THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

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MAIN EXAMINATION

JANUARY – APRIL 2019 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

REGULAR PROGRAMME

PHY 201: MECHANICS II

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

Q1. a) i) Show that for a particle executing a simple harmonic motion(SHM), its velocity At any instant is $\frac{dy}{dt} = \omega\sqrt{r^2 - x^2}$ **(3marks)**

ii) Derive an expression (the differential equation) for undamped harmonic oscillation. **(3marks)**

b) When a Simple Harmonic wave is propagated through a medium, the displacement of the Particle (in cm) at any instant of time is given by

$y = 10\sin\frac{2\pi}{100}(3600t - 20)$.

Calculate the amplitude of the vibrating particle, wave velocity and the periodic time of Particle. **(4marks)**

c) i) Define the following terms

i) Isochronous **(1mark)**

ii) Damped oscillation **(1mark)**

iii) Resonance **(1mark)**

iv) Amplitude **(1mark)**

ii) Given that the displacement of particle describing a simple harmonic motion is given by $y = r\cos\omega t$.

Show that the acceleration of the particle is given by

$$a = -\omega^2 y$$ **(5marks)**

d) A light spiral spring is loaded with a mass of 50g and it extends by 10cm. Calculate the Period of the small vertical oscillations. (Take g= $10ms^{-2}$) **(3marks)**

e) i) State the law of universal gravitation **(1mark)**

ii) If T_e is the time taken for the earth to make one orbit around the sun, the radius of the earth's orbit is $r_e=¿1.5 \times 10^{11} m$ and $T_e=¿3.0 \times 10^{7}$s. Calculate the mass of the Sun. **(4marks)**

f) A simple pendulum of length 2.5m and the mass of the bob is 40g. The extreme Displacement is 75^o from the mean position. Find the kinetic energy possessed by the System at 20^o from the mean position and the velocity of the bob at this point. **(3 marks)**

Q2. a) A particle moving with Simple Harmonic Motion has velocities of 4cm/s and 3cm/s at distances 3cm and 4cm respectively from the equilibrium position.

Find i) The amplitude of the oscillation **(3marks)**

ii) The period **(3marks)**

iii) The velocity of the particle as it passes through the equilibrium position. **(4 marks)**

b) A simple pendulum was observed to perform forty oscillations in 100s, of amplitude 4^o. Find

i) The length of the pendulum **(3marks)**

ii) The maximum linear acceleration of the pendulum bob

(3marks)

iii) The maximum velocity of the bob **(2marks)**

iv) The maximum angular velocity of the pendulum. **(2marks)**

Q3 a) State the principle of superposition of waves. **(2marks)**

b) Deduce an expression for the resultant displacement of two waves with equal amplitudes, A, and quite close frequencies $\omega_1 \wedge \omega_2$ respectively. **(8marks)**

c) The following two waves in a medium were superposed.

$y_1=4\sin(5x-10t)$ and

$y_2=4\sin(5x+10t)$

Where x is in metres and t is in seconds.

(i) Establish an equation for the combined disturbance. **(5marks)**

(ii) Find the value of the combined amplitude when $x=\frac{\pi}{10}$.

d) Differentiate between constructive and destructive interference of waves. **(2marks)**

Q4 a) Define the term Fourier series and show that the Fourier coefficient b_n is given By $b_n = \frac{1}{\pi}\int_0^{2x} f(x) sinnxdx$ **(5marks)**

b) Find the Fourier series for the function f(x) = x for $-\pi \leq x \leq \pi$. **(8marks)**

c) A particle of mass 2kg moves along the x axis and is attracted towards the origin O By a force whose magnitude is numerically equal to 8x. Suppose that the particle has A damping force whose magnitude is equal to 8times the instantenous speed. If it Is initially at rest at x = 20. Find

i) The position at any time

ii) The velocity at any time. **(7marks)**

Q5 a) The mass of the earth is 5.98 x 10^{24}kg and the gravitational constant is 6.67 x 10^{-11} m³/Kgs². Assuming the earth is a uniform sphere of radius 6.37 x 10m^6$10^6 m$. Find the gravitational force on a mass of 1.00Kg on the earth's surface. **(5marks)**

b) It is proposed to place a communication satellite in a circular orbit around the Equator at a height of 3.59 x 10^7m above the earth's surface. Find the period of Revolution of the satellite in hours and comment on the results.

Take $M_e = 5.98\, X\, 10^{24}\, Kg$

$R_e = 6.37\, X\, 10^6\, m$

$G = 6.67\, X\, 10^{-11}\, m^3/Kgs^2$ **(5marks)**

c) Explaining each step in your calculation and pointing out the assumptions you make, Use the information below to estimate the mean distance of the moon from the earth.

Period of rotation of the moon around the earth = 27.3 days

Radius of the earth = 6.37 x 10^3km

Acceleration due to the gravity at the earths surface. G = 9.8m/s².

(5marks)

d) From Newton's law of Gravitation, if the acceleration due to gravity, g_m, at the moon's Surface is 1.70m/s² and its radius is 1.74 x 10^6m, Calculate the mass of the moon.

To what height would a signal rocket rise on the moon, if an identical one is fired on the Earth could reach 200m? (ignore atmospheric resistance). Explain your reasoning. **(5marks)**

END