Code No: R09220304 **R09** **Set No. 2**

II B.Tech II Semester Examinations,APRIL 2011
MECHANICS OF FLUIDS AND HYDRAULIC MACHINES
Common to Mechanical Engineering, Information Technology, Production Engineering, Computer Science And Engineering

Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Calculate the least diameter of impeller of a centrifugal pump to just start delivering Water to a height of 30m, if the inside diameter of impeller is half of the outside diameter and the manometric efficiency is 85%. The pump runs at 1000rpm.
   (b) Derive an expression for the work saved against friction in the case of a single acting reciprocating pump with an air vessel. [7+8]

2. An orifice meter conveying water is fitted to a pipe line of 10cm diameter. The diameter of the orifice is 5 cm. if a mercury differential manometer indicates a reading of 12 cm, calculate the flow rate through the pipe line. Assume C_c= 0.62 and C_v = 0.90. [15]

3. (a) What is the Thoma's cavitation factor? What is its significance?
   (b) A Francis turbine working under a head of 6m at a speed of 240rpm develops 80 kW when the rate of flow of water is 19 m^3/sec. If the head is increased to 18m, determine the speed and power. [7+8]

4. (a) Explain the basic principle involved in measuring pressure and pressure difference using manometers. Indicate when the use of manometers is advantageous.
   (b) A vessel of the shape shown in figure 1 is filled with a liquid of specific gravity 0.92. The pressure gauge at A reads 400 kN/m^2. Determine the pressure read by a gauge (Bourdon type) fixed at B. Neglect gauge height. [7+8]

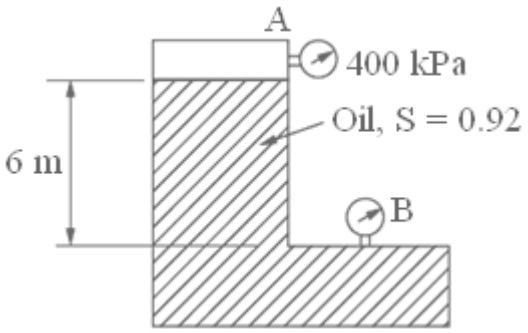

Figure 1:

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5. (a) A jet of water 45mm diameter having a velocity of 30 m/s normally a series of flat plates so arranged at the periphery of a wheel rotating at 100 rpm. That the entire discharge of the jet acts normally on the plates. The distance of the point of application of the jet from the center of the wheel is 1.2m. Find the:
   i. Power delivered by the jet to the wheel and
   ii. The hydraulic efficiency.

   (b) A 5 cm wide 2-dimensional horizontal jet strikes a stationary vertical plate inclined to the direction of the jet by 60^0 at a velocity of 25 m/s. Assuming frictionless flow, find the velocities and thickness of the stream at the two ends of the plate after the jet is deflected. Also, find the force exerted by the fluid on the plate per cm thickness of the 5 cm wide jet and its point of application. [8+7]

6. (a) Derive Bernoulli's equation for the flow of an incompressible frictionless fluid.

   (b) The diameters of a pipe at the sections 1 and 2 are 25 cm and 30 cm respectively. Find the discharge through the pipe if velocity of water at section 1 is 4 m/s. Determine also the velocity at section2. [7+8]

7. For the velocity profile for laminar boundary layer $\frac{u}{U} = \sin\left(\frac{\pi}{2}\right)\left(\frac{y}{\delta}\right)$. Obtain an expression for boundary layer thickness, shear stress, drag force on the one side of the plate and co-efficient drag in terms of Reynold number. [15]

8. A Pelton wheel is required to run at 600rpm. The water jet is 80mm in diameter and has a velocity of 100m/s. the deflects the jet through 160^0 and the ratio of the bucket speed to initial jet speed is 0.47. Neglecting the losses, determine:
   (a) The diameter of wheel to centerline of buckets,
   (b) Horse power developed and
   (c) Kinetic energy per kg remaining in the fluid. [15]

