Reg. No.

MANIPAL INSTITUTE OF TECHNOLOGY

(A constituent unit of MAHE, Manipal)

## V SEMESTER B.TECH. (AERONAUTICAL ENGINEERING) END SEMESTER EXAMINATIONS, NOV/DEC 2018

SUBJECT: ROCKET PROPULSION [AAE 3103]

## REVISED CREDIT SYSTEM (26/11/2018)

## Time: 3 Hours

MAX. MARKS: 50

4

4

## **Instructions to Candidates:**

- ✤ Answer ALL the questions.
- ✤ Missing data may be suitable assumed.
- (Thermodynamic Data Hand Book will be provided from Department)

**1A.** Derive the Euler equation from fundamentals. How it is useful in rocket propulsion?

- **1B.** Show that the nozzle equation is given by the relation  $\frac{dA}{A} = -\frac{dV}{V} [1 M^2]$
- **1C.** Determine the relationship between the stagnation temperature, stagnation pressure **2** with the static temperature, pressure under sonic conditions (Assume  $\gamma$ =1.4).

2A. A ramjet engine propels an aircraft at a Mach 3.0 and at an altitude of 6000m. The diameter of the inlet diffuser at entry is 40cm and the calorific value of fuel is 43MJ/kg. The stagnation temperature at the nozzle entry is 1450K. The properties of the combustion gases are same as those of air (γ=1.4, R=287 J/kg K). Determine: (a) Efficiency of ideal cycle, (b) Flight speed, (c) Airflow rate, (d) fuel – air ratio, (e) nozzle pressure ratio (f) nozzle jet Mach no. (g) Propulsive efficiency (h) Thrust Assume: Diffuser efficiency =0.92; Combustion efficiency =0.97; Nozzle jet efficiency = 0.95; Stagnation pressure loss in the combustion chamber=0.02 P<sub>02</sub>.

- 2B. Arrive at the expression for mass flow rate parameter (MFP) for a nozzle and show that the expression depends on the Mach number and heat capacity ratio. What is the significance of MFP?
- 3A. Explain the construction and working of a liquid propellant rocket. Describe any four 4 liquid propellant combinations and their characteristic features.

3B.	A rocket has the following data: Combustion chamber pressure of 35 bar, combustion chamber temperature of 3500K, oxidizer flow rate of 40kg/s, mixture ratio of 5, ambient pressure of 585 N/m <sup>2</sup> . Determine the (i) nozzle throat area, (ii) thrust, (iii) thrust coefficient, (iv) characteristic velocity, (v) exit velocity of the exhaust gases.	3
3C.	What are the advantages of a Bell nozzle over the conical nozzle? Describe with a neat sketch the construction and features of each?	3
4A.	Explain the differences between Pyrotechnic and Pyrogen Ignitors.	4

- **4B.** Obtain the expression for expansion ratio of the rocket nozzle. **3**
- **4C.** Explain any two types of combustion instability in solid propellants. **3**
- **5A.** Explain with a neat diagram the construction and working of Nuclear rocket engine. **4**
- **5B.** What are the advantages of Hybrid Propellant Rocket (HPR) over Solid Propellant **4** Rocket (SPR) and Liquid Propellant Rocket (LPR).
- **5C.** List any two hybrid propellants names used in rockets. **2**