60 cm diameter and 3000 m long. Then, the pipe branches into two pipes each 30 cm diameter and 1500 m long. The friction coefficient is 0.01. Neglecting minor losses, determine the flow rates in the pipe system?



Solution

$h_f = h_{f1} + h_{f2}$

$6 = h_{f1} + h_{f2}$

$6 = k_1\ Q_1^2 + k_2\ Q^{\ 2}$

$$k_1 = \frac{32\ f_1\ L_1}{\pi^2\ g\ d_1^5} = \frac{32*0.01*3000}{\pi^2 *9.81*0.6^5} = 127.64$$

$$k_2 = \frac{32\ f_2\ L_2}{\pi^2\ g\ d_2^{\ 5}} = \frac{32*0.01*1500}{\pi^2 *9.81*0.3^5} = 4084.48$$

$k_2 = 32\ k_1$

$\therefore\ 6 = k_1\ Q_1^2 + 32\ k_1\ Q_2^2$

$h_{f2} = h_{f3}\ \&\ k_2 = k_3$

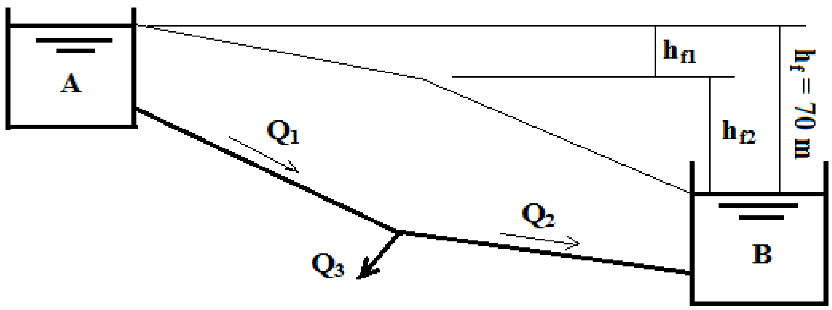
$Q_2 = Q_3 Q_1 = Q_2 + Q_3 = 2\ Q_2$

$6 = k_1\ Q_1^2 + 8\ k_1\ Q_1^2 = 9\ k_1\ Q_1^2 = (9 * 127.64)\ Q_1^2 = 1148.76\ Q_1^2$

$Q_1 = 0.072\ m^3/s$ & $Q_2 = 0.036\ m^3/s$

5. **Two tanks A and B have 70 m difference in water levels, and are connectedby a pipe 0.25 m diameter and 6 km long with 0.002 friction coefficient. The pipe is tapped at its mid-point to leak out 0.04 m³/s flow rate. Minor losses are ignored. Determine the discharge leaving tank A? Find the discharge entering tank B?**

<u>Solution</u>



$h_f = h_{f1} + h_{f2}$ 70

$= h_{f1} + h_{f2}$

$70 = k_1\ Q_1^2 + k_2 Q_2^2$

$$k_1 = k_2 = \frac{32\ f\ L}{\pi^2\ g\ d^5} = \frac{32*0.002*3000}{\pi^2*9.81*0.25^5} = 2032.7$$

