NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 2201 VIBRATIONS AND WAVES

SUPPLEMENTARY EXAMINATION

BSc HONOURS PART II: JULY 2001 DURATION : 3 HOURS

ANSWER **ALL** PARTS OF QUESTION 1 IN SECTION A AND ANY **THREE** QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS.

Boltzman Constant k	=	1.38×10^{-23} J/k
1 electron - volt 1 eV	=	1.602×10^{-19} J
Speed of light in vacuo	=	3.0×10^{8} m/s
Atomic mass unit 1 a.m.u.	=	1.66×10^{-27} kg
Mass of an electron m_e	=	9.11×10^{-31} kg
Charge on an electron	=	1.6×10^{-19}C

SECTION A

1. (a) Write down two simple equations to describe harmonic and anharmonic vibrations including definition for each symbol. [6]

(b) Explain light damping, heavy damping and critical damping of a vibrating system.

For a vibrator with mass, m = 0.01 kg and stiffness, S = 32 N/m what value of damping resistance would produce critical damping? [7]

(c) (i) Explain circuit oscillations by drawing a simple circuit. [4]

(ii) Find the resonance frequency if capacitance of 100 mH coil is 100 μF. [3]

(d) (i) Briefly explain scattering of light in electromagnetic radiation. [3]

(ii) Write down time dependent voltage equations for LCR resonant circuit. [4]

(e) Write down three general properties of free vibration. [3]

(f) Explain with mathematical expressions sinusoidal incident and reflected waves together with standing waves. [5]

(g) Describe what you understand about electromagnetic waves in vacuum and dielectric with reference to Faraday's law and Maxwell's explanation. [5]

SECTION B

2. (a) For a system with two equal and one different springs and two equal masses, write down equations of motion. [5]

(b) Write down two mathematical expressions for the normal modes of vibration for a two - coordinate vibrators and explain the symbols used. [4]

(c) Derive general solutions for the two displacements ψ_1 and ψ_2 of the two masses. [7]

(c) At a certain instant during the vibration of a symmetric system the mode coordinates have the values $q_1 = 1.2 \times 10^{-3}\,(kg)^{1/2}$ m and $q_2 = -0.25 \times 10^{-3}\,(kg)^{1/2}$ m. Calculate the displacements ψ_1 and ψ_2, if m = 0.020 kg. [4]

3. (a) Write down the coefficients of the Fourier function and show the phase diagram of the Fourier spectrum. [10]

(b) Derive total energy equation for two-coordinate system in terms of mode coordinates. [10]

4. (a) Give the characteristics of sinusoidal travelling wave of a string. [3]

(b) With the aid of a diagram, derive the wave equation for an acoustic wave as

$$\frac{\partial^2 \psi}{\partial t^2} \approx \frac{1}{K\rho} \frac{\partial^2 \psi}{\partial z^2}$$

where symbols have their usual meanings. Also, explain what you understand by 'pressure wave'. [9]

(c) Derive an equation for the total energy density of a stretched string. [8]

5. (a) What is attenuation of travelling wave for a string? Derive equations

$$K \approx \pm \omega / c \quad \text{and}$$

$$\kappa \approx \pm \Gamma / 2c$$

where $c = (T/\mu)^{0.5}$, T is tension and μ is mass per unit length;
$\Gamma = \beta / \mu$ and β is the resistance per unit length.
[12]

(b) Describe electromagnetic waves in a vacuum and in a dielectric.
State Maxwell's two wave equations that satisfy magnetic and electric fields explaining all the symbols. [8]

6. (a) (i) Give the general equations of incident, reflected and transmitted waves expressed in terms of wave vector. [3]

(ii) Express, in terms of the dispersion relation for a vacuum, total internal reflection. [3]

(iii) How are standing waves in an enclosure formed? Explain with mathematical expressions. [6]

(b) Give the differences between Fraunhofer conditions and Fresnel conditions of diffraction and illustrate with an appropriate diagram. Calculate the amplitude A for disturbances of equal amplitude A_e and phase difference α using a vector diagram. [8]

END OF PAPER