

**Fluid Mechanics & Hydraulic Machines**

**(23MEC241T)**

**Branch: Mechanical Engineering**

**Year/Sem: II-IV**

**Unit- I**

**Fluid Statics, Bouyancy and Floation**

**TWO MARK QUESTIONS**

1	Define fluid mechanics.
2	Define Mass Density.
3	Define Specific Gravity.
4	Name the Types of fluids.
5	Define Kinematic Viscosity.
6	Define Surface Tension.
7	Define Real fluid and Ideal fluid.
8	Write down the expression for capillary fall.
9	Define Manometers.
10	Define Buoyancy

**TEN MARK QUESTIONS**

1.	Define viscosity? And derive an expression for coefficient of viscosity.
2	<i>A plate 0.025 mm distant from a fixed plate, moves at 60 cm/s and requires a force of 2 N per unit area i.e., 2 N/m<sup>2</sup> to maintain this speed. Determine the fluid viscosity between the plates.</i>
3	<i>The space between two square flat parallel plates is filled with oil. Each side of the plate is 60 cm. The thickness of the oil film is 12.5 mm. The upper plate, which moves at 2.5 metre per sec requires a force of 98.1 N to maintain the speed. Determine : (i) the dynamic viscosity of the oil in poise, and (ii) the kinematic viscosity of the oil in stokes if the specific gravity of the oil is 0.95.</i>
4	<i>Calculate the capillary rise in a glass tube of 2.5 mm diameter when immersed vertically in (a) water and (b) mercury. Take surface tensions <math>\sigma = 0.0725</math> N/m for water and <math>\sigma = 0.52</math> N/m for mercury in contact with air. The specific gravity for mercury is given as 13.6 and angle of contact = 130°.</i>
5	<i>Find the kinematic viscosity of an oil having density 981 kg/m<sup>3</sup>. The shear stress at a point in oil is 0.2452 N/m<sup>2</sup> and velocity gradient at that point is 0.2 per second.</i>
6	<i>Calculate the capillary effect in millimetres in a glass tube of 4 mm diameter, when immersed in (i) water, and (ii) mercury. The temperature of the liquid is 20°C and the values of the surface tension of water and mercury at 20°C in contact with air are 0.073575 N/m and 0.51 N/m respectively. The angle of contact for water is zero and that for mercury is 130°. Take density of water at 20°C as equal to 998 kg/m<sup>3</sup>.</i>
7	<b>Derive an Expression for U-Tube differential manometer with suitable sketch.</b>
8	<i>A differential manometer is connected at the two points A and B of two pipes as shown in Fig. 2. 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<sup>2</sup> and 1.80 kgf/cm<sup>2</sup> respectively. Find the difference in mercury level in the differential manometer.</i>

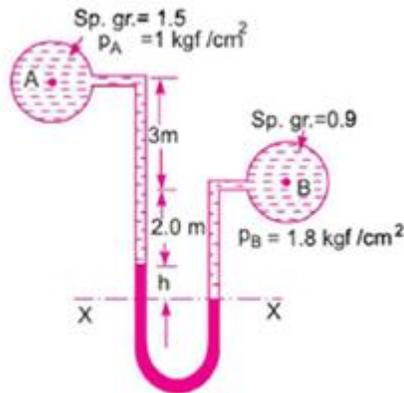


Fig. 2.

9	<i>Find the volume of the water displaced and position of centre of buoyancy for a wooden block of width 2.5 m and of depth 1.5 m, when it floats horizontally in water. The density of wooden block is 650 kg/m<sup>3</sup> and its length 6.0 m.</i>
10	<i>The dynamic viscosity of an oil, used for lubrication between a shaft and sleeve is 6 poise. The shaft is of diameter 0.4 m and rotates at 190 r.p.m. Calculate the power lost in the bearing for a sleeve length of 90 mm. The thickness of the oil film is 1.5 mm.</i>

## Unit-II

### Fluid Kinematics, Fluid Dynamics and Closed Conduit Flow

#### TWO MARK QUESTIONS

1	<b>Write down the types of fluid flow.</b>
2	<b>What do you understand by Continuity Equation?</b>
3	<b>What is mean by Rate flow or Discharge?</b>
4	<b>Write a short notes on “Laminar flow”.</b>
5	<b>Define “ Turbulent flow”.</b>
6	<b>Define Impulse Momentum Equation (or) Momentum Equation.</b>
7	<b>Mention the range of Reynold’s number for laminar and turbulent flow in a pipe.</b>
8	<b>Write the Bernoulli’s equation applied between two sections</b>
9	<b>Write the Bernoulli’s equation applied between two sections with losses</b>
10	<b>State the assumptions used in deriving Bernoulli’s equation</b>

