

II B.Tech I Semester Regular Examinations, November 2008
FLUID MECHANICS AND HYDRAULIC MACHINERY
 (Common to Electrical & Electronic Engineering and Production
 Engineering)

Time: 3 hours

Max Marks: 80

Answer any FIVE Questions
All Questions carry equal marks

1. (a) Discuss the influence of the following fluid properties on fluid motion
 - i. Viscosity
 - ii. Specific gravity
 - iii. Surface tension
 - iv. Bulk modulus
- (b) If the surface tension at air water interface is 0.073N/m, What is the pressure difference between inside and outside of an air bubble of diameter 0.01mm?
[10+6]

2. (a) Describe stream line and stream tube with the help of neat sketches.
- (b) For steady incompressible flow verify whether the following values of u and v are possible:
 - i. $u = 4xy + y^2, v = 6xy + 3x$
 - ii. $u = 2x^2 + y^2, v = -4xy$
 - iii. $u = -x/(x^2 + y^2), v = -y/(x^2 + y^2)$. [6+10]

3. (a) What are the construction details of a pitot tube and explain how it works?
- (b) An oil of relative density 0.90 flows through a vertical pipe of diameter 20cm. The flow is measured by a 20cm × 10cm venturimeter. The throat is 30cm above the inlet section. A differential U tube manometer containing mercury is connected to the throat and the inlet. If coefficient of discharge is 0.99 what is the manometer reading for a flow of 50 lit/sec. [6+10]

4. (a) A nozzle of 56 mm diameter delivers a stream of water at 30 m/sec perpendicular to a plate that moves away from the jet at 8 m/sec. Find the work done and efficiency of the jet.
- (b) Prove that the force exerted by a jet of water on a fixed curved vane when the jet strikes at the centre is $F = \rho av^2 (1 + \cos\theta)$ where

ρ = Mass density of water
 a = Area of cross section of the jet
 v = Velocity of the jet
 θ = Angle of the curved plate at the out let. [8+8]

5. (a) Explain the inherent advantages, which make Hydropower more attractive.

- (b) A runoff stream with an installed capacity of 12000KW operates at 15% load factor when it serves as a peak load station. What should be the lowest discharge in the stream so that the station may serve as the base load station. It is given that plant efficiency is 70% when working under a head of 18m. Also calculate maximum load factor of the plant when the discharge in the stream rises to 18 cumecs [8+8]
6. (a) Define the terms: speed ratio, flow ratio and jet ratio
- (b) An inward flow reaction turbine has external and internal diameters as 1.2 m and 0.6 m respectively. The velocity of flow through the runner is constant and is equal to 1.8 m/s. Determine:
- Discharge through the runner, and
 - Width at outlet if the width at inlet = 20 cm [16]
7. (a) Give the range of specific speed values of the Kaplan, Francis turbines and Pelton wheels. What factors decide whether Kaplan, Francis, or a Pelton type turbine would be used in a hydroelectric project ?
- (b) A Kaplan turbine working under a head of 25 m develops 16000 kW shaft power. The outer diameter of the runner is 4 m and hub diameter is 2 m. The guide blade angle is 35°. The hydraulic and overall efficiency are 90% and 85% respectively. If the velocity of whirl is zero at outlet, determine: (i) runner vane angles at inlet and outlet, and speed of turbine. [8+8]
8. (a) What do you understand by characteristic curves of a pump? What is the significance of the characteristic curves? Explain them in detail.
- (b) The diameter of a centrifugal pump, which is discharging $0.035 \text{ m}^3/\text{s}$ of water against a total head of 25 m is 0.05m. The pump is running at 1200 r.p.m. Find the head, discharge and ratio of powers of a geometrically similar pump of diameter 0.3 m when it is running at 2000 r.p.m. [8+8]

