ALUPE UNIVERSITY

OFFICE OF THE DEPUTY VICE CHANCELLOR

ACADEMICS, RESEARCH AND STUDENTS AFFAIRS

UNIVERSITY EXAMINATIONS

2024/2025 ACADEMIC YEAR

SECOND YEAR FIRST SEMESTER REGULAR MAIN EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **PHY 212**

COURSE TITLE: **OSCILLATIONS AND WAVES**

DATE: 15th January 2025 **TIME: 1100 - 1400**

INSTRUCTION TO CANDIDATES

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REGULAR MAIN EXAMINATION

PHY 212: OSCILLATIONS AND WAVES

STREAM: BED (Science) **DURATION: 3 Hours**

INSTRUCTIONS TO CANDIDATES

i. *Answer **TWO** questions in section **A** and any other **THREE** questions in section **B**.*

ii. *You may need to use the following constants*

Molar mass of Helium	$0.004 kg/mol$
Universal gas constant	$R = 8.314 J/mol/K$
Acceleration due to gravity	$g = 9.8 m/s^2$
Speed of sound in air	$v = 340 m/s$

SECTION A (24 MARKS)

Question One (12 Marks)

a) List any four examples of vibrational motion (4 Marks)

b) State the key features of vibrational motion (2 Marks)

c) Distinguish between transverse and longitudinal waves (2 Marks)

d) A steel wire 6 m long has a mass of 60g and is stretched with tension of 1000N. What is the speed of propagation of a transverse wave on this wire? (4 Marks)

Question Two (12 Marks)

a) A particle of mass 2 kg has damping force whose magnitude is numerically equal to 8 times the instantaneous speed. The particle is also attracted along the x-axis towards the origin by a force whose magnitude is numerically equal to 8x. If it is initially at rest (t=0) at x = 20 and $\frac{dx}{dt} = 0$.

Given that the general solution is of the form $x = e^{-2t}(A + Bt)$. Find

i) the position of the particle at any time (4 Marks)

ii) the velocity of the particle at any time (3 Marks)

iii) Illustrate graphically the position of the particle as a function of time, hence describe the motion. (2 Marks)

(b) A block of mass (m), on a horizontal frictionless table, is attached to a rigid support by a spring of spring constant (k). The horizontal oscillations of the system are simple harmonic in nature. Show that its period time is given by $T = 2\pi\sqrt{\frac{m}{k}}$. (3 Marks)

SECTION B (36 MARKS)

Question Three (12 Marks)

a) State the condition under which diffraction will occur (2 Mark)

b) State physical interpretation of the differential equation of LC circuit. (2 Marks)

c) Given that the charge on the capacitor is $Q = Q_0 \cos(wt)$, show that the voltage across the inductor (V_L) is given by $V_L = \omega^2 LQ$. (4 Marks)

d) What are standing waves and how are they produced (2 Marks)

e) An LCR circuit has $L = 10mH$, C = 1.0 μF, and R = 1 Ω. Determine angular frequency, ω that correspond to this oscillation. (2 Marks)

Question Four (12 Marks)

a) List any three factors influencing the speed of propagation of transverse and longitudinal waves (3 Marks)

b) A string has a linear mass density of $0.25kg/m$ and stretched with tension of $25N$. One end is given a sinusoidal motion with a frequency of $5Hz$ and amplitude of $0.01\ m$. At the time $t = 0$, the end has a zero displacement and moving in the positive y direction.

i. Determine speed of propagation of the wave (2 Marks)

ii. Find the amplitude of the wave (1 Mark)

iii. Find the wave length (1 Marks)

iv. Write a wave function describing this wave. (2 Marks)

c) On the same graph show critically damped, over-damped and under damped body oscillations (3 Marks)

Question Five (12 Marks)

a) What is a forced oscillation? (2 Marks)

b) A man enters a tall tower. He needs to know the height of the tower, but darkness obscures the ceiling. He does note, however, that a long pendulum extends from the ceiling almost to the floor and that its period is 12 s. How tall is the tower? (3 Marks)

c) Explain the term Beat in oscillation and waves (2 Marks)

d) A train moving at a speed of $40m/s$ sound its whistle, which has a frequency of $500\ Hz$. Determine the frequency heard by a stationary observer as the train approaches the observer. (5 Marks)

Question Six (12 Marks)

a) A standing wave on a string is expressed as $y = 0.5 \sin\frac{\pi}{3}x \cos 40\pi t$

i. What are the amplitude and frequency of the component waves whose superposition can give rise to these expressions. (4 Marks)

ii. Find the velocity of the wave in 4 a(i) above (3 Marks)

b) What is the meaning of quality factor or Q-value of damped harmonic oscillator (2 Marks)

c) Deduce the expression $\frac{\text{energy stored in the system}}{\text{energy lost per cycle}} = \frac{Q}{2\pi}$ and state the two roles of quality factor. (3 Marks)

Question Seven (12 Marks)

a) Two waves traveling in opposite directions produce a standing wave. The individual wave functions are: $y_1 = A\sin(kx - \omega t)$ and $y_2 = A\sin(kx + \omega t)$. Find the resultant wave function. (3 Marks)

b) The displacement of the medium in a sound wave is given by the equation $Y_1 = Acos(ax + bt)$. Where A, a and b are positive constants. Determine the wavelength and frequency of incident wave? (4 Marks)

c) The equation of motion $m\ddot{x} = -kx$ applies directly to the system a pendulum of mass m, and length l. If the pendulum bob is displaced by a small angular displacement θ and displacement of m along the circle of length l is $l\theta$ (θ in radians), show that $\omega^2 = \frac{g}{l}$. (5 Marks)