THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

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MAIN EXAMINATION

MAY – JULY 2019 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SPECIAL / SUPPLEMENTARY EXAMINATION

PHY 201: QUANTUM MECHANICS II

Date: JULY 2019	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and any other Two Questions	

1. (a) Define the following terms as used in Harmonic oscillations.
   i, Period
   ii, Amplitude
   iii, Frequency
   iv, Isochronous. (4mks)

   (b) A simple harmonic wave has its displacement given by

   $y = 20\sin[0.25\pi(10t + x)]$. Where y is in mm, x in metres and t in seconds.

   Calculate;

   i, Amplitude

   ii, Period

   iii, Frequency of the wave (5mks)

   (c) i, Show that for a particle describing a simple harmonic motion, its velocity is given by;

   $v = \omega\sqrt{(r^2 - x^2)}$ (3mks)

ii, Derive a differential equation for an undamped free vibration. (4mks)

(d) A simple pendulum was observed to perform 40 oscillations in 100seconds of amplitude 4°. Find

i, Length of the pendulum (2mks)

ii, The maximum linear acceleration of the bob. (2mks)

iii, The maximum linear velocity of the bob (2mks)

iv, The velocity of the bob 2° displacement from the mean position. (4mks)

(e) i, State the law of Universal gravitation (1mk)

ii, If T_m is the time taken for the moon to make one one orbitthe earth, the radius of the moons orbit is $r_m = 3.84\,X\,10^8\,m$ and $T_m = 27.3\,days$. Find the mass of the earth. (Take G $=6.67\,X\,10^{-11}\,N\,m^2\,Kg^{-2}$) (3mks)

2. (a) A simple pendulum of period 2.0s and amplitude of swing 5.0cm. Calculate the maximum magnitudes of
i, Velocity of the bob (2mks)
ii, Acceleration of the bob. (2mks)

(b) By reference to a particular system, explain what is meant by

i, Forced vibration (2mks)

ii, Resonance. What are the effects of damping? (3mks)

(c) A body moving with s.h.m has velocity of 3m/s when 375mm from the mean position and an acceleration of $1 m/s^2$ when 250mm from the mean position. Calculate the periodic time and amplitude. (10mks)

3. (a) State the principle of superposition of waves? (2mks)

(b) Show that the resultant displacement of two waves with equal amplitudes A and quite close frequencies $\omega_1 \wedge \omega_2$ is given by

$$x = 2A\cos\left(\frac{\omega_1+\omega_2}{2}\right)t\cos\left(\frac{\omega_1-\omega_2}{2}\right)t$$ (8mks)

(c) Two vibrations acting simultaneously on a particle are given by the equations

$$y_1 = 2\sin\left(\omega t + \frac{\pi}{3}\right)$$

$$y_2 = 3\sin\left(\omega t + \frac{\pi}{6}\right).$$

Determine the amplitude, phase constant and period of the resulting vibration (10mks)

4.(a) A particle P of mass 2kg moves along x – axis attracted towards the origin O by a force whose magnitude is numerically equal to 8x. It's initially at rest at x = 20m. Find

i, The differential equation and initial condition describing the motion (2mks)

ii, The position of the particle at any time (2mks)

iii, The speed and velocity of the particle at any time (2mks)

iv, Amplitude, period and frequency of the vibration (2mks)

(b) The mass of the earth is $5.98\,X\,10^{24}\,kg$ and the gravitational constant $G = 6.67\,X\,10^{-11}\,m^3/Kg$. Assuming that the earth is a perfect sphere of radius 6370Km. Find the gravitational force on a mass of 1.00 Kg on the earth's surface (6mks)

(c) From Newton's law of gravitation, If the acceleration due to gravity, g_m at the moon's surface is $1.7\ m/s^2$ and the radius of the moon is $1.74\,X\,10^6$m. Calculate the mass of the moon. (6mks)

5. (a) Define Fourier series and show that the Fourier coefficient a_n is given by;

$$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f_n(x)\cos(nx)\,dx$$ (5mks)

(b) Find the Fourier series for the function $f(x) = x\ for - \pi \le x \le \pi$ (8mks)

(c) Its proposed to place a communication satellite in a circular orbit around the equator at a height of $3.59\,X\,10^7\,m$ above the earth's surface. Find the period of the revolution of the satellite in hours and comment on the results. (Take $M_e = 5.98\,X\,10^{24}\,Kg$, $R_e = 6.37\,X\,10^6$ m and $G = 6.67\,X\,10^{-11}\,m^3/Kg\,s^2$ (7mks)

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