Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

FIRST SEMESTER M.TECH. (AEROSPACE ENGINEERING)

END SEMESTER EXAMINATIONS, NOV - 2017

SUBJECT: ORBITAL MECHANICS [ICE 5103]

Duration: 3 Hours | Max. Marks:50

Instructions to Candidates:

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

1A Derive the orbit trajectory equation. 3

1B Consider an elliptical Earth orbit with a semi major axis of 12,500 km and an eccentricity of 0.472. What is the time from periapsis passage to a position with a true anomaly of 198 deg? 4

1C Illustrate various coordinate systems used for orbit determination with suitable diagrams. 3

2A Given the following state vector of a satellite in geocentric equatorial coordinates, $\vec{r} = -3670\,\hat{I} - 3870\hat{J} + 4400\hat{K}(km)$ $\vec{v} = 4.7\hat{I} - 7.4\hat{J} + 1\hat{K}\,(\frac{km}{s})$, find the state vector after 4 days (96 h) of coasting flight, assuming that there are no perturbations other than the influence of the earth's oblateness on Ω and ω. 5

2B For the following orbital elements: p=0.23 DU, e=0.82, i=90^0, Ω=180^0, ω=260^0, θ=190^0, 5

(a) Express the r and v vectors for the satellite in the perifocal system.

(b) By a suitable coordinate transformation technique express the r and v vectors in the geocentric equatorial system.

3A Determine the Δv and time of flight for a transfer from an initial orbit of altitude 191.34411 km to a final orbit of altitude 35781.34857 km. The transfer point has to be at a true anomaly of 160^0. 4

3B A large spacecraft has a mass of 125,000 kg. Its orbital maneuvering engines produce a thrust of 50 kN. The orbiter is in a 400 km circular earth orbit. A delta-v maneuver transfers the spacecraft to a coplanar 300×400 km elliptical orbit. Estimate the Δv of the transfer. What percent of the initial mass was expelled as combustion products? 3

3C Derive an expression for synodic period in interplanetary flight. 3

4A Design a plane change for the following circular Earth orbit: Altitude = 1000 km, Inclination = 37 deg, Longitude of ascending node = 30° which results in an inclination of 63 deg and a longitude of the ascending node of 90° West. What are the angle of the plane change and the change in velocity? 3

4B Calculate the propellant mass required to launch a 2000-kg spacecraft from a 180 km circular earth orbit on a Hohmann transfer trajectory to the orbit of Saturn. Calculate the time required for the mission and compare it to that of Cassini. Assume the propulsion system has a specific 4

impulse of 300 s.

4C Assuming a circular lunar orbit of radius 384,400 km, coplanar with the transfer ellipse, injection point at the perigee, and negligible lunar mass, what is the time of flight to the moon if the injection altitude is 850 km and the injection velocity is 10.425 km/s? 3

5A What is the significance of Jacobi's integral in three-body motion? 2

5B Obtain the Lagrange's quintic equation. 4

5C Determine the semi major axis and inclination of an orbit of an Earth satellite to satisfy the following constraints: sun-synchronous, argument of perigee is constant, eccentricity = 0.25. If we decrease the semi major axis by 1000 km, which one (or more than one) of the three constraints listed above will be violated? What will be the new rates of node and argument of perigee? 4

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