KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2019/2020 ACADEMIC YEAR

FIRST YEAR FIRST SEMESTER
SPECIAL/SUPPLIMENTARY EXAMINATIONS

FOR THE DEGREE OF BSC (PHYSICS)

COURSE CODE: **SPC 112**

COURSE TITLE: **GRAVITATION AND OSCILLATORY MOTION**

DATE: 10/02/2021 **TIME:** 2:00-4:00Pm

INSTRUCTIONS TO CANDIDATES

Answer question ONE and any TWO of the remaining questions.

TIME: 2 Hours

KIBU observes ZERO tolerance to examination cheating

QUESTION ONE (30MARKS) (compulsory)

a) Define the following terms (3mks)
   i) Periodic motion
   ii) Period (T)
   iii) Frequency (f)

b) A point is executing simple harmonic notion with a period of π seconds. When it is passing through the centre of its path, its velocity is $0.1ms^{-1}$. What is its velocity when it is at a distance of 0.03m from the mean position? (8mks)

c) A mass M attached to a spring oscillates with a period of 2 seconds. If the mass is increased by 2kg, the period increases by one second. Find the initial mass M assuming that Hooke's law is obeyed. (7mks)

d) State Kepler's laws of planetary motion (3mks)

e) The coordinates of a particle moving in a plane are given by:

$$x(t) = a\cos pt$$

$$y(t) = b\sin pt$$

Where a, b (< a) and p are positive constants of appropriate dimensions. Show that:

   i) The velocity and the acceleration of the particle are normal to each other at $t = \frac{\pi}{2p}$ (5mks)
   ii) The acceleration of the particle is not always directed towards the focus (2mks)
   iii) The distance travelled by the particle after $t = \frac{\pi}{2p}$ is b (2mks)

QUESTION TWO (20MARKS)

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

b) Two simple harmonic motions of same angular frequency ω

$$x_1 = a_1 \sin \omega t$$
$$x_2 = a_2 \sin(\omega t + \Phi)$$

Act on a particle along x-axis simultaneously. Find the resultant motion (6mks)

c) A particle is subjected to two simple harmonic motions represented by the following equations:

$$x = a_1 \sin \omega t$$
$$y = a_2 \sin(2\omega t + \delta)$$

in a plane acting at right angles to each other. Discuss the formation of Lissajous figures due to superposition of these two vibrations. (13mks)

QUESTION THREE (20MARKS)

a) Define the term damped harmonic motion (1mk)

b) Given the equation of motion:

$$m\ddot{x} = -kx - \beta\dot{x}$$

Show that the equation of damped harmonic motion is given by:

$$\ddot{x} + 2b\dot{x} + \omega^2 x = 0$$ (3mks)

c) i) A steady force of 50N is required to lift a mass of 2kg vertically through water at a constant velocity of 2.5ms^{-1}. 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) (3mks)

ii) The same mass is then suspended in water by a spring with a spring constant k = 120nm^{-1}. 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. (13mks)

QUESTION FOUR (20MARKS)

Show that planets orbit in an elliptical path around the sun (20mks)

QUESTION FIVE (20MARKS)

a) A point moves with simple harmonic motion whose period is 4 seconds. If it starts from rest at a distance of 4.0cm from the centre of its path, find the time that elapses before it has described 2.0cm and the velocity it has then acquired. How long will the point take to reach the centre of its path (11mks)

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. Assuming that its motion is simple harmonic, show that the maximum force acting on the particle is π^2N. (4mks)

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

$$\ddot{x} + \omega^2 x = 0$$ (5mks)