Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
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DEPARTMENT OF AERONAUTICAL AND AUTOMOBILE ENGG
V SEM. B.Tech (AERONAUTICAL) DEGREE END SEMESTER EXAMINATIONS
DECEMBER 2017
SUBJECT: ROCKET PROPULSION (AAE-3103)
REVISED CREDIT SYSTEM
(27/12/2017)

Time: 3 Hours. Max. Marks: 50

Instructions to Candidate:
- Answer **ANY FIVE** FULL questions.
- Missing data, if any, may be suitably assumed.
- **Students are allowed to use the Data-Graph sheets supplied by Dept.**

1A) Explain the advantages and limitations of Hybrid propellant and Liquid Propellant Rockets (LPR). **(4)**

1B) The booster rocket of a satellite launch vehicle operates an altitude of 30 Km. The rocket has a constant chamber pressure of 7 MPa. **(6)**

(i) If the nozzle is designed for optimum expansion at an altitude of 16 km determine the area ratio of the nozzle. The specific heat ratio of the gases can be assumed constant and equal to 1.20. The throat area of the nozzle is 0.1 m^2. The variation of ambient pressure with altitude is given in the following:

Altitude (Km)	0	4	8	12	16	20	30
Pressure (N/m^2)	101325	61660	35651	19399	10353	5529	1186

(ii) What would be the thrust coefficient of the nozzle at the altitude of 30 Km? What is the percentage reduction from the value corresponding to optimum expansion at 30 Km?

(iii) Till what altitude would flow separation in the nozzle take place?

2A) What is standing wave? What is its role in the combustion chamber? Write the mathematical equation for each standing waves in given combustion chamber pressure. **(4)**

2B) An end-burning rocket uses a cylindrical double base propellant grain with a diameter of 200mm and generates a thrust of 350 N over a period of 300 sec. The thrust coefficient is 1.15. The characteristics of the propellant are; Density of propellant grain =1500 kg/m^3, Speed of Sound (a_{70})=4 mm/sec, Choice of index (n)=0.5, Characteristic velocity (C*)=1500 m/sec. **(6)**

Determine the thrust developed by the solid propellant rocket given in the above example, when the rocket is operated during day time in a

hot desert, wherein the ambient temperature is 50^0C and the propellant grain is soaked to the above temperature. The design of the can be assumed to be for a nominal initial propellant temperature of 25^0c. The values of C* and C_F can be assumed not to change with the initial temperature of the grain. The temperature sensitivity coefficient is 0.0035^0C^{-1}.

3A) An end burning rocket uses a cylindrical double base propellant grain with a diameter of 200 mm and generates a thrust of 350 N over a period of 300 sec. the thrust coefficient is 1.15. The characteristics of the propellants are: Density of propellant grain = 1500 Kg/m^3. Speed of Sound(a_{70}=4mm/sec) (4)

Choice of index (n)= 0.5

Characteristic velocity (C*) = 1500 m/sec .Calculate

(i) Length of propellant grain

(ii) Throat diameter of Nozzle

3B) Derive the Ejection velocity **"V_j"** expression of gas from a high pressure chamber and also draw the conclusions. **(6)**

4A) An ideal ramjet is flying at Mach 3 where the ambient temp is 310 K. The fuel has a heating value of 65,000 KJ/Kg and the temp inside the combustion chamber is 2900K. Find the jet exit velocity and fuel ratio. If the air mass flow through the engine is 240 kg / sec, what is the thrust produced and thrust specific fuel consumption? For air γ = 1.4 and C_p = 1.0035 KJ/Kg K which are assumed to remain constant. Take isentropic temperature ratio for M = 3 is 0.566. **(4)**

4B) Derive the Nozzle area ratio equation and draw the conclusions with neat diagrams. **(6)**

5A) The altitude and orbit of a satellite are maintained using a number of small rockets housed in the satellite. The altitude and orbit corrections required during the lifetime of satellite are estimated to be 950 m/sec. if the jet velocity of rocket is 2500 m/sec and dry mass of satellite (Dry mass without the propellant being loaded in the satellite) is 800 Kg, determine the mas of propellant required for the altitude and orbit corrections. **(4)**

5B) Explain the following with neat figures **(6)**

(i) Impinging jet injectors

(ii) Splash plate injector

(iii) Coaxial injector