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

II B.Tech II Semester Examinations,April/May 2012
MECHANICS OF FLUIDS AND HYDRAULIC MACHINES
(Common to ME, IT, MEP, CSE, MIM & MIE)

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

Answer any FIVE Questions
All Questions carry equal marks
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1. Differentiate between:
   (a) Stream function and velocity potential function.
   (b) Stream line and streak line
   (c) Rotational and irrotational flows.
   (d) Uniform flow and non-uniform flow. [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) What is governing and how it is accomplished for different types of water turbines?
   (b) A Kaplan turbine develops 1480 kW under a head of 7m. The turbine is set 2.5 m above the tailrace level. A vacuum gauge inserted at the turbine outlet records a suction head of 3.1m. If the hydraulic efficiency is 85%, What would be the efficiency of draft tube having inlet diameter of 3m? What would be the reading of suction gauge if power developed in reduced to half (740kW), the head and speed remaining constant. [7+8]

4. (a) Determine the error in calculating the excess pressure of water hammer in a steel pipe carrying water with an inner diameter 'd' is 15mm and a wall thickness 't' is 2mm if the elasticity of the material of the pipe wall is disregarded. Take E =2.07 $\times$ 10^5 MN/m^2 for steel and E=2.2 $\times$ 10^3 MN/m^2 water.
   (b) A steel penstock 1200mm diameter and 1500m long conveys water at the rate of 1.5m^3/sec. A valve at the end is closed in 2.5seconds. Assume E for steel as 2.07 $\times$ 10^8 kN/m^2, K=2.07 $\times$ 10^6 kN/m^2 and the thickness of the pipe wall is 20mm. Find the water hammer pressure developed. [7+8]

5. (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 300 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]

6. (a) An oil of Kinematic Viscosity 0.5 stoke is flowing through a pipe of diameter 300 mm at the rate of 320 litres per sec. Find the head lost due to friction for a length of 60 m of the pipe.

(b) Calculate the rate of flow of water through a pipe of diameter 300 mm, when the difference of pressure head between the two ends of a pipe 400 m apart is 5 m of water. Take the value of f = .009 in the formula $h_f = \frac{4fLV^2}{d \times 2g}$. [7+8]

7. (a) A multi-stage pump is required to feed preheated water to a boiler. The quantity of water to be handled is 40 liter per second against a pressure difference of 3200 kN/m^2. The speed of rotation of impeller being 3000rpm. The specific weight of the preheated water is 960kg/m^3. All impellers are identical and the specific speed per stage is not to exceed 5400. Determine:

i. The minimum number of stages and the head per stage.

ii. The diameter of the impeller assuming a peripheral velocity $0.95\sqrt{2gh}$.

iii. The shaft power required to drive the pump, if the overall efficiency is 80%.

(b) Derive an expression for the work done by a reciprocating pump with air vessels. [10+5]

8. (a) How are drag and lift forces caused on a body immersed in a moving fluid.

(b) What is the drag force on a sphere in the stoke range?

(c) Explain the terms:

i. Friction drag,

ii. Pressure drag and profile drag. [15]

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Code No: R09220304 **R09** **Set No. 4**

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

Answer any FIVE Questions
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1. (a) A jet of water having a velocity of 35m/s impinges on a series of vanes moving with a velocity of 22m/s. The jet makes an angle of 30^0 to the direction of motion of vanes when entering and leaving at an angle of 120^0 .Draw the velocity triangles at inlet and outlet and find:
   i. The angles of vanes tip so that water enters and leaves without shock
   ii. The work done per N of water entering the vanes and
   iii. The efficiency.
   (b) Prove that the force exerted by a jet of water on a fixed semi-circular plate in the direction of the jet when the jet strikes at the center of the semi circular plate is two times the force exerted by the jet on a fixed vertical plate. [8+7]

2. Find the displacement thickness and the momentum thickness for the velocity distribution in the boundary layer given by $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$. [15]

