Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL

A Constituent Institution of Manipal University

FIRST SEMESTER M.TECH. (AEROSPACE ENGINEERING)
END SEMESTER EXAMINATIONS, DEC 2016/JAN 2017

SUBJECT: ORBITAL MECHANICS [ICE 5103]

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. State the basic laws governing two body motions. **2**

1B. An Earth satellite is in an orbit with a perigee altitude of 400 km and an eccentricity of 0.6. Find (a) the perigee velocity, (b) the apogee radius, (c) the apogee velocity, (d) the orbit period,(e) the flight path angle at altitude 3622 km. **4**

1C. With the help of diagrams, explain different coordinate systems used in orbit determination. **4**

2A. Illustrate coordinate transformations with direction cosine matrices about all the three axes. **3**

2B. Obtain the station coordinates using the ellipsoidal model of earth. **3**

2C. The geocentric position vectors of a space object at three successive times are: **4**

$$\vec{r_1} = -294.32\hat{I} + 4265.1\hat{J} + 5986.7\hat{K} \text{ (km)}$$
$$\vec{r_2} = -1365.5\hat{I} + 3637.6\hat{J} + 6346.8\hat{K} \text{ (km)}$$
$$\vec{r_3} = -2940.3\hat{I} + 2473.7\hat{J} + 6555.8\hat{K} \text{ (km)}$$

Determine the classical orbital elements using Gibbs' procedure.

3A. For the Mars transfer orbit, given: **3**

$\boldsymbol{\vec{r_1} = 0.473265\hat{X} - 0.899215\hat{Y}\ AU, \vec{r_2} = 0.066842\hat{X} + 1.561256\hat{Y} + 0.030948\hat{Z}\ AU}$, p=1.250633 AU, a=1.320971 AU, $\Delta\theta$=149.770967^0. Calculate the departure and intercept velocity vectors. [μ_{mars}=3.964016×10^{-14} AU^3/TU^2]

3B. Illustrate the different types of orbit transfers using diagrams. **4**

3C. Consider an initial direct, circular Earth orbit of radius 9100 km and a final direct, coplanar, elliptical orbit with *e* = 0.1 and *rp*=9000 km. What velocity change is required to make the transfer? **3**

4A.	Explain patched conic approximation method employed in interplanetary transfers.	**4**
4B.	Explain the different phases in interplanetary transfers.	**3**
4C.	After a Hohmann transfer from earth, calculate the minimum delta-v required to place a spacecraft in Mars orbit with a period of seven hours. Also calculate the periapse radius, the aiming radius and the angle between periapse and Mars' velocity vector.	**3**
5A.	Obtain the expression for radius of sphere of influence.	**3**
5B.	Assume the lunar orbit is circular with radius 384,400 km and is coplanar with the transfer ellipse. Define a lunar trajectory with the following initial conditions: Injection at perigee $\gamma_0 = 0$, Injection radius $r_0 = 6700$ km, Injection velocity $V_0 = 10.88$ km/s, Arrival angle $\lambda = 60$ deg.	**4**
5C.	Describe Encke's method in orbit perturbation.	**3**

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