

UNIVERSITY EXAMINATIONS

1ST SEMESTER 2022/2023 ACADEMIC YEAR

FIRST YEAR EXAMINATION FOR THE DEGREES OF
BACHELOR OF EDUCATION (SCIENCE)/BACHELOR
OF SCIENCE (GENERAL)

PHYS 112: MECHANICS

STREAM: R

TIME: 2 HRS

DAY: THURS [11.30AM – 13.30]

DATE: 08/12/2022

THIS QUESTION PAPER CONSISTS OF FIVE (5) PAGES

PLEASE DO NOT OPEN UNTIL THE INVIGILATOR SAYS SO.

INSTRUCTIONS TO CANDIDATES:

Answer question **ONE** and any **TWO** questions

Question one carries 40 marks while all other carry 15marks:

QUESTION ONE (40 MARKS)

- (a) (i) State two applications to which dimensional analysis can be put and one limitation associated with one of the applications. (3 marks)
- (ii) Give an example of a vector and scalar quantity. (2 marks)
- (iii) A body of weight 100 N rests on a plane which is inclined at 30° to the horizontal. Calculate the components of the weight parallel and perpendicular to the plane. (2 marks)
- (b) (i) Distinguish between dynamics and kinematics as used in classical mechanics. (2 marks)
- (ii) If $A = 3i - j - 4k$, $B = -2i + 4j - 3k$, $C = i + 2j - k$, find $3A - 2B + 4C$. (3 marks)
- (c) A ball is thrown vertically upwards from ground level with a velocity of 28 m/s
- (i) What was its maximum height above the ground? (2 marks)
- (ii) How long did it take to return to the ground? (Use $g = 10 \text{ m/s}^2$) (2 marks)
- (d) A body is projected with a velocity of 200 m/s at an angle of 30° above the horizontal. Calculate the time taken to reach the maximum height and its velocity after 16 seconds. (5 marks)
- (e) (i) State Newton's second law of motion and give its equation form. (2 marks)
- (ii) In moving a 35kg desk from one side of a classroom to another, it is found that a horizontal force of 195N is necessary to keep it in motion with a constant speed. Find the coefficient of kinetic friction between the desk and the floor. (2 marks)
- (f) A particle A of mass m moving with an initial velocity u makes a 'head-on' collision with another particle B of mass $2m$, B being initially at rest. In terms of u , calculate the final velocity of A if the collision is elastic and when it's inelastic (3 marks)
- (g) (i) Show that the weight of a person of mass m in a lift moving down with an acceleration a is

$W = mg - ma.$ (2 marks)

(ii) If the acceleration due to gravity at the moon's surface is 2.50m/s^2 and its radius is $2.74 \times 10^6 \text{ m}$. Calculate the mass of the moon (3 marks)

(h) (i) Define moment of a force and a torque. (2 marks)

(ii) The wheel of a car has a radius of 0.29 m and is being rotated at 830 revolutions per minute (rpm) on a tyre balancing machine. Determine the speed at which the outer edge of the wheel is moving. (2 marks)

(i) (i) State the difference between kinetic and potential energy. (1 mark)

(ii) A man of mass 75kg climbs 300 m in 30 minutes, at what rate is he working. (2 marks)

QUESTION TWO (15 MARKS)

(a) A stone is thrown at an angle θ to the horizontal with an initial speed u_0 .

