DEPARTMENT OF PHYSICS
Indian Institute of Technology Kharagpur
Classical Mechanics-I
Course: PH20007
Assignment-6: Assignment-6 (Rigid body dynamics)

1. A body is thrown vertically upwards with a velocity of 100 m/s at a 60° latitude. Calculate the displacement from the vertical in 10 s
   (a) 24.5 cm on the west
   (b) 24.5 cm on the east
   (c) 24.5 cm on the north
   (d) 24.5 cm on the south

2. A quadrilateral ABCD has masses 1, 2, 3 and 4 units located at its vertices A(-1, -2, 2), B(3, 2, -1), C(1, -2, 4) and D(3, 1, 2). Find the center of mass
   (a) (2, 0, 2)
   (b) (2, 0, -2)
   (c) (-2, 0, 2)
   (d) (-2, 0, -2)

3. Three particles of masses 2, 1, 3 respectively have position vectors $\vec{r_1} = 5t\hat{i} - 2t^2\hat{j} + (3t-2)\hat{k}$, $\vec{r_2} = (2t-3)\hat{i} + (12-5t^2)\hat{j} + (4+6t-3t^3)\hat{k}$, $\vec{r_3} = (2t-1)\hat{i} + (t^2+2)\hat{j} - t^3\hat{k}$ where t is the time. Find the velocity of center of mass at $t = 1sec$
   (a) $\hat{i} - \hat{j} - \hat{k}$
   (b) $3\hat{i} - 2\hat{j} + \hat{k}$
   (c) $3\hat{i} + 2\hat{j} - \hat{k}$
   (d) $3\hat{i} - 2\hat{j} - \hat{k}$

4. Calculate the center of mass of a uniform semi-circular wire of radius a
   (a) $\frac{a}{2\pi}\hat{y}$
   (b) $\frac{3a}{2\pi}\hat{y}$
   (c) $\frac{a}{\pi}\hat{y}$
   (d) $\frac{2a}{\pi}\hat{y}$

5. Two particles having masses m_1 and m_2 move so that their relative velocity is v and the velocity of their center of mass is $\bar{v}$. If $M = m_1 + m_2$ is the total mass and $\mu = \frac{m_1 m_2}{m_1+m_2}$ is the reduced mass of the system, the total kinetic energy is
   (a) $\frac{1}{2}Mv^2 + \frac{1}{2}\mu\bar{v}^2$
   (b) $\frac{1}{2}M\bar{v}^2 + \frac{1}{2}\mu v^2$
   (c) $\frac{1}{2}Mv^2 - \frac{1}{2}\mu\bar{v}^2$
   (d) $\frac{1}{2}(M+\mu)\bar{v}^2$

6. Degrees of freedom of a linear tri-atomic molecule is
   (a) 3

(b) 5
(c) 6
(d) 7

7. A tri-atomic molecule is moving in a space such that distance between any two of them is always constant. Degrees of freedom of the system is
   (a) 3
   (b) 5
   (c) 6
   (d) 7

8. Find the center of mass of a semi-circular plate of radius a
   (a) $\frac{4a}{3\pi}\hat{y}$
   (b) $\frac{a}{3\pi}\hat{y}$
   (c) $\frac{4a}{\pi}\hat{y}$
   (d) $\frac{3a}{4\pi}\hat{y}$

9. Calculate the moment of inertia of a right circular cone of height h and radius a about its axis
   (a) $\frac{2}{5}Ma^2$
   (b) $\frac{3}{10}Ma^2$
   (c) $\frac{1}{10}Ma^2$
   (d) $\frac{7}{10}Ma^2$

10. Two particles of masses m_1 and m_2 are connected by a rigid massless rod of length a and move freely in a plane.The moment of inertia of the system about an axis perpendicular to the plane and passing through center of mass is
    (a) $\frac{1}{2}\mu a^2$
    (b) $\frac{2}{3}\mu a^2$
    (c) $\frac{2}{5}\mu a^2$
    (d) μa^2

End