Register Number: ……..

B.E., DEGREE EXAMINATIONS: MAY/JUNE 2013

Sixth Semester

AERONAUTICAL ENGINEERING

AER116**:** Rocket Propulsion

Time: Three Hours **Maximum Marks: 100**

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. Initial acceleration of the rocket is represented by
   a) Impulse to mass ratio b) Thrust to mass ratio
   c) Structural mass ratio d) Propellant mass ratio
2. Summerfield criterion for flow in conical nozzle is related to
   a) Choked flow b) Specific heat ratio
   c) Flow separation d) Mass flow rate
3. Which is the form of energy transfer achieved by ignition of solid propellant rocket?
   a) Electrical b) Shock
   c) Pressure d) Heat
4. Empirical correlation for igniter charge mass is given as function of
   a) Propellant port volume b) Propellant mass
   c) Propellant composition d) Propellant density
5. During which phase of solid propellant rocket operation, erosive burning can happen?
   a) Final phase b) Initial phase
   c) Throughout d) Intermittent
6. Solid propellant rocket is mostly preferred as
   a) Terminal stage b) Spacecraft attitude control system
   c) Booster / booster strap-on stage d) Rocket control thruster
7. Turbo-pump feed system is essential part of liquid propellant rocket application as
   a) Spacecraft propulsion system b) Terminal stage
   c) Control thruster d) Booster stage

8. Which one of the following parameters favour the use of cryogenic propellants?
   a) Molecular mass of exhaust gas
   b) Low temperature
   c) Combustion temperature
   d) Density of propellants
9. Which one of the following bi-propellant systems does not need igniter for operation?
   a) Hybrid propellants
   b) Hypergolic propellants
   c) Cryogenic propellants
   d) Solid propellants
10. Electrical rockets can provide
   a) High thrust
   b) High expansion ratio
   c) High specific impulse
   d) High energy

PART B (10 x 2 = 20 Marks)

11. Define optimum expansion, under-expansion and over-expansion of gas flow in nozzles.
12. Differentiate between thrust coefficient, optimum thrust coefficient and vacuum thrust coefficient.
13. Define the function of a squib and a cartridge in an igniter.
14. What is the function of nozzle closure disc in the solid propellant rocket?
15. What is the purpose of adding metallic fuel in the solid propellant composition?
16. What is the difference between CMDB (composite modified double base) propellant and nitramine propellant?
17. Why the fuel rich mixture ratio is always preferred in rockets over the stoichiometric mixture ratio?
18. List down the function of injector in thrust chamber of liquid propellant rocket.
19. Explain the differences between resisto jet and arc jet.
20. Name any two types of electrical rocket systems and their working principle.

PART C (5 x 14 = 70 Marks)

21. a) (i) Why staging and clustering of the rockets are considered necessary? (6)

    (ii) The attitude and orbit corrections required during the lifetime of the satellite are estimated to be 950 m/s. If the jet velocity of the rocket is 2500 m/s and the dry mass (mass without the propellant) of the satellite is 800 kg, determine the mass of propellant required for the attitude and orbit correction. (8)

(OR)

b) (i) Name any three performance parameters of a rocket and explain their significance in the evaluation of the rockets. (6)

(ii) A single stage rocket is used as a sounding rocket to make measurements in the Earth's atmosphere. It carries sensors and electronics packages that can withstand a maximum acceleration of 10 g. It develops a constant thrust of 6 kN and has a total impulse of 90 kN-s. It is launched vertically. If the mass of the empty rocket is 40 kg, what is the payload that the sounding rocket can carry so that its acceleration does not exceed 10g? (8)

22. a) (i) With a neat diagram, mark the components of a pyrotechnic igniter and explain their functions. (6)

(ii) A rocket has the following ground test data; Propellant mass= 140,000 kg; Burn duration = 105 seconds; Specific impulse = 260 seconds; Nozzle exit diameter = 2400 mm; Nozzle exit pressure = 0.07MPa. Determine the following; (8)

1) Average exhaust velocity ve.
2) Effective exhaust velocity C at an altitude of 25000 meters and the corresponding specific impulse at the above altitude.

Take ambient pressure at sea level as 0.1013MPa and pressure at 25000meters altitude as 0.00255MPa

(OR)

b) (i) Describe the ignition process in a solid propellant rocket. (6)

(ii) A rocket of mass 1000 kg contains 1500 kg of propellant which is consumed at a constant rate of 100 kg per second. The specific impulse of the propellant is 1500 Ns/kg. Find the acceleration of the rocket at lift-off and at just burnout. Assume vertical flight and no variation in the gravitational field. (8)

23. a) (i) Explain in detail the various aspects of designing a solid propellant grain. (10)

(ii) An inertial upper stage-I motor was found to have initial mass of 10620 kg and propellant mass fraction of 0.941. If the motor delivers a specific impulse of 293.5 seconds by burning for 146 seconds, calculate the following parameters: (4)

1. Mass of propellant
2. Mass of empty case
3. Propellant mass flow rate.
4. Thrust developed.

(OR)

b) (i) Explain the factors contributing to the burn rate design of solid propellant. (10)

(ii) An upper stage rocket generates a chamber pressure of 6.0 MPa and delivers a thrust of 75 kN. Its nozzle throat diameter is 90 mm through which 16.90 kg of mass flow per second takes place. Compute the following parameters: (4)

1. Specific impulse
2. Characteristic velocity
3. Thrust coefficient
4. Exit gas velocity.

24. a) A rocket with MMH-N_2O_4 system develops a thrust of 500 N at a mixture ratio of 1.65 and chamber pressure of 0.70 MPa . The C***** value is 1800 m / s and C_F is 1.5. The density of MMH is 868 kg / m^3 and the density of N_2O_4 is 1400 kg / m^3. For the 10 doublet injector elements used, the injection pressure of MMH and N_2O_4 is 1 MPa and discharge coefficient of the orifices is 0.95.
Determine the following:

(i) Mass flow rate of MMH and N_2O_4.
(ii) Diameter of injection holes for MMH and N_2O_4.

(OR)

b) (i) What are the three basic feed system cycles adopted in turbo pump fed liquid propellant rocket engines? (3)
With neat sketches of these cycles clearly mark the flow directions and name the components. (4)

(ii) What is a monopropellant rocket thruster? With a neat sketch briefly explain its operating principle. (4)
List its applications and any two monopropellants. (3)

25. a) Discuss the different techniques of cooling the liquid propellant thrust chamber.

(OR)

b) With neat sketches, explain the working of three types of electrical rockets.

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