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1. (a) What is the principle on which a peizometer works? Draw a neat sketch and explain. What are different types of the same?
(b) If the surface tension at the soap air interface is 0.088N/m, Calculate the internal pressure in a soap bubble of 3 cm diameter. [10+6]
2. (a) What is the criteria to distinguish laminar flow from turbulent flow?
(b) Determine whether the following velocity components satisfy the continuity equation.
 - i. $u = cx, v = -cy$
 - ii. $u = -cx/y, v = c \log xy$. [6+10]
3. (a) Draw neat sketches of total energy line and hydraulic gradient line for the following cases and discuss:
 - i. Uniform diameter parallel pipe line
 - ii. Parallel converging pipe line
 - iii. Parallel diverging pipe line.(b) Two reservoirs are connected by a pipeline consisting of two pipes in series, one of 15 cm diameter and 6m long and another of 22.5 cm diameter and 15m long. If the difference in water levels of the reservoirs is 6m, calculate the discharge by considering all the losses. Assume $f = 0.02$ for both the pipes. [8+8]
4. (a) A jet of water of 86 mm diameter strikes a curved vane at the centre with a velocity of 30 m/sec. The curved vane is moving with a velocity of 8m/sec in the direction of the jet. Find the force exerted on the plate in the direction of the jet, power and efficiency of the jet. Assume that the plate is smooth.
(b) Explain, how you find the impact of jet striking an unsymmetrical fixed curved plate at one of the tips. [8+8]
5. (a) Describe the status of hydroelectric power in India.
(b) Explain how the load factor, capacity factor and utilization factor interrelated. Also explain the significance of diversity factor. [8+8]
6. (a) In a Pelton wheel the buckets deflect the jet through 170° and the relative velocity is reduced by 12% due to bucket friction. For a speed ratio of 0.47,

calculate from first principles the hydraulic efficiency of the wheel. The bucket circle diameter of the wheel is 0.9 m and there is one jet for which $C_v = 0.98$. The actual efficiency of the wheel is 0.9 times its theoretical efficiency. The wheel develops 1700 kW under a head of 550 m. Calculate:

- i. The speed of wheel in r.p.m and
 - ii. The diameter of the nozzle.
- (b) A Francis turbine has to be designed to develop 367.5 kW under a head of $H = 70$ m while running at $N = 750$ r.p.m. Ratio of width of runner to diameter of runner, $n = 0.1$, inner diameter is half the outer diameter. Flow ratio = 0.15, hydraulic efficiency = 95%, mechanical efficiency = 84%. Four percent of the circumferential area of runner to be occupied by the thickness of vanes, velocity of flow is constant and the discharge is radial at exit. Calculate:
- i. The diameter of the wheel,
 - ii. The quantity of water supplied, and
 - iii. The guide vane angle at inlet and runner vane angles at inlet and exit.
- [16]

7. (a) Define the terms 'unit power', 'unit speed' and 'unit discharge' with reference to a hydraulic turbine. Also derive expressions for these terms.
- (b) Sketch and describe a modern method of regulation to maintain a constant speed for either
- i. Pelton wheel or
 - ii. Francis turbine. [8+8]
8. (a) Define indicator diagram. How will you prove that area of indicator diagram is proportional to the work done by the reciprocating pump?
- (b) A centrifugal pump impeller whose external and internal diameters are 400 mm and 200 mm respectively is running at 950 r.p.m. The rate of flow through the pump is $0.035 \text{ m}^3/\text{s}$. the suction and delivery heads are 5 m 25 m respectively. The diameters of the suction and delivery pipes are 120 mm and 80 mm respectively. If the outlet vane angle is 45° , the flow velocity is constant and equal to 1.8 m/s and power required to drive the pump is 15 kW, determine:
- i. Inlet vane angle
 - ii. The overall efficiency, and
 - iii. The manometric efficiency. [8+8]

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1. (a) What are the absolute and kinematic viscosities? Derive the equations for them. Discuss what factors will influence them.
 (b) Estimate the pressure inside a water droplet of size of 0.3mm. Assume $\sigma=0.073\text{N/m}$.
[10+6]

2. (a) What is the criteria to distinguish rotational flow from irrotational flow?
 (b) Determine whether the flowing velocity components satisfy the continuity equation.
 - i. $u = A \sin xy, v = -A \sin xy$
 - ii. $u = x + y, v = x - y$. [6+10]

3. (a) Differentiate between stagnation pressure head and static pressure head with reference to a pitot tube. Explain with the help of a neat sketch.
 (b) A venturimeter of throat diameter 5cm is fitted into a 12.5 cm diameter water pipe line. The coefficient of discharge is 0.96. Calculate the flow in the pipe line when the reading on a mercury water differential U tube manometer connected to the upstream and throat sections shows a reading of 20 cm. [6+10]

4. (a) A 15 cm diameter jet of water strikes a curved vane with a velocity of 40m/sec. The inlet angle of the vane is zero and the outlet angle is 30 degrees. Calculate the resultant force on the vane when it is moving with a velocity of 12m/sec in the direction of the jet.
 (b) State the equation used to find out the impact of jet on vanes. Derive the equation for resultant thrust when a jet strikes a stationary inclined flat plate. [8+8]

5. (a) What is a run off river plant. What are the different parts and arrangements of such plants? Draw a neat sketch and explain
 (b) What is meant by flow duration curve and power duration curve. How do you differentiate these two curves? Also explain power duration curve in detail. [8+8]

6. (a) Differentiate between:
 - i. The impulse and reaction turbines,
 - ii. Radial and axial flow turbines,

