Name: Enrolment No:	UPES University of Tomorrow

UPES

End Semester Examination, December 2024

Course: Propulsion-II — **Semester : V**

Program: B. Tech ASE — **Time : 03 hrs.**

Course Code: ASEG3004 — **Max. Marks: 100**

Instructions: Make use of sketches/plots to elaborate your answer. Brief and to-the-point, answers are expected. Assume suitable data if needed. Gas Table allowed, Refer attached formula sheet.

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Explain how bypass ratio (BPR) influences the efficiency of a turbofan engine.	**4**	**CO4**
2	Describe the differences in working principles between an ideal turboprop engine and a turboshaft engine.	**4**	**C01**
3	Determine the effect of engine back pressure on exhaust nozzle flow characteristics.	**4**	**C03**
4	Discuss the challenges associated with the supersonic wind tunnel and show how the shock wave helps reduce a compressor's power consumption.	**4**	**C02**
5	Compare the critical points in Rayleigh flow and Fanno flow to understand their similarities and differences.	**4**	**C01**

SECTION B
(4Qx10M= 40 Marks)

S. No.		Marks	CO
Q 6	A normal shock occurs in the diverging section of a convergent-divergent nozzle, where the throat area is one-third of the exit area. If the stagnation pressure at the inlet is 3 times the static pressure at the exit 1. Determine the Mach numbers before and after the shock. 2. Calculate the position of the shock in terms of its location relative to the throat area.	**10**	**CO3**
7	The data at intel to a ramjet engine combustion chamber employing a hydrocarbon fuel are as follows : Velocity of air–fuel mixture = 73 m/s , static temperature = 333 K , static pressure = 0.55 bar . The heat of reaction of the fuel – air mixture is 1400 kJ/kg . Assuming that the working fluid has the same thermodynamic properties as air before and after combustion, calculate (1) the loss in stagnation pressure due to heat addition ,and (2)the maximum heat of reaction for which flow with the specified initial conditions can be maintained.	**10**	**CO3**

8	The average friction factor for a 50 mm diameter pipe is 0.005. the Mach number of air at a particular section in the pipe is 0.26. determine the length of the pipe , if the flow ends at a Mach number of 0.51. **OR** An aircraft is flying at an altitude of 12000 m with a Mach number of 0.82. the cross-sectional area of the inlet diffuser is 0.5 m^2. Determine a) The mass of air entering the diffuser per second b) The speed of the aircraft c) The stagnation pressure and temperature of air at the diffuser entry.	**10**	**C02**
9	A ramjet engine operating at Mach number 3.5 at an altitude of 50000 ft and the maximum temperature permitted in the cycle is 2800 K, considering the calorific value of the solid propellent is 43900 KJ/kg. Calculate the thrust and trust-specific fuel consumption while considering the ideal condition.	**10**	**C04**
SECTION-C **(2Qx20M=40 Marks)**			
Q 10	The Dassault Étendard IV is a single-seat reconnaissance and strike fighter powered by two Rolls-Royce Viper 623 turbojets, each rated at 14.8 kN at an altitude of 8500 m, where the ambient conditions are 28 kPa and 230 K. The pressure ratio across the compressor is 10, and the turbine inlet temperature is 1350 K. The aircraft cruises at a speed of 350 m/s. Assuming ideal operation for all components, with an unchoked nozzle and constant specific heat: • Cp=1005 J/kg-K • Heating Value – 45000 kJ/kg 1. Calculate the specific thrust. 2. Determine the thrust specific fuel consumption (TSFC). 3. Evaluate the thermal efficiency of the engine. **OR** A turbofan engine of the mixing type, where the fan is driven by the LPT and the compressor is driven by the HPT a ground run of the engine, the following readings were recorded P_a = 100 kPa, T_a = 300 K, fan pressure ratio = 2, compressor pressure ratio = 8.0, TIT = 1600 K, $\eta_c = \eta_f = \eta_t = 0.9$, $f = 0.065$, γ air = 1.4, γ gas = 1.33. Calculate	**20**	**CO4**

	(i) The BPR on the assumption that the outlet streams of the fan and LPT have the same total pressure just before mixing (ii) The specific thrust (iii) TSFC		
11	An advanced single-spool turbojet engine has the following data: Compressor pressure ratio 10 TIT 1500 K Air mass flow rate 17 kg/s Aircraft flight speed 300 m/s Flight altitude 8000 m Isentropic efficiency of intake 0.93 Isentropic efficiency of compressor 0.94 Combustion chamber pressure loss = 7% of delivery pressure Combustion chamber efficiency 0.96 Isentropic efficiency of propelling nozzle 0.92 Calculate the propelling nozzle area, the net thrust developed, and the TSFC. If the gases in the jet pipe are reheated to 2000 K where a pressure loss of 3% is encountered, calculate 1. The percentage increase in nozzle area 2. The percentage increase in net thrust (T_a = 242.7 K, P_a = 41.06 kPa, Q_R = 43,000 kJ/kg)	**20**	**CO4**

