JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THEDEGREE OF BACHELOR OF EDUCATION (SCIENCE)

MAIN

SPECIAL RESITS EXAMINATIONS FEB 2022

COURSE CODE: SPB9209/SPH 204

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. Distinguish between driven harmonic motion and damped harmonic motion. (2 marks)

b. The position of a particle executing simple harmonic motion is given by $x = 1.5\cos(t + 14)m$ where t is in second. Determine

i. the period and range of the motion (3 marks)

ii. the position, velocity and acceleration of the particle at t=2 hours (6 marks)

c. Show that the energy E, contained by a spring whose spring constant is *k* executing a Simple Harmonic Motion, is given by $E = \frac{1}{2}kA^2$ where *A* is the amplitude (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. A uniform string has a mass M of 0.06 kg and a length L of 4.00 m. The speed of a transverse wave pulse on this string is 60m/s. Determine the tension on the string. (3 marks)

f. State any two applications of Doppler effect
(2 marks)

SECTION B

QUESTION TWO (20 Marks)

a. The position of a particle executing a simple harmonic motion is given by $x = 3.5\cos(27t + 7.5)m$.

i) Determine the frequency, period and the range of the oscillations. (3 marks)

ii) Determine the displacement, Velocity and the acceleration of the particle after 25 seconds

(6 marks)

iii) Sketch the displacement- time, velocity-time and acceleration- time graphs of this oscillation on a common cartesian plane (3 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.

i. Show that the period of oscillation is given by

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

(5 marks)

c. Determine the frequency of oscillations of a mass-spring system given that the mass of the suspended object is 0.4kg and the spring constant is 40N/m. (3 marks)

QUESTION THREE (20 Marks)

a. 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. (2 marks)

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

b. When an object executing simple harmonic motion is subjected to energy losses, it undergoes damping.

i) Show that the general equation of a damped harmonic motion takes the form

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

(2 marks)

ii) Evaluate the general solution of the damped harmonic equation above

(3 marks)

iii) From the general equation of the damped harmonic oscillator obtained in (ii) above, there can be three cases of damping namely **overdamping, underdamping and critical damping**. Analytically, present the general equations of each case, physical interpretation and sketch their graphs on a single cartesian plane. (7 marks)

QUESTION FOUR (20 Marks)

(5 marks)

a. If a solid bar of aluminum 16.0 m long is struck at one end with a hammer, a longitudinal pulse propagates down the bar. Find the speed of sound in the bar if it has a Young's modulus of $7.0\text{x}10^{10}$ Pa and a density of $2.7\text{x}10^{3}$ kg/m^3.
(3 marks)

b. A fire response truck travels down a highway at a speed of 150.0 m/s and has its siren emitting sound at a frequency of 1600 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 100.0 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 342m/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 60cm is always ideal for the entertainments in the wedding occasions. What are the wavelengths and frequencies of the first four harmonics that can be produced to entertain the groom and bride when such a flute is (a) open, (b) closed? Take the speed of sound *v= 350m/*s.

(10 marks)