Code No: RR322103 **Set No.1**

III B.Tech. II Semester Regular Examinations, April/May -2005
AEROSPACE PROPULSION-II
(Aeronautical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Write notes on the following with respect to axial turbine stage
   (a) Conventional Blading
   (b) Aspect Ratio
2. The following particulars relate to a single-stage turbine of free vortex design:
   Inlet stagnation temperature = 973^0K
   Inlet stagnation pressure = 4.5 kgf/cm^2
   Outlet static pressure = 1.2 kgf/cm^2
   Gas flow rate = 72000 kg/hr
   Nozzle outlet angle = 28 degrees
   Nozzle loss coefficient = 0.10
   Mean blade diameter/ blade height = 10
   Determine the gas temperatures, velocities and discharge at the blade mid, root and tip radii. Assume $C_p = 0.276$ and $\gamma = 1.333$.
3. What are the various assumptions made while analyzing an ideal ramjet engine? Explain the conditions occurring at the exit of diffuser section and combustion chamber.
4. (a) Write a note on **'SCRAMJET'**.
   (b) What are the advantages and disadvantages of integral ram-rocket over a simple ramjet? What are the applications of integral ram-rocket?
5. The following data are given for a certain rocket unit: propellant consumption = 10.7 lb/sec, thrust = 2000 lb, velocity of vehicle = 800 mph, energy content of propellant = 3000Btu/lb. Determine (a) the effective exhaust velocity, (b) the kinetic jet energy for 1 lb of propellant, (c) the internal efficiency, (d) the propulsive efficiency, (e) the overall efficiency, (f) the specific impulse and (g) the specific propellant consumption.
6. Explain the distinct features, advantages and disadvantages of the following with respect to solid rocket motor:
   (a) Jet vanes
   (b) Mechanical probes

(c) Hot gas injection

(d) Moveable nozzle (flexible bearing)

7. The engine performance data for a turbo-pump rocket system are as follows:
Engine system specific impulse = 212 sec
Engine system mixture ratio = 2.52
Engine system thrust = 5000 lb
Oxidizer vapour flow to press-urize oxidizer tank = 0.003% of total oxidizer flow
Propellant flow through pipe = 2.1% 0f total propellant flow
Gas generator mixture ratio = 0.23
Determine performance of the thrust chamber (I_s, r, F)

8. (a) List down various losses affecting the electric thruster efficiency.

(b) How will you select a particular electrical propulsion system for various space flight applications/ mission?

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Code No: RR322103 **Set No.2**

III B.Tech. II Semester Regular Examinations, April/May -2005
AEROSPACE PROPULSION-II
(Aeronautical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Differentiate between impulse blading and reaction blading of an axial flow turbine.
   (b) Explain the significance of exit swirl angle.

2. The following data refers to a single-shaft gas turbine running at its design speed:

compressor characteristics			turbine characteristics		
P_2/P_1	$\sqrt{T_1/P_1}$	η_c	P_3/P_4	$\sqrt{\left(T_3/P_3\right)}$	η_t
5.0	32.9	0.80	5.0	14.2	0.845
4.7	33.8	0.79	4.5	14.2	0.850
4.5	34.3	0.77	4.0	14.2	0.842

The chamber pressure loss is 5% of the compressor delivery pressure and the ambient conditions are 1.01 bar and 288 K. Mechanical losses can be neglected. The non-dimensional flows are based on m in kg/s, p in bar and T in K, all pressures and temperatures being stagnation values.

Calculate the power output when operating at a turbine inlet temperature of 1100K. Comment briefly on the variation in thermal efficiency as the load is reduced at constant speed.

