LAIKIPIA UNIVERSITY

UNIVERSITY EXAMINATIONS

SECOND SEMESTER 2023/2024 ACADEMIC YEAR

SECOND YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (GENERAL)

MATH 222: MECHANICS

STREAM: R ***TIME: 2 HRS***

DAY: WEDNESDAY[11.30A.M – 1.30P.M] ***DATE: 10/04/2024***

THIS QUESTION PAPER CONSISTS OF FIVE (5) PAGES

PLEASE DO NOT OPEN UNTIL THE INVIGILATOR SAYS SO.

INSTRUCTIONS: ANSWER QUESTION "?ONE AND ANY OTHER TWO QUESTIONS

QUESTION ONE (30 MARKS)

(a) Define simple harmonic motion **(2 Marks)**

(b) Write down a formula for the displacement x of a particle in SHM in terms of A, w, t and ϕ **(2 Marks)**

(c) Using the formula in (b) above, deduce the equations for the velocity v and acceleration a of the particle. What is the maximum value of v and a in terms of in terms of A and w? **(2 Marks)**

(d) Compute the gravitation force between the earth and the sun if they are 150 million km apart. (mass of the sun= $2.0\times10^{30}kg$ mass of the earth= $6.0\times10^{24}kg$ Take G= $6.67\times10^{-11}Nm^2/kg^2$) **(3 Marks)**

(e) In a machine, the load moves 2m when the effort moves 8m. If an effort of 20N is used to raise a load of 60N, what is the efficiency of the machine? **(3 Marks)**

(f) A 30g bullet is fired horizontally at a speed of 400m/s into a 1.6kg block that hangs on a vertical string.

The bullet remains embedded in the block.

(i) What is the final speed of the bullet and the block? **(3 Marks)**

(ii) How high will the bullet-block system rise? **(3 Marks)**

(g) The mass on the end of a spring oscillates with a period of 1.8s and amplitude of 3.2cm. Compute;

(i) The angular frequency of the oscillation **(3 Marks)**

(ii) Maximum velocity **(3 Marks)**

(iii) Maximum acceleration **(3 Marks)**

(iv) The speed of the particle when the displacement from the equilibrium position is 0.8cm **(3 Marks)**

QUESTION TWO (20 MARKS)

(a) State Newton's first law of motion. **(2 Marks)**

(b) A minibus of mass 1800kg travelling at a constant velocity of 72km/h collides head-on with a stationary car of mass 1000kg. The impact takes 2 seconds before the two move together at a constant velocity for 20s. Compute;

(i) The common velocity **(3 Marks)**
(ii) The distance moved after impact **(3 Marks)**
(iii) The impulsive force **(3 Marks)**
(iv) The change in kinetic energy **(3 Marks)**

(c) An object moving with simple harmonic motion has an amplitude of 2 cm and a frequency of 20Hz. Calculate;

(i) The period of Oscillation **(3 Marks)**
(ii) The acceleration at the middle and at the end of an oscillation **(3 Marks)**

QUESTION THREE (20 MARKS)

(a) Distinguish between forced and dumped oscillation **(2 Marks)**

(b) A clock pendulum has a period of 2.0s and a mass of 750g. The amplitude of the oscillation is 4.8cm.
Compute;

(i) The maximum kinetic energy and **(3 Marks)**
(ii) Its speed when it is travelling through the center **(3 Marks)**

(c) Define the following terms stating their SI units;

(i) Work **(2 Marks)**
(ii) Power **(2 Marks)**

(d) A force of $120\vec{i} + 50\vec{j}$ N acts on a body for 5 secs. If the body's displacement is $3\vec{i} + 4\vec{j}$ m. Calculate;

(i) The Work done **(3 Marks)**
(ii) The Power **(3 Marks)**

(e) Find the angle of banking for a vehicle moving with velocity of 20 m/s to negotiate a safe turn of radius 50m **(2 Marks)**

QUESTION FOUR (20 MARKS)

(a) A ball is kicked with a velocity of 120 m/s at an angle of 40^o above the horizontal. Find:

(i) the time the ball takes to reach the highest point of its path **(3 Marks)**

(ii) the greatest height reached above the ground **(3 Marks)**

(iii) the horizontal distance covered when it hits the ground at the same horizontal level. **(3 Marks)**

(b) A rectangular block of mass 48kg resting on a flat wooden surface requires a minimum force of 360N to start sliding and a force of 240N to keep it moving along the surface at a constant velocity. Determine;

(i) The coefficient static friction **(2 Marks)**

(ii) The coefficient of kinetic friction of the wooden surface **(3 Marks)**

(c) Assume you weigh 683N and the person sitting 2.3m away from you weighs 742N. What is the gravitational force between the two of you? (Take G=6.67x10^{-11} Nm^2/Kg^2) **(2 Marks)**

(d) Starting from rest, a disk rotates about its central axis at an angular velocity of 15.3 rad/s. If the drum then slows at a constant rate of 5.1 rad/s^2;

(i) How much time does it take to come to rest? **(2 Marks)**

(ii) Through what angle does it rotate when coming to rest? **(2 Marks)**

QUESTION FIVE (20 MARKS)

(a) Two particles A and B of mass 10 kg *and* 5 kg respectively are travelling along the same line with constant speeds 6 ms^{-1} and 4 ms^{-1} respectively. If they collide and stick together, find their speed just after impact:

(i) If they collide head on **(3 Marks)**

(ii) If they were originally travelling in the same direction. **(3 Marks**

(b) An object is projected with a velocity of u m/s at an angle of θ to the horizontal.

Show that;

(i) Time of flight, T is given by; **(2 Marks)**

$$T = \frac{2u\sin\theta}{g}$$

(ii) The maximum height reached, H is given by; **(3 Marks)**

$$H = \frac{u^2\sin^2\theta}{2g}$$

(iii) The Horizontal range, R is given by **(3 Marks)**

$$R = \frac{u^2\sin 2\theta}{g}$$

(c) A light string passing over a light smooth pulley carries two masses of 10kg and 14kg at its ends. Determine;

(i) The acceleration and **(3 Marks)**

(ii) Tension in the string if the system is allowed to move from rest. **(3 Marks)**