UNIVERSITY EXAMINATIONS
2023/2024 ACADEMIC YEAR

SECOND YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF B. ED (SCIENCE) & BACHELOR OF SCIENCE (PHYSICS)

COURSE CODE: SPH 211

COURSE TITLE: WAVES AND OSCILLATIONS

DURATION: 2 HOURS

DATE: 19/12/2023 **TIME: 9:00-11:00AM**

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.

QUESTION ONE [30 MARKS]

a) Define the following terms as used in waves and oscillatory motion:
   i. Periodic motion [1 mark]
   ii. Period, T [1 mark]
   iii. Frequency [1 mark]

b) The total energy of a particle executing SHM of period 2π s is $2.56x10^{-1}J$. The displacement of the particle at $\frac{\pi}{4}$ s is 11.312 cm. Calculate the amplitude of motion and mass of the particle. [3 marks]

c) Define the term *simple harmonic motion* and give two cases involving simple harmonic motion [3 marks]

d) Show that the frequency of the second overtone for vibrating air columns in an open pipe is $f = 3f_o$ [3 marks]

e) The density of hydrogen iodide gas is $5.79kgm^{-3}$ at STP. What is the speed of sound in hydrogen iodide at 50°C? Assume that the speed of sound in air is 331ms and Bulk modulus for ideal gases is the same (density of air = $1.29\ kg/m^3$) [3 marks]

f) Two frequencies of 260Hz and sounded together. How many maxima are heard per second? Find the beat period. [3 marks]

g) In a certain engine, a piston executes vertical simple harmonic motion with amplitude 2cm. A washer rests on the top of the piston. If the frequency of the piston is slowly increased, at what frequency will the washer no longer stay in contact with the piston? [4 marks]

h) The superposition of two harmonic oscillations in the same direction leads to the resultant displacement $y = A cos\pi t sin 15\pi$, where t is expressed in seconds. Find the frequency of the component vibrations the beat frequency. [4 marks]

i) Suppose a wave is represented by $y = aSin(2000\pi t - \frac{\pi t}{0.17})$. Find the frequency, wavelength, speed and phase difference, given that $x = 0.17$ [4 marks]

QUESTION TWO [20 MARKS]

a) Distinguish between a wave and an oscillation [2 marks]

b) The equation of motion for a damped oscillator is given by: [8 marks]

$2\frac{d^2x}{dt^2} + r\frac{dx}{dt} + 5x = 0$. For what range of values for damping constant will the motion be: Underdamped, over damped and critically damped.

c) *0.5kg* mass moves in a simple harmonic motion at the end of a horizontal spring of force constant *2.0N/m*. if the amplitude is *0.1m*, what is the period of motion, the equation of displacement at any instant of time and the equation of acceleration of the mass as a function of time. [6 marks]

d) A wave motion is described by the equation $y = 20mm\ Sin\ 10\pi t$ where t is in seconds. What is the amplitude and period? [4 marks]

QUESTION THREE [20 MARKS]

a) i) Distinguish between damped and undamped simple harmonic motion [3 marks]

ii) A mass of 1 g vibrates through 1 mm on each side of the middle point of its path and makes 500 complete vibrations per second. Assume that its motion is simple harmonic, show that the maximum force [6 marks]

acting on the particle is $\pi^2 N$

iii) A loudspeaker produces musical sound by means of the oscillation of the diaphragm. If the amplitude of the oscillation is limited to $1.0\ x\ 10^{-3}$ mm, what frequency will result in the magnitude of the diaphragm's acceleration exceeding g? [6 marks]

b) Using Kundts' apparatus, an oscillator is set at 3KHz. The dust settles in the tube such that the distance between the adjacent heaps is 5.75 cm. calculate the speed of sound in air and the new distance between heaps of dust when the frequency is set at 5KHz. [5marks]

QUESTION FOUR [20 MARKS]

a) Define the term Doppler's effect [1mark]

b) The frequency of a car horn is 400 Hz. What frequency is observed if the car moves towards a stationary receiver at a velocity of 30 m/s (take velocity of sound in air as 340 m/s) [5marks]

c) The equation of motion for forced oscillations is: [8 marks]

$2\frac{d^2x}{dt^2} + 4\frac{dx}{dt} + 16x = 32cos2t$ Find: Amplitude, Phase lag, Q factor and Power dissipation

d) Suppose a mass, m is attached to the end of a spring of force constant, k (whose other end is fixed) and slides on a frictional surface through a distance x from the mean position. Show that the frequency, f of the motion is given by: $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ [6 marks]

QUESTION FIVE [20 MARKS]

a) Differentiate between a standing wave and a progressive wave [4 marks]

b) A wire of uniform cross – section area has a tension of 20N and produces a note of 100Hz when plucked in the middle. Find its diameter if it is 1m long and has a density of 6000kg/m3. State the frequency of the third overtone and the wavelength of the third harmonic. [6 marks]

c) When sounding a tuning fork, a frequency 528Hz is placed over a column of air dipped in water, a resonance is obtained at length of 14.8 cm and 45.0 cm respectively of the air column. Find the velocity of sound in air and the end connection of the pipe. [6 marks]

d) At a cocktail party, 38 people were speaking equally loudly. If only one person was talking, the sound level would be 72 decibels. Find the sound level when all 38 people were talking (take $I_o = 1 \times 10^{-12} W/m^2$). [4 marks]