$\therefore\ 70 = k_1\ Q_1^2 + k_1 Q_2^2$

$Q_1 = Q_2 + Q_3 = Q_2 + 0.04$

$\therefore\ 70 = k_1\ (Q_2 + 0.04)^2 + k_1\ Q_2^2$

$= k_1\ (Q_2^2 + 0.08\ Q_2 + 0.0016) + k_1\ Q_2^2$

$= k_1\ Q_2^2 + 0.08\ k_1\ Q_2 + 0.0016\ k_1 + k_1\ Q_2^2$

$= 2\ k_1\ Q_2^2 + 0.08\ k_1\ Q_2 + 0.0016\ k_1$

$= 4065.4\ Q_2^2 + 162.6\ Q_2 + 3.25$

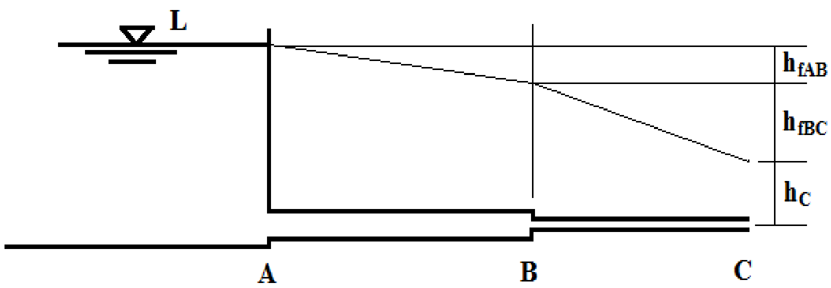
$0.0172 = Q_2^2 + 0.04\ Q_2 + 0.0008$

$Q_2^2 + 0.04\ Q_2 - 0.0164 = 0$

$\therefore\ Q_2 = 0.11\ m^3/s$ & $Q_1 = 0.15\ m^3/s$

6. **A tank transmits 100 L/s of water to the point C where the pressure is maintained at 1.5 kg/cm^2. The first part AB of the pipe line is 50 cm diameter and 2.5 km long, and the second part BC is 25 cm diameter and 1.5 km long. The friction coefficient is 0.005 and minor losses are ignored. Assuming level at C is (0.0); find the water level (L) in the tank?**

Solution



$h_C = P_C / \gamma = 1500 / 1 = 1500 \text{ cm} = 15 \text{ m}$

$h_C = 15 = L - h_{fAB} - h_{fBC}$

$$h_{fAB} = \frac{32 f_1 L_1}{\pi^2 g d_1^5} = \frac{32*0.005*2500}{\pi^2*9.81*0.5^5} = 1.32$$

$$h_{fBC} = \frac{32 f_2 L_2}{\pi^2 g d_2^5} = \frac{32*0.005*1500}{\pi^2*9.81*0.25^5} = 25.38$$

$15 = L - 1.32 - 25.38$

$\therefore$ L = 41.7 m

UNIT 4 FLOW IN OPEN CHANNELS

2 MARK QUESTIONS AND ANSWERS

1. Define open channel flow with examples.

Flow of liquid with a free surface (i.e., surface exposed to atmosphere) through any passage is known as open channel flow. The liquid flowing through any closed passage without touching the top can also treated as open channels.

Examples:

1. Flow in natural waterfalls, river and streams
2. Flow in artificial or man-made channels such as irrigation channels and flumes.
3. Closed conduit or pipe carries liquid partially (sewers that carry domestic or industrial waste water). Generally, liquid flowing in open channel in water.

2. Explain laminar and turbulent flow.

(a) Laminar flow:

If Reynolds number of flow is less than 500, it is called as Laminar flow. The value of Reynolds number is between 500 and 2000, the flow is transitional.

(b) Turbulent flow:

For values of Reynolds number greater than 2000, the flow is turbulent.

3. What are the various types of flow in open channels?

The flow in open channel is classified into the following types:

(a) Steady and unsteady flow
(b) Uniform and non- uniform flow
(c) Laminar and turbulent flow
(d) Subcritical, critical and supercritical flow.

4. Define the term uniform flow.

If the depth of flow, slope of the bed of channel and cross section remain constant with respect to distance is called uniform flow.

$$\left(\frac{\partial y}{\partial s}\right) = 0, \quad \left(\frac{\partial V}{\partial s}\right) = 0$$

5. **Define non uniform flow.**

Flow properties, such as depth of flow, velocity of flow are not constant with respect to distance is called non uniform flow.

$$\left(\frac{\partial y}{\partial s}\right) \neq 0, \quad \left(\frac{\partial V}{\partial s}\right) \neq 0$$

6. **Distinguish between steady and unsteady flow.**

In steady flow, various characteristics of flowing fluids such as velocity, pressure, density, temperature etc. at a point do not change with time. In other words, a steadyflow may be defined as that in which the various characteristics are independent of time. Mathematically it can be expressed as

$$\left(\frac{\partial u}{\partial t}\right) = 0, \quad \left(\frac{\partial v}{\partial t}\right) = 0 \;; \quad \left(\frac{\partial w}{\partial t}\right) = 0$$

$$\left(\frac{\partial p}{\partial t}\right) = 0, \quad \left(\frac{\partial \rho}{\partial t}\right) = 0$$

In unsteady flow, various characteristics of flowing fluids such as velocity, pressure, density, etc. at a point change with respect to time. Unsteadiness refers to the change of flow pattern with the passage of time at a position inthe flow.

