Name: **Enrolment No:**	

UPES

End Semester Examination, May 2023

Course: Fundamental of Aircraft Propulsion **Semester : IV**
Program: B. Tech Aerospace **Time : 03 hrs.**
Course Code: ASEG2009 **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. Refer attached formula sheet.

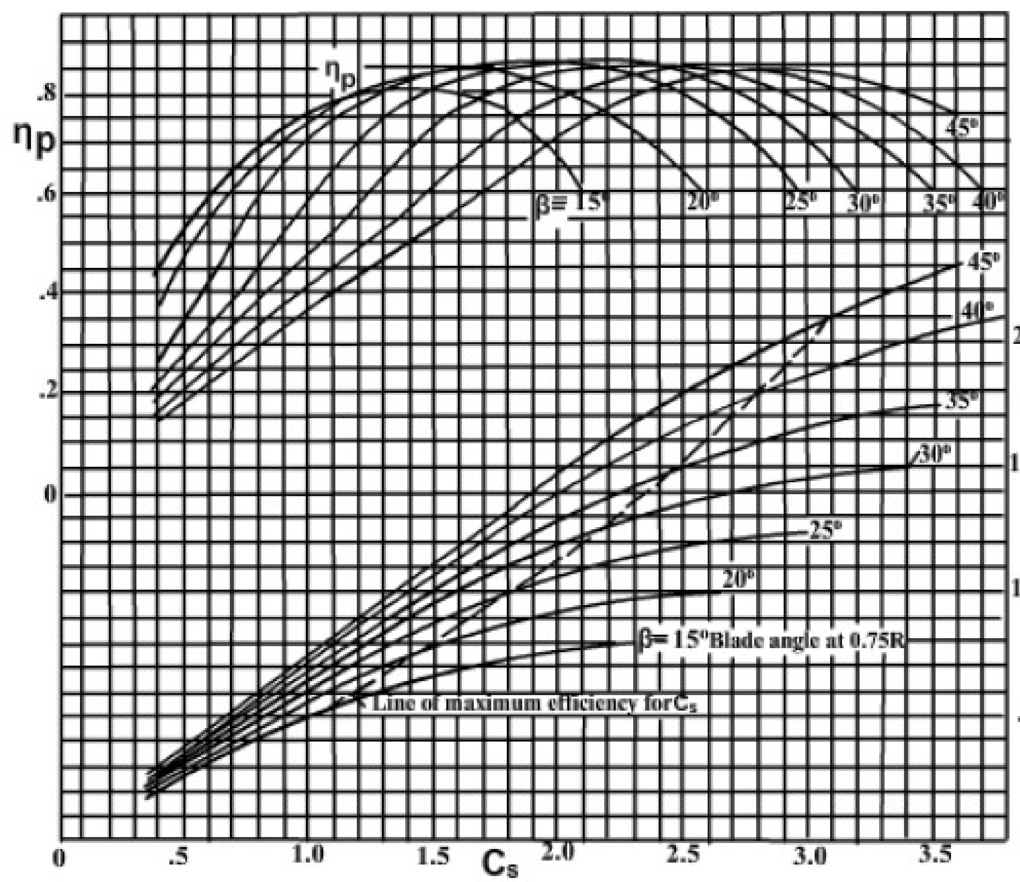
SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Discuss the different optimization of method in Bryton cycle and their benefits.	**4**	**CO1**
2	Explain the Ideal and actual valve timing diagram for 4-stroke SI engine with neat sketch.	**4**	**C02**
3	Explain the performance curve of a axial flow compressor and their significance.	**4**	**C01**
4	Why propeller is twisted? Also explain the concept of varying airfoil configuration from root to tip.	**4**	**C03**
5	State the importance of blade cooling technology in Turbine.	**4**	**C01**