- fuel-to-air ratio $(f) = \frac{\dot{m}_f}{\dot{m}_a}$

- $T_{momentum} = \dot{m}_a(1+f)U_e$ $\quad$ $T_{pressure} = (P_e - P_a)A_e$

  $T = \dot{m}_a[(1+f)U_e - u]$ $\quad$ or $T = \dot{m}_a[U_e - u]$

  $\therefore$ Thrust $= \dot{m}_a[(1+f)U_e - u] + (P_e - P_a)A_e$

- $\boxed{T = \dot{m}_h[(1+f)U_{eh} - u] + \dot{m}_c(U_{ec} - u) + A_{eh}(P_{eh} - P_a) + A_{ec}(P_{ec} - P_a)}$ – For turbofan & propfan

- η_p (propulsive eff.) $= \frac{uT}{uT + 0.5\dot{m}_e(U_e - u)^2} = \frac{u\{\dot{m}_a[(1+f)U_e - u] + A_e(P_e - P_a)\}}{u\{\dot{m}_a[(1+f)U_e - u] + A_e(P_e - P_a)\} + (0.5\dot{m}_a(1+f)(U_e - u)^2)}$

- $\eta_p = \frac{2uT}{\dot{m}_a[(1+f)U_e^2 - u^2]}$ $\rightarrow$ Turbofan & propfan

- $\eta_p = \frac{u(T_h - T_c)}{u(T_h - T_c) + W_h + W_c}$

  Hot thrust $(T_h) = \dot{m}_h[(1+f)U_{eh} - u] + A_{eh}(P_{eh} - P_a)$
  Cold thrust $(T_c) = \dot{m}_c[U_{ec} - u] + A_{ec}(P_{ec} - P_a)$
  Wake losses $(W_h) = \frac{1}{2}\dot{m}_h(1+f)(U_{eh} - u)^2 = \frac{1}{2}\dot{m}_{eh}(U_{eh} - u)^2$
  $W_c = \frac{1}{2}\dot{m}_c(U_{ec} - u)^2$

- $\eta_p = \frac{Tu}{Tu + 0.5\{\dot{m}_{eh}(U_{eh} - u)^2 + \dot{m}_c(U_{ec} - u)^2\}}$

- $\eta_p = \frac{2uT}{\dot{m}_h\{(1+f)U_{eh}^2 + \beta U_{ec}^2 - (1+\beta)u^2\}}$; Bypass ratio $(\beta) = \dot{m}_c/\dot{m}_h$

- η_{th} (Thermal eff.) $= \frac{Tu + \frac{1}{2}\dot{m}_a(1+f)(U_e - u)^2}{\dot{m}_f Q_R}$ $\rightarrow$ Ramjet & Turbojet

- $\eta_{th} = \frac{Tu + \frac{1}{2}\dot{m}_h(1+f)(U_{eh} - u)^2 + \frac{1}{2}\dot{m}_c(U_{ec} - u)^2}{\dot{m}_f Q_R}$ $\rightarrow$ Turbofan & Propfan

- unchoked condition, $\eta_{th} = \frac{[(1+f)U_e^2 - u^2]}{2fQ_R}$; $\eta_{th} = \frac{U_{eh}^2 + \beta U_{ec}^2 - (1+\beta)u^2}{2fQ_R}$

- η_o (overall eff.) $= \frac{Tu}{\dot{m}_f Q_R}$; unchoked, $\eta_o = \eta_{th}\frac{2u}{u + U_e}$

- Specific Thrust $= T/\dot{m}_a$ $\quad$ • TSFC $= \dot{m}_{fuel}/T = \frac{f}{(T/\dot{m}_a)}$

- Specific Impulse $(I_{sp}) = T/\dot{m}_f g$

- $f = \frac{C_{ph}T_{03} - C_{pc}T_{02}}{\eta_b Q_R - C_{ph}T_{03}}$

- Exhaust velocity $(U_e) = \sqrt{2C_{ph}T_{03}\left[1 - \left(\frac{P_a}{P_{03}}\right)^{\frac{\gamma_h - 1}{\gamma}}\right]}$

} Pulsejet & Ramjet