Hall Ticket No | | | | | | | | | | Question Paper Code: AAE007

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Four Year B.Tech V Semester End Examinations(Regular) - November, 2019

Regulation: IARE – R16

AIRCRAFT PROPULSION

Time: 3 Hours **(AE)** **Max Marks: 70**

Answer ONE Question from each Unit
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

UNIT – I

1. (a) Describe the factors that affect thrust in turbojet engine.
[BL: Remember | CO: 1 | Marks: 7]

(b) The effective jet exit velocity from a jet engine is 2700 m/s. The forward flight velocity is 1350 m/s and the air flow rate is 78.6 kg/s. Calculate thrust, power and propulsive efficiency. Assume $\dot{m_f}$ « $\dot{m_a}$ & ideal operating condition. [BL: Remember | CO: 1 | Marks: 7]

2. (a) Write different types of gas turbine engine? Deduce specific impulse of Ramjet.
[BL: Remember | CO: 1 | Marks: 7]

(b) A turboprop aircraft is flying at 600 km/h at an altitude where the ambient conditions are 0.458 bar and -15^0 Compressor pressure ratio is 9:1. Maximum gas temperature is 1200K. The intake duct efficiency is 0.9 and total head entropic efficiency of compressor and turbine are 0.89 and 0.93 respectively. Calculate the specific power output in kJ/kg, thermal efficiency of the unit taking mechanical efficiency of transmission as 98% and neglecting losses other than specified. Assume that exhaust gases leave the aircraft at 600 km/h relative to aircraft.
[BL: Remember | CO: 1 | Marks: 7]

UNIT – II

3. (a) Explain the nature of internal flow and stall in subsonic inlets.
[BL: Remember | CO: 2 | Marks: 7]

(b) Briefly classify the combustion chambers of gas turbine engines with neat sketches.
[BL: Remember | CO: 2 | Marks: 7]

4. (a) Describe about the isentropic efficiency of a diffuser. Write short notes on inlet stalling and their effect on engine performance. [BL: Remember | CO: 2 | Marks: 7]

(b) A turbofan engine during ground ingests airflow at the rate of $\dot{m_\infty}$ = 500 kg/s through an inlet area (A1) of 3.0 m^2. If the ambient conditions (T_∞ , P_∞) are 288 K and 100 kPa, respectively, calculate the area ratio (A_∞/A_1) for different free stream Mach numbers. What is the value of the Mach number where the capture area is equal to the inlet area? Draw the air stream tube for different Mach numbers.
[BL: Remember | CO: 2 | Marks: 7]

UNIT – III

5. (a) What is the need for variable area nozzle and describe about different methods to achieve variable area nozzle in a jet engine. **[BL: Remember | CO: 3 | Marks: 7]**

   (b) A turbojet engine powering an aircraft flying at an altitude of 11,000m where T_a= 216.7K and P_a= 24.444 kPa. The flight Mach number is 0.9. The inlet conditions to the nozzle are 1000 K and 60 kPa. The specific heat ratio of air and gases at nozzle are 1.4 and 1.3 . The nozzle efficiency is 0.98. Determine the thrust per inlet frontal area for convergent nozzle.

   [BL: Remember | CO: 3 | Marks: 7]

6. (a) Explain the concept of thrust reversing and types of thrust reversing.

   [BL: Remember | CO: 3 | Marks: 7]

   (b) Calculate the dragging force developed by thrust reversers of the two engine aircraft in the following case $\dot{m_a}$ = 50 kg/s, f = 0.02, $\beta = 60^0$, V_j= 600 m/s and V_f = 80 m/s.

   [BL: Remember | CO: 3 | Marks: 7]

UNIT – IV

7. (a) What is the function of the compressor? Differentiate in detail axial and centrifugal compressor.

   [BL: Remember | CO: 4 | Marks: 7]

   (b) Illustrate and explain the various components of centrifugal compressor and describe the pressure rise along the centrifugal compressor. **[BL: Remember | CO: 4 | Marks: 7]**

8. (a) State the advantages of the axial-flow compressor over the centrifugal compressor.

   [BL: Remember | CO: 4 | Marks: 7]

   (b) A 10 stage axial compressor provides an overall pressure ratio of 5:1 with an overall isentropic efficiency of 87%. When the temperature of air at inlet is 15^{o}C, the work is equally divided between the stages. A 50% reaction is used with a blade speed of 210 m/s and a constant axial velocity of 170 m/s. Estimate the blade angles. Assume a work done factor of 1.

   [BL: Remember | CO: 4 | Marks: 7]

UNIT – V

9. (a) Describe the radial turbine and its parts by highlighting its parts with a neat sketch.

   [BL: Remember | CO: 5 | Marks: 7]

   (b) A single stage axial turbine has the following characteristics:
   T_{01}= 1144 K, P_{01}= 1300kPa, ΔT_0 = 140 K, U= 320 m/s, Flow coefficient φ = 1, Nozzle losses coefficient λ = 0.05, α_1 = 0, α_3= 10, assuming C_1= C_3
   Calculate
   i) Angles α_2, β_2 and β_3
   ii) Blade loading and degree of reaction **[BL: Remember | CO: 5 | Marks: 7]**

10. (a) What is the need for turbine blade cooling? Illustrate the concept of impingement cooling and film cooling techniques in axial turbine with a neat sketch.

   [BL: Remember | CO: 5 | Marks: 7]

   (b) Gases at a total temperature of 1400 K and a total pressure of 2.23 MPa enters the nozzle row of a turbine stage in the axial direction at the rateof 22.7 kg/s. Other data are turbine rotor speed 14,000 rpm, mean blade diameter 48.3 cm, C_2= 470m/s, α_2= 72^o, C_3= 215m/s, α_3=22^o(γ=1.33 and R=287 J/kg-k)
   i) Construct the velocity diagrams at the mean blade diameter
   ii) Calculate the absolute Mach number
   iii) Calculate the specific work and power developed by this stage

   [BL: Remember | CO: 5 | Marks: 7]