Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech (ME/PWE)/SEM-4/ME-401/2010

2010
FLUID MACHINERY

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 T pe Questions)

1. Choose the correct alter atives for the following : 10 × 1 = 10

   i) Blowers are turbo machines which deliver air at a

      a) high velocity and dynamic pressure

      b) low velocity but high dynamic pressure

      c) high velocity and static pressure

      d) high velocity but at a low static pressure.

   ii) To produce a high head by multistage centrifugal pumps, the impellers are connected

      a) in parallel

      b) in series

      c) in parallel and in series both

      d) none of these.

iii) Cavitations take place when the pressure at any point in a flowing fluid

a) is more than the vapour pressure of the fluid

b) is equal to the vapour pressure of the fluid

c) is less than the vapour pressure of the fluid

d) does not have any relation with vapour pressure.

iv) The function of diffuser in centrifugal compressor is

a) to increase the velocity of air

b) to decrease the velocity of air

c) to neither increase nor decrease the velocity of air

d) to increase the pressure of air.

v) The specific speed o a centrifugal pump is given by

a) $\frac{N\sqrt{Q}}{H^{3/4}}$ b) $\frac{N\sqrt{P}}{H^{5/4}}$

c) $\frac{N\sqrt{Q}}{H^{2\ 3}}$ d) $\frac{N\sqrt{P}}{H^{3/2}}$.

vi) The degree of reaction of a Kaplan turbine is

a) equal to zero

b) greater than zero but less than 1/2

c) greater than 1/2 but less than 1

d) equal to 1.

vii) For a model and prototype turbine, which of the following parameters are common ?

a) Unit speed b) Unit discharge

c) Unit power d) All of these.

viii) The draft tube in reaction turbine is used

a) to carry water to tail race level

b) to convert K.E. to pressure head

c) to ensure safety to the turbine

d) all of these.

ix) Muschel curves mean

a) curves of constant head

b) curves of constant speed

c) curves of constant efficiency

d) curves of constant discharge.

x) The unit speed (N_u) of a turbine is given by the expression

a) $N_u = N/H^{3/2}$

b) $N_u = N/H^{3/4}$

c) $N_u = N/H^{1/2}$

d) $N_u = N/H^{5/4}$.

GROUP – B
(Short Answer Type Questions)

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

2. Show that the work done per second per unit weight of water in a reaction turbine can be given as

$(u_1 . V_{u1} \pm u_2 . V_{u2})/g$

where $u1$, $u2$ = peripheral velocities at inlet and outlet

V_{u1}, V_{u2} = velocities of whirl at inlet and outle

3. Show that for a general centrifugal fan

$$\psi_{st} = \frac{2}{1 + \tan\alpha_2/\tan\beta_2}$$

where ψ_{st} is the stage pressure coefficent and α_2 & β_2 are absolute & relative velocity angles at impeller exit.

Hence show that ψ_s = 2, for radial tipped blade impeller.

4. a) What is meant by 'priming' ?

   b) Why is the acceleration head zero at the middle of every stroke of a reciprocating pump ? 2 + 3

5. Draw the constant head characteristic curves for Pelton wheel, Francis turbine and Kaplan turbine.

6. Define the terms 'unit speed', 'unit power' and 'unit discharge'.

GROUP – C
(Long Answer Type Questions)

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

7. a) A single acting reciprocating pump having a cylinder diameter of 150 mm and stroke of 300 mm is used to raise the water through a height of 20 m. Its crank rotates at 60 rpm. Find the theoretical power required to run the pump and the theoretical discharge. If actual discharge is 5 litre/s, find the percentage slip. If delivery pipe is 100 mm in diameter and is 15 m long, find the acceleration head at the beginning of the stroke. 8

   b) A centrifugal pump, 1·3 m in diameter delivers 3·5 m^3/min of water at a tip speed of 10 m/s and a flow velocity of 1·6 m/s Th outlet blade angle is 30° to the tangent at the impell r periphery. Assuming zero whirl at inlet, and zero slip, calculate the torque delivered by the impeller. 7

8. a) A centrifugal fan running at 1500 rpm has inner and outer diameters of the impeller as 0·2 m and 0·24 m. The absolute and relative velocities of air at entry are 21 m/s and 20 m/s respectively and those at exit are 25 m/s and 18 m/s respectively. The flow rate is 0·6 m/s and motor efficiency is 80%. Determine,

   i) the stage pressure size

   ii) degree of reaction

   iii) the power required to drive the fan.