7. **Explain the terms: (i) Gradually varied flow and (ii) Rapidly varied flow.**

1. **Gradually varied flow**

If the depth of flow changes gradually over a long length of the channel, the flow is said to gradually varied flow (GVF)

2. **Rapidly varied flow.**

If the depth of flow changes rapidly over a small length of the channel, the flow is said to be rapidly varied flow.

8. **Write down the formula for Froude number**

$$Froute \;\; Number \;\; F = \frac{V}{\sqrt{gD}} < 1.0$$

Where

V = Average velocity of flow in m/s

g = Acceleration due to gravity =9.81 m

/ s^2D = Hydraulic depth in meter

$$= \frac{\text{Cross Section Area of flow}}{\text{Top Width}} = \frac{A}{T}$$

9. Define hydraulic mean depth.

D = Hydraulic depth in meter

$$= \frac{\text{Cross Section Area of flow}}{\text{Top Width}} = \frac{A}{T}$$

10.Define specific energy. [Anna Univ.Nov'06&Nov'08]

Specific energy of a flowing liquid is defined as energy per unit weight of a liquidwith respect to the bottom of the channel. By a symbol *E*.

$$E = y + \frac{V^2}{2g}$$

Where

E = Specific Energy

V = Velocity of flow

y = Depth of flow

11. Differentiate prismatic and non-prismatic channels.

Prismatic channel

Geometric dimensions of the channel, such as cross section and bottom slope are constant throughout the length of the channel is called as a prismatic channel. Eg. Most of the artificial channels of circular, rectangular, trapezoidal and triangular cross section are called prismatic channels.

Non- prismatic channel

Geometric dimensions of the channel, such as cross section and bottom slope are constant for length of the channel is called as a non-prismatic channel. Eg. All natural channels such as river, are non-prismatic channels.

12. Explain specific force (F_C)

Specific force is the sum of the pressure force (F) and momentum force due to flow (M) per unit weight of the liquid at a section.

$$Specific\ \ Force = F_s = \frac{F + M}{\gamma}$$

Where

$$\gamma = weight\ density\ of\ Liquid$$

13. What is specific energy and what is condition for obtaining only one depth for agiven specific energy?]

Total Energy on open channel flow

$$E = Z + y + \frac{V^2}{2g}$$

Considering the channel bed as datum line , $z = 0$

$$Specific\ Energy\ E = y + \frac{V^2}{2g}$$

From Specific Energy curve ,Corresponding to the Minimum specific energy $E_{(min)}$,there is only one depth of floe that is called Critical depth

14. Differentiate closed flow closed conduit flow and open channel flow.

S.No	Closed conduit flow	Open channel flow
1.	Water does not have with free surface.	Water flows with a free surface.
2.	Water does not contact with atmosphere pressure but it has only hydraulicpressure.	Water contents with atmospheric pressure.

3.	Flow may be due to either by pumppressure or by gravity flow	Flow is obtained onlyby gravity.

15.Define sub critical flow:

If the Froude number is less than one then the flow is said to be sub critical flow

16.Define critical flow:

If the Froude number is less equal to one it is called as critical flow.

17.Define supercritical flow:

If the Froude number is greater than one it is called as super critical flow

18. What are the possible types of flow in open channel with respect to space andtime?

A. steady and unsteady flow

B. uniform and non-uniform flow

19.What do you know about uniform and non uniform flow?

Uniform flow: If the given length of the channel ,depth ,velocity ,the rate of flow, cross section are constant.

Non Uniform flow: If the given length of the channel ,depth ,velocity ,the rate of flow, cross section are not constant.

20.Define specific energy:

It is defined as energy per unit weight of the liquid with respect to the bottom of the channel.

16 Mark Question and Answers

1. A Trapezoidal channel has a bottom width of 6.1 m and side Slopes of 2 H : 1 V .When the depth of the flow is 1.07 m. The flow is 10.47 m^3/s. What is the Specific energy of flow? Is the Flow is sub critical or super critical.

