MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR BACHELOR OF EDUCATION

SPH 300: WAVE THEORY

DATE: 27/7/2017 **TIME: 11:00 – 1:00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

Required data and constants:

Earth's gravitational pull = 9.8 N/Kg

The Universal Gravitational Constant G = 6.67 × 10 $^{-11}$ N.m^2/Kg^2

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Differentiate between a wave and a vibration. (2 marks)

b) Distinguish between the epoch and phase of a vibration. (2 marks)

c) Define simple harmonic motion? Give two examples of such a motion. (3 marks)

d) Two parallel simple harmonic vibrations having amplitudes 4 cm and 5 cm respectively are acting simultaneously on a particle. The two vibrations have the same epoch angle equal to $\pi/4$. Find the equation describing the vibration of the particle. (3 marks)

e) Write down three conditions that are necessary for interference of sound waves.(3 marks)

f) Sound waves are longitudinal waves in air. The speed of sound depends on temperature; at 20^0C it is 344 m/s. What is the wavelength of a sound wave in air at 20^0C if the frequency is 262 Hz? (3 marks)

g) Describe briefly the phenomenon of diffraction. Clearly distinguish between Fraunhofer and Fresnel diffraction. (4 marks)

h) Obtain an expression for the apparent frequency of the note heard by the listener when he moves away from a stationery source. (3 marks)

i) Explain how the frequency of a tuning fork can be determined by the method of beats. (3 marks)

j) Distinguish between an overtone and a harmonic. Find the length of a closed organ pipe that can produce a musical note A=440Hz. Assume the speed of sound in air is 343 m/s. (4 marks)

QUESTION TWO (20 MARKS)

a) A note produces 4 beats/second with a tuning fork of frequency 512 Hz and 6 beats/second with a tuning fork of frequency 514 Hz. Find the frequency of the note. (3 marks)

b) Show that for a particle executing simple harmonic motion, the instantaneous velocity is $\omega\sqrt{a^2 - y^2}$ and instantaneous acceleration $-\omega^2 y$ where ω and y are the angular frequency and displacement respectively. (5 marks)

c) Two simple harmonic motions acting simultaneously on a particle are given by:

$y_1 = 2\sin\left(\omega t + \frac{\pi}{6}\right)$ and $y_2 = 3\sin\left(\omega t + \frac{\pi}{3}\right)$. Calculate:

(i) Amplitude (2 marks)

(ii) Phase constant (2 marks)

(iii) Time period of the resultant vibration. (2 marks)

d) A simple harmonic motion is represented by the equation: $y = 8\sin\left(12t - \frac{\pi}{15}\right)$: where y is measured in meters, t in seconds and the phase angle in radians. Calculate:

(i) Frequency (1 mark)

(ii) Maximum displacement (2 marks)

(iii) Maximum velocity (2 marks)

(iv) Maximum acceleration (1 mark)

QUESTION THREE (20 MARKS)

a) For a particle vibrating simple harmonically, the displacement is 15 cm at the instant the velocity is 5 cm/sec and the displacement is 8 cm at the instant the velocity is 18 cm/sec. calculate:

(i) Amplitude (2 marks)

(ii) Frequency (2 marks)

(iii) Time period. (2 marks)

b) A tuning fork A produces 4 beats/second with a tuning fork B of frequency 256. A is filed and the beats occur at shorter intervals. What was its original frequency? (4 marks)

c) Find the tension in a 60 cm guitar string that has a mass of 1.40 g if it is to play the note G with a frequency of 396 Hz. Assume that the wavelength of the note will be two times the length of the string, or $\lambda = 120\,cm$. (4 marks)

d) A submarine (sub A) travels through water at a speed of 8.00 m/s, emitting a sonar wave at a frequency of 1 400 Hz. The speed of sound in the water is 1 533 m/s. A second submarine (sub B) is located such that both submarines are traveling directly toward each other. The second submarine is moving at 9.00 m/s.

i. What frequency is detected by an observer riding on submarine B as the subs approach each other? (2 marks)

ii. The subs barely miss each other and pass. What frequency is detected by an observer riding on submarine B as the subs recede from each other? (2 marks)

iii. While the subs are approaching each other, some of the sound from submarine A reflects from sub B and returns to sub A. If this sound were to be detected by an observer on submarine A, what is its frequency? (2 marks)

QUESTION FOUR (20 MARKS)

a) A particle performs simple harmonic motion given by the equation: $y = 20\sin(\omega t + \alpha)$. If the time period is 20 seconds and the particle has a displacement of 5 cm at $t = 0$, find:

(i) The Epoch (2 marks)

(ii) The Phase angle at $t = 8\,\text{sec}$ (2 marks)

(iii) The phase difference between two positions of the particle 20 seconds apart. (2 marks)

b) State the Huygens' Principle. (2 marks)

c) A double-slit source with slit separation 0.2 mm is located 1.2 m from a screen. The distance between successive bright fringes on the screen is measured to be 3.30 mm. What is the wavelength of the light? (4 marks)

d) Coherent laser light of wavelength 633 nm is incident on a single slit of width 0.25 mm. The observation screen is 2.0 m from the slit.

(i) What is the width of the central bright fringe? (2 marks)

(ii) What is the width of the bright fringe between the 5th and 6th minima? (2 marks)

e) Two waves traveling in opposite directions produce a standing wave. The individual wave functions are; $\begin{matrix} y_1 = 4.0\sin(3.0x - 2.0t) \\ y_2 = 4.0\sin(3.0x + 2.0t) \end{matrix}$. Where x and y are measured in centimeters and t is in seconds. (i) Find the amplitude of the simple harmonic motion of the element of the medium located at $x = 2.3\,\text{cm}$. (ii) Find the positions of the nodes and antinodes if one end of the string is at $x = 0$. (4 marks)

QUESTION FIVE (20 MARKS)

a) Explain how the frequency of a tuning fork can be determined by the method of beats. (3 marks)

b) A tuning fork A produces 4 beats/second with a tuning fork B of frequency 256. A is waxed and the beats occur at shorter intervals. What was its original frequency? (4 marks)

c) A 200-g block connected to a light spring for which the force constant is 5.00 N/m is free to oscillate on a frictionless, horizontal surface. The block is displaced 5.00 cm from equilibrium and released from rest

(i) Find the period of its motion. (2 marks)

(ii) Determine the maximum speed of the block. (3 marks)

(iii) What is the maximum acceleration of the block? (2 marks)

d) A sinusoidal wave traveling in the positive *x*- direction has an amplitude of 15.0 cm, a wavelength of 40.0 cm, and a frequency of 8.00 Hz. The vertical position of an element of the medium at t = 0 and x = 0 is also 15.0 cm.

(i) Find the wave number k, period T, angular frequency v, and speed v of the wave. (4 marks)

(ii) Determine the phase constant f and write a general expression for the wave function (2 marks)