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**TEN MARK QUESTIONS**

1	<b>Discuss in detail of different types of fluid flows.</b>
2	<b>Obtain an expression for continuity equation for two dimensional flow.</b>
3	<i>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 at section 1 is 5 m/s. Determine also the velocity at section 2.</i>
4	<i>A 30 cm diameter pipe, conveying water, branches into two pipes of diameters 20 cm and 15 cm respectively. If the average velocity in the 30 cm diameter pipe is 2.5 m/s, find the discharge in this pipe. Also determine the velocity in 15 cm pipe if the average velocity in 20 cm diameter pipe is 2 m/s.</i>
5	<i>Water is flowing through a pipe of 5 cm diameter under a pressure of 29.43 N/cm<sup>2</sup> (gauge) and with mean velocity of 2.0 m/s. Find the total head or total energy per unit weight of the water at a cross-section, which is 5 m above the datum line.</i>
6	<i>A pipe, through which water is flowing, is having diameters, 20 cm and 10 cm at the cross-sections 1 and 2 respectively. The velocity of water at section 1 is given 4.0 m/s. Find the velocity head at sections 1 and 2 and also rate of discharge.</i>
7	<b>What is venturimeter? Derive an expression for the discharge through a venturimeter.</b>
8	<i>A horizontal venturimeter with inlet and throat diameters 30 cm and 15 cm respectively is used to measure the flow of water. The reading of differential manometer connected to the inlet and the throat is 20 cm of mercury. Determine the rate of flow. Take <math>C_d = 0.98</math>.</i>
9	<i>An oil of sp. gr. 0.8 is flowing through a venturimeter having inlet diameter 20 cm and throat diameter 10 cm. The oil-mercury differential manometer shows a reading of 25 cm. Calculate the discharge of oil through the horizontal venturimeter. Take <math>C_d = 0.98</math>.</i>
10	<i>An orifice meter with orifice diameter 10 cm is inserted in a pipe of 20 cm diameter. The pressure gauges fitted upstream and downstream of the orifice meter gives readings of 19.62 N/cm<sup>2</sup> and 9.81 N/cm<sup>2</sup> respectively. Co-efficient of discharge for the orifice meter is given as 0.6. Find the discharge of water through pipe.</i>

Unit-III

**Boundary Layer Theory and Dimensional Analysis**

**TWO MARK QUESTIONS**

1	<b>Mention the range of Reynold's number for laminar and turbulent flow in a pipe.</b>
2	<b>Define Boundary layer.</b>
3	<b>Classification of boundary layer.</b>
4	<b>Define Boundary layer Thickness.</b>
5	<b>List the various types of boundary layer thickness.</b>
6	<b>Define displacement thickness.</b>
7	<b>Define momentum thickness.</b>
8	<b>Define dimensional analysis</b>
9	<b>List the primary and derived quantities.</b>

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**10 | State Buckingham's  $\pi$  theorem.**

