Reg. No. \_\_\_\_\_\_\_\_\_\_\_\_\_



**End Semester Examination – Nov / Dec – 2019**

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| **Code :** | **14AE2016** | **Duration :** | **3hrs** |
| **Sub. Name :** | **SPACE DYNAMICS** | **Max. Marks :** | **100** |

**ANSWER ALL QUESTIONS (5 x 20 = 100 Marks)**

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| **Q. No.** | **Sub Div.** | **Questions** | **Course**  **Outcome** | **Marks** |
| 1. | a. | Write Kepler’s laws of motion. Use third law of motion to calculate the orbital period of Jupiter if its distance from Sun is 5.2 Astronomical Units (AU). | CO2 | 7 |
| b. | Find the orbital period of an Earth satellite in minutes whose semi-major axis (*a*) is 7900 km. Gravitational constant (µ) for Earth =398600 km3/s2. | CO2 | 4 |
| c. | From the Kepler’s equation M = E – e sin E, where e is the eccentricity of an elliptic orbit and E and M are eccentric and mean anomaly, respectively, if E = 85 degrees and e = 0.2, calculate the mean anomaly M in radians and degrees. | CO2 | 4 |
| d. | Compute the eccentric anomaly E from the true anomaly θ and the eccentricity e using the following relations  cos E = ( e + cos θ) / (1 + e cos θ),  sin E = (1-e2)1/2 sin θ / (1 + e cos θ),  for e = 0.2 and θ = 65 degrees. | CO2 | 5 |
| **(OR)** | | | | |
| 2. | a. | Draw a neat diagram to show the six orbital elements of a satellite moving in an elliptic orbit. | CO2 | 4 |
| b. | If the position and velocity of a satellite are (-6045, -3490, 2500) km and (-3.457, 6.618, 2.533) km/s, respectively; find the angular momentum and the orbital elements: eccentricity (e), inclination (i), argument of perigee (ω), right ascension of ascending node (Ω) and true anomaly of the satellite. | CO2 | 16 |
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| 3. | a. | Define vernal equinox. Explain briefly geocentric-inertial coordinate system. | CO2 | 4 |
| b. | Define Sun-synchronous orbit. Calculate the orbital inclination for an elliptic Sun-synchronous orbit, whose semi-major axis is 7400 km and eccentricity is 0.01. Earth’s gravitational constant (μ) = 398600 km3s-2, J2= 0.00108263 and Earth’s radius is 6378 km. | CO2 | 11 |
| c. | If the eccentric anomaly (F) and eccentricity for the Kepler’s equation for hyperbola Mh = e sinh F – F, are 5 radians and 1.5, respectively, calculate the mean anomaly Mh. |  | 5 |
| **(OR)** | | | | |
| 4. | a. | Explain Cowell’s and Encke's methods. Give their advantages and disadvantages. | CO2 | 12 |
| b. | Write four important perturbing forces acting on an Earth satellite. Explain briefly any two of the perturbing forces. | CO2 | 8 |
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| 5. | a. | Find the additional velocity required for a Hohmann transfer from  circular Earth satellite orbit of radius 7000 km to a circular Earth  satellite orbit of radius 8000 km. Earth’s gravitational constant  (μ) = 398600 km3s-2. | CO2 | 10 |
| b. | Calculate the velocity change required to transfer a satellite from a circular orbit of 400 km altitude with an inclination of 30° to an orbit of the same size at an inclination of 20°. Earth’s gravitational constant = 398600 km3s-2. | CO2 | 6 |
| c. | Calculate the synodic period of Venus relative to the Earth. The orbital periods of Earth and Venus are 365.26 days and 224.7 days, respectively. | CO2 | 4 |
| **(OR)** | | | | |
| 6. | a. | Calculate the radius of sphere of influence of the Mars. The mass of the Mars and the Sun are 6.419x1023 kg and 1.989 x1030 kg, respectively. The radius of Mars’s orbit about Sun is 227.9x106 km. | CO2 | 5 |
| b. | At a given point of a spacecraft’s geocentric trajectory, the radius (r) is 14500 km, the speed (v) is 8.6 km/s, and the flight path angle (γ) is 45 degrees. Show that the path is a hyperbola. Calculate the hyperbolic excess velocity, angular momentum, true anomaly and eccentricity. Earth’s gravitational constant = 398600 km3s-2. | CO2 | 10 |
| c. | For a spacecraft trajectory around the Earth, the radial distance r = 14000 km when the true anomaly θ = 40 degrees, and r = 31000 km when θ = 95 degrees. Calculate the eccentricity e of the orbit. | CO2 | 5 |
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| 7. | a. | Describe briefly Earth's atmosphere. Show in a figure the change in temperature up to 120 km altitude. | CO2 | 10 |
| b. | A geocentric trajectory has perigee velocity of 13 km and perigee altitude of 300 km. Find its eccentricity. Earth’s gravitational constant is 398600 km3s-2. | CO2 | 5 |
| c. | Estimate the trip time T from the Earth to Mars in days along the Hohmann transfer orbit by assuming the orbits of Earth and Mars around the Sun to be circular with radii of 149.6 x 106 and 227.9 x 106 km, respectively. The value of the Sun’s gravitational constant (µ) = 1.32715 x 1011 km3s-2. | CO2 | 5 |
| **(OR)** | | | | |
| 8. | a. | Explain static stability margin. | CO1 | 4 |
| b. | Explain the purpose of fins on a rocket. | CO1 | 5 |
| c. | Explain static and dynamic stability of rockets. | CO1 | 11 |
|  | | **Compulsory**: |  |  |
| 9. | a. | From the first principles, derive the rocket equation.  Vb = g0Isp ln(Mi/Mf),  whereVb is the burnout velocity, g0 is the acceleration due to gravity at sea level, Isp is specific impulse and Mi/Mf is the mass ratio. | CO1 | 7 |
| b. | If the Isp of a rocket using hydrogen and oxygen as fuel and oxidizer is 440 s, and Vb is 9000metres/s, calculate its mass ratio  (g0= 9.8 m/s2). | CO1 | 4 |
| c. | A two-stage rocket has the following design characteristics.  First stage: propellant mass = 25000 kg, structural mass = 8000 kg.  Second stage: propellant mass = 15000 kg, structural mass = 4000 kg.  The payload mass is 100 kg. The specific impulse for first stage is 300 s and for the second stage is 400 s. Calculate the final burnout velocity(g0=9.8 m/s2). | CO1 | 9 |