NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

BED PHYSICS

SPH 1201- WAVES AND OPTICS

SUPPLIMENTARY EXAMINATION

BSc HONOURS PART 1: **December 2010** DURATION: 3 HOURS

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

Atomic mass of Oxygen	=	16 a.m.u
Atomic mass of Hydrogen	=	1 a.m.u
Speed of sound in air	=	343 ms^{-1}
Speed of light	=	3.. x 10^8 m/s
Acceleration due to gravity	g =	9,81 ms^{-2}
Permittivity of free space	ε_0 =	8.854 x 10^{-12} Fm^{-1}
1 a.m.u	=	1.66 x 10^{-27} kg

SECTION A

1. (a) Distinguish between phase velocity and group velocity of a propagating wave giving an expression for each in terms of ω and k, where all the symbols have their usual meanings. [8]

(b) A 3.0 kg particle is in Simple Harmonic Motion in one direction and moves according to the equation

$$x = 5\cos\left[\left(\frac{\pi}{3}\right)t - \frac{\pi}{4}\right]$$

(i) At what value of x is the potential energy equal to half the total energy? [5]

(ii) How long does it take the particle to move to this position from the Equilibrium position? [5]

(c) Show that the wave function y = 2Asinkxcosωt, where A is a constant, is a solution of the wave Equation. [6]

(d) Light of intensity I_0 is incident on two ideal linear polarisers whose transmission axes differ by 60^o.

(i) Calculate the intensity of the transmitted light if the incident light is unpolarised. [5]

(ii) Calculate the intensity of the transmitted light if the incident light is linearly polarised along an axis oriented at an angle of 30^o to the axis of the first polarizer. [5]

(e) Monochromatic light from a distant source is incident on a slit 0.800mm wide. On a screen 3.00m away, the distance from the central maximum of the diffraction pattern to the first minimum is measured to be 1.25mm. Calculate the wavelength of the light. [6]

SECTION B

2. (a) A 3.00kg block is attached to an ideal spring with force constant k=120N/m. The block is given an initial velocity in the positive direction of magnitude v_0=12.0 m/s and no initial displacement (x=0).

Find:-

(i) The amplitude [5]

(ii) The phase angle [5]

(iii) Write an equation for the position as a function of time. [5]

(b) The speed of a radio wave in a vacuum (equal the speed of light) is $3.00x10^8$m/s. Find the wavelength:-

(i) For AM radio station with frequency 1070 kHz. [3]

(ii) FM radio station with frequency 91.7MHz. [2]

3. (a) The equation of a lightly damped oscillator is: $x = Ae^{-\left(\frac{b}{2m}\right)t}\cos(\omega' t + \phi)$

Where $\omega' = \sqrt{\left(\frac{k}{m} - \frac{b^2}{4m^2}\right)}$. Let the phase angle ϕ be zero.

(i) According to this equation, what is the value of x at t=0? [2]

(ii) What is the magnitude and direction of the velocity at t=0? What does the result tell you about the slope of the graph x versus t near t=0? [8]

(iii) Obtain an expression for the acceleration at t=0. For what value or range of values of the damping constant b (in terms of k and m) is the acceleration at t=0 negative, zero and positive? [8]

(b) Explain what is meant by *plane polarized light*. [2]

4. (a) An ideal spring with force constant k=800N/m is mounted horizontally to a fixed end. A 0.400kg mass is attached to the other end undergoes SHM with an amplitude 0.075m. There is no friction on the mass. Compute:-

(i) The maximum speed of the mass. [2]

(ii) The speed of the mass when it is at x=0.030m [2]

(iii) The magnitude of the maximum acceleration of the mass. [2]

(iv) The acceleration of the mass at x=0.030m [2]

(v) The total mechanical energy of the mass at any point of its motion. [2]

(b) The equation of a certain transverse wave is:

$$y(x,t)=(4.00cm)\sin 2\pi\left|\frac{t}{0.0300s}-\frac{x}{50.0cm}\right|$$

Determine the wave's:-

(i) Amplitude [2]

(ii) Wavelength [3]

(iii) Frequency [3]

(iv) Speed of propagation. [2]

5. (a) Light with wavelength 648nm in air is incident perpendicular from the air on a film $8.76x10^{-6}$m thick that has refractive index 1.35. Part of the light is reflected from the first surface of the film, and part enters the film and is reflected back at the second surface, where the film is again in contact with air:-

(i) How many waves are contained along the path of this second part of the film? [5]

(ii) What is the phase difference between these two parts of the light as they leave the film? [5]

(b) In the Young's double-slit interference experiment, suppose d = 0.100mm and L = 1.00m, and the incident light is monochromatic with a wavelength λ=500 nm.

(i) What is the phase difference between the two waves arriving at a point *P* on the screen when $\theta = 0.80^0$? [3]

(ii) What is the phase difference between the two waves arriving at a point *P* on the screen when y = 4.00mm? [3]

(iii) If the phase difference (φ =1/3 rad), what is the value of θ? [2]

(v) If the path difference is $\lambda/4$, what is the value of θ? [2]

6. A string of length 3L and negligible mass is attached to two fixed supports at its end. The tension in the string is T.

(i) A particle of mass m is attached at a distance l from one end of the string. Set up the equation for small transverse oscillations of m and find the period. [10]

(ii) An additional particle of mass m is connected to the string, dividing the string into three equal segments each with tension T. Sketch the appearance of the string and masses in the two separate normal modes of transverse oscillations. [8]

(iii) Calculate ω for that normal mode which has the higher frequency. [2]

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