Given

b = 6.1 m

m = 2 m

y = 1.07m

Q = 1.07 m^3/s

SOLUTION

To find the Specific Energy

A = (b + my) y

= (6.1 + (2 x 1.07)) 1.07

= 8.22 m2

V = Q/A

= (10.47/8.82)

= 1.19 m/sec

E = y + (V^2/2g)

= 1.07 +(1.192/(2x9.81))

= 1.14m

Fr = 0.41 < 1.0

Hence the flowis called Tranquil or Sub-critical flow

2. Calculate the Specific Energy of 12 m^3/s of water flowing with a velocity of 1.5 m^3/s in a Rectangular channel 8 m wide. Find the depth of water in the channel when the Specific energy would be minimum. What would be the value of Critical as well minimum Specific Energy.

Given

V = 1.5 m/sec

m = 2m

b = 8m

$$Q = V \times A \qquad A = \frac{Q}{V} = b \times d = \frac{Q}{V}$$

b = y = 1m , Finally we Will Get

Specific energy,

E = y + (V^2/2g)

E = 1 +(1.5^2/(2x9.81)) = 1.115m

Critical Velocity,

$$V_c = \sqrt{g * y_c}$$

$$= \sqrt{9.81 * 0.612}$$

= 2.45 m/sec

Minimum specific energy

E_{min} = 3/2Y_c

= 3/2 x 0.612

= 0.918 m

3. A 8 m wide Channel conveys 15 cumecs of water at a depth of 1.2 m. Determine the

(1) Specific energy of the flowing water

(2) Critical depth, Critical velocity and minimum Specific Energy

(3) Froude number and the weather flow is sub-critical or Super-critical

Given

V = 1.5 m/sec

m = 2m

b = 8m

SOLUTION

Specific Energy:

$$V = \frac{Q}{A}$$

$$= \frac{15}{8 * 1.2}$$

$$= 1.563\ m/s$$

$$E = y + \frac{V^2}{2g}$$

$$= 1.2 + \frac{1.563^2}{2 * 9.81}$$

m = **1.32**

=1.32m

Critical Velocity

$$V_c = \sqrt{g * y_c}$$

$$= \sqrt{9.81 * 0.71}$$

$$= 2.63\ m/s$$

Minimum Specific Energy:

$$E_{\min} = \frac{3}{2} y_c$$

$$E_{\min} = \frac{3}{2} * 0.71$$

$$= 1.06\ m$$

Froude Number:

$$F = \frac{V}{\sqrt{gD}} = \frac{V}{\sqrt{gy}}$$

$$D = \frac{A}{T} = \frac{b * y}{b} = y$$

$$= \frac{1.563}{\sqrt{9.81 * 1.2}}$$

$$= 0.455 < 1.0$$

Hence the Flow is Sub-Critical

4. A Trapezoidal channel with side slope of 2H:3V Has to carry 20 m^3 /s. Find the slope of the channel when the bottom width of the channel is 4 m and the depth of the water is 3m. Take manning's n=0.03

Given

b = 4 m

y = 3 m

m = 2 m

Q = 20 m^3/s
n = 0.03

SOLUTION

Slope of the trapezoidal Channel

$$A = (b + my)\ y$$
$$= (4 + 2 \text{x} 3) 2$$
$$= 30\ m^2$$
$$P = (b + 2my)$$
$$= (4 + 2 \text{x} 2 \text{x} 3)$$
$$= 16\ m$$
$$R = \frac{A}{P}$$
$$= \frac{30}{16}$$
$$= 1.875\ m$$

Use manning's constant Formulae

$$C = \frac{1}{N} R^{\frac{1}{6}}$$

C = 36.49

Slope of the Channel

$$Q = AC\sqrt{RS}$$
$$= 18 \text{x} 36.4 \sqrt{1.875 \text{x} S}$$
$$S = \frac{400}{832117.11}$$
$$= 0.00048$$
$$S = \frac{1}{2080}$$

5. **Find the discharge through a rectangular channel of width 2m having a bed slope of 4 in 8000. The depth of flow is 1.5m and take the value of N in mannings formula as 0.012.**