3. (a) What is a compound pipe? What will be loss of head when pipes are connected in series?
   (b) A Venturimeter with 0.08 m throat diameter is used to measure the flow in a pipe line of 0.16 m diameter. A mercury manometer attached to it shows deflection of 0.29 m. Assuming coefficient of discharge as 1, calculate the flow rate in the pipe. [15]

4. (a) Name different forces present in a fluid flow. For Euler's equation of motion, which forces are taken into consideration?
   (b) The diameters of a pipe at the sections 1 and 2 are 15 cm and 25 cm respectively. Find the discharge through the pipe if velocity of water at section 1 is 10 m/s. Determine also the velocity at section2. [7+8]

5. (a) A straight pipe 600m length and 1m in diameter, with a constant friction factor f=0.025 and a sharp inlet, leads from a reservoir where a constant level is maintained at 25 m above the pipe outlet which is initially closed by a globe valve (K=10). If the valve is suddenly opened, find the time required to attain 90% of steady state discharge.
   (b) A valve at the outlet end of a pipe 1m in diameter and 700m long is rapidly opened. The pipe discharges to atmosphere and the piezemetric head at the inlet end of the pipe is 23m (relative to outlet level). The head loss through open valve is 10 times the velocity head in the pipe, other minor losses of

amount to twice the velocity head and friction factor f=0.02. What is the velocity after 12 seconds. [7+8]

6. (a) A centrifugal pump with impeller of 150mm diameter discharges 0.038m^3/sec water When running at 1500 rpm against a head of 10m. Determine the corresponding speed and the head of a geometrically similar pump with impeller of 375mm diameter delivering 0.75m^3/sec.

   (b) Starting from first principles show that in a rotodynamic fluid machine, the head transferred by the fluid to the machine is given by $(V_{w1}u_1 - V_{w2}u_2)/g$, where V_{w1},V_{w2} are the whirl velocity components of the inlet and outlet respectively while u_1 and u_2 are the velocity of vane of inlet and outlet respectively. [8+7]

7. (a) Explain the concepts of
   i. vapour pressure
   ii. partial pressure
   iii. surface tension.

   (b) A shaft of 150 mm dia rotates in bearings with a uniform oil film of thickness 0.8 mm. Two bearings of 15 cm width are used. The viscosity of the oil is 22 Centi Poise. Determine the torque if the speed is 210 rpm. [7+8]

8. (a) An inward flow reaction turbine is required to produce a power of 280 kW at 220 r.p.m. The effective head on the turbine is 20 m. The inlet diameter is twice as the outlet diameter. Assume hydraulic efficiency as 83% and overall efficiency as 80%. The radial velocity is 3.75m/s and is constant. The ratio of wheel diameter to breadth is 0.1 and 6% of the flow area is blocked by vane thickness. Determine the inlet and outlet diameters, inlet and exit vane angle and guide blade angle at the inlet. Assume radial discharge.

   (b) In a Francis turbine, the blade angle is 15^0 and the flow enters in a radial direction. The flow velocity is constant and is equal to 8.25m/s. The outlet diameter is 0.6 times the inlet diameter and the runner rotates at 400 r.p.m. The width of the wheel is 0.1 times the inlet diameter and 7% of the flow area is blocked by blade thickness. Assume radial flow at outlet. Calculate:
   i. Diameters at outlet and inlet.
   ii. Blade angle at outlet.
   iii. The head and power developed. [8+7]

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Code No: R09220304 **R09** **Set No. 1**

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Answer any FIVE Questions
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1. (a) What are the functions of air vessels in reciprocating pumps? Explain with neat sketches.
   (b) Draw a neat sketch of an indicator diagram, considering the effect of acceleration and friction in suction and delivery pipe. Derive an expression for work done per second for a single acting reciprocating pump. [5+9]

