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# Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

**FIRST SEMESTER M.TECH (ASTRONOMY & SPACE ENGINEERING)**

**END SEMESTER EXAMINATIONS, NOV/DEC 2015**

SUBJECT: ASTRODYNAMICS [ICE 501]

Time: 3 Hours MAX. MARKS: 50

**Instructions to Candidates:**

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

**1A.** Derive the orbit equation for an earth satellite. **(05)**

**1B.** Illustrate classical orbital elements with neat diagram. **(05)**

**2A.** The elements of the Magellan mapping orbit about Venus are given as $\boldsymbol{a = 10424.1}$ km and $\boldsymbol{e = 0.39433}$. The mapping pass is started at a true anomaly of $\boldsymbol{280^0}$. What are the altitude, flight path angle, velocity and time since periapsis at this point? ($\mu_{venus} = 324858.8$ km$^3$/s$^2$) **(05)**

**2B.** Define right ascension $\boldsymbol{\alpha}$ and declination $\boldsymbol{\delta}$ with neat sketch in geocentric equatorial frame. If the position vector of the international space station is given by **(05)**

$$\boldsymbol{r = -5368\,\hat{I} - 1784\hat{J} + 3691\hat{K}}\ \text{(km)}.$$

What are its right ascension $\boldsymbol{\alpha}$ and declination $\boldsymbol{\delta}$**?**

**3A.** A geocentric parabola has a perigee velocity of **10** km/s. How far is the satellite from the centre of the earth after six hours perigee passage? ($\mu_{earth} = 398600$ km$^3$/s$^2$) **(04)**

**3B.** Find the total $\boldsymbol{\Delta V}$ requirement for a bi-elliptical Hohmann transfer from a geocentric circular orbit of $\boldsymbol{7000}$ km radious to one of $\boldsymbol{105000}$ km radius. Let the apogee of the first ellipse be $\boldsymbol{210000}$ km. Compare $\Delta V$ schedule and total flight time with that for an ordinary single Hohmann transfer ellipse. **(06)**

**4A.** The space shuttle is in a **280** km by **400** km orbit with an inclination of $\boldsymbol{51.43^0}$**.** Find the rates of node regression and perigee advance. **(05)**

**4B.** Design a Hohmann transfer from a circular Mars orbit of radius **8000** km to a circular Mars orbit of radius **15000** km. ($\mu_{mars} = 42828.3$ km$^3$/s$^2$) **(05)**

**5A.** Illustrate sphere of influence of a planet. Calculate the radius of the earth's sphere of influence. **(05)**

($m_{earth} = 5.974 \times 10^{24}\ kg,\ m_{sun} = 1.989 \times 10^{30}\ kg,\ R_{earth} = 149.6 \times 10^{6}\ km$)

**5B.** Briefly describe the patched conic procedure. **(05)**

**6A.** Describe the procedure for designing a lunar mission **(05)**

**6B.** Assume the lunar orbit is circular with radius 384400 km and is coplanar with the transfer ellipse. **(05)**

Design a transfer ellipse for 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.