Given

b = 2m

d = 1.5m

N = 0.012

Solution

$A = (b \times d) = (2 \times 1.5) = 3m^2$

$P = b + 2d = 2 + (2x1.5) = 5m$

Hydraulic mean depth

$m = (A/P) = (3/5) = 0.6m$

Bed Slope

$i = 4$ in $8000 = 4/8000 = 1/2000$

From Mannings formula

$C = m^{1/6}/N = 0.6^{1/6}/0.012 = 76.54$

Discharge

$Q = AC \times (m \times i)^{1/2}$

$Q = 3x76.54x(0.6/2000)^{1/2}$

$Q = 3.977m^3/sec$

6. **In a rectangular channel 12m wide and 3.6m deep water is flowing with a velocity of 1.2m/sec. The bed slope of the channel is 1 in 4000. If flow of water through the channel is regulated in such a way that energy line is having a slope of 0.00004. Find the rate of change of depth of water in the channel.**

Given

b = 12m

y = 3.6m

v = 1.2m/sec

$S_b = 1/4000 = 0.00025$

$S_e = 0.00004$

Solution

$dy/dx = (S_b – S_e)/(1-Fr^2)$

$= (0.00025 – 0.00004)/(1-(1.2^2/9.81 \times 3.6))$

$= 0.0002189$

7. **A triangular gutter, whose sides include an angle of 60° conveys water at a uniform depth of 250mm. If the discharge is 0.04 m^3/sec. Determine the gradient of the trough. C = 52**

Given

d = 250 mm = 0.25m

Q = 0.04 m^3/sec

C = 52

Solution

Sides AO and BO = (0.25/cos 30°)

= 0.288m

Center distance from one side

AC = 0.25xtan 30°

= 0.144m

Wetted perimeter, P = 0.288 + 0.288

= 0.576m

Hydraulic radius, R = (A/P)

= (0.036/0.576)

= 0.0625m

Chezy's formula

$Q = AC \times (m \times i)^{1/2}$

$0.04 = 0.036 \times 52 \times (0.0625 \times S)^{1/2}$

S = 1/137

UNIT 5-HYDRAULIC MACHINES

2 MARK QUESTIONS AND ANSWERS

1. How are fluid machines classified?

Fluid machines are classified into 2 categories depending upon the direction of transfer of energy:

1. Turbines
2. Pumps or compressors. .

2. What is centrifugal pump?

The hydraulic machines which convert mechanical energy in to pressure energy by means of centrifugal force is called centrifugal pump. It acts a reverse of inward radial flow turbine.

3. What are the main parts of centrifugal pump?

1. Suction pipe with foot valve and strainer
2. Impeller
3. Casing
4. Deliver y pipe

4. Write down the use of centrifugal pump?

1. Used in deep sump and basement
2. The high discharge capacity
3. It is driven by electric motors

5. Define multistage pump:

If centrifugal pump consists of two or more impellers the pump is called Multistage pump. To produce a high head impellers are connected in series .To produce high discharge impellers are connected in parallel.

6. Define slip of a reciprocating pump and negative slip:

Slip is defined as the difference between theoretical discharges and actual discharge.

If actual discharge is greater than theoretical discharge negative value is found this negative value is called negative slip.

7. What is separation of reciprocating pump?

If the pressure in the cylinder is below the vapour pressure , dissolved gasses will be liberated from the liquid and cavitations will takes place . The continuous flow of liquid will not ex it which means separation of liquid takes place. Th e pressure at which separation takes place is called separation pressure and head corresponding to the separation pressure is called separation pressure head.

8. What is Air vessel?

Air vessel is a closed chamber containing compressed air in the top portion and liquid at the bottom of the chamber . It is used to obtain a continuous supply of water at uniform rate to save a considerable amount of work and to run the pump at high speed with out separation

9. What is the purpose of an air vessel fitted in the pump?

1. To obtain a continuous supply of liquid at a uniform rate.
2. To save a considerable amount of work in overcoming the frictional resistance in the suction and delivery pipes, and
3. To run the pump at a high speed with out separation.

10. What is Discharge through a Reciprocating Pump in per sec?

For Single acting

Discharge (Q)=ALN/60

Where,

A=Area of the Cylinder

L=Length of Stroke in m.

