JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THEDEGREE OF BACHELOR OF EDUCATION (SCIENCE)

COURSE CODE: SPB 9209

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 the term damping as used in oscillations (2 marks)

b. On a similar Cartesian plane, sketch the displacement-time graphs of the three cases of damped harmonic motion stating the conditions under which each one occurs (6 marks)

c. Derive the equation for the average power P_{av} transmitted by a wave of angular frequency ω and propagating at wave velocity v on a string of linear mass density μ. (4 marks)

d. By obtaining the second order derivatives of a wave function y(x,t), obtain the general wave equation 3 marks

e. Show that the velocity of propagation of a mechanical wave is given by v=root of F over miu 3 arks

f. State the principle of superposition of waves 1 mark

g. 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)

h. Write down the general equation of the wave formed when the two waves y_1 and y_2 are superimposed, given that
$y_1 = 25\,sin[(3x - 4t)]\,m$ and $y_2 = 25\,sin[(3x + 4t)]\,m$ (3 marks)

i. Define Doppler's effect and mention any three areas of its applications (5 marks)

j. The open end of an air column is approximately a displacement antinode and a pressure node. Explain? (3 marks)

SECTION B

QUESTION TWO (20 Marks)

a. The position *x,* in metres, of a particle executing simple harmonic motion is given by $x = 0.45\,cos(25t + 60)\,m$ Determine

i) the period, frequency, phase and the range of the motion (4 marks)

ii) the position, velocity and acceleration of the particle after 25 seconds (6 marks

b. Show that the general equation of a Driven Harmonic motion takes the form
$\ddot{x} + \gamma\dot{x} + \omega^2 x - \frac{F_0}{m}cos(w_0 t) = 0$
Give the meaning of all the constants involved (4 marks)

c. By expressing the general equation of the DHM given in (b) above, in complex exponential form, show that the general solution of the amplitude of oscillation A takes the form

$$A = \frac{\frac{F_0}{m}}{\sqrt{\left(w_0^2 - W^2\right)^2 + (\gamma\omega)^2}} = 0$$ (6 marks)

QUESTION THREE (20 Marks)

a. Define a simple harmonic motion (2 marks)

b. Apoint mass *m* is freely suspended on a spring whose spring constant is *k. The spring is subjected to an external force that stretches it and eventually withdrawn such that it is set in uniform harmonic motion*.

i. Show that the period of oscillation is given by $T = 2\pi\sqrt{\frac{m}{k}}$

(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 20N/m. (3 marks)

a. The equation of a mechanical travelling wave is given by

$$y(x,t) = 25\sin\left[\frac{5\pi}{4}(3x - 4t) + \frac{\pi}{8}\right]m$$

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

ii) Find the position, velocity and acceleration of the particle at *x=10m and t=1.8minutes* (6 marks)

QUESTION FOUR (20 Marks)

a. A string of length 1.6m and mass 40g is held taut between two pivots. A playing force of 60N is applied at one end to set standing waves on the string. Determine

i) the fundamental frequency andthe corresponding fundamental wavelength of the wave 4 marks

ii) The first three overtones and their corresponding wavelengths of the standing wave formed 6 marks

b. A pipe is 3.6m long, Determine the frequency and wavelengths of the first four harmonics when the pipe is (i) open (ii) closed.

Take the velocity of sound to be 340m/s

(10 marks)

QUESTION FIVE (20 Marks)

a. A simple experimental setup for demonstrating resonance in an air column consists of a vertical pipe open at both ends partially submerged in water and a tuning fork vibrating at an unknown frequency placed near the open top of the pipe. The length L of the pipe above water surface, which corresponds to the air column in the pipe, can be adjusted by moving the pipe vertically upwards. The sound waves generated by the fork are reinforced when L corresponds to one of the resonance frequencies of the pipe.
For a certain pipe, the smallest value of L for which a peak occurs in the sound intensity is 180mm. determine
   i) The frequency of the tuning fork. (3 marks)
   ii) The values of L for the next three resonance frequencies. (6 marks)

b. A student running back to school at a speed of 30m/s hears the bell stationed at the gate ringing at a frequency of 600Hz. What frequency is heard by the student
   i) as he runs approaching the gate (2 marks)
   ii) as he runs past the gate entering the classroom at double the speed. (3 marks)

c. Safaricom Sales and Marketing team hoisted a disco on top of a trailer moving at 60m/s. The disco emits musical waves at 3,000Hz. A sales manager, who is in supervision mission, is driving his car in the opposite direction at 100m/s. What frequency of sound is heard by the manager in his car.
   i) When he is approaching the marketing team. (3 marks)
   ii) When he has passed the marketing team. (3 marks)

Take velocity of sound in air to be 340m/s.