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 : 2hours **DATE: May 2016**

INSTRUCTION TO CANDIDATES

This paper consists of five questions.

Answer question ONE (COMPULSORY) ANY other two questions. The maximum marks for each question is shown.

Mathematical tables and scientific calculators may be used.

The following constraints may be useful.

Gravitation acceleration, g = 9.89 m/s²

Velocity of sound in air = 340m/s

QUESTION ONE (30 MRKS)

a) (i) Describe and illustrate with a well labeled diagram a critically damped oscillation. (2mks)

(ii) Describe and illustrate a heavily damped oscillation with a well labeled diagram. (2mks)

(iii) Give three examples where damped oscillations are applied in real life application. (3mks)

b) Use Newton's second law of motion to show that Hooke's law for a spring satisfies the equation a Simple Harmonic Motion of a vibrating spring. (3mks)

c) A small block of mass 0.10 kg starts from rest at point A, which is at a height of 1.0 m on surface between points A and B and C and D that is frictionless but between points B and C is rough having a coefficient of friction of 0.10. After traveling the distance ℓ = 1.0 m, the small block (P) strikes a larger block (Q) of mass 0.30 kg and sticks to it, compressing the spring to a maximum distance x = 0.50 m. From this system, determine;

Figure 1: Mass sliding on an inclined surface of different

i. the speed of the 0.10 kg block at point B. (3mks)

ii. the acceleration of the 0.10 kg block between points B and C. (3mks)
iii. the speed of the block at point C. (3mks)
iv. the speed of the combined small and large block immediately after they collide. (2mks)
v. the spring constant of the spring. (3mks)

d) A butcher throws a cut of beef on spring scale which oscillates about the equilibrium position with a period of T = 0.500 s. The amplitude of the vibration is A = 2.00 cm (path length 4.00 cm). Find: (i) frequency; (ii) the maximum acceleration; (iii) the maximum velocity; (iv) the acceleration when the displacement is 1.00 cm; (v) the velocity when the displacement is 1.00 cm; (vi) the equation of motion as a function of time if the displacement is A at t = 0. (6mks)

QUESTION TWO (20MRKS)

a) Explain the terms Forced vibration and Resonance giving one example of each. (2mk)

b) (i) Differentiate between a longitudinal wave and a transverse wave. (2mks)
(ii) Is light a wave? Explain. (3mks)

c) (i) A particle with mass, $m = 2.00 \times 10^{-2}$ kg is in SHM at the end of a spring with spring constant, k = 50.0 N/m. The initial displacement and velocity of the particle is 3.00×10^{-2} m and –1.32 m/s respectively. Calculate (a) the angular frequency; (b) the initial phase; (c) the amplitude of the vibration; (d) the period; (e) the frequency. (10 mks)

d) Find the time taken for a particle moving in simple harmonic motion from $\frac{1}{2}A$ to - $\frac{1}{2}A$, given that the period of oscillation is 12s. (3mks)

QUESTION THREE (20MRKS)

a) State five effects caused by damping force on a slowly travelling wave on a string. (5mks)

b) Suppose that the displacements of two vibrations x_1 and x_2 having same vibratory direction and identical frequency are $x_1 = A_1\cos(\omega t + \phi_1)$ and $x_2 = A_2\cos(\omega t + \phi_2)$ respectively, show that the resultant vibration can be described by x, which is the sum of x_1 and x_2 and expressed as $A\cos(\omega t + \Phi)$ where **A** is the resulting amplitude and Φ, is the resulting phase angle. (4mks)

c) A U-tube contains a liquid of density, ρ, at a height, l and internal area of cross-section, A, as in figure 2 below. One surface is depressed a distance x and released to performs a simple harmonic motion.

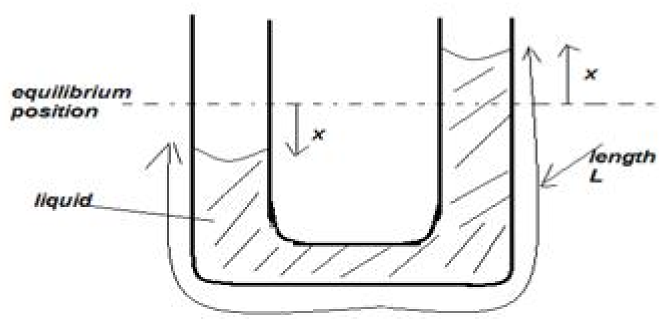


Figure 2: Liquid in a U-tube of length L

Show that the liquid oscillates with a period given by, $T = 2\pi\sqrt{\frac{l}{2g}}$ (4mks)

d) A siren on travelling 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;

i. the train passes her at 96 km/h? (2mrk)

ii. the train moves away from the listener (2mrk)

iii. Calculate the mutation of frequency as the train just passes the listener. (1mrk)

e) State Brewster's Law of polarization. (2mks)

QUESTION FOUR (20MKS)

a) (i) State Huygens principle of optics. (2mks)

(ii) Define the term simple harmonic motion. (2mks)

(iii) What is an oscillator? (2mks)

b) A certain wave source moves in SHM forming an equation of motion of the wave as ***s*** = 0.04 cos(2.5®*t*) (m) propagating in a medium along positive *x*-direction at the speed of 100 m s^{-1}. Find: (i) the wave equation of motion; (ii) the displacement; (iii) velocity of the point mass which is 20 meters away from the wave source at the time of 1.0 second after the wave source starts its motion. (6mrks)

c) A mass m of 1.00kg oscillates at the end of a spring (k = 39.4 N/m) on a horizontal, frictionless surface. At time t = 0s, the mass is at x = +2.00m. Its equilibrium position is x = 0. Find its; (i) angular frequency (ii) linear velocity (iii) and (iv) maximum energy of oscillation acceleration when the amplitude A is 2.00m. (8mks)

QUESTION FIVE (20MRKS)

a) (i) Define the term 'Doppler effect' as used in sound? (2mks)

(ii) Does Doppler Effect occur in a vacuum? Explain. (3mks)

(iii) Define the term intensity of Wave. (1mk)

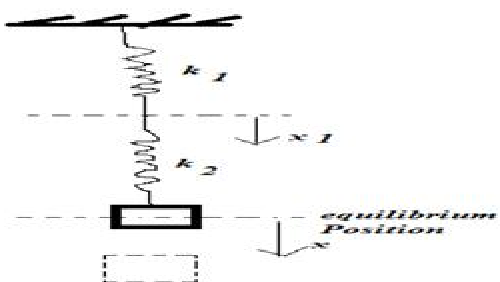
(iv) Explain how a standing wave is produced. (2mks)

b) Given two waves of the same angular frequency, $s_1 = A\cos(\mu t - kx)$ and $s_2 = A\cos(\mu t + kx)$. Show the equation of the wave resulting superposed waves s_1 and s_2 respectively. (4mks)

c) A mass of 0.5 kg oscillates on the end of a spring on a horizontal surface with negligible friction according to the equation, $x = A\cos(\mu t)$. If the spring constant *k* = 50 N/m and the maximum amplitude is *A* = 1.2 m. Determine the; (i) Angular frequency *ω* of the oscillation, (ii) Frequency *f* of oscillation; (iii) displacement from equilibrium position (*x* = 0) at a time of 2 s. (5mks)

d) A Physics student of Technical University of Mombasa assembled two springs ***Q*** and ***R***. Spring **Q** was held tightly at one end joined to spring ***R*** respectively shown in figure below.

Figure 3: Two springs connected in series



If a block of mass, m was attached and allowed to executes a simple harmonic motion, show that the system. (3mks)

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

END