   Assume the flow to be incompressible with the density of air as 1·2 kg/m^3. $7\frac{1}{2}$

b) A centrifugal pump impeller having external and internal diameters 480 mm and 240 mm respectively is running at 100 rpm. The rage of flow through the pump is 0·0576 m^3/s and velocity of flow is constant and equal to 2·4 m/s. The diameters of the suction and delivery pipes are 180 mm and 120 mm respectively and suction and delivery heads are 6·2 m (abs) and 30·2 m of water respectively. If the power required to drive the pump is 23·3 kW and the outlet vane angle is 45°, determine :

i) Inlet vane angle

ii) The overall efficiency of the pump and

iii) The manometric efficiency of the pump. $7\frac{1}{2}$

9. a) Describe the function of the impeller and the diffuser in a centrifugal compressor. 2

b) Explain the phenomenon of surging, choking and stalling in centrifugal compressor. 6

c) A centrifugal comp essor is desired to have the total pressure ratio of 4 : 1. The inlet eye of the compressor is 30 cm in diameter. The axial velocity at inlet is 130 m/s and the mass flow is 10 kg/s. The velocity in the delivery duct is 115 m/s. The tip speed of the impeller is 450 m/s and runs at 16000 rpm with total head isentropic efficiency of 78% and pressure co-efficient of 0·72. The ambient condition is 1·013 bar and 15° C, calculate,

i) the static pressure ratio

ii) the static pressure and temperature at inlet and outlet of compressor

iii) work of compressor per kg of air and

iv) the theoretical power required. 7

10. a) Show that the degree of a reaction turbine is given as

$R = 1 - \cot\alpha_1/2\ (\cot\alpha_1 + \cot\beta_1)$

where α_1 = inlet guide blade angle

β_1 = inlet runner vane angle. 7

b) A Kaplan turbine working under a head of 15 m develops 7357·5 kW shaft power. The outer diameter of the runner is 4 m and hub diameter is 2 m. The guide blade angle at the extreme edge of the runner is 30°. The hydraulic and overall efficiencies of the turbine are 90% and 85% respectively. If the velocity of whirl is zero at outlet, determine runner vane angles at inlet and outlet at the extreme edge of the runner and speed of the turbine. 8

11. a) Explain the purpose of providing 'Scroll casing' and 'Guide vanes' to reaction turbine. 4

b) Explain the function of a 'Draft tube' in a reaction turbine. 2

c) A Francis turbine with an overall efficiency of 75% is required to produce 150 kW when working under a head of 7·62 m. Its peripheral velocity is $0 \cdot 26\sqrt{2\ gH}$ and the radial velocity of flow at inlet is $0 \cdot 96\sqrt{2\ gH}$. The wheel runs at 150 rpm and the hydraulic losses in the turbine are 22% of the available energy. Assuming radial discharge, determine,

i) guide vane angle

ii) wheel vane angle at inlet

iii) diameter of wheel at inlet and

iv) width of the wheel at inlet. 9

12. a) What is degree of reaction ? 3

b) What is meant by Net Positive Suction Head (NPSH) ?3

c) A Pelton wheel operates with a jet of 150 mm diameter under the head of 500 m. Its mean runner diameter is 2·25 m and t rotates with a speed of 375 rpm. The angle of bucket tip at outlet is 15°, coefficient of velocity is 0·98, mechanical losses equal to 3% of power supplied and the reduction in relative velocity of water while passing through bucket is 15%. Find,

i) the force of jet on the bucket

ii) the power developed

iii) bucket efficiency and

iv) overall efficiency. 9