JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THEDEGREE OF BACHELOR OF EDUCATION (SCIENCE)

2022/2023 ACADEMIC YEAR 2ND YEAR 2ND SEMESTER

MAIN CAMPUS

COURSE CODE: SPB9209

COURSE TITLE: OSCILLATIONS AND WAVES

EXAM VENUE: **STREAM: (BED SCI)**

DATE: **EXAM SESSION:**

TIME: 2:00HRS

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1. **Instructions:** **Answer question 1 (Compulsory) in Section A and ANY other 2 questions in Section B.**
2. **Answer Question 1 (compulsory) and ANY other 2 questions**
3. **Candidates are advised not to write on the question paper.**
4. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

SECTION A

QUESTION ONE (Compulsory) (30 Marks)

a. Define simple harmonic motion. (2 marks)

b. Show that the standard equation of a simple harmonic motion with displacement x and angular frequency *w* is given by

$$\ddot{x} + \omega^2 x = 0$$

(3 marks)

c. An object of mass m is attached to a spring of spring constant k and made to oscillate in a simple harmonic motion on a smooth horizontal plane. Its mechanical energy of motion is E. Show that the maximum amplitude A of this oscillations is given by

$$A = \sqrt{\frac{2E}{k}}$$

(4 marks)

d. A physical pendulum of mass *m* and length *d* is suspended to swing freely. Show that its period of oscillations is given by $T = 2\pi\sqrt{\frac{I}{mgd}}$ (4 marks)

e. Define the term damping as used in oscillations and waves (1 marks)

f. Show that the general equation of a damped harmonic motion takes the form

$$\ddot{x} + 2\gamma\dot{x} + \omega^2 x = 0$$

(4 marks)

g. By taking repeated partial derivatives of the general mechanical wave's vertical displacement equation, y(x, t) , with respect to time t and displacement *x* respectively, derive the general wave equation. (4 marks)

h. Describe the three classes of sound as per frequency range (3 marks)

i. Define the term resonance (2 marks)

j. Waves can be broadly classified inti three classes. Name the three classes and briefly describe each (3 marks)

k.

SECTION B

QUESTION TWO (20 Marks)

a. The position of a particle executing simple harmonic motion is given by $x = 1.8sin(60t + 56)m$. Determine

i) the angular frequency, phase, period, frequency, amplitude and range of the motion (3 marks)

ii) the position, velocity and acceleration of the particle at after 40 seconds (6 marks)

iii) the velocity and acceleration of the system when displacement is zero. (4 marks)

b. A point mass m is freely suspended on a string of length l and given a displacement from horizontal so that it swings freely as an oscillating simple pendulum. Show that the period of oscillation is given by

$$T = 2\pi\sqrt{\frac{l}{g}}$$

(4 marks)

c. Determine the frequency of oscillations of a simple pendulum whose length is 40cm (3 marks)

QUESTION THREE (20 Marks)

a. Show that the equation of a damped harmonic oscillator, that oscillates in x direction is given by $\ddot{x} + \gamma\dot{x} + \omega^2 x - \frac{F_o}{m}cos\omega t = 0.$

Further show that the general solution of the above equation takes the form

$$A = \frac{\frac{F_o}{m}}{\sqrt{(\omega_0^2 + \omega^2) + (\gamma\omega)^2}}$$

(10 marks)

b. The equation of a mechanical wave is given by $y(x,t) = 2.5\sin\left[\frac{\pi}{4}(20x - 32t) - \frac{\pi}{6}\right]m$

i) Find the wavelength, frequency and the velocity of the wave. (4 marks)

ii) Find the position, velocity and acceleration of the particle at *x=24m and t=12 minutes* (6 marks)

QUESTION FOUR (20 Marks)

a. A string of length 3.2 m and mass 80g is held taut between two pivots. A playing force of 100N is applied at one end to set standing waves on the string.

i) Determine the frequency of its first four harmonics

ii) Determine the wavelengths of sound heard from the string that corresponds to these first four harmonics. (10 marks)

a. A fire response truck travels down a highway at a speed of 120.0 m/s and has its siren emitting sound at a frequency of 1500 Hz.

i.) What frequency is heard by a stationary observer;

a) being approached by the truck

b) being left by the truck (4 marks)

ii.) What frequency is heard by a passenger in a car traveling at 150.0 m/s in the opposite direction as the car and truck

a) approach each other and

b) pass and move away from each other? Take the speed of sound in air to be 340m/s (6 marks)

QUESTION FIVE (20 Marks)

a. The displacement x of a simple harmonic motion is given by $x = A\sin(\omega t + \phi)$

Show that the ratio of the displacement x to the velocity v of this motion is given by

$$\frac{x}{v} = \omega^{-1}\tan(\omega t + \phi)$$

(4 marks)

b. The wave functions for two waves on a string are

$y_1 = 0.03\sin[\pi(2x + 10t)]m$ And $y_2 = 0.03\sin[\pi(2x - 10t)]m$

i) Write down the equation of the standing wave formed when the two are superposed and obtain the maximum amplitude of the superposed wave (6 marks)

c. A flute of length 2m is used to produce sound waves by blowing into it. What are the wavelengths and frequencies of the first four harmonics that can be produced from the flute when it is (a) open, (b) closed? Take the speed of sound $v = 350m/s$.
(10 marks)