



MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

BACHELOR OF EDUCATION (SPECIAL NEEDS)

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION

SPH 300: WAVE THEORY

DATE: 15/03/2022

TIME: 8:30 – 10:30 AM

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

Take: Acceleration due to gravity, $g = 10 \text{ N/Kg (m/s}^2\text{)}$

SECTION A

QUESTION ONE (30 MARKS)

- (a) (i) Define 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 (ii) can also be written in the form
- $$y = D \cos(kx + \alpha)$$
- and that $y = D e^{j(kx + \alpha)}$ (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 200 g 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)

SECTION B

QUESTION TWO (20 MARKS)

- (a) Distinguish damped and forced vibrations (1 mark)
- (b) Show that a charged capacitor discharging through an inductor and resistor represents damped harmonic vibrations (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 1 Hz. 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 $x \ll l$. (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 0.02 m, 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 between interference and diffraction (4 marks)
- (b) Show that the n^{th} maxima will be produced at X_n and is given by $X_n^2 = \frac{(2n-1)(a+p)p\lambda}{a}$ where a is the distance from the source to the barrier and p is 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)