MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

BACHELOR OF SCIENCE IN APPLIED PHYSICS AND TECHNOLOGY

BACHELOR OF EDUCATION (SCIENCE)

SPH 300: WAVE THEORY

DATE: **TIME:**

INSTRUCTIONS:

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

Take: Acceleration due to gravity, g = 10 N/Kg (m/s^2)

SECTION A

QUESTION ONE (COMPULSORY) (30 MARKS)

(a) (i) Define simple harmonic motion (2 marks)

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

(iii) Show that the solution in (ii) can also be written in the form

$$y = D\sin(\omega t + \alpha)$$

and that $y = De^{j(\omega t+\alpha)}$ is also a solution (6 marks)

(b) Derive the equation for the periodic time and frequency of a loaded spring executing simple harmonic motion (6 marks)

(c) Explain why a loaded bus is more comfortable than an empty one in terms of harmonics (3 marks)

(d) Show that energy in a mechanical system is sinusoidal (4 marks)

(e) (i) A 200g mass hanging from a spring causes an extension of 8 cm. If the mass is displaced and allowed to vibrate freely, calculate the period and frequency of the vibration (4 marks)

(ii) If two similar parallel springs to that in (i) were used, how will the period and frequency be affected (2 marks)

QUESTION TWO (20 MARKS)

(a) Distinguish damped and forced vibrations (2 marks)

(b) Show that a charged capacitor discharging through an inductor and resistor represents damped harmonic motion (5 marks)

(c) Show that $x = \frac{A}{\sqrt{(\omega_0{}^2 - \omega^2)^2 + 4\omega^2\beta^2}}\cos(\omega t - \delta)$ is the particular solution to forced vibrations in 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 (14 marks)

QUESTION THREE (20 MARKS)

(a) A mass on a spring oscillates at an amplitude of 5 cm at a frequency of 1Hz. If at $t = 0$, $x = 0$, determine the: -

(i) Equation describing the position of the mass as a function of time in the form $x = A\cos(\omega t + \alpha)$ (4 marks)

(ii) Position, velocity and acceleration at t = $\frac{8}{3}$ seconds. (3 marks)

(b) (i) Derive the equation of motion of a simple pendulum of length l when the horizontal displacement of its mass from equilibrium is x for $x << l$. (3 marks)

(ii) Show that the period $T = 2\pi\sqrt{\frac{l}{g}}$. Find T when l = 2 m (3 marks)

(iii) If the 0.1 kg pendulum bob in (i) has an amplitude of 0.02m, find the energy of the bob. (7 marks)

QUESTION FOUR (20 MARKS)

(a) Show that a transverse wave in a vibrating string obeys the wave equation (8 marks)

(b) A source of wavelengths is moving away from a source at a velocity V_s. If the observer is also moving away at V_o along a straight line too, deduce the formula for the apparent frequency. (7 marks)

(c) Two cars are approaching each other on a straight track with a speed of 72 km/h each. If the engine of one emits a note of 1000 Hz, what will be the frequency of the note heard by a person in the other car. Take velocity of sound in air = 330 m/s (5 marks)

QUESTION FIVE (20 MARKS)

(a) Distinguish interference and diffraction (4 marks)

(b) Show that n^{th} maxima will be produced at X_n given by

$X_n^{\,2} = \dfrac{(2n-1)(a+p)p\lambda}{a}$, where a is the distance from the source to the barrier and p is the the distance from barrier to the screen (6 marks)

(c) If X is the distance between the first two minima, derive the expression for the wavelength of the light used (4 marks)

(d) A narrow slit is illuminated by light of wavelength 589 nm is placed at a distance of 20 cm from a straight edge. If a screen is placed at a distance of 1.7 m from the slit, calculate the distance between the first and the third maxima. (6 marks)