3. (a) Compare the general features of a ramjet and turbojet engines.
   (b) Write short notes on the following with respect to ramjet engines:
      i. Net thrust
      ii. Effective jet velocity

4. A preliminary performance analysis is to be made of a two dimensional ramjet engine which is to be installed in the wing of a supersonic airplane. The design flight Mach number is $M_0 = 3.0$ at 50000 ft altitude and the maximum total temperature due to combustion is 4000^0R. The ramjet engine is to be equipped with a diverging diffuser. Calculate (a) the area ratio of the diffuser A_2/A_1, (b) the area ratio for converging exhaust nozzle A_6/A_7, (c) the weight ratio of air flow into the engine, (d) the pressure ratio P_6/P_0, (e) The gross thrust coefficient C_{Fg} and (f) the TSFC. Assume that the Mach number M_2 at the entrance to the constant area combustion chamber is 0.2, k=1.4=constant, the lower heating value of the fuel is 19300 Btu/lb, $A_1 = 10ft^2$ and the flow is frictionless and neglect the effect of the fuel flow on the thrust.

5. (a) What is Multistaging and why is it employed? Which factors decide the number of stages for a given vehicle?
   (b) Write short note on 'problems associated with re-entry'.

6. Explain the distinct features, advantages and disadvantages of the following with respect to solid rocket motor:
   (a) Jet vanes
   (b) Mechanical probes
   (c) Hot gas injection
   (d) Moveable nozzle (flexible bearing)

7. Explain the salient features of a liquid propellant rocket motor with turbo-pump feed system with the help of a schematic diagram. Write down its advantages and disadvantages.

8. (a) Explain the various applications of the electrical rocket motor. How electric rocket motor is different from liquid propellant rocket motor?
   (b) Distinguish between electro-thermal, electrostatic and electromagnetic devices of electric propulsion

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Code No: RR322103 **Set No.3**

III B.Tech. II Semester Regular Examinations, April/May -2005
AEROSPACE PROPULSION-II
(Aeronautical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Explain the elementary theory of axial flow turbine with the help of velocity diagrams.

2. The following data apply to a single stage turbine of free vortex design:

   Inlet temperature T_{01} = 1050 K

   Inlet pressure p_{01} = 3.8 bar

   Pressure ratio (p_{01}/p_{03}) = 2.0

   Outlet velocity C_3 = 275 m/s

   Blade speed at root radius = 300 m/s

   Isentropic efficiency η_t = 0.88

   Nozzle efflux angle $\alpha_2$at root radius = $61^0 9'$

   Blade inlet gas angle $\beta_2$at the root radius = $40^0 14'$

   The turbine is designed for zero reaction ($\wedge$ =0) at root radius and the velocities at inlet and outlet (C_1& C_3) are both equal and axial.

   If the tip/root radius ratio of the annulus at the exit from the nozzle blade is 1.5, determine the nozzle efflux angle and degree of reaction at the tip radius.

   Assuming a nozzle loss coefficient of 0.05, calculate the static pressure at inlet and outlet of the rotor blades at the root radius and thereby show that even at the root there is some expansion in the rotor blade passage under these conditions.

3. (a) Define 'effective jet Mach number' for a ramjet engine and derive the relationship for it.

   (b) Write a short note on 'external drag' of a ramjet engine.

4. A two dimensional converging-diverging diffuser is employed on a ramjet engine which is designed for a flight Mach number of M_0 = 2 at an altitude of 20000 ft. The area of the entrance section is 2 ft^2. At the design point, the Mach number of the air entering the combustion chamber is M_2 = 0.2 and the total temperature of the working fluid entering the exhaust nozzle is $T_6 = 3000^0$R. Calculate (a) the area ratio of the diffuser A_2/A_1, (b) the area ratio for converging exhaust nozzle A_6/A_7, (c) the pressure ratio P_6/P_0, (d) the gross thrust coefficient C_{Fg}, (e) the TSFC. Assume that W_a = 169 lb/sec, specific heat ratio k = 1.4 = constant, the calorific value of the fuel is ΔH_c = 19300 Btu/lb, combustion efficiency is η_B = 1.0, the flow is frictionless and neglect the effect of the fuel flow on the thrust.

