KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

FIRST YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF B.SC (PHYSICS)

COURSE CODE: SPC 112

COURSE TITLE: GRAVITATION AND OSCILLATORY MOTION

DATE: ~~02~~ 03/02/2022 **TIME:** 8-10AM

INSTRUCTIONS TO CANDIDATES

TIME: 2 Hours

Answer question ONE and any TWO of the remaining

QUESTION ONE (30 marks) Compulsory

(a) Define the following terms as used in oscillatory motion:

i) Periodic motion (1mk)

ii) Period, T (1mk)

iii) Frequency (1mk)

(b) 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:

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$ (5mks)

(c) Show that the energy of a simple harmonic oscillator is directly proportional to the square of the amplitude of the oscillator. (9mks)

(d) A loudspeaker produces musical sound by means of the oscillation of the diaphragm. If the amplitude of the oscillation is limited to 1.0×10^{-3} mm, what frequency will result in the magnitude of the diaphragm's acceleration exceeding g? (8mks)

(e) Derive Kepler's' third law of gravitation motion (5mks)

QUESTION TWO (20 marks)

(a) State the three Kepler's laws of gravitational motion (3mks)

(b) Show that the line joining a planet to the sun sweeps out equal areas in equal interval of time. (12mks)

(c) 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? (5mks)

QUESTION THREE (20 marks)

(a) State the superposition principle of periodic motions. (1mk)

(b) At t = 0, displacement of a point x (0) in a linear oscillator is -8.6cm, its velocity, v (0) = -0.93m/s and its acceleration, a (0) = $48 m/s^2$. Calculate:

i) Angular frequency, ω (4mks)

ii) Frequency, f (2mks)

iii) Phase constant (4mks)

iv) Amplitude of the motion (3mks)

(c) Consider a body of mass, m lying on a frictionless horizontal surface connected to a spring of length, a_0. If a mass, m is given a displacement along the x-axis, it oscillates to and fro in a straight line about the mean position, O, show that the equation of motion of the body is given by:

$$\ddot{x} + \omega^2 x = 0$$ (6mks)

QUESTION FOUR (20 marks)

(a) i) A steady force of 50N is required to lift a mass of 2kg vertically through water at a constant velocity of 2.5m/s. assuming that the effect of viscosity can be described by a force proportional to velocity, determine the constant of proportionality (the effect of buoyancy is neglected)

ii) The same mass is then suspended in water by a spring with spring constant, k = 120N/m. determine the equilibrium extension of the spring. The mass is further pulled through a small distance below its equilibrium position and released from rest at time, t = 0. Show that it will vibrate about the equilibrium position according to an equation of the form $\ddot{x} + 2b\dot{x} + \omega^2 x = 0$ and determine b and ω for this system. Show that the motion is under-damped and find its period of oscillation. Find the time in which the amplitude of oscillation falls by a factor e. (18mks)

(b) Distinguish between damped and undamped simple harmonic motion (2mks)

QUESTION FIVE (20 marks)

(a) Define the term displacement of a body (1mk)

(b) A mass of 1g vibrates through 1mm 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 acting on the particle is $\pi^2 N$ (6mks)

(c) A point is executing simple harmonic motion with a period of π s. When it is passing through the centre of its path, its velocity is 0.1m/s, what is its velocity when it is at a distance of 0.03m from the mean position? (9mks)

(d) The displacement of a particle at t = 0.25s is given by the expression:

$x = 4\cos(3\pi t + \pi)$ where x is in metres and t is in seconds.

Determine the frequency and period of the motion (4mks)