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

VI SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, JUNE 2023

SUBJECT: TURBOMACHINERY AERODYNAMICS [AAE - 4034]

REVISED CREDIT SYSTEM

(01/06/2023)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

Q.No	Question	Marks	CO attained	BT level
1A	Derive the propulsive equation for an aircraft engine.	**(02)**	**CO1**	**BT1**
1B	Describe the significance of air mass flow rate in air breathing engines and explain how it influences the performance of an engine.	**(03)**	**CO1**	**BT2**
1C	An axial flow compressor has a tip diameter of 0.95m and a hub diameter of 0.85 m. The absolute velocity of air makes an angle of 28° measured from the axial direction and relative velocity angle is 56°. The absolute velocity outlet angle is 56° and the relative velocity outlet angle is 28°. The rotor rotates at 5000 rpm and the density of air is 1.2 kg/m^3. Determine: (i). The axial velocity. (ii). The mass flow rate. (iii).The power required. (iv) The flow angles at the hub, and (v) The degree of reaction at the hub.	**(05)**	**CO1**	**BT5**
2A	Draw the compressor stage full annulus diagram with the detailed parts.	**(02)**	**CO2**	**BT3**
2B	Describe the performance parameters related to the design of axial flow compressor.	**(03)**	**CO2**	**BT4**
2C	Explain the thermodynamics of single-stage and multi-stage axial flow compressors and performance characteristics using velocity triangles.	**(05)**	**CO2**	
3A	Draw a detailed diagram of centrifugal compressor's both front and side views.	**(02)**	**CO3**	**BT1**
3B	Discuss the technical differences between the centrifugal compressor and an axial flow compressor.	**(03)**	**CO3**	**BT2**
3C	The following design data applying to a pure jet	**(05)**	**C03**	**BT5**

	engine double sided centrifugal compressor. Impeller eye root diameter 18 cm, impeller eye tip diameter 31.75 cm, mass flow 18.5 kg/s, impeller speed 15,500 rpm, inlet stagnation temperature 288 K axial velocity at inlet (constant) 150 m/s. Find the suitable values for the impeller vane angles at the root and tip of eye if the air is given 20° of pre-whirl at all radii and also find the maximum Mach number at the eye.			
4A	With the clear notations construct the velocity triangle of a single stage axial flow turbine.	**(02)**	**CO4**	**BT3**
4B	A single stage axial flow gas turbine has the following design data. Mean blade speed 340 m/s, stator exit angle 15°, axial velocity (constant) 105 m/s, turbine inlet temperature 900°C, turbine outlet temperature 670°C, Degree of reaction 50%. Calculate the enthalpy drop per stage and the number of stages required. Take Cpg = 1147 J/kgK.	**(03)**	**CO4**	**BT4**
4C	In a single stage axial flow gas turbine gas enters at stagnation temperature of 1100 K and stagnation pressure of 5 bar. Axial velocity is constant through the stage and equal to 250 m/s. Mean blade speed is 350 m/s. Mass flow rate of gas is 15 kg/s and assume equal inlet and outlet velocities. Stator efflux angle is 63°, stage exit swirl angle equal to 9°. Determine the rotor blade gas angles, degree of reaction and power output.	**(05)**	**CO4**	**BT5**
5A	Discuss the performance parameters that constitute the fan design requirements.	**(02)**	**CO5**	**BT1**
5B	Air leaves the fan with the radial velocity 110 m/s makes an angle of $25^0.30'$ with an axial direction. The fan tip speed is 475 m/s. Fan efficiency is 0.8 and mechanical efficiency 0.96. Find slip factor, overall pressure ratio, power required to drive the fan. Neglect power input factor and assume Y=1.4, T_{01}=298 K, and mass flow rate is 3 kg/s.	**(03)**	**CO5**	**BT5**
5C	A radial fan is running at 10,000 rpm and enters in the axial direction. The inlet stagnation temperature of air is 290 K and the exit from the tip the stagnation temperature 440 K. The isentropic efficiency of the fan 0.85, work input factor 1.04 and the slip factor 0.88. Calculate the tip diameter, overall pressure ratio and power required to drive the fan per unit mass flow rate flow.	**(05)**	**CO5**	**BT5**