TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF APPLIED SCIENCES
MATHEMATICS AND PHYSICS DEPARTMENT

UNIVERSITY EXAMINATION FOR BACHELOR OF TECHNOLOGY DEGREE IN APPLIED PHYSICS (BTAP) AND BACHELOR OF TECHNOLOGY DEGREE IN RENEWABLE ENERGY (BTRE)

APS 4106: WAVES AND VIBRATIONS

END OF SEMESTER EXAMINATION

SERIES: May Series 2016:

TIME: 2 HOURS **DATE: May 2016**

Instructions to Candidates

You should have the following for this examination
-Answer Booklet, examination pass and student ID
This paper consists of ***FIVE*** *questions. Attempt Question* ***ONE*** *and any other* ***TWO*** *questions.*
Do not write on the question paper.
The following constraints may be useful.
Gravitation acceleration, g = 9.89 m/s^2
Velocity of sound in air v = 340m/s

QUESTION ONE (30 MKS)

a) (i) Define the following terms as used in simple harmonic motion. (2mrks)

(i) Periodic motion
(ii) Restoring force

(ii) A siren on the train emits a sound wave of frequency 2 kHz. What change in the frequency of the sound does a girl standing near the railroad notice when;

a. the train passes her at 96 km/h? (2mrk)
b. the train moves away from the listener (2mrk)
c. Calculate the mutation of frequency as the train just passes the listener. (1mrk)

(iii) State Huygen's principle. (1mrks)

b) (i) Differentiate between longitudinal and transverse waves. (2mrks)

(ii) Differentiate between a harmonic oscillator and a coupled oscillator. (4mrks)

c) A spring of constant k = 100 N/m hangs at its natural length from a fixed stand as shown in figure 1 below. A mass of 3 kg is hung on the end of the spring and slowly let down until the spring and mass hang at their new equilibrium position.

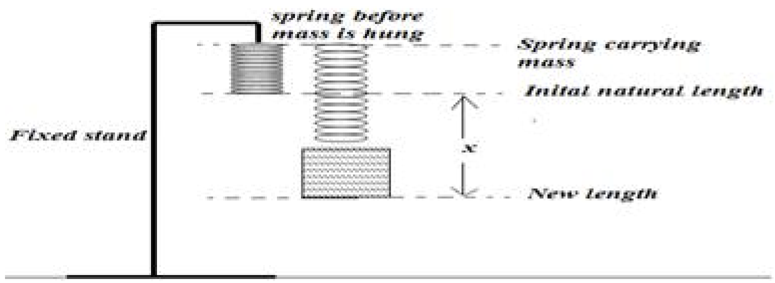

Figure 1: Spring Pendulum

(i) Find the value of the quantity *x* in the figure 1 above. (2mrks)

(ii) The spring is now pulled down an additional distance *x* and released from rest.

(a) What is the potential energy in the spring at this distance? (2mrks)

(b) What is the speed of the mass as it passes the equilibrium position? (2mrks)

(c) What is the period of oscillation for the mass? (2mrks)

d) A pendulum of mass 0.4 kg and length 0.6 m is pulled back and released from an angle of 10˚ to the vertical. If its reference potential energy is chosen to be zero at the bottom of the swing;

(i) What is the potential energy of the mass at the instant it is released. (3mrks)

(ii) What is the speed of the mass as it passes its lowest point? (2mrks)

(iii) If this same pendulum is taken to another planet where its period is 1.0 second, what will be its acceleration due to gravity on this planet? (2mrks)

QUESTION TWO (20 marks)

a) (i) Define the term mechanical resonance. (1mrk)

(ii) Using a sketch diagram, explain a longitudinal wave. (3mrks)

(iii) Describe the energy changes that occur in a spiral spring loaded with a mass M, executing simple harmonic motion vertically when the mass is pulled down and released. (2mrks)

(iv) Define the term Simple Harmonic Motion. (1mrk)

b) Consider a point P that moves at a constant uniform angular velocity (ω) round a circle of radius A and centre O describing a circle as shown figure 2 where N is the projection of P on x-axis.

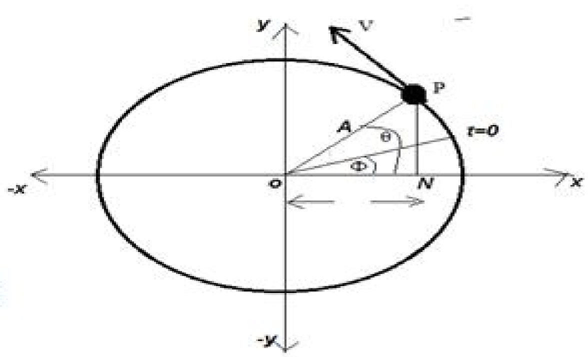

Fig 2

Derive an expression to show;

i) Displacement of particle P? (1mrk)

ii) Acceleration for particle P. (2mrks)

iii) Period for the particle P. (2mrks)

iv) Velocity of particle P. (3mrks)

c) Study figure 3 below where the distance x varies as ***x = A cos (ωt+φ)***. Given that at the initial time t= 0, the displacement of the block m, is at $x = x_o$ with a velocity, $v = v_o$. Determine its frequency, f and amplitude A for this block if it executes simple harmonic motion. (5mrks)

