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

III B.Tech II Semester Regular Examinations, Apr/May 2006
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. Derive the relationship for stagnation pressure ratio for an axial turbine stage.[16]

2. Construct the velocity diagram indicating the magnitude of all the vectors and nozzle & rotor angles for a turbine to be designed for the following conditions:

   Aircraft speed = 960 km/hr

   Air flow = 6 kg/s

   Altitude = 6000m

   Compressor efficiency = 0.83

   Turbine efficiency = 0.85

   Turbine inlet temperature = 1000^0C

   Ram efficiency = 100%

   Assume reasonable hub-tip ratio, a maximum outer diameter of 375mm and a maximum rotor tip speed of 360m/s. Velocity diagrams are required for only the pitch line energy condition in the turbine. It is suggested that flow in the turbine be subsonic throughout. [16]

3. Define the gross thrust of a ramjet engine and derive the relationship for it. [16]

4. Explain the preliminary concepts in supersonic combustion. [16]

5. An ideal rocket motor operates under steady conditions at a combustion pressure of 300 psia. The exhaust nozzle gives complete expansion of the exhaust gases when the back pressure is 14.5 psia. The divergence semi-angle of the nozzle is 15^0 and the area of its throat is $4in^2$. The propellant combustion rate is 7 lb/sec and the thermodynamic properties of the combustion gases at the entrance section of the nozzle are t_c = 5400R, k = 1.25 and R = 60 ft.lb/lb.^{0}R. Calculate:

   (a) the thrust developed at sea level,

   (b) the characteristics velocity,

   (c) the thrust coefficient,

   (d) the weight flow coefficient,

   (e) the velocity of the gas in the throat of the nozzle and

   (f) the ideal exhaust velocity of the gases. [16]

6. (a) Explain the following with the help of a diagram:

i. Neutral burning
ii. Progressive burning
iii. Regressive burning.

(b) Explain the process of combustion in a solid propellant rocket motor. [9+7]

7. (a) Explain the process of combustion in a liquid propellant rocket motor. Explain the various factors affecting the combustion process.

(b) What do you understand by 'buzzing' combustion instability and how it can be controlled? [10+6]

8. Describe the concept of solid-core reactor rocket with the help of a schematic diagram. [16]

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

III B.Tech II Semester Regular Examinations, Apr/May 2006
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) Define 'temperature drop coefficient' and derive relationship for it with the help of velocity diagrams for an axial turbine stage.
   (b) Show that the product of whirl velocity and turbine radius is constant for free vortex turbine stage. [8+8]

2. Products of combustion flow through an axial turbine stage with the following properties: T_{t1} = 1800, P_{t1} = 1000 kPa, u_3/u_3 = 1, M_2 = 1.1, U =ω, r_m = 360 m/s, α_2= 45^0 and α_3= 5^0. For the gas, use γ= 1.3 and R = 0.287 kJ/(kg.K). Determine the following:
   (a) V_2, u_2 and v_2
   (b) V_3,u_3 and v_3
   (c) ΔT_t and τ_s for the stage
   (d) Π_s and P_{t3} for a polytropic efficiency of 0.89. [16]

3. (a) Write a note on 'Gross thrust coefficient' of ramjet engine.
   (b) Explain the effect of following variables on gross thrust coefficient for a fixed geometry ramjet engine.
      i. Effect of fuel air ratio at constant altitude
      ii. Effect of specific fuel consumption. [6+5+5]

4. A two-dimensional ramjet is to be installed in the wing of a supersonic airplane. The two-dimensional diffuser is to be designed for a flight Mach number M_0 = 2. At the design Mach number, an oblique shock is attached to the vertex of the wedge and a normal shock at the lip of the diffuser. Determine
   (a) The wedge angle for obtaining the maximum possible recovery,
   (b) The maximum total pressure ratio and
   (c) The total pressure recovery for a wedge angle of 90^0. [16]

