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



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

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| **Code :** | **17AE2015** | **Duration :** | **3hrs** |
| **Sub. Name :** | **FOUNDATIONS OF SPACE ENGINEERING** | **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. | If **a** = 2**i** + 2**j**-**k**, **b**= 6**i -** 3 j + 2 k; find the vector product of **a** and **b** and a unit vector perpendicular to **a** and **b**. Also determine the sine of the angle between **a** and **b**. | CO1 | 7 |
| b. | Given: **g**is vector from A [1,2,3] to B [4,5,6], **ℓ** is the unit vector in the direction from O to A. Find **m**, a unit vector along **g** ×**ℓ.** | CO1 | 7 |
| c. | Find the scalar triple product of the three vectors **a** = **i** - 2**j**+ 3**k**,  **b** = -2**i** + 3**j**– 4 **k**, **c** = **i** -3**j** + 5**k**. | CO1 | 6 |
| **(OR)** | | | | |
| 2. | a. | A cube has four diagonals, connecting opposite vertices. Find the angle between an adjacent pair. | CO1 | 6 |
| b. | If **r** = x**i** + y**j**+ z**k**, show that grad r = **r** / r. | CO1 | 5 |
| c. | Find the divergence and curl of the vector **V** = (xyz)**i** + (3x2y)**j**  +(xz2 – y2z) **k**, at the point (2, -1, 1). | CO1 | 9 |
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| 3. | a. | Derive the radial and tangential components of velocity and acceleration in plane polar coordinates. | CO1 | 10 |
| b. | is a curve, where **s** is arc length and **h**, **a** are constants. Show that the tangent dr/ds to the curve has a constant elevation angle w.r.t. the xy -plane. | CO1 | 6 |
| c. | Define vernal eqinox. Explain geocentric-inertial coordinate system. | CO1 | 4 |
| **(OR)** | | | | |
| 4. | a. | If x=6500 km, y= -6000 km, z= 7000 km, find the values of r, θ and φ using the following relations. | CO2 | 8 |
| b. | If x-axis is rotated through an angle θ to new ξ- axis, find relations of point P in the two co-ordinate systems in terms of θ. | CO2 | 4 |
| c. | Two smooth bodies A and B of masses m1 and m2 moving with velocities u1 and u2 make a direct impact. Their velocities after the impact are v1 and v2, respectively. e is the coefficient of restitution. Find v1 and v2.  A ball of mass 8 kg moving with a velocity of 5m/s impinges directly on a ball of 16 kg moving in the same direction with a velocity of 3m/s. The velocity of the latter after the impact is 4m/s. Find the value of e. | CO2 | 8 |
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| 5. | a. | Write the Kepler three laws of motion. Use Kepler’s third law of motion to calculate the orbital period of Saturn if its distance from Sun is 9.6 Astronomical Units (AU). | CO3 | 7 |
| b. | Find the orbital period of an Earth satellite in minutes, whose semi-major axis (a) is 7200 km. The gravitational constant (µ) of the Earth is 398600 km3/s2. | CO3 | 3 |
| 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 = 0.2 and θ = 130 degrees. | CO3 | 5 |
| d. | Given cos θ = (cos E – e) /(1 – e cos E),  sin θ = (1- e2)1/2 sin E/(1 – e cos E),  If E = 110 degrees, e = 0.15, find the true anomaly θ. | CO3 | 5 |
| **(OR)** | | | | |
| 6. | a. | Draw a neat diagram to show the six orbital elements of a satellite moving in an elliptic orbit. | CO3 | 4 |
| b. | If the position and velocity of a satellite are (-6100, – 3550, 2450) and (-3.45, 6.62, 2.55) km/s, respectively; find the angular momentum (h) and the orbital elements: inclination (i) and right ascension of ascending node (Ω) of the satellite. | CO3 | 10 |
| c. | Using the Kepler’s equation, M = E – e sin E, derive an approximate expression for E up to second-order terms in e in the form:  E = M + e sin M + e2 sin 2M / 2 +…., by assuming e to be small. | CO3 | 6 |
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| 7. | a. | A particle is projected from a point P(x0, y0) with a velocity v0 at an angle γ to the horizon. Its motion is given byd2x/dt2 = 0, d2y/dt2 = -g; prove that the path of the projectile is a parabola. g is acceleration due to gravity.Prove that the projectile moves the horizontal distance = v02 sin 2 γ /g. | CO4 | 10 |
| b. | If two point masses m1 and m2 are acted upon only by the mutual force of gravity between them, prove that the centre of mass of this system moves with constant velocity in a straight line. | CO4 | 7 |
| c. | Write advantages of liquid propellants. | CO4 | 3 |
| **(OR)** | | | | |
| 8. | a. | Describe Earth's atmosphere. Show using a figure, the change in temperature up to 120 km altitude. | CO4 | 9 |
| b. | Describe briefly space debris around the Earth. | CO5 | 7 |
| c. | Explain briefly Earth’s magnetic field. | CO5 | 4 |
|  | | **Compulsory**: |  |  |
| 9. | a. | From the first principles, derive the rocket equation  Vb = g0Ispln(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. | CO4 | 7 |
| b. | If the Isp of a rocket using hydrogen and oxygen as fuel and oxidizer is 380 s, and Vb is 9800 metres/s, calculate its mass ratio. (g0=9.8 m/s2). | CO4 | 3 |
| c. | A two-stage rocket has the following design characteristics.  1st stage: propellant mass = 28000 kg, structural mass = 10000 kg. 2nd stage: propellant mass = 15000 kg, structural mass = 4500 kg. The payload mass is 100 kg. The specific impulse for first stage is 290 s and for the second stage is 360 s. Calculate the final burnout velocity(g0=9.8 m/s2). | CO4 | 10 |