[This question paper contains 4 printed pages.]

3080 *Your Roll No.* .....

MEM **J**

Paper – ME.553

TURBOMACHINERY – I

Time : 3 Hours *Maximum Marks : 100*

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any **five** *questions.*

1. (a) What are the different variables involved in determining the performance of axial and centrifugal compressors? Develop the dimensionless parameters that are used to describe the performance of these turbomachines. Show graphically the performance curves for these machines. (15)

   (b) A fan delivers 2 m^3/s of air at 10 mm WG, while running at 1470 rpm. Determine the discharge of a geometrically similar blower which runs at 360 rpm developing the same head. What is the specific speed of these fans. (5)

2. (a) Explain and plot the effect of varying the back pressure for a convergent-divergent nozzle. Explain the occurance of a shock wave within or outside the nozzle. (8)

P.T.O.

(b) A jet of air at 275K and 0.69 bar has an initial Mach number of 2.0. If it passes through a normal shock wave determine, (i) Mach number (ii) pressure (iii) temperature (iv) jet velocity, downstream of the shock. (12)

3. (a) Draw an illustrated sketch of a straight cascade tunnel and explain its working. How is the angle of incidence varied ? How is the static pressure on blade surfaces measured ? What is the effect of wall boundary layer and how can this be removed. (12)

(b) Show that the discharge through a nozzle is maximum when there is a sonic condition at its throat. (8)

4. (a) Discuss the variation of deflection and pressure loss with incidence for a compressor cascade, showing the working range. (6)

(b) What is the efficiency of compressor cascade ? How does it vary with inlet flow angle ? (6)

(c) Discuss briefly the aerodynamic losses occuring in turbomachines. (8)

5. (a) Why is radial-tipped impeller most widely used in centrifugal compressor stage ? What is the purpose of inlet guide vanes and inducer blades. (10)

(b) For a centrifugal compressor explain the following terms

(i) Slip factor

(ii) Power input factor

(iii) Effect of prewhirl (10)

6. (a) Derive relation for degree of reaction for an axial flow compressor and explain advantages of 50% reaction stages. (8)

(b) Discuss the terms surging, stalling and rotating stall applied to compressor characteristics with suitable sketches. (12)

7. An axial flow compressor stage is designed to give free-vortex tangential velocity distribution for all radii before and after the rotor blade row. The tip diameter is constant and 1.0 m; the hub diameter is 0.9 m and constant for the stage. At the rotor tip the flow angles are as follows :

Absolute inlet angle $\alpha_1 = 30°$

Relative inlet angle $\beta_1 = 60°$

Absolute outlet angle $\alpha_2 = 60°$

Relative outlet angle $\beta_2 = 30°$

Determine the axial velocity, mass flow rate, power absorbed by the stage, flow angle at the hub and the reaction ratio of the stage at the hub.

Given that the rotational speed of the rotor is 6000 rpm and gas density is 1.5 kg/m^3, which can be assumed constant for the stage. It can be further assumed that stagnation enthalpy and entropy are constant before and after the rotor row for the purpose of simplifying the calculations. (20)

8. A single sided centrifugal compressor is to deliver 14 kg/s of air when operating at a pressure ratio of 4:1 and a speed of 12,000 rpm. The inlet stagnation conditions may be taken as 288 K and 1 bar. Assuming slip factor of 0.9, a power input factor of 1.04 and isentropic efficiency of 80% estimate the overall diameter of the impeller.

If the Mach number is not to exceed unity at the impeller tip and 50% of the losses are assumed to occur in the impeller, find the minimum possible depth of the diffuser. (20)