5. (a) What is ballistic factor? How it affects the free flight dispersion?
   (b) Show that the burnout velocity of a single stage rocket motor moving vertically is given by:
   $$V_b = g.I_{sp}.\ln[m_o/(m_o - m_f)]$$
   Where m_o is initial mass of missile, m_f is mass of fuel and I_{sp} is the specific impulse. State any assumptions, if made. [6+10]

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? [10+6]

7. What are the various types of propellant tanks in case of liquid rocket motors? Explain the role, desirable characteristics, advantages and disadvantages of propellant tanks. [16]

8. (a) Show the various subsystems of a typical electrical propulsion system? How will you relate them to liquid propellant rocket motor subsystems?
   (b) Write a note on 'arcjets'. [10+6]

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

III B.Tech II Semester Regular Examinations, Apr/May 2006
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. What do you understand by free vortex turbine stage design?
   Derive the following relationship
   C_w.r = constant [16]

2. The following particulars relate 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

   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. Calculate the nozzle efflux angle α_2 and blade inlet gas angle β_2 at the root radius. If the tip/root radius ratio of the annulus at the exit from the nozzle blade is 1.4, determine the nozzle efflux angle and degree of reaction at the tip radius. [16]

3. Explain the sub-critical, critical and supercritical conditions with the help of sketches under which a ramjet engine diffuser can operate. [16]

4. What do you understand by 'Integral Ram-rocket'? Explain the working principle and operation of Integral Ram-rocket with the help of a suitable diagram. [16]

5. (a) Describe various types of rocket engines and the concept of staging of rockets.
   (b) How control is achieved on space vehicles? [10+6]

6. The following data relates to composite solid propellant :

Specific impulse	= 240 sec at sea level and 1000 psi
Burning rate	= 1.0 in/sec at 1000 psi & 60^oF
Specific weight	= 0.066 lb/in^3
Specific heat ratio	= 1.25
Chamber pressure	= 1000 psi
Desired average thrust	= 20000 lb
Maximum vehicle dia	= 16 in
Desired duration	= 5.0 sec
Ambient pressure	= 3 psi (at altitude)

Vehicle payload = 5010 lb
Thrust coefficient = 1.73
Make a preliminary determination of

(a) propellant weight & volume,

(b) web thickness,

(c) wall thickness,

(d) grain configuration and

(e) nozzle design. [16]

7. What are the various types of propellant tanks in case of liquid rocket motors? Explain the role, desirable characteristics, advantages and disadvantages of propellant tanks. [16]

8. A cesium ion rocket using a porous tungsten ionizer and a simple ideal electrode configuration has the following operating conditions:
Energy lost in radiation, conduction and heating of tungsten = 20 W
Diameter of source = 1 cm
Electrode spacing = 0.90 cm
Applied voltage = 10000 V
Determine current density, power, thrust, specific impulse and propellant flow rate. [16]

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

III B.Tech II Semester Regular Examinations, Apr/May 2006
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) What factors affect the efficiency of an axial flow turbine and how?
   (b) Differentiate between an axial flow and radial turbine. [10+6]

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 α_2 at root radius = $61^0 9'$

   Blade inlet gas angle β_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. [16]

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. [6+5+5]

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 engine is operating at supercritical Mach number M_0 = 3.3 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) M_2,
   (b) P_2/P_0,

(c) P_6/P_0,

(d) The gross thrust coefficient C_{Fg},

(e) the weight ratio of air flow into the engine 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. [16]

5. Explain the general principle of rocket motor with the help of a suitable diagram. Explain the various applications of rockets. [16]

6. (a) Explain the following with the help of a diagram:
   i. Neutral burning
   ii. Progressive burning
   iii. Regressive burning.

   (b) Explain the process of combustion in a solid propellant rocket motor. [9+7]

7. What are the various types of propellant tanks in case of liquid rocket motors? Explain the role, desirable characteristics, advantages and disadvantages of propellant tanks. [16]

8. Write notes on the following:

   (a) Solar Sail

   (b) Antimatter rockets. [8+8]

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