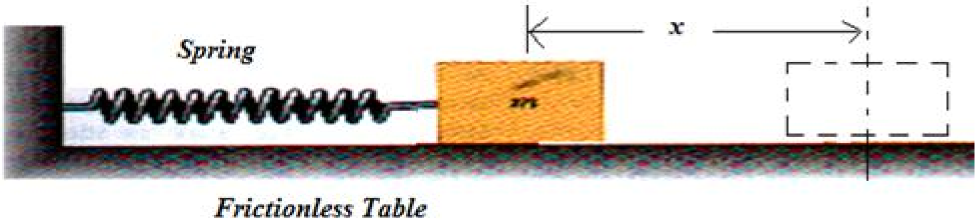

Fig. 3 Horizontally oscilating system

QUESTION THREE (20 MARKS)

a) (i) Describe Simple harmonic motion using an expression. (3mks)

(ii) Consider loaded spring of spring constant, **k,** carrying a small block of mass, **m**, having a displacement ***x*** from its equilibrium position. Show that if it is displaced, the spring can perform a simple harmonic motion with a period given by; $T = 2\pi\sqrt{\frac{m}{k}}$ (4mks)

b) A string pendulum of length, ***l***, carries a small bob of mass, **m,** has a displacement ***x*** from the equilibrium position along the horizontal direction. Show that if it is released it can perform a simple harmonic motion with a period given by; $T = 2\pi\sqrt{\frac{l}{g}}$ (4mks)

c) Consider a string pendulum of length, l carrying a small bob of mass, **m**, have a displacement ***x*** from the equilibrium position along the horizontal direction. If the system is undamped and there is no work done against resistive forces, derive the expression for;

i) instantaneous kinetic energy (E_k) at displacement x . (3mks)

ii) instantaneous Potential energy (E_p) at x given that at x = 0, the potential is zero. (3mrks)

iii) the total energy (E_t) for the system. (3mrks)

QUESTION FOUR (20 MARKS)

a) (i) Explain energy changes occurring in a vertically spring oscillating. (4mrks)

(ii) Define the terms as used in waves: Wavelength, Frequency, Wavefront and Pulse (4mrks)

b) The figure 4 shows a rod of mass, m and cross-sectional area ***A*** floating in a liquid of density ρ.

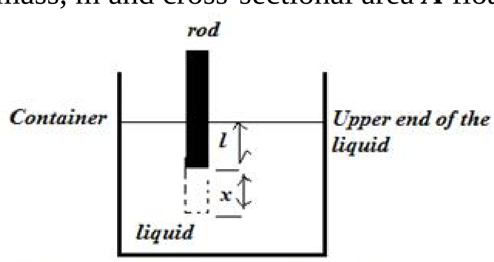

Figure 4: Floating rod oscillating harmonically

If ***l*** is the length of rod below the surface and a small force is applied to the rod so as to depress it a distance x and then its released, show that the rod can perform a simple harmonic motion with a period given by $T = 2\pi\sqrt{\dfrac{l}{k}}$ (4mrks)

c) Consider a system consisting of two springs held tightly at the ends shown below. If the block, m is given a displacement, ***x*** so that the system executes a simple harmonic motion,

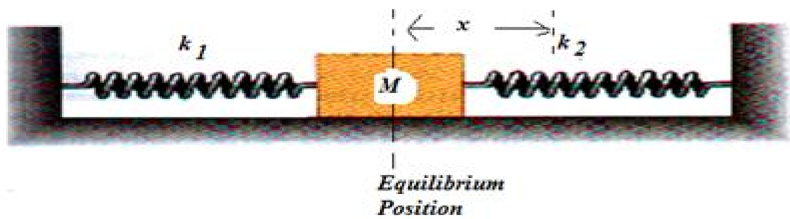

Figure 5: Two spring attached to ome block on a frictionless surface

(i) show that the springs are identical, its period can be given by $T = 2\pi\sqrt{\dfrac{m}{2K}}$ (4mrks)

(ii) show that the springs are **<u>NOT</u>** identical, if its period is given by (4mrks)

$$T = 2\pi\sqrt{\frac{m(k_1 + k_2)}{k_1 k_2}}$$

<u>QUESTION FIVE (20 MRKS)</u>

a) Define the following terms;
   (i) A damped oscillation (1mrk)
   (ii) Damping (1mrk)
   (iii) Undamped oscillation (1mrks)
   (iv) Forced oscillation (1mrks)
   (v) Damping factor (1mrks)

b) (i) Differentiate between a wave and an oscillation. (2mrks)
   (ii) "Undamped oscillations are said to be free oscillation," explain using diagram (2mrks)
   (ii) Describe and illustrate with a well labeled diagram a slightly damped oscillation. (2mrks)

c) Given that the average radius of the earth as **R,** the partial mass of the earth is $\mathbf{M_1}$ while the acceptable mass of the earth is $\mathbf{M_2}$, assuming that the earth performs a simple harmonic oscillation inside the earth, show that its period can be given by; $T = 2\pi\sqrt{\dfrac{R}{g}}$ (5mrks)

d) Ali is a first year physics student at Technical University of Mombasa. He constructed a torsion pendulum with a torsion constant, k, and moment of inertia, I as shown in figure below. He displaced the torsion pendulum as shown to perform simple harmonic motion. Derive an expression to show that its period T, can be given by; $T = 2\pi\sqrt{\dfrac{I}{k}}$ (4mrk)

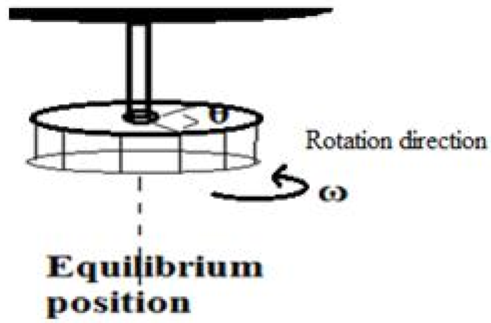

Figure 6: Torsional Pendulum

<u>END</u>