- iii. Inward and outward radial flow turbine, and
 - iv. Kaplan and propeller turbines.
- (b) A Pelton wheel is having a mean bucket diameter of 0.8 m and is running at 1000 r.p.m. The net head on the Pelton wheel is 400 m. If the side clearance angle is 15° and discharge through nozzle is 150 litres/s, find:
- i. Power available at the nozzle, and
 - ii. Hydraulic efficiency of the turbine. [16]
7. (a) By means of a neat sketch explain the governing mechanism of Francis Turbine.
- (b) A Hydraulic turbine is to develop 845.6 kW when running at 100 r.p.m. under a head of 10 m. Work out the maximum flow rate and specific speed for the turbine if the overall efficiency at the best operating point is 92 percent. In order to predict its performance, a 1:10 scale model is tested under a head of 6 m. What would be the speed, power output and water consumption of the model if it runs under the conditions similar to the prototype? [8+8]
8. (a) What is the effect of acceleration in suction and delivery pipes on indicator diagram? Does the area of the indicator diagram change as compared to the area of ideal indicator diagram?
- (b) A centrifugal pump impeller whose external diameter and width at the outlet are 0.8 m and 0.1 m respectively is running at 550 r.p.m. The angle of impeller vanes at outlet is 40° . The pump delivers 0.98 m^3 of water per second under an effective head of 35 m. If the pump is driven by a 500 kW motor, determine:
- i. The manometric efficiency
 - ii. The overall efficiency, and
 - iii. The mechanical efficiency. Assume water enters the vanes radially at inlet. [8+8]

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1. (a) Define dynamic viscosity and kinematic viscosity. What are their units? Explain the significance of viscosity on fluid motion.
 (b) Find the pressure in N/m^2 represented by a column of
 - i. 10cm of water
 - ii. 5 cm of oil of relative density 0.75
 - iii. 2cm of mercury. [8+8]

2. (a) Derive the equation of continuity in differential form.
 (b) Determine whether the following velocity components satisfy the continuity equation:
 - i. $u = 2x^2 + zy, v = -2xy + 3y^3 + 3zy, w = -3/2 z^2 - 2xy - 6yz$
 - ii. $u = -cx/y, v = c \log xy$. [6+10]

3. (a) Explain how do you measure the velocity of flowing water in a stream using pitot tube.
 (b) An oil of relative density 0.90 flows through a vertical pipe of diameter 20cm. The flow is measured by a 20cm \times 10cm venturimeter. The throat is 30cm above the inlet section. A differential U tube manometer containing mercury is connected to the throat and the inlet. If coefficient of discharge is 0.99 what is the manometer reading for a flow of 50lit/sec. [6+10]

4. (a) A 15 cm diameter jet of water with a velocity of 20 m/sec strikes a plate normally. If the plate is moving with a velocity of 8m/sec in the direction of the jet, calculate the work done per second on the plate and the efficiency of the energy transfer.
 (b) Prove that the force exerted by a jet of water on a fixed hemispherical curved vane when the jet strikes at the centre is $F = \rho av^2$ where
 ρ = Mass density of water
 a = Area of cross section of the jet
 v = Velocity of the jet. [8+8]

5. (a) What are valves used in a penstock. Explain with neat sketches, various types of valves with their suitability under various conditions.
 (b) What is intake structures. Explain different types with the help of neat sketches. [8+8]

6. (a) How will you classify the turbines? Explain
- (b) A Pelton wheel is to be designed for the following specifications. Power = 735.75 kW S.P. Head = 200 m, Speed = 800 r.p.m., $\eta_0 = 0.86$ and jet diameter is not to exceed one-tenth of the wheel diameter. Determine :
- i. Wheel diameter,
 - ii. The number of jets required, and
 - iii. Diameter of the jet. Take $C_v = 0.98$ and speed ratio = 0.45. [16]
7. (a) What is cavitation? How can it be avoided in reaction turbine?
- (b) What is governing and how it is accomplished for different types of water turbines? [8+8]
8. (a) Draw an indicator diagram, considering the effect of acceleration and friction in suction and delivery pipes. Find an expression for the work done per second in case of single-acting reciprocating pump.
- (b) A single-acting reciprocating pump having a bore of 150 mm and a stroke of 300 mm is raising water to height of 20 m above the sump level. The pump has an actual discharge of $0.0052 \text{ m}^3/\text{s}$. The efficiency of the pump is 70%. If the speed of pump is 60 r.p.m. Determine:
- i. Theoretical discharge
 - ii. Theoretical power
 - iii. Actual power, and
 - iv. Percentage slip. [8+8]