**TEN MARK QUESTIONS**

1	<p>Find the displacement thickness, the momentum thickness and energy thickness of the velocity distribution in the boundary layer given by <math>\frac{u}{U} = \frac{y}{\delta}</math>, where <math>u</math> is the velocity at a distance <math>y</math> from the plate and <math>u = U</math> at <math>y = \delta</math>, where <math>\delta =</math> boundary layer thickness. Also calculate the value of <math>\delta^*/\theta</math>.</p>
2	<p>For the velocity profile given in problem 13.3, find the thickness of boundary layer at the end of the plate and the drag force on one side of a plate 1 m long and 0.8 m wide when plate is in water flowing with a velocity of 150 mm per second. Calculate the value of co-efficient of drag <math>C_D</math>. Take <math>\mu</math> for water = 0.01 poise.</p>
3	<p>Air is flowing over a smooth plate with a velocity of 10 m/s. The length of the plate is 1.2 m and width 0.8 m. If laminar boundary layer exists up to a value of <math>R_e = 2 \times 10^5</math>, find the maximum distance from the leading edge upto which laminar boundary layer exists. Find the maximum thickness of laminar boundary layer if the velocity profile is given by</p> $\frac{u}{U} = 2 \left( \frac{y}{\delta} \right) - \left( \frac{y}{\delta} \right)^2$ <p>Take kinematic viscosity for air = 0.15 stokes.</p>
4	<p>A thin plate is moving in still atmospheric air at a velocity of 5 m/s. The length of the plate is 0.6 m and width 0.5 m. Calculate (i) the thickness of the boundary layer at the end of the plate, and (ii) drag force on one side of the plate. Take density of air as <math>1.24 \text{ kg/m}^3</math> and kinematic viscosity 0.15 stokes.</p>
5	<p>A plate of 600 mm length and 400 mm wide is immersed in a fluid of sp. gr. 0.9 and kinematic viscosity (<math>\nu =</math>) <math>10^{-4} \text{ m}^2/\text{s}</math>. The fluid is moving with a velocity of 6 m/s. Determine (i) boundary layer thickness, (ii) shear stress at the end of the plate, and (iii) drag force on one side of the plate.</p>
6	<p>Determine the dimensions of the quantities given below : (i) Angular velocity, (ii) Angular acceleration, (iii) Discharge, (iv) Kinematic viscosity, (v) Force, (vi) Specific weight, and (vii) Dynamic viscosity.</p>
7	<p>The time period (<math>t</math>) of a pendulum depends upon the length (<math>L</math>) of the pendulum and acceleration due to gravity (<math>g</math>). Derive an expression for the time period.</p>
8	<p>The resisting force <math>R</math> of a supersonic plane during flight can be considered dependent upon the length of the aircraft <math>l</math>, velocity <math>V</math>, air viscosity <math>\mu</math>, air density <math>\rho</math> and bulk modulus of air <math>K</math>. Express the functional relationship between these variables and the resisting force.</p>
9	<p><b>State Buckingham's <math>\pi</math>-theorem in detail.</b></p>
10	<p>The frictional torque <math>T</math> of a disc of diameter <math>D</math> rotating at a speed <math>N</math> in a fluid of viscosity <math>\mu</math> and density <math>\rho</math> in a turbulent flow is given by <math>T = D^5 N^2 \rho \phi \left[ \frac{\mu}{D^2 N \rho} \right]</math>.</p> <p>Prove this by the method of dimensions.</p>

**UNIT -4**

**Basics of turbo machinery and Hydraulic Turbines**

**TWO MARK QUESTIONS**

1	Define the term impact of jet.
2	Write down the equation of impulse momentum?
3	Classify the turbines according to flow.
4	Classify Hydrodynamic machines?
5	What are high head turbines?
6	How is specific speed of a turbine defined?
7	What is hydraulic turbine?
8	List down the main components of pelton wheel.
9	What is draft tube?
10	Explain the type of flow in Francis turbine.

**TEN MARK QUESTIONS**

1	Obtain an expression for the force exerted by the jet on a stationary vertical plate in the direction of jet.
2	Obtain an expression for the force exerted by the jet on an inclined moving plate in the direction of jet.
3	<i>A jet of water of diameter 75 mm moving with a velocity of 25 m/s strikes a fixed plate in such a way that the angle between the jet and plate is 60°. Find the force exerted by the jet on the plate (i) in the direction normal to the plate and (ii) in the direction of the jet.</i>
4	<i>A jet of water of diameter 75 mm moving with a velocity of 30 m/s, strikes a curved fixed plate tangentially at one end at an angle of 30° to the horizontal. The jet leaves the plate at an angle of 20° to the horizontal. Find the force exerted by the jet on the plate in the horizontal and vertical direction.</i>
5	<i>A jet of water of diameter 10 cm strikes a flat plate normally with a velocity of 15 m/s. The plate is moving with a velocity of 6 m/s in the direction of the jet and away from the jet. Find: (i) the force exerted by the jet on the plate (ii) work done by the jet on the plate per second. and (iii) power and efficiency of the jet.</i>
6	Draw a layout of hydroelectric power plant and explain its working briefly.
7	Derive an expression for pelton wheel turbine.
8	<i>A Pelton wheel has a mean bucket speed of 10 metres per second with a jet of water flowing at the rate of 700 litres/s under a head of 30 metres. The buckets deflect the jet through an angle of 160°. Calculate the power given by water to the runner and the hydraulic efficiency of the turbine. Assume co-efficient of velocity as 0.98.</i>