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1. A horizontal pipe-line 50 m long is connected to a water tank at one end and discharges freely into the atmosphere at the other end. For the first 30 m of its length from the tank, the pipe is 200 mm diameter and its diameter is suddenly enlarged to 400 mm. The height of water level in the tank is 10 m above the centre of the pipe. Considering all minor losses, determine the rate of flow. Take f = .01 for both sections of the pipe. Draw the hydraulic gradient lines (H.G.L) and total energy lines (T.E.L). [15]

2. A jet of water, 50mm in diameter, impinges on a stationary curved vane at a velocity of 50 m/s. The vane deflects the jet by 120 degree. Find:
   (a) The magnitude, direction and location of the force exerted by the jet on the stationary vane assuming that the flow over the vane is frictionless. If the vane (single) moves away in the direction of the jet with a velocity of 20 m/s. find the
   (b) Power delivered by the jet to the vane and the efficiency of the power transfer. [15]

3. (a) Define displacement thickness. Derive an expression for the displacement thickness.
   (b) Prove that the momentum thickness for boundary layer flows are given by $\theta = \int_0^{\delta} \frac{u}{U}\left[1 - \frac{u}{U}\right] dy$. [7+8]

4. (a) The mean bucket speed of a Pelton wheel turbine is 15 m/s. The rate of flow of water supplied by the jet under a head of 45m is 1.15 m^3/s. If the jet is deflected by the buckets at an angle of 165^0, find the power and efficiency of the turbine. Assume coefficient of velocity C_v=0.985.
   (b) A radial flow hydraulic turbine is required to be designed to produce 20 MW under a head of 18m at a speed of 95 r.p.m. A geometrically similar model with an output of 30kW and a head of 5m is to be tested under dynamically similar conditions. At what speed must the model be run? What is the required impeller diameter ratio between the model and prototype and what is the volume of flow rate through the model if its efficiency can be assumed to be 90percent? [7+8]

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5. (a) Derive the expression for the pressure variation in a static fluid under gravitational forces. Indicate the modifications where pressure varies along vertical and horizontal directions.

   (b) A vessel of the shape shown in figure 2 is filled with a liquid of specific gravity 0.92. The pressure gauge at A reads 400 kN/m^2. Determine the pressure read by a gauge (Bourdon type) fixed at B. Neglect gauge height. [7+8]

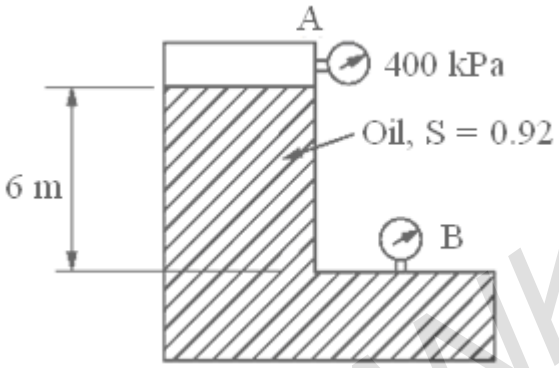

Figure 2:

6. (a) What do you understand by water hammer in pipe flow? Discuss its effects on the pipe Networks?

   (b) In a pipe of 500 mm diameter and 2500m length provided with a valve at its end, water is flowing with a velocity of 1.5 m/s. Assuming velocity of pressure wave as 1460 m/s, Find:

   i. The rise in pressure if the valve is closed in 25 seconds and

   ii. The rise in pressure if the valve is closed in 2 seconds. Assume the pipe to be rigid and take bulk modulus of water as 1.962 GN/m^2. [7+8]

7. A horizontal Y is shown in figure 3. Determine the x and y components of the force exerted in the pipe. [15]

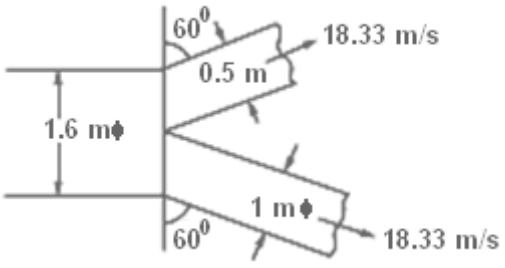

Figure 3:

8. (a) A single acting reciprocating pump, having a plunger diameter 220mm and 320mm stroke, is placed 4 m above the water level of a sump. The suction

pipe is 80mm in diameter and 5m long. If the separation takes place at a pressure head of 2.5m of water find the maximum speed of the pump, in order to avoid separation. Take barometer reading as 10.4m of water.

