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321  
B. Tech  
BENG 1208

Fourth Semester Examination – 2007

FLUID MECHANICS AND HYDRAULICS

Full Marks – 70

Time : 3 Hours

Answer Question No. 1 which is compulsory and any five from the rest.

The figures in the right-hand margin indicate full marks for the questions.

1. Answer the following questions: 2×10
- (a) The velocity distribution of a fluid over a plate is given by  $u = y(0.8 - y)$  where  $u$  is the velocity along the plate, in m/sec at a distance of  $y$  metres above the plate. Find the shear stress at  $y = 0.1$  m. The dynamic viscosity of the fluid is  $8.3 \times 10^{-4}$  Ns/m<sup>2</sup>.

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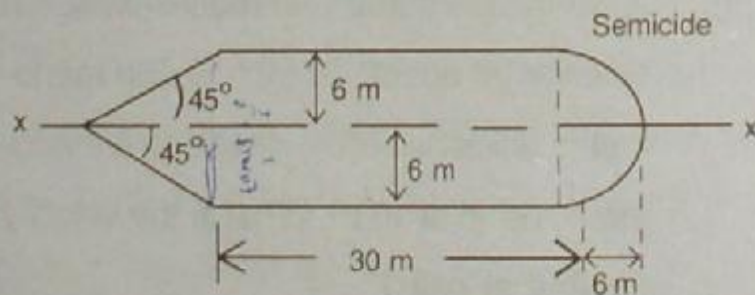
- (b) Mention three ways by which the sensitivity of a manometer can be increased.
- (c) A vertical semicircular area of radius 'r' is submerged in a liquid with its diameter at the liquid surface, find the depth of centre of pressure.
- (d) A body of volume  $0.15 \text{ m}^3$  needed a force of 300 N to keep it submerged in water. How much force would be needed to submerge it in another liquid of RD=0.932 ?
- (e) Distinguish between rotational and irrotational flow. Give one example for each type of flow.
- (f) Calculate the workdone in forcing 250 litres of water into a boiler in which the pressure is  $1200 \text{ KN/m}^2$ . If this work is to be done in 5 minutes, what power is expended ?

- (g) A jet of water 150 mm in diameter moving at 25m/s strikes a plate at rest. Find the force exerted normal to the plate when
- plate is held normal to the jet
  - the plate makes  $30^\circ$  to the jet.
- (h) If the surface roughness factor of a pelton wheel buckets is 90% and the bucket deflection angle is  $170^\circ$ , what is its hydraulic efficiency ?
- (i) The B/D ratio (inlet width to diameter ratio) of a Francis turbine increases with specific speed. Substantiate the reason.
- (j) A centrifugal pump with radial inflow, rim velocity (at outlet) 19.62 m/s and manometric efficiency 80%, develops a manometric head of 16 m. What is the velocity of whirl at exit ?

2. A tank with vertical sides is  $1.5\text{ m} \times 1.5\text{ m} \times 1.5\text{ m}$  deep. It contains water for the lower  $0.6\text{ m}$  depth. The upper remaining part is filled with oil of relative density  $0.9$ . Calculate

- the total pressure on one vertical side of the tank
- the position of the centre of pressure for one vertical side. 10

3. A ship of mass  $2 \times 10^6\text{ Kg}$  has a cross section at the waterline as shown in figure. The centre of buoyancy is  $1.5\text{ m}$  below the free surface and the centre of gravity is  $0.6\text{ m}$  above the free surface. Calculate the metacentric height for rolling about  $x-x$  axis. 10



4. If in a two-dimensional flow over a solid plate, the velocity component perpendicular to the plate is  $v = 2x^2y^2 + 3xy^3$ , obtain

- the equation of stream line, passing through the point  $(2,3)$
- acceleration at a point  $(2,3)$
- Verify whether the flow is irrotational. 10

5. A pipe of  $200\text{ mm}$  diameter conveying  $0.18\text{ m}^3/\text{sec}$  of water has a  $90^\circ$  bend in a horizontal plane. The pressure intensities at inlet and outlet of the bend are  $290\text{ KPa}$  and  $280\text{ KPa}$  respectively, find the resultant force exerted on the bend. 10

6. A Kaplan turbine develops  $6500\text{ KW}$  under a head of  $6\text{ m}$ . The velocity of flow through the runner is  $6.5\text{ m/sec}$ . The diameter of the boss is  $0.35$  times the external diameter. The vane

tips have a velocity of 22 m/sec. The overall efficiency is 85%. Determine the diameter of the runner and specific speed of the turbine.

10

7. The impeller of a centrifugal pump is of 30 cm diameter, 50 mm width at the periphery and has blades whose tips incline backwards  $60^\circ$  from the radius. The pump delivers  $17 \text{ m}^3/\text{min}$  at 1000 rpm. Assuming radial entry, calculate

- (i) the velocity and direction of flow as it leaves the impeller.
- (ii) torque exerted by the impeller
- (iii) shaft power required

Assume mechanical efficiency as 95% and hydraulic efficiency as 75%.

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8. A single acting reciprocating pump has a cylinder of bore 80 mm and stroke of 120 mm.

Water is to be drawn from a sump 3.5 m below the axis of the cylinder through a pipe of 40 mm diameter and 5 m long. The pump delivers to a tank at a height of 12 m through a 20 m long, 40 mm diameter pipe. If separation occurs at a pressure of  $0.075 \text{ N/mm}^2$  below the atmospheric pressure, find the maximum speed at which the pump can run. The barometer reads 760 mm of mercury.

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