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



**UNIVERSITY**

(Karunya Institute of Technology & Sciences)

(Declared as Deemed-to-be University under Sec.3 of the UGC Act, 1956)

**End Semester Examination – April/May– 2017**

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| **Code :** | **16AE3001** | **Duration :** | **3hrs** |
| **Sub. Name :** | **ORBITAL 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. | Describethird law of Kepler’s planetary motion.Calculate the orbital period of Saturn if its distance from Sun is 9.6 Astronomical Units (AU). | CO1 | 5 |
| b. | 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 M = 80 degrees and e = 0.1, calculate the eccentric anomaly E in degrees. If the semi-major axis (a) is 10000 km, find the radial distance (r) at this point. | CO1 | 10 |
| c. | 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 = 0.15 and θ = 120 degrees. | CO1 | 5 |
| (OR) | | | | |
| 2. | a. | Prove that the centre of mass of the two-body system moves in a straight line. | CO1 | 5 |
| b. | Explain Lambert's problem. Derive it analytically. | CO2 | 15 |
| 3. | a. | Calculate the radial distance r, if the semi-major axis (a), eccentricity (e) and true anomaly (θ) of an Earth satellite are 9500 km, 0.04 and 150 degrees, respectively. | CO1 | 4 |
|  | b. | Draw a neat diagram to show the orbital elements of a satellite moving in an elliptic orbit. If the position and velocity of a satellite areare (-6000, -3500, 2500) km and (-3.5, 6.6, 2.5) km/s, respectively; find the angular momentum (h), orbital inclination (i), right ascension of ascending node (Ω) and argument of perigee (ω), true anomaly (θ) of the satellite. | CO1 | 16 |
| (OR) | | | | |
| 4. | a. | Define Sun-synchronous orbits for Earth satellites. Calculate the orbital inclination for aSun-synchronous orbit, whose semi-major axis is 7050 km and eccentricity is 0.01. Earth’s gravitational constant (μ ) = 398600 km3s-2, J2 = 0.00108263 and Earth’s radius is 6378 km. If the eccentricity is zero, find the difference in orbital inclination between the two orbits. | CO1 | 15 |
|  | b. | A geocentric trajectory has perigee velocity of 13 km and perigee altitude of 322 km. Find its eccentricity. Find the radius vector when the true anomaly is 45 degrees. Earth’s gravitational constant is 398600 km3s-2. | CO1 | 5 |
| 5. | a. | Name two gravitational and two non-gravitational forces. | CO1 | 4 |
|  | b. | List two general approaches to solve the equations of motion with perturbations. Explain Cowell’s and Encke's methods. Describe their advantages and disadvantages. | CO1 | 16 |
| (OR) | | | | |
| 6. | a. | Explain Hohmann transfer. Find the additional velocity required for a Hohmann transfer from a circular Earth satellite orbit of radius 7500 km to a circular Earth satellite orbit of radius 9000 km. | CO1 | 10 |
|  | b. | Calculate the velocity change required to transfer a satellite from a circular orbit of 400 kmaltitude with an inclination of 40°to an orbit of the same size at an inclination of20°. Earth’sgravitational constant = 398600 km3s-2. | CO1 | 6 |
|  | c. | Calculate the synodic period of Mars relative to the Earth. The orbital periods ofEarth and Mars are 365.26 days and 687days, respectively. | CO2 | 4 |
| 7. | a. | At a given point of a spacecraft’s geocentric trajectory, the radius is 16000 km, the speed is 8.4 km/s, and the flight path angle is 45 degrees. Show that the path is a hyperbola. Calculate the hyperbolic excess velocity, angular momentum, true anomaly, eccentricity and turn angle. Earth’s gravitational constant = 398600 km3s-2. | CO2 | 12 |
|  | b. | Calculate the radius of sphere of influence of the Earth. The mass of the Earth and the Sun are 5.974 x1024 kg and 1.989 x1030 kg, respectively. The radius of Earth’s orbit about Sun is 149.6 x106 km. | CO2 | 4 |
|  | c. | Estimate the trip time T from the Earth to Mars 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 | 4 |
| (OR) | | | | |
| 8. | a. | To study the motion near any Lagrangian point Li, write the expression for the force function Ω expanded up to second-order terms. Use it to obtain the equations of motion around any Lagrangian point Li. Obtain the fourth-order equation for λ for finding the characteristic roots. Prove that all the four roots are imaginary at the equilateral points if the mass parameter µ is less than 0.03852. | CO2 | 12 |
|  | b. | Find the locations of the equilateral points. Construct the principal system of co-ordinates at the equilateral point L4 to show the angle α, which the major-axis of the elliptic orbit makes with the ξ-axis for mass ratio μ = 0.15 in the restricted three-body problem. | CO2 | 8 |
|  | | **Compulsory**: |  |  |
| 9. |  | Write equations of motion for planar restricted three body problem in synodic (rotating) coordinate system. Derive Tisserand's criterion for the identification of comets. Derive the two equations to find the locations of the five equilibrium points. Derive the fifth-degree algebraic equations to find the locations of any two of the three collinear Lagrangian points Li (i=1, 2, 3). | CO2 | 20 |

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