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

VI SEMESTER, B. TECH (Aeronautical Engineering)
END SEMESTER EXAMINATION MAY/JUNE 2022
COURSE:PE II TURBOMACHINERY AERODYNAMICS (AAE 4034)

Duration: 3 Hrs **Date: 21/05/2022** **MAX. MARKS: 50**

Note:

- *All questions are compulsory*
- *Draw a neat diagram wherever necessary*
- *Stepwise answers carry marks*

Q1A.	Write the significance of "Degree of Reaction" in turbomachinery aerodynamics	**[2]**
Q1B.	With the help of plots explain clearly the jet engine performance parameters	**[3]**
Q1C.	An axial flow compressor has the following design data. Inlet stagnation 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 and reaction at the mean radius is 50%. Determine (i) The blade and air angles at the mean radius (ii) The mean radius (iii) The blade height.	**[5]**
Q2A.	List the various turbomachinery components used in engineering applications	**[2]**
Q2B.	Explain axial flow compressor stage analysis using velocity triangles	**[3]**
Q2C.	An axial flow compressor has an overall pressure ratio of 4.5 to 1 and mean blade speed of 245 m/sec. Each stage of 50% reaction and the relative air angles are the same as 30^0 for each stage. The axial velocity is 158 m/sec and is constant through the stage. If the polytropic efficiency is 87% then calculate the no. of stages required. Assume T_{01}= 290 K	**[5]**
Q3A.	Define flow coefficient (Φ) and Stage loading (Ψ)	**[2]**
Q3B.	Write down the various steps involved in design of compressor.	**[3]**

Q3C. The following data refer to an aircraft single-stage axial flow gas turbine with convergent nozzle: Inlet stagnation temperature 1100K, Inlet stagnation pressure 4bar, Pressure ratio (P_{01}/P_{03}) 1:9, Stagnation temperature drop 145K, Mean blade speed 345 m/s, Mass flow rate 24 kg/s, Rotational speed 14,500 rpm, Flow coefficient 0:75, Angle of gas leaving the stage 12^0, C_{pg} = 1147 J/kgK; Υ=1:333; λ_N=0:05 . Assuming the axial velocity remains constant and the gas velocity at inlet and outlet are the same, determine the following quantities at the mean radius: (i) The blade loading coefficient and degree of reaction. (ii) The gas angles. (iii) Exit gas density. (iv) The nozzle throat area. **[5]**

Q4A. Write a short note on free vortex design in compressor blades **[2]**

Q4B. Explain the advantages of ducted fan and afterburner concept in aircraft engines. **[3]**

Q4C. The following design data refers to an aircraft engine axial flow compressor air enters the compressor at 1 bar and 290 k. The first stage of the compressor designed on free vortex principles, with no inlet guide vanes. The rotational speed is 5500 rpm and stagnation temperature rise is 22 k. The hub tip ratio is 0.5, the work done factor is 0.92, and the isentropic efficiency of the stage is 0.90, assuming the inlet velocity of 145 m/sec. Calculate: (i) The tip radius and corresponding rotor air angles, if the Mach number relative to the tip is limited to 0.96 (ii) The mass flow at compressor inlet. (iii) The stagnation pressure ratio and power required to drive the compressor. (iv) The rotor air angles at the root section. **[5]**

Q5A. With the clear notations draw the Brayton cycle diagram. **[2]**

Q5B. Derive the equation for turbojet engine efficiency. **[3]**

Q5C. Explain clearly the performance parameters of axial flow compressors. **[5]**