

MANIPAL INSTITUTE OF TECHNOLOGY MANIPAL

V SEMESTER B.TECH. (AERONAUTICAL ENGINEERING) **END SEMESTER EXAMINATIONS, DEC 2017**

SUBJECT: TURBOMACHINERY AERODYNAMICS [AAE 4017]

REVISED CREDIT SYSTEM (/12/2017)

Time: 3 Hours

MAX. MARKS: 50

Instructions to Candidates:

- ✤ Answer ALL the questions.
- ✤ Missing data may be suitable assumed.
- 1A. Write the significance of "Degree of Reaction" in turbomachinery (4) aerodynamics.
- 1B. A centrifugal compressor impeller rotates at 9000 rpm. If the impeller tip (6) diameter is 0.914m and $\alpha_2=20^{\circ}$, calculate the following for operation in standard sea level atmospheric conditions: (i) U_2 , (ii) C_{w2} , (iii) C_{r2} , (iv) β_2 , and (v) C₂.
- **2A.** Explain clearly jet engine performance parameters with various plots. (4)
- A radial fan is running at 10,000 rpm and air enters in the axial direction. 2B. (6) The inlet stagnation temperature of air is 290K and at the exit from the impeller tip the stagnation temperature is 440 K. The isentropic efficiency of the compressor is 0.85, work input factor = 1.04, and the slip factor = 0.88. Calculate the impeller tip diameter, overall pressure ratio, and power required to drive the compressor per unit mass flow rate of air.
- 3A. (i) Define the stage efficiency of axial flow compressor. (4) (ii) Discuss the analysis of centrifugal compressor.
- **3B.** An axial flow compressor has the following design data. Inlet stagnation (6) temperature 290 K, Inlet stagnation pressure 1 bar, stage stagnation temperature rise 24 K, mass flow of air 22kg/sec, axial velocity through the stage 155.5 m/sec, rotational speed 152 revolutions per second, work done factor 0.93, mean blade speed 205 meters per second, reaction at the mean radius 50%. Determine (i) The blade and air angles at the mean radius (ii) The mean radius (iii) The blade height.

- **4A.** Explain the thermodynamic analysis of compressor and turbine. (4)
- **4B.** In a single-stage axial flow gas turbine, gas enters the turbine at a **(6)** stagnation temperature and pressure of 1150K and 8 bar, respectively. Isentropic efficiency of stage is equal to 0.88, mean blade speed is 300 m/s, and rotational speed is 240 rps. The gas leaves the stage with velocity 390 m/s. Assuming inlet and outlet velocities are same and axial, find the blade height at the outlet conditions when the mass flow of gas is 34 kg/s, and temperature drop in the stage is 145 K.
- 5A. (i) List the advantages and dis advantages of centrifugal and axial (4) compressors.(ii) Write a short note on free vortex design in compressor blades.
- 5B. A single-stage axial flow gas turbine has the following data: Mean blade (6) speed 340m/s, Nozzle exit angle 158, Axial velocity (constant) 105m/s, Turbine inlet temperature 900°C, Turbine outlet, temperature 670°C, Degree of reaction 50%, Calculate the enthalpy drop per stage and number of stages required.