UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF BED (SCIENCE) & BSC. PHYSICS

COURSE CODE: SPH 326 & SPC 221

COURSE TITLE: PHYSICAL OPTICS

DATE: 17/04/2023 **TIME**: 2:00-4:00PM

INSTRUCTIONS TO CANDIDATES

TIME: 2 Hours

Answer question ONE and any TWO of the remaining

QUESTION ONE (30 marks) compulsory

(a) Briefly describe interference, diffraction and polarization of waves in terms of their occurrence (3mks)

(b) State the Superposition principle (1mk)

(c) A double-slit source with slit separation 0.2mm is located 1.2m from a screen. The distance between successive bright fringes on the screen is measured to be 3.30mm. determine the wavelength of the wave (6mks)

(d) State one common use of single-layer films deposited on glass substrates (1mk)

(e) Determine the minimum thickness of an AR coat of magnesium fluoride deposited on a glass substrate (n = 1.52) if the coating is to be highly antireflective for the centre of the white light spectrum at $\lambda_{air} = 550nm$. The refractive index for magnesium fluoride is near 1.38. (3mks)

(f) A monochromatic light is incident on a single slit of width 0.30mm. on a screen located 2.0m away, the width of the central bright fringe is measured and found to be near 7.8mm. determine the wavelength of the incident light (3mks)

(g) Differentiate between Fraunhofer diffraction and Fresnel diffraction (2mks)

(h) What is the meaning of the term polarization as used in waves? (1mk)

(i) State any three ways in which polarization of unpolarized light can be realized (3mks)

(j) What is the meaning of the term Brewster's angle as used on Optics? (1mk)

(k) Two transparent media 1 and 2 are separated by a plane interface. Waves travel in each medium with speed v_1 and v_2. A plane wave front in medium 1 reaches the interface at an angle, θ_i and propagates in to medium 2 at a different angle, θ_r with respect to the interface. Show that:

$$\frac{\sin\theta_i}{v_1} = \frac{\sin\theta_r}{v_2}$$ (6mks)

QUESTION TWO (20 marks)

(a) A cork is dropped on a quiet water pond surface such that the cork bobs up and down and back again a complete cycle once per second and generates waves that measure 10cm from crest to crest. Sometime after the wave motion has been established, the motion was timed using a stopwatch. At a certain time, t = 10s on the watch, the maximum displacement of the wave was $+y_0$ and $-y_0$ from the mean position respectively. Determine:

(i) The wave speed (3mks)

(ii) The phase angle, ϕ for the wave front at r= 102.5cm at time, t = 10s (3mks)

(iii) The wave displacement, y on the wave front at r = 107.5cm and state its nature (5mks)

(b) Consider light waves from a coherent source focused on a screen after interference of light waves. Given that the distance of separation of the double slits (acting as coherent sources of waves) is, a, and the screen is s(m) away from the double slits. Show that the average intensity of light on the screen is given by:

$$I_{AV} = 4E_0^2 \cos^2(\frac{\pi a}{\lambda s} y)$$

The symbols carry the usual meaning (9mks)

QUESTION THREE (20 marks)

(a) State Huygens's Principle (1mk)

(b) State two ways in which interference of light waves can be demonstrated (2mks)

(c) Considering the Young's double slit experiment, show that the position, y of a bright fringe on the screen is given by:

$$y_B = \frac{\lambda s}{a} m \text{ where m} = 0, \pm1, \pm2, \ldots\ldots$$ (7mks)

(d) A double-slit source with slit separation 0.2mm is located 1.2m from a screen. The distance between successive bright fringes on the screen is measured to be 3.30mm. determine how the average intensity varies along a screen as a function of y (7mks)

(e) White light is incident normally on the surface of a soap bubble. A portion of the surface reflects green light of wavelength, $\lambda_0 = 540nm$. Assume that the refractive index of the soap film is near that of water, so that $n_f = 1.33$. Estimate the thickness (in nm) of the soap bubble that appears green in second order (3mks)

QUESTION FOUR (20 marks)

(a) State any one application of interference with multi-layer films (1mk)

(b) A coherent laser light of wavelength 633nm is incident on a single slit of width 0.25mm. the observation screen is 2.0m from the slit. Determine the width of the central bright fringe as well as the width of the bright fringe between the 5th and the 6th minima (8mks)

(c) Kitomboli, a photonics technician, has been asked to produce a Fraunhofer diffraction pattern formed when light from HeNe laser ($\lambda = 6.33nm$) passes through a pinhole of 150 μm diameter. Clearly describe a setup in terms of the distance from the laser to the pinhole, Z, and the distance from the pinhole to the screen, Z', for the pattern to be produced by the technician. (9mks)

(d) State any two types of diffraction (2mks)

QUESTION FIVE (20 marks)

(a) State the law of Malus (1mk)

(b) Consider unpolarized light incident on a pair of polarizers. Determine the angle, θ required between the transmission axes of the 1st amd 2nd polarizers that will reduce the intensity of the light, I_0 incident on polarizer 2 by 50% hence or otherwise, determine by how much the electric field, E_0 incident on polarizer 2 has been reduced. (8mks)

(c) State any three methods through which light can be polarized (3mks)

(d) Using Snell's law, show that:

$$\tan B = \frac{n_2}{n_1}$$

where B is the Brewster's angle, n_1 and n_2 are refractive indices of incident medium and refractive medium respectively. (6mks)

(e) Unpolarized light in air is to be reflected off a glass surface ($n = 1.5$). determine the Brewster's angle in this case (2mks)