Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

V SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOV 2019

SUBJECT: TURBOMACHINERY AERODYNAMICS [AAE 4017]

REVISED CREDIT SYSTEM
(25/11/2019)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Draw a neat sketch and velocity triangle wherever necessary

1A. Explain various applications of turbomachines. **(02)**

1B. Derive an expression for the degree of reaction for an axial flow compressor. **(04)**

1C. The preliminary design of an axial flow compressor is to be based upon a simplified consideration of the mean diameter conditions. Suppose that the stage characteristics of a repeating stage of such a design are as follows: Stagnation temperature rise = 25°C, Reaction ratio = 0.6, Flow coefficient = 0.5, Blade speed = 275 m/s. The compressed gas is air with a specific heat at constant pressure of l.005 kJ/(kg°C). Assuming constant axial velocity across the stage and equal absolute velocities at inlet and outlet, determine the relative flow angles for the rotor. **(04)**

2A. For an axial flow compressor, obtain an expression for the vortex energy equation with reference to the radial equilibrium equation. **(04)**

2B. An axial flow compressor is required to deliver 50 kg/s of air at a stagnation pressure of 500 kPa. At inlet to the first stage the stagnation pressure is l00 kPa and the stagnation temperature is 23°C. The hub and tip diameters are 0.436 m and 0.728 m. At the mean radius, which is constant through all stages of the compressor, the reaction is 0.50 and the absolute air angle at stator exit is 28.8^{o} for all stages. The speed of the rotor is 8000 rev/min. Determine the number of stages needed assuming that the polytropic efficiency is 0.89 and that the axial velocity at the mean radius is constant through the stages and equal to 1.05 times the average axial velocity. **(06)**

3A. Define the following terms for an axial flow turbine with suitable notations: (i). Total-to-Total efficiency (ii). Total-to-Static efficiency. **(02)**

3B. With the help of enthalpy-entropy diagram explain the various processes involved in an axial flow turbine. **(03)**

3C. A mean diameter design of a turbine stage having equal inlet and outlet velocities has the mass flow = 20 kg/s, inlet stagnation temperature = 1000 K, inlet stagnation pressure = 4 bar, axial velocity which is constant through the stage = 260 m/s, blade speed = 360 m/s, nozzle exit angle = 65^{o} and the stage exit swirl angle = 10^{o}. Determine the rotor blade angles, temperature **(05)**

drop coefficient and power output.

4A. For a centrifugal compressor draw the velocity triangle with and without slip. **(02)**

4B. With a neat sketch, explain the construction and working principle of a centrifugal compressor. **(03)**

4C. The impeller of a centrifugal compressor has the inlet and outlet diameter of 0.25 m and 0.5 m, respectively. Air enters the compressor without any prewhirl with a stagnation condition of 100 kPa and 300 K. The outlet blade angle is 70^o. The speed is 12000 rpm and axial flow velocity is constant at 130 m/s. The isentropic stage efficiency of the compressor is 88%. If the blade width at inlet is 7 cm, determine (i). Specific work (ii). Stage pressure ratio (iii). Mass flow rate and (iv). Power required to drive the compressor. **(05)**

5A. Write a short note on losses in a radial flow turbine. **(02)**

5B. Draw the enthalpy-entropy diagram for a radial flow turbine and explain the actual and isentropic processes for the static and stagnation conditions. **(03)**

5C A single stage axial flow turbine has a mean radius of 0.25 m and blade height of 0.05 m. The gas enters the turbine at static conditions of 1600 kPa and 1000 K. The gas leaves the nozzle with an absolute velocity of 450m/s making an angle of 70^o with the axial direction. The rotor inlet and outlet blade angles are 20^o and 50^o, respectively. Draw the velocity triangle and determine (i). Rotational speed of the rotor (ii). Degree of reaction and (iii). Mass flow rate. **(05)**