Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

VI SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, APRIL/MAY 2018

SUBJECT: SPACEFLIGHT DYNAMICS [AAE 4015]

REVISED CREDIT SYSTEM
(26/04/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. Consider a rocket comprising three similar stages (i.e., each stage has the same specific impulse, structural ratio and payload ratio). The common specific impulse is $310\ s$. The total mass of the vehicle is $150000\ kg$, the total structural mass (empty mass) is $20000\ kg$ and the payload mass is $10000\ kg$. Calculate **(06)**

a) The mass ratio n and the total Δv for the three-stage rocket.
b) $m_{p_1}, m_{p_2}, and\ m_{p_3}$.
c) $m_{E_1}, m_{E_2}, and\ m_{E_3}$.
d) $m_{0_1}, m_{0_2}, and\ m_{0_3}$.

1B. Analyzing the motion of a axisymmetric spinning top, explain the prolate condition, oblate condition and the conditions when $A = C$ and $A \neq C$. **(04)**

2A. A communication satellite in a circular orbit has a spin rate about its axis of symmetry of $5\ rad/s$ and $I = 300\ kg.m^2$. Initially the spin axis is pointed toward the Earth along $'g'$ and the x-axis is along the velocity vector (tangent to the circular orbit) **(06)**

a) If the satellite is at geosynchronous altitude with a period of $24\ h$, find the required precession rate and the magnitude and direction of the applied torque required.
b) Find the same parameters for a period of $1\ h$, in lower Earth orbit.
c) Which appear to be preferable for such satellites, higher or lower altitudes.

2B. A satellite is spinning at $0.01\ rev/s$. The moment of inertia of the satellite about the spin axis is $2000\ kg.m^2$. Paired thrusters are located at a distance of $1.5m$ from the spin axis. They deliver their thrust in pulses, each thruster producing an impulse of $15N.s$ per pulse. At what rate will the satellite be spinning after 30 pulses? **(04)**

3A. **(07)**

a) Relative to a body axis frame xyz, $[I_G] = \begin{bmatrix} 10 & 0 & 0 \\ 0 & 20 & 0 \\ 0 & 0 & 30 \end{bmatrix} kg.m^2$ and velocity $\vec{\omega} = 2t^2\hat{\imath} + 4\hat{\jmath} + 3t\hat{k}\ rad/s$, where t is time in seconds. Calculate the magnitude of the net moment about the center of mass G at $t = 3\ seconds$.

b) In the above case, the system is at rest when a $100N$ force is applied to point A as shown in figure 1. Calculate the inertial components of angular acceleration at that instant.

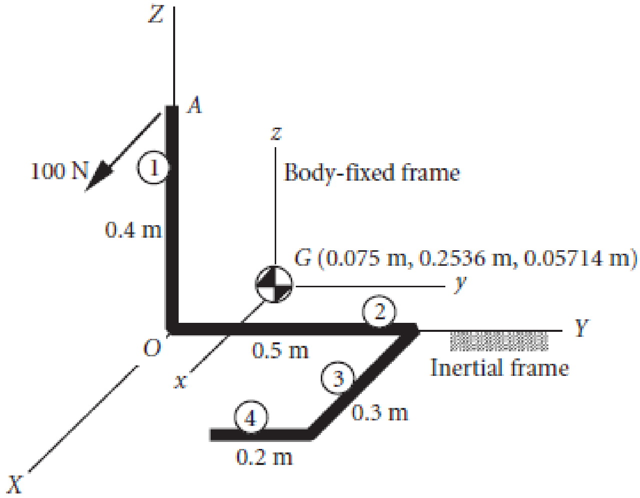

Figure 1

3B. Explain the relationship between the ballistic coefficient and the re-entry angle and show that **(03)**

$$\frac{dV}{V} = -\frac{\rho_0 g_0}{2(BC)\sin\Phi_{re}} e^{-\beta h} dh$$

4A. An entry vehicle has an entry angle of -22^0 and an entry velocity of $8000\ m/s$. **(06)**

a) Find the maximum deceleration and the associated altitude and velocity for $BC = 5000\ Pa$.

b) With $BC = 5000\ Pa$, find the deceleration at an altitude of $18\ Km$ $(59{,}020\ ft)$.

c) What would be part (a) for a more slender and pointed shape ($BC = 50000\ Pa$).

4B. In case of dual spin spacecraft in torque free motion, Explain what happens when $\frac{d\omega_\perp{}^2}{dt} > 0$ and $\frac{d\omega_\perp{}^2}{dt} < 0$. **(04)**

5A. An $8\ kg$ thin ring in torque-free motion as shown in figure 2 is spinning with an angular velocity of $30\ rad/s$ and a constant nutation angle of 15^0. Calculate the rotational kinetic energy if $A = B = 0.36\ kg.m^2, C = 0.72\ kg.m^2$. **(05)**

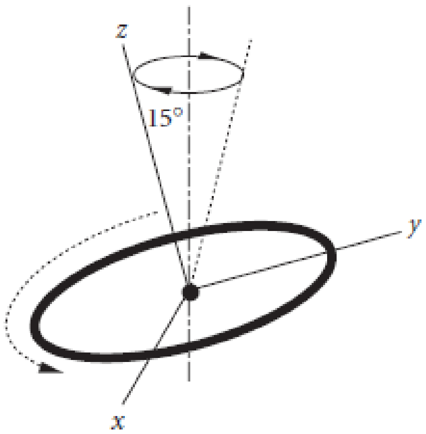

Figure 2

5B. Twelve identical slender homogeneous rods, each of mass m and length a are welded together at the endpoints so that they constitute the edges of a regular octahedron as a shown in figure 3. Find the moment of inertia of this body with respect to an axis through the midpoint. **(05)**

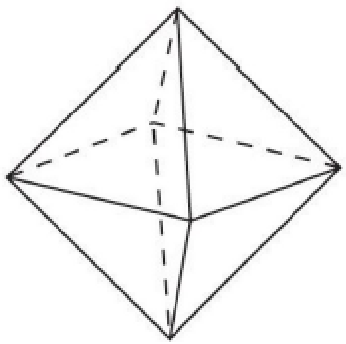

Figure 3