2. (a) What do you mean by equivalent pipe? Obtain an expression for equivalent pipe.
   (b) An orifice meter of 0.15 m diameter is fitted in a 0.3 m diameter pipe to measure the flow rate of water through it. If the pressure difference across the orifice is 10 m of water head, calculate the discharge in the pipe. Assume the coefficient of discharge of the orifice meter as 0.59. [7+8]

3. (a) The following are the data of a Pelton wheel turbine ; Head at nozzle is 600m; shaft power is 70MW; speed is 550rpm; Discharge is $13m^3$/sec; number of jets are 4; runner diameter is 2m; Diameter of jets is 0.20m; outlet vane angle is 16^0; mechanical efficiency is 98%. Determine the head lost in the nozzle, head lost in the buckets. Find also the power lost in the nozzle and the buckets.
   (b) The runner of pelton wheel turbine has tangential velocity of 18m/s and works under ahead of 62m. The jet is turned through 17^0. The discharge through the nozzle is 110 liters per second. Determine the power developed by the runner and the efficiency of. Assume C_v=0.98. [10+5]

4. (a) A free jet of water of velocity V strikes against a series of curved semi-circular vanes tangentially. The vanes are moving in the direction of the jet with velocity equal to 0.6V. Assuming the relative velocity of water is reduced by 10% by moving over the Vanes, show that the vanes have an efficiency of 91.23%.
   (b) A jet of water of diameter 40mm and velocity 22 m/s impinges on:
      i. A normal flat vane moving in the direction of jet at 8 m/s and
      ii. A series of normal flat vanes mounted on a wheel which has a tangential velocity of 7.5 m/s. Calculate force exerted, work done by water and efficiency of the system in both cases. [7+8]

5. The suction pipe of a pump slopes at 1 m vertical for 5 m length. If the flow velocity in the pipe is 1.8 m/s and if the pressure in the pipe should not fall by more than 7 m of water, determine the maximum length. [15]

6. (a) Determine the pressure difference between A and B shown in figure 1.

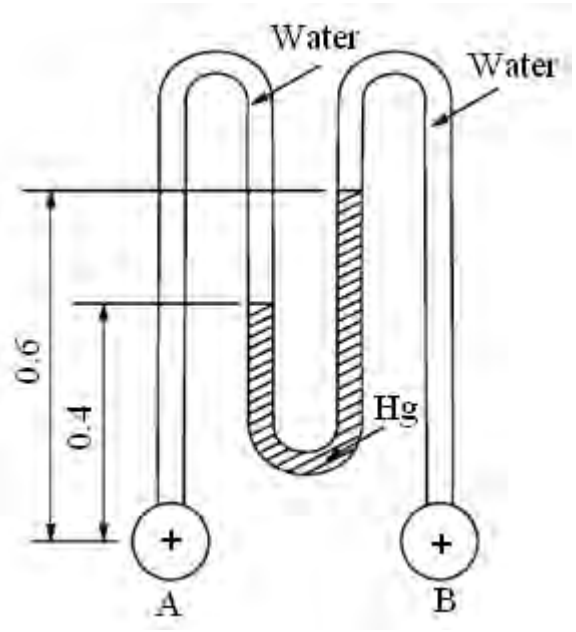

Figure 1:

(b) Determine the pressures at location 1 and 2 in figure 2. [7+8]

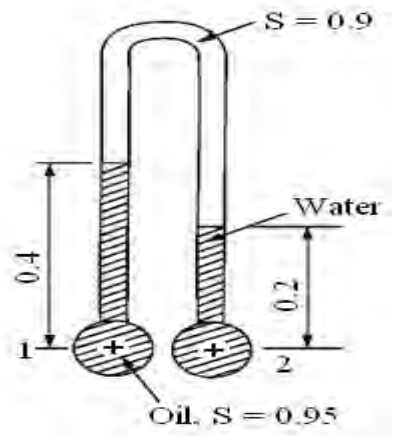

Figure 2:

7. (a) What are the load-efficiency curves? Discuss the load-efficiency curves for reaction Turbines.

