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

IV SEMESTER B. TECH (AERONAUTICAL ENGINEERING)
END-SEMESTER EXAMINATION, MAY, 2023
COURSE: AIRCRAFT PROPULSION (AAE 2255)

REVISED CREDIT SYSTEM

Duration: 3 Hours | **Date: 26/05/2023** | **MAX. MARKS: 50**

Note:

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

Q1A. Write the classification of the aerospace propulsion system. **[2M]**

Q1B. Explain the working principle of a turboshaft engine along with its advantages and disadvantages. **[4M]**

Q1C. Air passes through a convergent-divergent nozzle which is connected to an exhaust chamber at the divergent section. For the below-given conditions, with the help of a neat sketch explain the pressure variation through the nozzle. **[4M]**
(i) Backpressure is higher than the nozzle exit pressure and
(ii) Backpressure is lower than the nozzle exit pressure.

Q2A. What is choking of a nozzle and how it affects the thrust generation? **[2M]**

Q2B. Prove that the aircraft with a turboprop engine requires a short runway length. **[3M]**

Q2C. An aircraft is powered by two turbojet engines having the exhaust velocity = 2300 km/h, overall efficiency = 15%, fuel-to-air ratio = 0.0175, lift-to-drag ratio = 10 and mass ratio at the beginning and end of the trip = 1.2. The flight speed is given by the relation **[5M]**

$$u = \frac{(1+f)}{2} u_e$$

Where, u is the flight velocity, f is fuel-air ratio and u_e is the exhaust velocity.
Determine (i) The flight speed (ii) The fuel heating value (iii) The range of aircraft and (iv) The trip time.

Q3A. Derive an expression for the thermal efficiency of the ideal Brayton cycle. **[2M]**

Q3B. Draw the actual Brayton cycle diagram with intercooling and regeneration and explain the different processes involved in it. **[3M]**

Q3C. Air enters a gas turbine engine at 288 K with a pressure ratio of 6. The air then passes through a 100% effective regenerator and the combustion chamber. The air is heated to a maximum temperature of 1023 K in the combustion chamber. The combustion gases are then reheated to the same **[5M]**

temperature in the second combustion chamber. Assuming the equal expansion ratio of 2.5 in both the turbines, determine (i) the net work output (ii) the cycle thermal efficiency and (iii) the work ratio. Assume constant specific heat of air as 1.005 kJ/kg-K.

Q4A. Derive an expression for the fuel-air ratio of a turbofan engine using the energy balance principle. **[2M]**

Q4B. State the advantages and disadvantages of a turboprop engine. **[2M]**

Q4C. Calculate the specific thrust and the thrust-specific fuel consumption of a single-spool turbojet engine having the following specifications: **[6M]**
Cruise velocity of 280 m/s at an altitude of 7000 m, ambient pressure of 41 kPa and ambient temperature of 243 K, compressor pressure ratio of 8:1 and compressor efficiency of 87%, burner efficiency of 98%, pressure drop in the combustion chamber of 4% of the delivery pressure of the compressor, turbine inlet temperature of 1200 K and turbine efficiency of 90%, nozzle efficiency of 95% and fuel heating value of 43 MJ/kg-K. Assume the unchoked nozzle.

Q5A. Why the turbofan engines are the most fuel-efficient engines for medium speed applications? **[2M]**

Q5B. With the help of a neat sketch and temperature-entropy plot, explain the working principle of a valved pulsejet engine. **[3M]**

Q5C. A ramjet is travelling at Mach 3.5 at an altitude of 5600 m and ambient pressure and ambient temperature of 49.8 kPa and 251 K, respectively. The mass flow rate of the air through the engine is 38 kg/s. The fuel heating value is 42,500 kJ/kg-K. The burner exit stagnation temperature is 1850 K. Assume the specific heat of the working fluid through the intake and the combustion chamber as 1.005 kJ/kg-K and 1.14 kJ/kg-K, respectively. Draw the temperature-entropy plot and determine the (i) thrust (ii) fuel-air ratio and (iii) thrust-specific fuel consumption. **[5M]**