(i) Find an expression for the maximum range (3 marks)

(ii) Derive an expression for the trajectory of the stone (4 marks)

(iii) State the uses of projectile motion in our daily life. (2 marks)

(b) (i) Calculate the recoil velocity of a gun having mass equal to 5 kg , if a bullet of 25 g acquires the velocity of 500 ms^{-1} after firing from the gun. (3 marks)

(ii) A body, A of mass 4 kg moves with a velocity of 2m/s and collides head – on with another body, B of mass 3 Kg moving in the opposite direction at 5 m/s . After the collisions the bodies move off together with velocity v . calculate v . (3 marks)

QUESTION THREE (15 MARKS)

(a) The rate of energy spend by a dragonfly when it is hovering above a pond depends on the density ρ of the air, the length of the wings l and the upward force on its wings F . If the power it would have to spend hovering above the pond is given by P . Use the method of dimensions to determine how P is related to ρ , l and F . (4 marks)

(b) Consider a body that starts with an initial velocity u and has a constant acceleration a . If it covers a certain distance (displacement) s in time t and its velocity is v , derive the three equations of motion. (5 marks)

(c) The speed of a motorcycle moving on a straight road is given by the equation

$v = 3 + 2\sqrt{t}$. Determine the distance travelled by the motorcycle between $t = 0$ s and $t = 4$ s. (3 marks)

(d) A stone is dropped from the top of a tower 50 m tall and another stone is projected vertically upwards at 40 m/s at the same time. Determine the time taken for the two stones to meet. (3 marks)

QUESTION FOUR (15 MARKS)

(a) A small block with a mass of 2 kg is tied to a rope 2 m and is spinning at 200 rev/min in a vertical circle. Calculate the tension in the rope when the block is at:

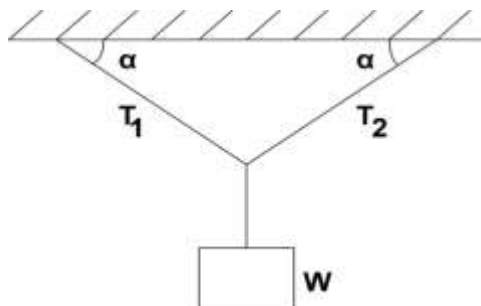
(i) The highest point of the circle. (2 marks)

(ii) The lowest point of the circle. (2 marks)

(iii) Calculate the linear velocity the block must have at the highest point in order for tension in the rope to be zero. (2 marks)

(b) An object of weight W hangs by three ropes as shown below.

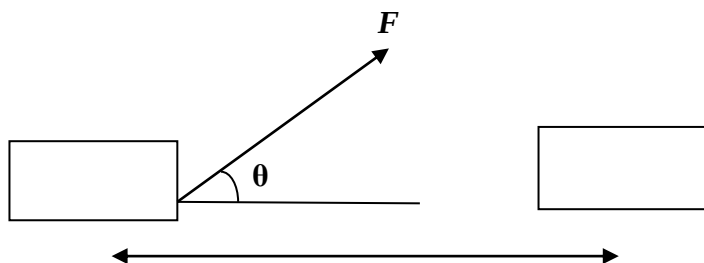
(i). Determine the angle α if $T_1 = T_2 = W$. (3 marks)



- (ii) If $\alpha=41^\circ$ and $W=100\text{N}$, determine the values of tensions T_1 and T_2 (3 marks)
- (c) A body of 2 Kg mass rests on a board which is gradually tilted until at an angle of 27° to the horizontal. The body begins to move down the plane. Determine the co-efficient of friction and the magnitude of the normal and frictional forces when the body begins to slip. (3 marks)

QUESTION FIVE (15 MARKS)

- (a) Determine the work done by a force F directed along 40° frictionless incline plane used to push a block of mass 60kg up the incline a distance of 15m. How much work would have been done if the block was lifted up directly to the final position? (5 marks)
- (d). Figure below shows a force F , causing a displacement S . Derive an expression of the work done by F . (2 marks)



A uniform beam AB of length 5 m and which weighs 200 N is supported horizontally by two vertical ropes X and Y at A and B respectively. Calculate the tensions in the ropes if a man weighing 700 N stands on the beam at a distance of 2 m from A. (3 marks)

- (iii) Explain what is meant by kinetic energy and show that for a particle of the mass m moving with velocity v , the kinetic energy is $\frac{1}{2}mv^2$. (4 marks)