N=Speed of Crank in RPM

For Double acting

Q=2ALN/60

11. Define pump :

It is defined as the hydraulic machine which convert mechanicalenergy in to hydraulic energy

12. Define Multistage pump:

If centrifugal pump consists of two or more impellers the pump is called multistage pump. To produce a high head impellers are connected in series .To produce high discharge impellers are connected in parallel.

13. What do you mean by turbine?

The hydraulic machine which converts the hydraulic energy in to mechanical energy iscalled turbine

14. What is breaking jet?

When the nozzle is completely closed, the amount of water striking the runner reduces to zero but the runner due to inertia goes on revolving for a long time to stop the runner in a short time a small nozzle is provided which direct the jet of water on the back of vanes .This jet of water is called breaking jet.

15. What is jet ratio?

It is the ratio of pitch diameter (D) to the diameter of jet (d).

16. What is Draft tube?

A tube or pipe of gradually increasing area is used for discharging water from theexit of the turbine to the tail race is called draft tube.

17. What is radial discharge?

This means the angle made by absolute velocity with the tangent on the wheel is andthe component of whirl velocity is zero.

18. Define Kaplan turbine:

This is an example of axial flow reaction turbine. Here the vanes are not fixed to thehub and are adjustable.

19. What are the uses of draft tube?

1. The net head on the turbine increases.
2. Due to increase in net head the power and efficiency of the turbine alsoincreases.
3. The large amount of rejected kinetic energy is converted in to useful pressureenergy

16 MARK QUESTIONS AND ANSWERS

1. **A centrifugal pump delivers salt water against a head of 15 m at a speed of 100 rpm. The vanes are curved backward at 30º with the periphery. Obtain the discharge for an impeller diameter of 30 cm and outlet width of 5 cm at a manometric efficiency of 90%.**

Given

H = 15 m

N = 100 rpm

D_2 = 0.3 m = 30 cm

B = 0.05 m= 5 cm

Max efficiency = 90%

$\phi = 30^0$

Solution

$$S_{max} = \frac{g \times H}{V \times w_2 \times u_2}$$

$$0.9 = \frac{9.81 \times 15}{V \times w_2 \times u_2}$$

$$V \times w_2 \times u_2 = 163.50$$

$$\tan\theta = \frac{VF_2}{u_2 - V \times w_2}$$

$$\tan 30^0 = \frac{VF_2}{u_2 - V \times w_2}$$

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 0.3 \times 100}{60} = 1.57\ m/\sec$$

$$V_w = \frac{163.50}{1.57} = 104.14\ m/\sec$$

$$VF_2 = 59.22\ m/\sec$$

$$Q = \pi \times D_2 \times B_2 \times V \times F_2$$

$$= \pi \times 0.3 \times 0.05 \times 59.22$$

$$= 2.79\ m^3/\sec$$

2.For a hydraulic machine installed between A and B, the following data is available:

	At A	At B
Diameter	**20cm**	**30cm**
Elevation	**105m**	**100m**
Pressure	**100 kPa**	**200 kPa**

The direction of flow is from A to B and the discharge is 200 litres per second. Isthe machine a pump or a turbine?

Solution:

At A:

Applying Bernoulli's theorem

$$H_A = \frac{P}{\rho g} + \frac{V^2}{2g} + Z$$

$$Q = 200 \times 10^{-3}\ m^3$$

$$H_A = 10.19 + 2.06 + 105$$

$$H_A = 117.26\ m$$

At B:

Applying Bernoulli's theorem

$$H_B = \frac{P}{\rho g} + \frac{V^2}{2g} + Z$$

$$Q = 200 \times 10^{-3}\ m^3 / \text{sec}$$

$$H_A =$$

$$= 10.19 + 0.408 + 100$$

$$H_A = 110.60\ m$$

Where $V_A < V_B$ and $H_A < H_B$. Hence the machine is a turbine, not a pump

3. **A pelton wheel has a mean bucket speed of 10m/sec with a jet of water flowing at a rate of 700 lit/sec under a head of 30m. The bucket deflect the jet through an angle of 100°. Calculate the power given by water to the runners and hydraulic efficiency of the turbine. Assume Cv = 0.9**

