1. Attempt any **six** from the following :

(a) Three freight trucks of mass m each are pulled with force F by a locomotive in horizontal direction towards right. Considering the friction is negligible. Find the forces on each car and the direction of force. (3)

(b) Define moment of Inertia of a body rotating about an axis and explain its physical significance.

(c) Find the work done in moving a particle in the force field $\vec{F}=3x^2\hat{i}+(2xz-y)\hat{j}+z\hat{k}$ along the straight line from (0,0,0) to (2,1,3).

(d) What would be the effective weight of an astronaut normally weighing 70 kg when his rocket moves vertically upward with 5 g acceleration?

(e) A block of mass M slides along a horizontal table with speed Vo. At x = 0 it hits a spring with spring constant k and begins to experience a friction force (see figure 1 given below). The coefficient of friction is variable and is given by $\mu = bx$, where b is a constant. Find the loss in mechanical energy when the block has first come momentarily to rest.

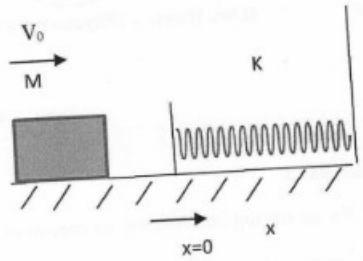

Figure 1

(f) A uniform sphere of mass M and radius R and a uniform cylinder of mass M and radius R, are released simultaneously from rest at- the top of an inclined plane. Which body reaches the bottom first if they both roll without slipping?

(g) An observer sees two spaceships flying apart with speed 0.99c.What is the speed of one spaceship as viewed by the other?

2. (a) Does the Center of mass of a solid body necessarily lies within the body? Give example. (2)

(b) A bomb-shell is thrown obliquely in air. It explodes during its flight & fragments fly off in various directions. Show that the Center of mass of the fragments continues to move along the same path which the unexploded shell would have followed. Neglect the air resistance. (6)

(c) A rocket starts from rest with an initial mass 'M_o' & reaches a final velocity 'V_f' at burn out when its mass is 'M_f'. Show that $\frac{M_f}{M_o}=e^{-\left(\frac{V_f}{u}\right)}$, Where u = exhaust velocity. (10)

3. (a) What are the fictitious forces? Give examples. (3)

(b) What is the importance of a potential energy curve? Define turning point and points of equilibrium on potential energy curve of a particle. (3)

(c) State the Kepler's first and second law of planetary motion. Derive the expression for the velocity of a satellite in circular orbit around the earth. (12)

4. (a) The acceleration due to gravity measured in an earthbound coordinate system is denoted by g . However, because of the earth's rotation, g differs from the true acceleration due to gravity g_o. Assuming that the earth is perfectly round, with radius R, and angular velocity Ω, find g as a function of latitude λ. (10)

(b) A constant torque $4\hat{i}+4\hat{j}+6\hat{k}$ Nm acts on a particle. At time t = 0, the angular momentum of the particle is $2\hat{i}+7\hat{j}+8\hat{k}$ kg m²/s, find its angular momentum after 6 seconds. (6)

(c) Find the moment of inertia of a uniform cube of side a about an axis passing through its center and parallel to one of the faces. (2)

5. (a) Mass m_1 slides along a frictionless table and suffers a one-dimensional elastic collision with a stationary mass $m_2 = 3m_1$. If the speed of the center of mass of the system is 3 m/s before collision, what are the speeds of the center of mass and mass m_2 after collision? (7)

(b) The position vector of a moving particle at any time t is given by $R = a\cos(wt)\hat{i} + b\sin(wt)\hat{j}$; where a and b are constant. Show that the force acting on the particle is conservative. (3)

(c) What do you understand by the concept of angular momentum of a system of n-number of particles? How its angular momentum varies in the absence of any external torque? (8)

6. (a) Calculate the length and orientation of a meter rod in a frame of reference which is moving with velocity equal to 0.6c, in a direction making an angle of 30° with the rod. Taking velocity of light as c. (5)

(b) Explain why particle cannot move faster than light. (3)

(c) Obtain Einstein formula for addition of velocities. If the kinetic energy of a particle is 3 times its rest mass energy, then what will be its resultant velocity? (10)