ICE 506

3A.

MANIPAL INSTITUTE OF TECHNOLOGY

Reg. No.

Manipal University

SECOND SEMESTER M.Tech. (A&SE) DEGREE END SEMESTER EXAMINATION May/June 2016 SUBJECT: SPACECRAFT ENGINEERING (ICE-506)

TIME: 3 HOURS MAX. MARKS: 50 Instructions to candidates Answer ANY FIVE full questions. • Missing data may be suitably assumed.

1A. Explain the effects of earth environment and launch environment on a spacecraft.

Mass after rocket operation

Initial mass

1B. A rocket projectile has the following characteristics:

Rocket operating duration	3 s
Average specific impulse of propellant	240 s
etermine the vehicle's mass ratio, propellant mass fraction, pro-	pellant flow rate, thrust, thrust-

Payload, non-propulsive structure, etc.

200 kg

130 kg

110 kg

D -toweight-ratio and effective exhaust velocity.

1C. Obtain the continuity equation and mention its importance.

2A. Derive the equation of spacecraft flight in the atmosphere of a celestial body.

- 2B. A three stage booster has to place a 10,000 kg spacecraft into LEO. The Δv required is 9,000 m/s, $I_{sp1}=330$ s, $I_{sp2}=420$ s and $I_{sp3}=420$ s. Find the total mass m₁ and stage weights.
- A spacecraft has a monopropellant propulsion system that delivers an I_{sp} of 225 s. How much 2C. propellant would be consumed to trim the orbit if a ΔV of 200 m/s and the spacecraft weighed 950 kg at the end of the burn?

Briefly explain the different types of propulsion systems with basic diagrams.

- 3B. Discuss how solid propellants are classified.
- 3C. Describe the different spacecraft mechanisms.

4A. Briefly explain the different types of load environments encountered by the spacecraft structures.

- 4B. Explain different space vehicle disturbance torques affecting the spacecraft's operation.
- 4C. A rigid body has angular velocity $\omega = (10, 10, 10)^T$ rad/s and angular momentum $h = (200, 200, 400)^T$ in body coordinates. The inertia matrix is:





$$(5+3+2)$$

(5+3+2)

(4+3+3)

$$I = \begin{bmatrix} 30 & -I_{xy} & -I_{xz} \\ -10 & 20 & -I_{yz} \\ 0 & -I_{zy} & 30 \end{bmatrix} \text{kg m}^2$$

- (a) What are the inertia moments I_{xy} , I_{xz} , I_{yz} and I_{zy} ?
- (b) What is the rotational kinetic energy?

(4+4+2)

- 5A. Briefly explain the different types of inertial sensors used in attitude determination.
- 5B. Describe the power system layout with a neat diagram.
- 5C. How many 22 A-h batteries are required to power an eclipse load of 462 W at 28 V for a duration of 4.6 min, with a maximum depth of discharge 38% and a battery to load loss of 4.2%?

(4+4+2)

- 6A. Explain active thermal control techniques with neat diagrams.
- 6B. With the help of a neat diagram, illustrate the working of a transponder system in the communications payload.
- 6C. List and mention the function of the command subsystem elements with the help of a diagram.

(4+3+3)