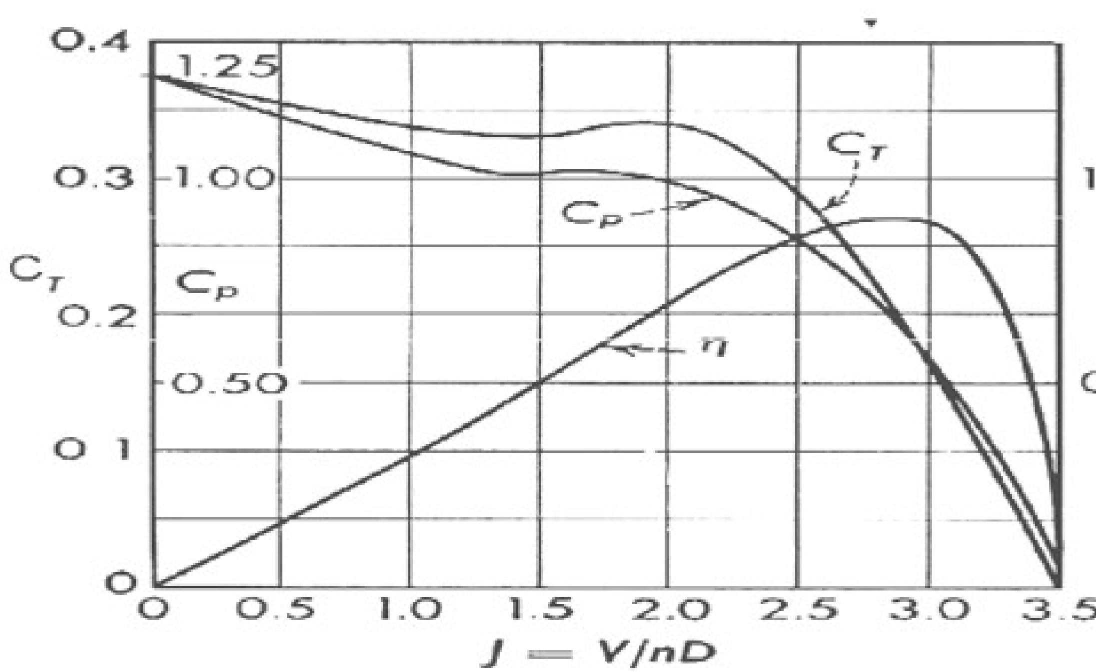
SECTION B
(4Qx10M= 40 Marks)

6	Explain the concept of actuator disc. Established the relation between overall increments of velocity to incremental velocity through the disc.	**10**	**CO2**
7	Calculate the air standard efficiency of the cycle of an oil engine works on diesel cycle, which has maximum compression ratio is 16. At the beginning of compressor temperature is 20oC and 750 KJ/Kg of air of heat is supplied at constant pressure and it reaches to 4300C temperature at the end of adiabatic expansion. What would be the theoretical work-done per Kg of air. take Cv = 0.717 KJ/Kg K and specific heat ratio = 1.4 **OR** An engine used for pumping water develops a brake power of 3.68 kW. Its indicated thermal efficiency is 30%, mechanical efficiency is 80%, calorific value of the fuel is 42,000 kJ/kg and its specific gravity = 0.875. Calculate (i) the fuel consumption of the engine in (a) kg/h (b) litres/h (ii) indicated specific fuel consumption and (iii) brake specific fuel consumption	**10**	**C03**

