UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR

SECOND YEAR FIRST SEMESTER
SUPPLEMENTARY/SPECIAL EXAM

FOR THE DEGREE OF B.Sc (PHYSICS)

COURSE CODE: SPC 212

COURSE TITLE: VIBRATIONS AND WAVES

DURATION: 2 HOURS

DATE: 4/8/2023 **TIME: 2:00-4:00PM**

INSTRUCTIONS TO CANDIDATES

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

QUESTION ONE [30 Marks]

a) A particle oscillates with SHM of amplitude 4cm and frequency 5 Hz. At time t=0 the particle is at its equilibrium position (ψ=0). Write down the equations describing the position of the particle as a function of time in the form of $\psi = A\cos(wt+\phi)$, giving the numerical values of A, ω and ϕ. [4]

b) Define Simple Harmonic Motion and give two examples. [3]

c) A massless spring with no mass attached to it is hangs from a rigid support. A mass m is now hung on the lower end of the spring. The mass is supported on the platform so that the spring remains relax. The supporting platform is suddenly removed. The mass begins to oscillate. The lowest position of the mass during the oscillation is 5 cm below the place where it was resting on the platform. What is the frequency of oscillation? [4]

d) Name three physical parameters that characterize simple harmonic motion. [3]

e) Compute the frequency of an electrical circuit consisting a coil of inductance 0.1 mH and a capacitor 1.0 μF. What is the maximum current in the circuit if the capacitor is charged to 5 volts? Neglect the resistance of the coil. [4]

f) Give the meaning of "Relaxation time, τ". [2]

g) Diana goes to bed at 10:00 pm sharp every day. Is it an example of periodic motion? If yes, what is the time period? If no, why? Is it an example of simple harmonic motion? If yes, why? [4]

h) Show that the sine and cosine functions describing the displacement of the oscillating body executing simple harmonic motion are equivalent. [3]

i) We would like to make an LC circuit that oscillates at 440 Hz. If we have a 2 H inductor, what value of capacitance should we use? [3]

QUESTION TWO [20 Marks]

a) A particle of mass 0.50 kg executes simple harmonic motion under a force $F = -(50\frac{N}{m})X$. If it crosses the center of oscillation with a speed of 10 m/s, find the amplitude of the motion. [4]

b) Consider a particle of mass *m* moving along the x-axis. Suppose, a force $F = -kX$ acts on the particle where *k* is a positive constant and *X* is the displacement of the particle from origin. If the particle executes simple harmonic motion with the center of oscillation at the origin, show that the displacement and velocity at time t is given as $X = A\sin(\omega t+\delta))$ and $v = A\omega\cos(\omega t+\delta)$ respectively. [16]

QUESTION THREE [20 Marks]

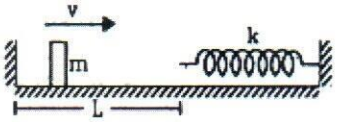
a) Using vector method, show that the resultant amplitude of two simple harmonic motions represented by $X_1 = A_1 \sin \omega t$ and $X_2 = A_2 \sin(\omega t + \delta)$ is given as

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos\delta}$$ [4]

b) Find the amplitude of simple harmonic motion obtained by combining the motions

$X_1 = (2.0cm)\sin \omega t$ and $X_2 = (2.0cm)\sin\left(\omega t + \frac{\pi}{3}\right)$. [4]

c) Describe the motion of mass *m* shown. The walls and the block are elastic. [12]



QUESTION FOUR [20 Marks]

Obtain an expression for the displacement of the damped harmonic oscillator where the damping force is proportional to the velocity. Discuss the effect of the damping on the displacement and frequency of the oscillator.

[20]

QUESTION FIVE [20 Marks]

a) A small spherical steel ball is placed a little away from the center of a concave mirror whose radius of curvature is 2.5m. When the ball is released, it begins to oscillate about the center. What is the period of oscillation? Neglect friction and take g=10m/s^2. [4]

b) A simple pendulum of length 40cm oscillates with an angular amplitude of 0.04 rad. Find:
   i) The time period, [2]
   ii) The linear amplitude of the bob, [2]
   iii) The speed of the bob when the string makes 0.02 rad with vertical and, [2]
   iv) The angular acceleration when the bob is in momentary at rest. Take g=10m/s^2 . [2]

c) Two vibrations along the same line are described by the equations:
   $X_1 = 0.03\cos 10\pi t$ and $X_2 = 0.03\cos 12\pi t$.
   Obtain the equation describing the resultant motion and hence the beat period. [4]