Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

V SEMESTER B. TECH (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOV/DEC 2016

SUBJECT: ROCKET PROPULSION [AAE 3103]

REVISED CREDIT SYSTEM

(03/01/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A. Consider a single stage rocket with a total mass of 5000 kg, payload mass of 50 kg and structural mass of 500 kg. the specific impulse for the propellant is 350 s and it operates for a time duration of 150 s. Determine: **(06)**

i. Vehicle mass ratio
ii. Propellant mass fraction
iii. Mass flow rate of propellant
iv. Thrust
v. Acceleration of vehicle
vi. Total impulse

1B. "A small amount of underexpansion is less harmful than overexpansion in nozzle operation", Justify with reason. **(02)**

1C. Plot the variation of mass flow rate with exit pressure for a C-D nozzle. Give the condition for 'frozen throat'. **(02)**

2A. Two rockets (single stage and double stage) has same total mass of 5000 kg and same specific impulse of 350 sec. The payload mass M_L= 50 kg for both rockets. Total structural mass of two stages are $M_{S1} + M_{S2}$ = 400 + 100 =500 kg, which is the structural mass of single stage rocket. Propellant mass $M_{P1} + M_{P2}$= 3450 + 1000= 4450 kg. Calculate and compare the burnout velocities for the rockets. **(05)**

2B. With neat sketches, give the various grain configurations in solid propellant rockets. **(03)**

2C. A bipropellant liquid rocket motor operates at a chamber pressure of 40 bar with a nozzle throat of diameter 50 mm. The characteristic velocity is 1540 m/s. If the fuel-oxidizer ratio of the propellant is 1.75, and the fuel density is 900 kg/m^3, what should be the minimum fuel tank volume for a burn time of 7 minutes? **(02)**

3A. A supersonic wind tunnel nozzle is to be designed for Mach 3 with a throat area 1.25 m^2. The supply pressure and temperature at nozzle inlet, where the velocity is negligible, are 7.5 x 10^5 N/m^2 and 35℃ and the atmospheric pressure is 1.0x10^5 N/m^2. The design assumes that the flow is 1-D at the throat and the test section. Compute: **(04)**

i. Mass flow rate
ii. The test section area
iii. The flow properties at the test section (P, T, ρ)
iv. The maximum back pressure to choke the nozzle.

3B. Give the working of expander and staged combustion engine cycles for a liquid propulsion rocket engine. **(06)**

4A. What are Hall effect thrusters? **(03)**

4B. How can you classify inlets? Differentiate between external and internal compression supersonic inlets. **(03)**

4C. Consider two rockets P and Q fired vertically up with identical specific impulses and a payload of 2 kg. Rocket P has 2 identical stages, each stage having 200 kg of propellant and 20 kg of structural weight. Rocket Q has a single stage with 400 kg of propellant and 40 kg of structural mass. Neglecting drag and gravity effects, find the ratio of the change in velocity of P to that attained by Q. **(04)**

5A. Write a brief note on the following: **(06)**

i. Thrust Vector Control
ii. Solar Sail

5B. Give the three mode of operations of a Ramjet engine with a neat sketch. **(04)**