

Name : .....

Roll No. : .....

Invigilator's Signature : .....

**CS/B.Tech(ME/PWE)-(OLD)/SEM-4/ME-401/2012**

**2012**

**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 Type Questions )**

1. Choose the correct alternatives for the following :

10 × 1 = 10

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

ii) Maximum hydraulic efficiency of a Pelton turbine is

a)  $(1 - \cos \phi)/2$

b)  $(1 + \cos \phi)/2$

c)  $(1 + \sin \phi)/2$

d)  $(1 - \sin \phi)/2$ .

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- iii) In a reciprocating pump the air vessel is used for which of the following purposes ?
- a) To get continuous supply of liquid at a uniform rate
  - b) To save power required to drive the pump
  - c) To run the pump at much higher speed without any danger of separation
  - d) All of these.
- iv) Reciprocating pumps are most suited where
- a) constant heads are required on mains despite fluctuation in discharge
  - b) operating speeds are much high
  - c) constant supplies are required regardless of pressure fluctuations
  - d) none of these.
- v) While starting centrifugal pump, the delivery valve is kept
- a) fully closed
  - b) fully open
  - c) half open
  - d) in any position.

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- vi) In centrifugal pump cavitation is reduced by
- a) increasing the flow velocity
  - b) reducing the discharge
  - c) increasing the suction head
  - d) reducing the suction head.
- vii) Speed governor of a Pelton turbine actuate
- a) Deflector plate
  - b) Spear rod
  - c) Inlet guide vane
  - d) Sluice gate
- viii) The relation between hydraulic efficiency ( $\eta_h$ ), mechanical efficiency ( $\eta_m$ ) and overall efficiency ( $\eta_o$ ), is
- a)  $\eta_h = \eta_o \times \eta_m$
  - b)  $\eta_o = \eta_h \times \eta_m$
  - c)  $\eta_o = \eta_h / \eta_m$
  - d) none of these.

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- 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) A compressor mostly used for supercharging of IC engines is
- a) radial flow compressor
  - b) axial flow compressor
  - c) roots blower
  - d) reciprocating compressor.

**GROUP - B**

**( Short Answer Type Questions )**

Answer any *three* of the following.  $3 \times 5 = 15$

2. Determine the power given by the jet of water to the runner of a Pelton wheel which is having tangential velocity of 20 m/s. The net head on the turbine is 50 m and discharge through the jet water is  $0.03 \text{ m}^3/\text{s}$ . The side clearance angle is  $15^\circ$  and  $C_v = 0.975$ .

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3. What do you mean by NPSH ? What is the criterion of the available and required NPSH for a centrifugal pump to avoid cavitation ? Define Thomas cavitation factor. 2 + 2 + 1

4. Show that the hydraulic efficiency for a Francis turbine having velocity of flow through runner as constant, is given by the relation

$$\eta_h = \frac{1}{\tan^2 \alpha} \left[ 1 + \frac{1}{2 \left[ 1 - \frac{\tan \alpha}{\tan \theta} \right]} \right]$$

where  $\alpha$  = guide blade angle and  $\theta$  = runner vane angle at inlet. The runner has radial discharge at outlet.

5. a) Why are backward curved vanes preferred for centrifugal pump impeller ?
- b) Define the terms "suction head", "delivery head", "static head" and "manometric head" as applicable for a centrifugal pump. Draw a neat sketch of pump layout to illustrate these. 1 + 4

6. What do you mean by 'stalling' in a centrifugal compressor ? What are the precautions taken to avoid this phenomenon ?

3 + 2

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**GROUP – C****( Long Answer Type Questions )**Answer any *three* of the following.  $3 \times 15 = 45$ 

7. a) What is priming ? Why is it necessary ? 2 + 3
- b) A three stage centrifugal pump has impellers 40 cm in diameter and 2 cm wide at outlet. The vanes are curved back at the outlet at  $45^\circ$  and reduce the circumferential area by 10%. The manometric efficiency is 90% and the overall efficiency is 80%. Determine the head generated by the pump when running at 1000 rpm delivering 50 litres per second. What would be shaft horse power ? 10
8. a) Describe the function of impeller and the diffuser in a centrifugal compressor. 3
- b) Explain the phenomenon of surging and choking in centrifugal compressor. 5
- c) A centrifugal compressor 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 130m/s and the mass flow is 10kg/s. The velocity in the delivery duct is 115m/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 coefficient of 0.72. The ambient condition is 1.013 bar and  $15^\circ\text{C}$ .
- 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
  - iv) the theoretical power required. 7

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9. a) Draw a neat sketch of a Kaplan turbine and label its important parts. 6
- b) For what kind of head and discharge conditions are Kaplan turbines suitable ? 1
- c) Determine the overall efficiency of a Kaplan turbine developing 2850 kW under a head of 5.2m. It is provided with a draft tube with its inlet (diameter 3 m) set 1.8 m above the tail race level. A vacuum gauge connected to the draft tube indicates a reading of 5.2 m of water. Assume draft tube efficiency as 75 per cent. 8
10. a) The diameter and stroke length of a single acting reciprocating pump are 12 cm and 20 cm respectively. The lengths of the suction and delivery pipes are 8 m and 25 m respectively and their diameters are 7.5 cm. If the pump is running at 40 rpm and suction and delivery heads are 4 m and 14 m respectively, find the pressure head in the cylinder :
- i) at the beginning of the suction and delivery strokes
- ii) at the end of the suction and delivery strokes
- Take  $f = 0.009$  for both pipes. 5

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- b) A centrifugal fan running at 1500 rpm has inner and outer diameters of the impeller as 0.24 m and 0.30 m respectively. The absolute and relative velocities of air at entry are 23 m/s and 21 m/s respectively and those at exit are 28 m/s and 19 m/s respectively. The flow rate is 0.8 kg/s and the motor efficiency is 85%.

Determine

- i) the stage pressure rise
- ii) the degree of reaction
- iii) the power required to drive the fan

Assume the flow to be incompressible with the density of air as  $1.2 \text{ kg/m}^3$ . 10

11. a) State in brief, the principle of similarity and dimensional analysis applied to turbo machines. 5
- b) What do you mean by 'affinity laws' in pumps? 3
- c) To predict the performance of a large centrifugal pump, its model having the following parameters was constructed :

$H = 8 \text{ m}$ ,  $N = 925 \text{ rpm}$ ,  $P = 17.64 \text{ kW}$ . The diameter of the model is 9 times smaller than that of the prototype. The prototype has to work against a head of 30 m. Find the working speed and the power required to drive it. Determine the rate of flow for both the pumps. 7