<table>
<tr><td>8</td><td>A simple gas turbine takes in air at 1.0 bar and 27 °C and compresses to a pressure of 6 bar with the isentropic efficiency of compression being 85%. The air passes to the combustion chamber, and after combustion the gases enter the turbine a temperature of 560 °C and expand to 1.00 bar, the turbo efficiency being 80%. Neglecting the change of mass flow rate due to fuel, calculate the flow of air in kg per second for a net output of 1500 kW making the following assumptions: Loss of pressure in combustion chamber = 0.08 bar</td><td>10</td><td>CO3</td></tr>
<tr><td>9</td><td>A 50% reaction axial flow compressor has inlet and outlet blade angles of 45 0 and 12o respectively. The blade speed at the tip of the rotor is 320 m/s. If the inlet total temperature is 300 K, determine the tip relative Mach number.</td><td>10</td><td>C02</td></tr>
<tr><td colspan="4">SECTION-C
(2Qx20M=40 Marks)</td></tr>
<tr><td>10</td><td>Analyze an axial flow compressor in which Air at 1 bar and 288K enters to the compressor with an axial velocity of 150 m/s. There are no inlet guide vanes. The rotor stage has a tip diameter of 60 cm and a hub diameter of 50 cm and rotates at 100 rps. The air enters the rotor and leaves the stator in the axial direction with no change in velocity or radius. The air is turned through 30.2^0 as it passes through the rotor. Assume an overall pressure ratio of 6 and a stage pressure ratio of 1.2. Find a)the mass flow rate of air, b) the power required to drive the compressor, c) the degree of reaction at the mean diameter, d) the number of compressor stages required if the isentropic efficiency is 0.85.</td><td>20</td><td>C04</td></tr>
<tr><td>11</td><td>A multi-stage axial turbine is to be designed with impulse stages and is to operate with an inlet pressure and temperature of 6 bar and 900 K and outlet pressure of 1 bar. The isentropic efficiency of the turbine is 85 %. All the stages are to have a nozzle outlet angle of 75° and equal inlet and outlet rotor blade angles. Mean blade speed is 250 m/s and the axial velocity is 150 m/s and is a constant across the turbine. Estimate the number for stages required for this turbine.
OR
Analyze Piper Cherokee aircraft propeller which is coupled with 4 stroke CI engine having cylinder diameter 12 cm and stroke 15 cm has mechanical efficiency 75%, assume frictional power for IC engine is 50KW, air fuel ratio 18:1 and its fuel consumption is 60 kg/h. If the engine rotates at 3000 RPM. Calculate the diameter of the propeller and pitch angle at 220 KMPH speed of an aircraft. Refer the table and graph for the Piper Cherokee aircraft.
<table>
<tr><td>Maximum Takeoff weight</td><td>10673 N</td></tr>
<tr><td>Wing area</td><td>14.864 m^2</td></tr>
<tr><td>Drag polar</td><td>$CD = 0.0349 + 0.0755\ 2C_L^2$</td></tr>
<tr><td>Density at sea level</td><td>1.22 Kg/m^2</td></tr>
</table></td><td>20</td><td>CO4</td></tr>
</table>



ηp
.8
.6
.4
.2
0
β= 15°
20°
25°
30°
35°
40°
45°
2.0
J
1.5
1.0
.5
0
β= 15° Blade angle at 0.75R
Line of maximum efficiency for C_s
0 .5 1.0 1.5 2.0 2.5 3.0 3.5
C_s



0.4
1.25
0.3
1.00
C_T
C_P
0.2
0.50
0 1
0
1.0
η
0.5
0 0.5 1.0 1.5 2.0 2.5 3.0 3.5
J = V/nD

FORMULAS

η of diesel cycle:-

$$\eta_{Die} = 1 - \left(\frac{1}{\gamma (r_k)^{\gamma-1}}\right) \times \left(\frac{r_c^{\gamma} - 1}{r_c - 1}\right)$$

Volumetric effeciency.

