MACHAKOS UNIVERSITY COLLEGE

(A Constituent College of Kenyatta University)
University Examinations for 2015/2016 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

SPH 300: WAVE THEORY

DATE: 3/8/2016 **TIME: 11:00 – 1:00 PM**

INSTRUCTIONS:

Answer question **ONE** which is compulsory and any other **TWO**

SECTION A

QUESTION ONE (COMPULSORY)

a) i) State two characteristics of the forces responsible for simple harmonic motion. (2 marks)

ii) Show that $y = A\cos kx + B\sin kx$ is a solution to simple harmonic motion where A and B are constants. (3 marks)

iii) Show that the solution in (a) (ii) can also be written in: -

(I) Polar form (3 marks)

(II) Exponential form (3 marks)

b) For a compound pendulum,

i) Show that it executes simple harmonic motion (4 marks)

ii) Find equations for its periodic time and frequency (2 marks)

c) In terms of harmonics, explain why a loaded bus is more comfortable than an empty one (3 marks)

d) Show that energy in a purely reactive circuit is sinusoidal (4 marks)

e) i) A 200g mass hanging from a spring causes an extension of 4 cm. If the mass was displaced and allowed to vibrate freely, calculate the period and frequency of the vibration. (4 marks)

ii) If two springs, similar to that in (e) (i) were used in series, explain the effect on the period and frequency of the system (2 marks)

QUESTION TWO

a) Distinguish damped and forced vibrations (2 marks)

b) Show that $D = \frac{A}{\sqrt{(\omega_0{}^2 - \omega^2)^2 + 4\omega^2\beta^2}}$ is the amplitude of a forced vibration for a mechanical systems of mass m and stiffness constant k where $\omega_0 = \sqrt{\frac{m}{k}}$ and ω is the frequency of the driving force and $\beta = \frac{b}{2m}$ for damping constant b. (9 marks)

c) Show that current in a R-L-C series circuit connected to a battery of emf $\in_0$ is given by $I = I_0 e^{-i(\omega t - \theta)}$ where $Z=|Z|e^{-i\theta}$ and $I_0 = \frac{\in_0}{Z}$ (9 marks)

QUESTION THREE

a) Derive the partial differential equation y(x,t) ,the equation of a travelling wave. (7 marks)

b) Show that a transverse wave in a vibrating string obeys the wave equation and hence give the velocity of the waves (7 marks)

c) Show that a longitudinal wave in a rod of density ρ and Young's modulus E obeys the wave equation with the wave moving at $\sqrt{\frac{E}{\rho}}$ (6 marks)

QUESTION FOUR

a) i) What is meant by a coupled oscillator? Give a an example a practical system that consists of a coupled oscillator explaining the coupling involved (3 marks)

ii) Describe the motion of a coupled system of masses in which mass m_1 is displaced a distance A to the right while mass m_2 is displaced an equal distance to the left. (5 marks)

b) An alternating current through a rectifier is given as $I = \begin{cases} I_0 \sin\theta \; for \; 0 < \theta < \pi \\ 0 \qquad\qquad \pi < \theta < 2\pi \end{cases}$ where I_0 is the maximum current and 2π is the period. Express I in Fourier Series (12 marks)

QUESTIONFIVE

a) Show that a charged capacitor discharging through an inductor and resistor represents damped harmonic motion (6 marks)

b) Derive an expression for the distance X_n on the screen for the n^{th} maxima in a diffraction pattern in terms of the distance from the source to the barrier, a and the distance from barrier to the screen, p (8 marks)

c) (i) Derive an expression for the wavelength of light λ using the 2^{nd} and 4^{th} minima in a diffraction pattern. (4 marks)

(ii) A diffracting edge is placed between a monochromatic point source of light and a screen. Given that its distance from the source is 20 cm while that from the screen is 150 cm, determine the wavelength of light used if the separation of the 2^{nd} and 4^{th} minima is 0.0227 cm. (4 marks)