END SEMESTER EXAMINATION, MARCH-2023
UNIVERSITY PHYSICS MECHANICS (PHY-1001)

Programme: B. Tech **Semester: 1st**
Full Marks: 60 **Time: 3 Hours**

Subject/Course Learning Outcome	*Taxonomy Level	Ques. Nos.	Marks
PHY/ a,e	L_1, L_2, L_3	1	6
PHY/ a,e	L_1, L_2, L_3	2	6
PHY/ a,e,g	L_1, L_2, L_3	3	6
PHY/ a,e,g	L_1, L_2, L_3	4	6
PHY/ a,e	L_1, L_2, L_3	5	6
PHY/ a,e	L_1, L_2, L_3	6	6
PHY/ a,e,g	L_1, L_2, L_3	7	6
PHY/ a,e,g	L_1, L_2, L_3	8	6
PHY/ a,e,g	L_1, L_2, L_3	9	6
PHY/ a,e,g	L_1, L_2, L_3	10	6

*Bloom's taxonomy levels: Knowledge (L1), Comprehension (L2), Application (L3), Analysis (L4), Evaluation (L5), Creation (L6)

Answer all questions. Each question carries equal mark.

1. (a) $\vec{A}$ and $\vec{B}$ are two vectors in x-y plane. Write their scalar and vector product in component form. 2

   (b) Find the angle between the vectors $\vec{A} = 2\hat{i} + 3\hat{j} + \hat{k}$ and $\vec{B} = -4\hat{i} + 2\hat{j} - \hat{k}$ 2

   (c) Vector $\vec{A}$ has magnitude 2 and vector $\vec{B}$ has magnitude 3. The angle ϕ between $\vec{A}$ and $\vec{B}$ is known to be 0°, 90°, or 180°. For each of the following situations, state what the value of ϕ must be. (In each situation there may be more than one correct answer.) (a) $\vec{A}.\vec{B} = 0$ (b) $\vec{A} \times \vec{B} = 0$ (c) $\vec{A}.\vec{B} = 6$ (d) $|\vec{A} \times \vec{B}| = 6$. 2

2. (a) Deduce the relation $x - x_0 = v_{0x}t + \frac{1}{2}a_x t^2$. The notations have its usual meaning. 2

1.08×10^{-4}

(b) You throw a ball vertically upward from the roof of a tall building. The ball leaves your hand at a point even with the roof railing with an upward speed of 15.0 m/s; the ball is then in free fall. On its way back down, it just misses the railing. Find the ball's position and velocity 4.0 s after leaving your hand. 2

(c) A stone is thrown up vertically with a velocity of *72 Km/h*. Find out the instances at which the magnitudes of its kinetic energy will be half its initial value ($g = 10\ m/s^2$). 2

3. (a) Derive an expression for the maximum height that can be attained by a projectile. 2

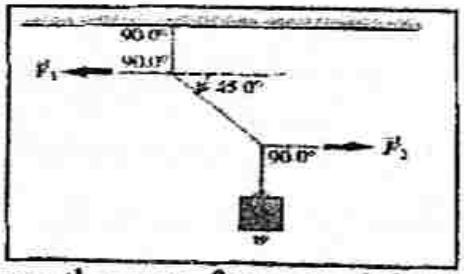
(b) A batter hits a baseball so that it leaves the bat at speed $v_0 = 37$ m/s, at an angle $\alpha_0 = 53.1^0$, at a location where $g = 9.8\ m/s^2$. Find the position of the ball and its velocity at $t = 2.0$ s. 2

(c) An airplane's compass indicates that it is headed due north, and its airspeed indicator shows that it is moving through the air at *240 km/h*. If there is a *100 km/h* wind from west to east, what is the velocity of the airplane relative to the earth? 2

4. (a) A passenger on a Ferries wheel moves in a vertical circle of radius R with constant speed v. The seat remains upright during the motion. Find expressions for the force the seat exerts on the passenger at the top of the circle and at the bottom. 2

(b) A 2.49×10^4 N Rolls-Royce Phantom travelling in the $+x$-direction makes an emergency stop; the x-component of the net force acting on it is -1.83×10^4N. What is its acceleration? 2

(c) In the given figure the weight w is 60.0 N. What is the tension in the diagonal string? 2



5. (a) Derive work–energy theorem for a straight-line motion enacted by a constant force. 2

(b) A 50.0-kg marathon runner runs up the stairs to the top of Chicago's 443-m-tall Willis Tower, the tallest building in the United States. To lift herself to the top in 15.0 minutes, what must be her average 2

power output? Express your answer in watts, and in horsepower.

(c) A bullet of 50g and travelling at 80 m/s, hit a sand bag, penetrates it and gets stopped after passing through a distance of 10 cm. Find the force exerted by the sand bag on the bullet. 2

6. (a) Calculate the work done if a spring is elongated by a distance 'x'. 2

(b) A puck with coordinates x and y slides on a level, frictionless air hockey table. It is acted on by a conservative force described by the potential-energy function $U(x,y) = \frac{1}{2} k (x^2 + y^2)$. Find a vector expression for the force acting on the puck, and find an expression for the magnitude of the force. 2

(c) A force of 800 N stretches a certain spring a distance of 0.200 m. What is the potential energy of the spring when it is stretched 0.200 m? 2

7. (a) What is elastic collision? Write general expressions for conservation of kinetic energy and momentum when a body had 1-dimensional elastic collision with another body at rest. 2

(b) A spring-loaded toy sits at rest on a horizontal, frictionless surface. When the spring releases, the toy breaks into three equal mass pieces, A, B, and C, which slide along the surface. Piece A moves off in the negative x-direction, while piece B moves off in the negative y-direction. What are the signs of the velocity components of piece C? 2

(c) One 110-kg football lineman is running to the right at 2.75 m/s while another 125-kg lineman is running directly toward him at 2.6 m/s. What are the magnitude and direction of the net momentum of these two athletes? 2

8. (a) Analyze static and kinetic friction. 2

(b) You are trying to move a 500 N crate across a floor. To start the crate moving, you have to pull with a 230 N horizontal force. Once the crate starts to move, you can keep it moving at constant velocity with only 200 N. What are the coefficients of static and kinetic friction. 2

(c) The flywheel of an engine has moment of inertia 2.50 kg.m^2 about its rotation axis. What constant torque is required to bring it up to an angular speed of 400 rev/min in 8.00 s, starting from rest? 2