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9	<p>A Francis turbine with an overall efficiency of 75% is required to produce 148.25 kW power. It is working under a head of 7.62 m. The peripheral velocity = <math>0.26 \sqrt{2gH}</math> and the radial velocity of flow at inlet is <math>0.96 \sqrt{2gH}</math>. The wheel runs at 150 r.p.m. and the hydraulic losses in the turbine are 22% of the available energy. Assuming radial discharge, determine :</p> <p>(i) The guide blade angle, (ii) The wheel vane angle at inlet, (iii) Diameter of the wheel at inlet, and (iv) Width of the wheel at inlet.</p>
10	<p>A Kaplan turbine runner is to be designed to develop 9100 kW. The net available head is 5.6 m. If the speed ratio = 2.09, flow ratio = 0.68, overall efficiency = 86% and the diameter of the boss is 1/3 the diameter of the runner. Find the diameter of the runner, its speed and the specific speed of the turbine.</p>

**Unit-V**

**Hydraulic Turbines, Centrifugal pumps and Reciprocating pumps**

**TWO MARK QUESTIONS**

1	Mention the main parts of the centrifugal pump.
2	List commonly used castings in centrifugal pumps.
3	What is priming?
4	Define cavitation.
5	Define specific speed.
6	What is a reciprocating pump?
7	What is Discharge through a Reciprocating Pump?
8	Define slip of reciprocating pump. When does negative slip occur?
9	What is indicator diagram?
10	List the advantages of double acting reciprocating pump.

**TEN MARK QUESTIONS**

1	What is a centrifugal pump? Describe the principle and working of a centrifugal pump with a neat sketch.
2	The internal and external diameters of the impeller of a centrifugal pump are 200 mm and 400 mm respectively. The pump is running at 1200 r.p.m. The vane angles of the impeller at inlet and outlet are 20° and 30° respectively. The water enters the impeller radially and velocity of flow is constant. Determine the work done by the impeller per unit weight of water.
3	A centrifugal pump is to discharge 0.118 m <sup>3</sup> /s at a speed of 1450 r.p.m. against a head of 25 m. The impeller diameter is 250 mm, its width at outlet is 50 mm and manometric efficiency is 75%. Determine the vane angle at the outer periphery of the impeller.
4	A centrifugal pump delivers water against a net head of 14.5 metres and a design speed of 1000 r.p.m. The vanes are curved back to an angle of 30° with the periphery. The impeller diameter is 300 mm and outlet width is 50 mm. Determine the discharge of the pump if manometric efficiency is 95%.

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5	<p style="text-align: center;"><i>The outer diameter of an impeller of a centrifugal pump is 400 mm and outlet width is 50 mm. The pump is running at 800 r.p.m. and is working against a total head of 15 m. The vanes angle at outlet is <math>40^\circ</math> and manometric efficiency is 75%. Determine :</i></p> <p style="text-align: center;"><i>(i) velocity of flow at outlet, (ii) velocity of water leaving the vane, (iii) angle made by the absolute velocity at outlet with the direction of motion at outlet, and (iv) discharge.</i></p>
6	<p style="text-align: center;"><i>Find the number of pumps required to take water from a deep well under a total head of 89 m. All the pumps are identical and are running at 800 r.p.m. The specific speed of each pump is given as 25 while the rated capacity of each pump is <math>0.16 \text{ m}^3/\text{s}</math>.</i></p>
7	<p style="text-align: center;"><i>A single-acting reciprocating pump, running at 50 r.p.m., delivers <math>0.01 \text{ m}^3/\text{s}</math> of water. The diameter of the piston is 200 mm and stroke length 400 mm. Determine :</i></p> <p style="text-align: center;"><i>(i) The theoretical discharge of the pump, (ii) Co-efficient of discharge, and (iii) Slip and the percentage slip of the pump.</i></p>
8	<p style="text-align: center;"><i>A double-acting reciprocating pump, running at 40 r.p.m., is discharging <math>1.0 \text{ m}^3</math> of water per minute. The pump has a stroke of 400 mm. The diameter of the piston is 200 mm. The delivery and suction head are 20 m and 5 m respectively. Find the slip of the pump and power required to drive the pump.</i></p>
9	<p><b>What is a reciprocating pump? Describe the principle and working of a reciprocating pump with a neat sketch.</b></p>
10	<p><b>What is negative slip in a reciprocating pump? Explain with neat sketches the function of air vessels in a reciprocating pump.</b></p>