5. The following data are given for a certain rocket unit: propellant consumption = 10.7 lb/sec, thrust = 2000 lb, velocity of vehicle = 800 mph, energy content of propellant = 3000Btu/lb. Determine (a) the effective exhaust velocity, (b) the kinetic jet energy for 1 lb of propellant, (c) the internal efficiency, (d) the propulsive efficiency, (e) the overall efficiency, (f) the specific impulse and (g) the specific propellant consumption.

6. (a) Sketch the various configurations of solid propellants and give their salient features.

   (b) Explain the following with respect to solid propellant rocket motor:

   i. Pulse rocket burning

   ii. Step-thrust rocket burning

   iii. Effective burning time

7. You are given a liquid oxygen-liquid hydrogen rocket thrust chamber of 1000 lb thrust operating at a chamber pressure of 1000 psia, a mixture ratio of 3.4, exhaust products with a mean molecular weight of 8.9 lb/mole, a combustion temperature of 4380^0F and a specific heat ratio of 1.26. Determine the nozzle area, exit area for optimum operation at a 100000 ft altitude (p_2 = 1.58 psia), the propellant weight and volume flow ratio and the total propellant requirement for 2 minute of operation. Assume the actual specific impulse to be 97% of the theoretical value.

8. (a) Explain the following with the help of suitable diagrams:

   i. Co-axial pulsed-plasma thruster

   ii. Magneto-plasma dynamic arc thruster

   (b) How thrust is produced in electro-thermal thruster?

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Code No: RR322103 **Set No.4**

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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. Derive the following relationships with the help of velocity diagrams for an axial turbine stage

   (a) $\psi = 2\Phi\,(\tan\beta_2 + \tan\beta_3)$

   (b) $\wedge = {}^{\Phi}/_{2}\,(\tan\beta_3 - \tan\beta_2)$

   Where $\wedge$ = degree of reaction, Φ = flow coefficient β_2 ,β_3 = rotor blade angle, ψ = temperature drop coefficient

2. Why matching of compressor and turbine is required? Explain the procedure for matching compressor and turbine with the help of flow chart.

3. (a) What are the various problems coming across while designing a supersonic diffuser for a ramjet engine and how these problems can be reduced / eliminated?

   (b) Write a note on 'variable geometry ramjet engine'.

4. A preliminary performance analysis is to be made of a two dimensional ramjet engine which is to be installed in the wing of a supersonic airplane. The design flight Mach number is $M_0 = 3.0$ at 50000 ft altitude and the maximum total temperature due to combustion is 4000^0R. The ramjet engine is to be equipped with a diverging diffuser. Calculate (a) the area ratio of the diffuser A_2/A_1, (b) the area ratio for converging exhaust nozzle A_6/A_7, (c) the weight ratio of air flow into the engine, (d) the pressure ratio P_6/P_0, (e) The gross thrust coefficient C_{Fg} and (f) the TSFC. Assume that the Mach number M_2 at the entrance to the constant area combustion chamber is 0.2, k=1.4=constant, the lower heating value of the fuel is 19300 Btu/lb, $A_1 = 10\text{ft}^2$ and the flow is frictionless and neglect the effect of the fuel flow on the thrust.

5. (a) What is Multistaging and why is it employed? Which factors decide the number of stages for a given vehicle?

   (b) Write short note on 'problems associated with re-entry'.

6. (a) What do you understand by burning rate of solid propellant? Explain the various factors affecting the burning rate in a full scale rocket motor.

   (b) Distinguish between composite and double base solid propellant. What are their merits and demerits?

7. (a) Explain the desirable characteristics of a typical rocket thrust chamber.

(b) Write down the relative merits and demerits of liquid propellants over solid propellants.

8. Explain the working principle of an electrical rocket with the help of a schematic diagram. Write down the merits and demerits of an electric rocket motor over a solid propellant rocket motor.

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