Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(ME/PE/AUE/PWE)(NEW)/SEM-4/ME-401/2012

2012

FLUID MECHANICS AND HYDRAULIC MACHINES

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following : $10 \times 1 = 10$

   (i) To produced a high head by multistage centrifugal pumps, the impellers connected

   a) in parallel

   b) in series

   c) in parallel and in series both

   d) none of these.

   (ii) The continuity equation $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$

   a) is not valid for unsteady, incompressible flow

   b) is valid for steady flow, whether compressible or incompressible

   c) is valid for steady or unsteady, incompressible flow

   d) is valid for ideal fluid flow only.

(iii) The momentum correction factor is given by

a) $\frac{1}{V^3 A}\int_A u^3 dA$ b) $\frac{1}{VA}\int_A u dA$

c) $\frac{1}{A^2}\int_A A^2 du$ d) $\frac{1}{V^3 A}\int_A u^2 dA$.

(iv) The potential function (Φ) is defined as

a) $u = -\frac{\partial \Phi}{\partial x}$ and $v = -\frac{\partial \Phi}{\partial y}$

b) $u = \frac{\partial \Phi}{\partial x}$ and $v = -\frac{\partial \varphi}{\partial y}$

c) $u = -\frac{\partial \varphi}{\partial y}$ and $v = -\frac{\partial \varphi}{\partial x}$

d) none of these.

(v) The loss of head H_L in an orifice discharging under a head H is

a) $\sqrt{H}/(C_v - 1)$

b) $H(1 - C_v)$

c) $H\left(1 - C_v{}^2\right)$

d) $\left[\frac{1}{C^2_v} - 1\right] H$.

(vi) The stress-strain relation of the Newtonian fluid is

a) linear b) parabolic

c) hyperbolic d) inverse type.

(vii) A two-dimensional flow in x-y plane is irrotational if

a) $\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}$ b) $\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}$

c) $\frac{\partial v}{\partial x} = \frac{\partial v}{\partial y}$ d) $\frac{\partial v}{\partial x} = \frac{\partial u}{\partial y}$.

(viii) Which of the following is not a dimensionless parameter ?

a) Friction factor

b) Specific speed

c) Thomas's cavitation parameter

d) Pressure co-efficient.

(ix) Dynamic viscosity (μ) has the dimensions as

a) MLT^{-2} b) $ML^{-1}T^{-1}$

c) $ML^{-1}T^{-2}$ d) $M^{-1}L^{-1}T^{-1}$.

(x) Muschel curves mean

a) curves of constant head

b) curves of constant speed

c) curves of constant efficiency

d) curves of constant discharge.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. State the significance of each terms of the Bernoulli's equation. What is the basic conservation equation behind Bernoulli's equation ?

3. An office-meter with orifice diameter 10 cm is inserted in a pipe of 20 cm diameter. Pressures at upstream and downstream of the orifice-meter are 19·62 N/cm^2 and 9·81 N/cm^2 respectively. Co-efficient of discharge for the meter is given as 0·6. Find discharge of water through the pipe.

4. A circular disk of radius R is kept at a small height h above a fixed bed by means of a layer of oil of dynamic viscosity μ. If the disk is rotated at an angular velocity ω. Considering a linear variation of velocity within the oil film, show that the torque required to maintain this speed is expressed as, $T = \frac{\pi\mu\omega R^4}{2h}$.

5. a) What is Dimensional Homogeneity ?

   b) A ship 300 m long moves in sea-water, whose density is 1030 kg/m^3, a 1 : 100 model of this ship is to be tested in a wind tunnel. The velocity of air in the wind tunnel around the model is 30 m/s and the resistance of the model is 60 N. Determine the velocity of the ship in sea-water and also the resistance of the ship in sea-water. The density of air is given as 1·24 kg/m^3. Take kinematic viscosity of sea water and air as 0·012 stokes and 0·018 stokes respectively. 1 + 4

6. Show that the maximum wheel efficiency of a Pelton wheel is given by $\eta_{wheel} = (1 + k\cos\beta_2)/2$.

   where k is a coefficient which takes into account of friction loss in flow through the bucket and β_2 is the outlet blade angle.

7. Why is draft tube used in reaction turbine ? Explain how the net head on the reaction turbine increased with the use of draft tube.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

8. a) In a two dimensional incompressible flow, the fluid velocity components are given by $u = x - 4y$, $v = -y - 4x$. Show that velocity potential exists and determine its form as well as stream function .

   b) A vertical Venturimeter carries a liquid of relative density 0·8 and has inlet and throat diameter of 150 mm and 75 mm respectively. The pressure connection at the throat is 150 mm above that the inlet. If the actual rate of flow is 40 litres/sec and the $C_d = 0 \cdot 96$, calculate the pressure difference between inlet and throat in N/ m^2.

c) Two identical orifices are mounted on one side of a vertical tank the height of water above the upper orifice is 3 m. If the jets of water from the two orifices intersect at a horizontal distance of 8 m from the tank, estimate the vertical distance between the two orifices. Calculate the vertical distance of the point of intersection of the jets from the water level in the tank. Assume $C_v = 1$ for orifices. 5 + 5 + 5

9. a) Define and derive the expression of specific speed for a turbine.

b) For the velocity profile for laminar boundary layer

$$\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$$

obtain an expression for boundary layer thickness and momentum thickness. 6 + 9

10. a) Prove that the hydraulic efficiency of a Francis turbine is $\eta_h = V_{w_1} U_1 / gH$

b) A conical type draft tube attached to a Francis turbine has an inlet diameter of 3 m and its area at outlet is 20 m^2. The velocity of water at inlet, which is 5 m above tail race level, is 5m/s. Assuming the loss in draft tube equal to 50% of velocity head at outlet, find the pressure head at the top of the draft tube. 7 + 8

11. a) What is degree of reaction ?

b) What is meant by Net Positive Suction Head (NPSH) ?

c) Two reservoirs open to atmosphere are connected by a pipe of 800 m long. The pipe goes over a hill whose height is 6 m above the level of water in the upper reservoir. The pipe diameter is 300 mm and the friction factor f = 0·032. The difference in water levels in the two reservoirs is 12·5 m. If the absolute pressure of water anywhere in the pipe is not allowed to fall below 1·2 m of water in order to prevent vapour formation, calculate the length of pipe in the portion between the upper reservoir and the hill summit, and also the discharge through the pipe. Neglect bend losses only. 3 + 3 + 9

12. a) A centrifugal pump having outer diameter equal to two times of the inner diameter and running at 1000 rpm works against a total head of 40 m. the velocity of flow through the impeller is constant and equal to 2·5 m/s. The vanes are set back at back at an angle of 40° at outlet. If the outer diameter of the impeller is 500 mm and width at outlet is 50 mm, determine :

(i) the vane angle at inlet

(ii) work done by impeller on water per second

(iii) manometric efficiency.

b) Derive an expression for the head lost due to friction in the delivery pipe of a reciprocating pump with and without an air vessel. 8 + 7