(b) A single acting reciprocating pump 275mm bore and 420mm stroke delivers water through a 110 mm diameter delivery pipe to a tank located at 15m above and 20m horizontally form the cylinder. If separation occurs at 2.3m of water absolute, find the maximum permissible speed at which the pump can run without separation for the following two conditions:

i. The delivery pipe is horizontal from the pump and then vertical.

ii. The delivery pipe is vertical from the pump and then horizontal. Take atmospheric pressure as 10.3m of water. [7+8]

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1. Derive the linear momentum equation using the control volume approach and determine the force exerted by the fluid flowing through a pipe bend. [15]

2. A Francis turbine is being designed for hydroelectric dam. It is decided to geometrically scale up a previously designed hydro-turbine. The existing turbine has a diameter of 2.05m and spins at 20 rpm. At its best efficiency point, the discharge is 350 m^3/sec under a head of 75m of water and develops 242MW power. The new turbine is for a larger facility. Its generator spins at 120rpm but its net head is 104m. Calculate:
   (a) The diameter of the new turbine such that it operates most efficiently, and also calculate discharge, power and efficiency of new turbine.
   (b) Calculate and compare the turbine specific speed for both the turbines. [15]

3. A double-acting reciprocating single cylinder pump of 180mm bore and 350mm stoke runs at 40 rpm. The piston rod is 80mm diameter. The suction and delivery lifts are 1.2m and 32m. The suction pipe is 3m long and the delivery pipe is 42m long and both of them are 100mm in diameter. No air vessel is provided either on suction or delivery pipe. The local losses can be neglected and for both the pipes the friction factor is 0.028. The motion of piston can be assumed to be simple harmonic motion. Determine the net force due to fluid pressure on the piston when it has moved through a distance of 100mm from the inner dead center. [15]

4. (a) A Kaplan turbine is to develop 2500kW when running under a net head of 50m. In order to predict its performance a model of scale 1:6 is tested under a net head of 25m. At what speed should the model run and what power would it develop. Determine the discharge in the model and in the model and in full scale turbine if the overall efficiency of the model is 88%.
   (b) A cast iron pipe of 150mm diameter and 12mm metal thickness carries water from a reservoir. Calculate the maximum permissible discharge pipe if a sudden stoppage of flow should not stress the pipe to more than 45 N/mm^2. Assume Young's modulus E of cast iron is 1.25×10^5 N/m^2 bulk modulus of water is 2000 n/mm^2 and sonic velocity is 1420 m/s. [8+7]

5. A 30 mm diameter jet of water, having a velocity of 60 m/s, impinges tangentially on a series of vanes which moves away in the same direction as that of the jet. The shape of each vane is such that, if stationary, they would deflect the jet by 150

degree. The friction loss over a vane is $0.2\frac{V_{r1}^2}{2g}$, V_{r1} being the relative velocity at entry to the vanes, and the windage loss is $0.4\frac{U^2}{2g}$, U being the vane velocity. Find the:

(a) Vane velocity corresponding to maximum efficiency.

(b) The maximum efficiency.

(c) The force on the vanes in and at right angles to the direction of motion and

(d) The power delivered to the vanes. [15]

6. (a) Define: laminar boundary layer, turbulent, boundry layer, laminar sub-layer and boundary layer thickness.