$$\eta_v = \frac{\dot{V}_{air}}{V_s \times \frac{N}{2}}$$

$N \rightarrow$ rev/min

$V_s = \frac{\pi}{4} D^2 L$

Mean effective Pressure

$$I.P = \frac{P_{IMEP} \, L A n k}{60 \times 1000}$$

$k \rightarrow$ no of cylinder

$n \rightarrow N/2 \rightarrow$ 4 stroke

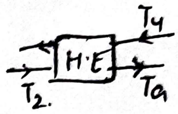
$n \rightarrow N \rightarrow$ 2 stroke

$$\phi_s = \frac{\text{Theo Power}}{\text{ideal Power}} = \frac{V_{w_2}}{U_2}$$

$$\phi_w = \frac{P_{actual}}{P_{theo}}$$

Effectiveness of H.E

$$\epsilon = \frac{T_a - T_2}{T_4 - T_2}$$



$$P_{actual} = \dot{m} \, \phi_w \phi_s U_2^2 = \dot{m} C_p \Delta T$$

$$W = V_{w_2} U_2 - V_{w_1} U_1$$

$$T_0 = T + \frac{V^2}{2C_p}$$

$$\frac{T_0}{T} = 1 + \frac{M^2(\gamma-1)}{2}$$

$$\eta_c = \frac{\pi_c^{\frac{\gamma-1}{\gamma}} - 1}{\left(T_{02}/T_{01}\right) - 1}$$

$$\frac{U}{C_a} = \tan\alpha_1 + \tan\beta_1 = \tan\alpha_2 + \tan\beta_2$$

$$W = U C_a (\tan\alpha_2 - \tan\alpha_1) = U C_a (\tan\beta_1 - \tan\beta_2)$$

$$\left(\frac{P_{03}}{P_{01}}\right) = \left[1 + \eta_{st} \frac{U \Delta C_w}{C_p T_{01}}\right]^{\frac{\gamma}{\gamma-1}}$$

$$\phi = \frac{C_a}{U}$$

$$\psi = \frac{\Delta C_w}{U} = \frac{\Delta h_0}{U^2}$$

$$R_x = \frac{C_a}{2U} (\tan\beta_1 + \tan\beta_2)$$

$$\Delta T_{0s} = \frac{\lambda U C_a}{C_p} (\tan\beta_1 - \tan\beta_2)$$

$$\Delta T_{overall} = \frac{T_{01}}{\eta_{st}} \left(\pi_0^{\left(\frac{\gamma-1}{\gamma}\right)} - 1\right)$$

$$\frac{V_e + V_\infty}{2} = V$$

$$T = \rho A (V_\infty + V) 2V = 2\dot{m} V$$

$$C_s = \left(\frac{\rho V_\infty^5}{P n^2}\right)^{1/5} = \frac{J}{(C_p)^{1/5}}$$

$$\eta_i = \frac{1}{1 + (V/V_\infty)}$$

$$V = \frac{\left[-V_\infty + \sqrt{V_\infty^2 - (2T/\rho A)}\right]}{2}$$

$$J = \frac{V_\infty}{nD}$$

Turbine

$$R_x = \frac{1}{2}\left[1 - \frac{C_a}{U}(\tan\alpha_2 + \tan\beta_3)\right]$$

$$\psi = \frac{C_{w_2} - C_{w_3}}{U}$$

$$\frac{\Delta T_0}{T_{01}} = \frac{U(C_{w_2} - C_{w_3})}{C_p T_{01}}$$

$$W_T = U(C_{w_2} - C_{w_3}) = C_p (T_{02} - T_{03}) \quad T_{02} = T_{01}$$

$$P = \dot{m} U (C_{w_2} - C_{w_3})$$

$$\eta_{TS} = \frac{1 - (T_{03}/T_{01})}{1 - (P_3/P_{01})^{\frac{\gamma-1}{\gamma}}}$$

$$\eta_{TT} = \frac{\eta_{TS}}{1 - C_3^2 \left[2C_p (T_{01} - T_{3s})\right]}$$

$$W_T = \eta_{TT} C_p T_{01} \left(1 - \left(\frac{P_{03}}{P_{01}}\right)^{\frac{\gamma-1}{\gamma}}\right)$$

$$W_T = \eta_{TS} C_p T_{01} \left[1 - \left(\frac{P_3}{P_{01}}\right)^{\frac{\gamma-1}{\gamma}}\right]$$