JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THEDEGREE OF BACHELOR OF EDUCATION (SCIENCE)

MAIN

REGULAR RESIT

COURSE CODE: SPH 204

COURSE TITLE: OSCILLATIONS AND WAVES

EXAM VENUE: LAB 1 **STREAM: (BED SCI)**

DATE: 4/5/2016 **EXAM SESSION: 2.00 – 4.00PM**

TIME: 2:00 HRS

Instructions:

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

QUESTION ONE (Compulsory) (30 Marks)

a. Define simple harmonic motion (1 mark)

b. The position of a particle executing simple harmonic motion is given by $x = 0.25\sin(30t + 34)m$ where t is in second. Determine

i. the period and range of the motion (4 marks)

ii. the position, velocity and acceleration of the particle at t=0.9sec (6 marks)

c. Show that the energy E, contained by a spring whose spring constant is *k* executing simple harmonic motion, is given by $E = \frac{1}{2}kA^2$ where *A* is the amplitude (4 marks)

d. A uniform string has a mass M of 0.08 kg and a length L of 6.00 m. Tension is maintained in string by suspending a block of mass 6.0 kg on the free end.

i. Find the speed of a transverse wave pulse on this string. (2 marks)

ii. Find the time it takes the pulse to travel from the point of suspension of the string to the end where the mass is attached. (2 marks)

e. Derive the linear wave equation of the form $\frac{\partial^2 y}{\partial x^2} - \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2} = 0$ (3 marks)

f. The length of an air column is varied by adjusting the water level in a pipe. A vibrating tuning fork is placed at the open end. As the water is lowered, the first resonance is heard when the length of the column is 18.9cm while the fourth resonance is heard when when the length of the column is it is 96.1 cm. determine the frequency of the tuning fork.

(3 marks)

g. Show that the velocity of a longitudinal wave e.g. sound propagating in a fluid of density *p* and bulk modulus *B* is given by the equation

$$v = \sqrt{\frac{B}{\rho}}$$

(3 marks)

a. Define Doppler Effect (2marks)

QUESTION TWO **(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

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

(5 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

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

(5 marks)

c. Distinguish between simple harmonic motion and damped harmonic motion (2 marks)

QUESTION THREE **(20 Marks)**

a. The equation of a mechanical wave is given by $y(x,t) = 1.5\sin\left[\frac{\pi}{2}(20x - 30t) - \frac{\pi}{8}\right]m$

Find

i) The wavelength, the frequency and the velocity of the wave pulse(5marks)

ii) The particle position, velocity and acceleration at *x=2m and t=4 seconds*

(9 marks)

b. A wave that propagates along a string transports energy and transmits power. Show that 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 is given by

$$P_{av} = \frac{1}{2}\mu(\omega A)^2 v$$

(6 marks)

QUESTION FOUR **(20 Marks)**

a. If a solid bar of aluminum 1.00 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, which 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.

How long does the pulse take to travel from one end of the bar to the other? (5 marks)

b. An ambulance travels down a highway at a speed of 75.0 m/s, its siren emitting sound at a frequency of 400 Hz.

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

a) being approached by the ambulance

b) being left by the ambulance (5 marks)

ii.) What frequency is heard by a passenger in a car traveling at 55.0 m/s in the opposite direction as the car and ambulance

a) approach each other and

b) pass and move away from each other? Take the speed of sound in air to be 350m/s (10 marks)

QUESTION FIVE (20 Marks)

a) In an effort to get your name in the Guinness Book of World Records, you set out to build a bass viol with strings that have a length of 5.0 m between fixed points. One of the strings has a mass per unit length of 12g/m and a fundamental frequency of 20.0 Hz.

i. Calculate the tension in this string. (2 marks)

ii. Calculate the frequency and wavelength of the second harmonic. (4marks)

iii. Calculate the frequency and wavelength of the second overtone. (4 marks)

b. The production of sound during speech or singing is a complicated process. Let's concentrate on the mouth. A typical depth for the human mouth is about 8.0 cm, although this number can vary. We can model the mouth as an organ pipe that is open at the back of the throat.

What are the wavelengths and frequencies of the first four harmonics you can produce if your mouth is (a) open, (b) closed? Take the speed of sound $v = 350 m/s$. (10 marks)