(b) A hydraulic turbine develops 1200 hp under a head of 10m at a speed of 90 rpm and gives an efficiency of 92%. Find the water consumption and the specific speed. If a model is 1:10 full size is constructed to operate under a head of 8m, what must be its speed, power and water consumption to run under the conditions similar to the prototype. [7+8]

8. (a) Differentiate between:
   i. Stream-lines body and bluff body,
   ii. Friction drag and pressure drag.
   (b) What do you mean by 'Terminal velocity of a body'? What is the relation between the weight of the body, drag force on the body and buoyant force when the body has acquired terminal velocity? [7+8]

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Code No: R09220304 **R09** **Set No. 3**

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

Answer any FIVE Questions
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⋆ ⋆ ⋆ ⋆ ⋆

1. A U-tube manometer has both its limbs enlarged to 25 times the tube area. Initially the tube is filled to some level with oil of specific weight. Then both limbs are filled with fluid of specific weight to the same level, both limbs being exposed to the same pressure. When a pressure is applied to one of the limbs the manometric fluid rises by h m. Derive an expression for the pressure difference in the limbs. In both cases assume that the liquid level remains in the enlarged section. [15]

2. During a laboratory test on a pump, appreciable cavitation began when the pressure plus the velocity head at inlet was reduced to 3.26m while the change in total head across the pump was 36.5m and the discharge was 48 liters per second. Barometric pressure was 750mm of Hg and the vapour pressure of water is 1.8 kPa. What is the value of α_c? If the pump is to give the same total head and discharge in a location where the normal atmospheric pressure is 622 mm of Hg and the vapour pressure of water is 830 Pa, by how much must the height of the pump above the supply level be reduced? [15]

3. (a) What are the different types of efficiencies of turbine?
   (b) Hydraulic tests were conducted on Francis turbine of 0.75m diameter under a head of 10m. The turbine developed 120 kW running at 240 r.p.m and consuming 1.25 m^3/sec. If the same turbine is operated under a head of 15 m predict its new speed, discharge and power. [5+10]

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) Define and explain the terms:
      i. Hydraulic gradient line and
      ii. Total energy line.
   (b) Air velocity in a duct is measured as 38.2 m/s by a pitot tube. Density of flowing air 1.3 kg/m^3. If the pressure difference recorded by the pitot static tube is 0.1 m of water, calculate the coefficient of velocity of the pitot static tube. [7+8]

6. (a) What do you mean by boundary layer separation? What is the effect of pressure gradient an boundary layer separation?

   (b) Air is flowing over a smooth plate with a velocity of 8 m/s. The length of the plate is 1.5 m and width 1m. If the laminar boundary exists upto a value of Reynold number = 5 x 10^5, 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 $\frac{u}{U} = (y/\delta) - (y/\delta)^2$. Take v for air = 0.15 stokes. [15]

7. (a) A1250m long pipeline, with frictional coefficient 0.005, supplies three single jet Pelton wheels the top water level of the reservoir being 350m above the nozzles. The C_v for each nozzle is 0.98. The efficiency of each turbine based on the head at the nozzle is 85%. The head lost in the friction is 12.50m. The specific speed of each wheel is 15, and the working speed is 550rpm. Find the:

      i. Total power developed.
      ii. Discharge.
      iii. Diameter of each nozzle.
      iv. Diameter of the pipe line.

   (b) For maximum conversion of hydraulic power into mechanical power, what should be the shape of velocity diagram at the outlet in case of a reaction turbine. [10+5]

8. (a) A jet of diameter 40mm strikes horizontally on a plate held vertically. What force is required to hold plate for a flow of oil of specific gravity 0.8 with a velocity of 30 m/s.

   (b) A 75mm diameter jet having a velocity of 37m/s strikes normally a flat plate, the normal at 45^0 to the axis of jet. Find the normal pressure on the plate:

      i. When the plate is stationary.
      ii. When the plate is moving with a velocity of 17m/s in the direction of the away from the jet. Also determine the power and the efficiency of the jet when the plate is moving. [7+8]

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