Given

Speed, u = 10m/sec

Discharge, Q = 0.7 m^3/sec

Head, H = 30m

Angle, Ø = 180° - 160° = 20°

Solution

Velocity of jet, $V_1 = C_v x(2gH)^{1/2}$

$= 0.98x(2x9.81x30)^{1/2}$

$= 23.77$ m/sec

$V_{r1} = 23.77 – 10 = 13.77$ m/sec

$V_{w1} = V_1 = 23.77$ m/sec

$V_{r1} = V_{r2} = 13.77$ m/sec

$V_{w2} = V_{r2} \cos \theta – u_2$

$= 13.77x \cos 20° - 10$

$= 2.94$ m/sec

Work done by the jet per sec = $\rho x A x V_1 (V_{w1} + V_{w2})\ u$

$= 0.7 \text{ x } (23.77 + 2.94) \text{ x } 10$

$= 186.97$ kW

Hydraulic efficiency = $(2(V_{w1} + V_{w2}) \text{ x } u) / V_2$

$= (2 \text{ x}(23.77 + 2.94) \text{ x } 10)/23.77$

$= 94.541$ %

4. **A cylinder bore diameter of a single acting reciprocating pump is 150mm and its stroke is 300mm. The pump runs at 50 rpm and lifts water through a height of 25m. The delivery pipe is 22m long and 10mm in diameter. Find the theoretical discharge and theoretical power required to run the pump. If the actual discharge is 4.2 lit/sec. Find the percentage slip. Also determine the acceleration head at the beginning and middle of the delivery stroke.**

Given

D = 150mm = 0.15m

L = 300mm = 0.3m

N = 50rpm

H = 25m

l_d = 22m

d_d = 0.1m

Q_{act} = 4.2 lit/sec

Solution

Theoretical discharge

$Q_{th} = ALN/60$

$= (0.0176 \text{ x } 0.3 \text{ x } 50)/60$

$= 4.4$ lit/sec

Theoretical power

$P_{th} = (\rho g\ Q_{th} H)/1000$

$= 9.81 \text{ x } 0.0044 \text{ x } 25$

$= 1.083$ kW

% of slip = $((Q_{th} – Q_{act})/ Q_{th})$ x 100

= ((0.0044 – 0.0042)/0.0044) x 100

= 4.92 %

Acceleration head

h_{ad} = 20.75 m (Beginning)

h_{ad} = 0 (middle)

5. **Water is flowing through a pipe at the end of which is a nozzle is fixed. The diameter of the nozzle is 100mmand the head of water at the centre of nozzle is 100mm. Find the force exerted by the jet of water on a fixed vertical plate. Co-efficient of velocity is 0.95.**

Given

H = 100m

d = 100mm

Solution

$V = 0.95 (2gH)^{1/2}$

$= 0.95 (2 \times 9.81 \times 100)^{1/2}$

= 42.08 m/sec

Force, $F = \rho \times A \times V^2$

$= 1000 \times \pi \times 0.1^2 \times 42.08^2/4$

= 13.9 kN

6. **A jet of water 60mm diameter strikes a flat fixed plate inclined at 60° to the axis of jet. If the velocity of the jet is 30 m/sec. Find the normal force on the plate and also the force in the direction of jet.**

Given

d = 60mm

θ = 60°

V = 30 m/sec

Solution

$F_y = \rho \times A \times V^2 \times \sin\theta \times \cos\theta$

$= 1000 \times 0.00283 \times 30^2 \times \sin 60° \times \cos 60°$

= 2205.76 N

$F_x = \rho \times A \times V^2 \times \sin^2\theta$

$= 1000 \times 0.00283 \times 30^2 \times \sin^2 60°$

= 1910.25 N

7. **The jet of water of diameter 50mm moving with a velocity of 40 m/sec strikes a curved fixed symmetrical plate centre. Find the force exerted by the jet of water in the direction of jet, if the jet is deflected through an angle of 120° at the outlet of wheel plate.**

Given

$d = 50mm = 0.05m$

$V = 40$ m/sec

$\theta = 60°$

Solution

$F_x = \rho \text{ x } A \text{ x } V^2 \text{ x } (1 + \cos\theta)$

$= 100 \text{ x } \pi \text{ x } 0.05^2 \text{ x } 40^2 \text{ x } (1 + \cos 60°)$

$= 4711.15$ N