(b) Prove that the momentum thickness and energy thickness for boundary layer flows are given by $\theta = \int_0^{\delta} \frac{u}{U}\left[1 - \frac{u^2}{U^2}\right]dy$. [7+8]

7. A Venturimeter is used to measure the flow of water through a 20 cm diameter pipe. The pressure at the inlet is 6m of water when the flow rate is 440 lps. Find the smallest diameter of the throat to ensure that the pressure head does not fall below the atmospheric pressure. Assume C_d= 0.98. [15]

8. (a) Derive an expression for the capillary rise or depression, given the value of the contact angle and the density and surface tension of the liquid.

(b) Two large planes are parallel to each other and are inclined at 30^0 to the horizontal with the space between them filled with a fluid of viscosity 20 Centi Poise. A small thin plate of 0.125 m square slides parallel and midway between the planes and reaches a constant velocity of 2 m/s. The weight of the plate is 1 N. Determine the distance between the plates. [7+8]

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1. A Venturimeter is introduced in a pipe of 10 cm diameter inclined 60^0 to the horizontal for measuring the flow of oil. The throat diameter is 5 cm. the mercury differential manometer gives a reading of 10 cm. find the discharge in the pipe if the specific gravity of oil is 0.85 and $C_d = 0.97$. [15]

2. (a) The pressure of water increases with depth in the ocean. At the surface, the density was measured as 1024.5 kg/m^3. The atmospheric pressure is 1.01 bar. At a certain depth where the pressure was 900 bar the density was measured as 1065.43 kg/m^3. Determine the average value of bulk modulus.
   (b) Differentiate between the three states of matter.
   (c) Distinguish between compressible and incompressible fluids and vapour & gas. [5+5+5]

3. (a) Briefly discuss the main difference in the way that dynamic pumps and reaction turbines are classified centrifugal (radial), mixed flow or axial.
   (b) Discuss the meaning of reverse swirl in reaction hydroturbines, and explain why reverse swirl is desirable. Why is not wise to have too much reverse swirl. [6+9]

4. (a) Define the following:
      i. Steady flow,
      ii. Non-uniform flow,
      iii. Laminar flow and
      iv. Two-dimensional flow.
   (b) The velocity vector in a fluid flow is given by V=2x^{3}i-5x^{2}yj+4tk. Find the velocity and acceleration of a fluid particle at (1,2,3) at time, t=1. [15]

5. (a) A Pelton wheel turbine rotating at a speed of 220 rpm under a head of 200m develops 5900 kW shaft power with an overall efficiency of 82%. Determine unit speed, unit discharge, and unit power. The speed ratio of turbine is 0.48. Find the speed, discharge, and power when working under a head of 150m.
   (b) Two inward floe reaction turbines have the same runner diameter of 0.5m and the same efficiency, they work under the same head and they have the same velocity of flow of 5m/s. One of the runners revolves at 500rpm, and has an inlet vane angle of 60^0. If the other runner has an inlet vane angle of 120^0, at what speed should it run? [8+7]

6. (a) A jet of water is moving at 60 m/s and is deflected by a vane moving at 25m/s in a direction at 30^0 to the direction of the jet. The water leaves the blades with no velocity component in the direction of motion of vane. Determine the inlet and outlet angles of the vanes for no shock at entry or exit. Assume outlet velocity of water relative to the blades to be 0.85 of the relative velocity at entry.

   (b) A 100 mm diameter jet discharging at 0.40 m^3/sec impinges on a series of curved vanes moving at 18 m/s. the direction of the jet and the direction of motion of the vane are the same at inlet. Each vane is so shaped that if stationary it would deflect the jet by 170^0. Calculate:

   i. The force exerted in the direction of motion of the vanes
   ii. The power developed and
   iii. The hydraulic efficiency. [8+7]

7. (a) What do you understand by work done by impeller of centrifugal pump? Derive the fundamental equation of centrifugal pump.

   (b) Discuss the various losses and efficiencies occurring during the operation of centrifugal pump. [9+6]

8. For the velocity profile for laminar boundary layer $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - 2\left(\frac{y}{\delta}\right)^3 + \left(\frac{y}{\delta}\right)^4$. Determine the boundary layer thickness, shear stress, drag force and co-efficient drag in terms of Reynold number. [15]

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