NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF TECHNICAL TEACHER EDUCATION

BACHELOR OF EDUCATION HONOURS DEGREE
SPH 1201- WAVES AND OPTICS

BSc HONOURS PART 1: **MAY/ JUNE 2011** 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

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

(b) 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]

(c) 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 1070kHz. [4]

(ii) FM radio station with frequency 91.7MHz. [4]

(d) Show that the wave function $y = 2Asinkxcos\omega t$, where A is a constant, is a solution of the wave Equation. [4]

(e) 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. [4]

(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. [4]

(f) 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]

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 [4]

(ii) The phase angle [4]

(iii) Write an equation for the position as a function of time. [4]

(b) Describe how a beam of plane polarized light may be produced by

(i) Reflection, and [4]

(ii) Absorption [4]

3. (a) 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 [4]

(ii) Wavelength [4]

(iii) Frequency [4]

(iv) Speed of propagation. [4]

(b) A polarizer and an analyser are oriented so that the maximum amount of light is transmitted. To what fraction of its maximum value is the intensity of the transmitted light reduced when the analyser is rotated through:-

(i) 22.5^0 [4]

(ii) 45.0^0 [4]

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) A wave of frequency $20s^{-1}$ has a velocity of 80m/s.

(i) How far apart are the two points whose displacements are 30^0 apart in phase. [5]

(ii) At a given point, what is the phase difference between two displacements occurring at times separated by 0.01sec? [5]

5. (a) Light with wavelength 648nm in air is incident perpendicular from the air on a film 8.76×10^{-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]

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

6. (a) The following two waves in a medium are superposed:

$Y1 = A\sin(5x - 10t)$ and $y2 = A\sin(4x - 9t)$

Where x is in metres and t in sec.

(i) Write an equation of combined disturbance [5]

(ii) What is its group velocity? [5]

(iii) What is the disturbance between points amplitude in the combined disturbance? [5]

(b) 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. [5]

END OF PAPER