UNIVERSITY OF FORT HARE

ELEMENTARY MECHANICS
PHY 113

DEGREE EXAMINATIONS

MAY / JUNE

YEAR

2025

Time: 2 hours

Subject: PHY 113

Marks: 100

This paper consists of 4 pages, including the cover page

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INSTRUCTIONS

Answer ALL Questions.
Useful information on the back page.
Round off your answers to TWO decimal places.

Question 1 (20)

1. The average hair growth for a person is 1 cm every 3 months. Calculate the speed of the hair growth in m/s. (5)
2. The density of a liquid is found to be 840 kg/m^3. Convert this to grams per cubic centimeter. (5)
3. Newton's law of universal gravitation is represented by $F = \frac{GMm}{r^2}$, where F is the gravitational force exerted by an object of mass M on another object of mass m, and masses are separated by a distance r. Force has units of kg·m/s^2. What are the units of G? (5)
4. Convert a speed of 140 km/hr to m/s. (5)

Question 2 (20)

1. What is the magnitude and direction of the force that must be added to make the resultant of the four forces zero? (10)

   Given the following forces:

   A=200 N,60° west of south

   B=200 N,60° south of east

   C=200 N,60° east of north

   D=200 N,30° north of west

2. A bullet is fired from a rifle that is held 1.6 m above the ground in a horizontal position with an initial speed of 1100 m/s.

   i. Find the time it takes for the bullet to strike the ground. (5)

   ii. What is the horizontal distance traveled by the bullet? (5)

Question 3 (20)

1. A 10 g bullet moving horizontally at 1.8 km/s strikes and passes through a 5.0 kg block initially at rest on a frictionless horizontal surface. The bullet emerges from the block with a speed of 1.0 km/s.

   i. What is the kinetic energy of the block immediately after the bullet emerges? (10)

2. A 2.0 kg brick is moving at a speed of 6 m/s.

   i. How large a force is needed to bring the brick to rest in 7.0×10^{-4} s. (5)

3. In a crash test, a car of mass 1.50×10^3 kg collides with a wall and rebounds. The initial and final velocities of the car are $v_i = 15.0$ m/s and $v_f = 2.60$ m/s, respectively. If the collision lasts for 0.150 s, find

   i. the impulse delivered to the car due to the collision (3)

   ii. the size and direction of the average force exerted on the car. (2)

Question 4 (20)

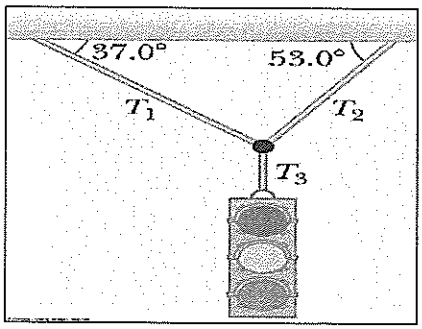
1. A bullet of mass 8 g is fired into a block of mass 250 g that is initially at rest at the edge of a table 1.0 m high. The bullet remains in the block, and after the impact, the block lands 2.0 m from the bottom of the table.

   i. Determine the initial speed of the bullet. (10)

2. Mars has a mass of 6.46×10^{23} kg and a radius of 3.39×10^6 m.

   i. What is the acceleration due to gravity on Mars? (5)

3. A traffic light weighing 150 N hangs from a vertical cable tied to two other cables that are fastened to a support as shown. The upper cables make angles of 37° and 53° with the horizontal.



i. Find the tension values for T_1 and T_2 (5)

Question 5 (20)

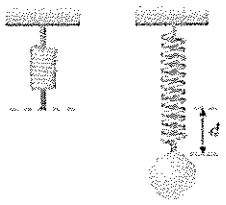
1. A 0.500-kg object connected to a light spring with a spring constant of 20.0 N/m oscillates on a frictionless horizontal surface.

   i. Calculate the total energy of the system and the maximum speed of the object if the amplitude of the motion is 3.00 cm. (4)

   ii. What is the velocity of the object when the displacement is 2.00 cm? (3)

   iii. Compute the kinetic and potential energies of the system when the displacement is 2.00 cm. (3)

2. A common technique used to measure a spring constant is illustrated in the figure below. A spring is hung vertically (Fig. a), and an object of mass m is attached to the lower end of the spring and slowly lowered a distance d to the equilibrium point (Fig. b). Find the value of the spring constant if the spring is displaced by 2.00 cm and the mass is 0.550 kg.



(a) (b) (5)

3. A 0.350-kg object attached to a spring of force constant 1.30×10^2 N/m is free to move on a frictionless horizontal surface. If the object is released from rest at x = 0.100 m, find the force on it and its acceleration. (5)

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The answer isn't always in the book—it's in your confidence to try!

Useful Information

1. $\Delta x = v_{average} t = \frac{(v_o + v)}{2} t$
2. $v = v_o + at$
3. $x = v_o t + \frac{1}{2} a t^2$
4. $v^2 = v_o{}^2 + 2a\Delta x$
5. $g = 9.8\ m/s^2$
6. $G = 6.674 \times 10^{-11}\ N.m^2/kg^2$