KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER
SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF BED (SCIENCE)

COURSE CODE: SPH 326

COURSE TITLE: PHYSICAL OPTICS

DATE: 21/11/2022 **TIME:** 8:00AM-10:00AM

INSTRUCTIONS TO CANDIDATES

TIME: 2 Hours

Answer question ONE and any TWO of the remaining

QUESTION ONE (30 marks) compulsory

(a) Justify the divergence of physical optics from Geometrical optics (3mks)

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

(c) 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)

(d) Briefly describe interference, diffraction and polarization of waves in terms of their occurrence

(3mks)

(e) 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)

(f) State one common use of single-layer films deposited on glass substrates

(1mk)

(g) 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)

(h) 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)

QUESTION TWO (20 marks)

(a) What is meant by the term Diffraction grating as used in physical optics

(1mk)

(b) Joyce has been handed a transmission grating by her supervisor who wants to know how widely the red light and blue light fringes in second order are separated are separated on a screen 1m from the grating. Joyce is told that the separation distance between the red and the blue colors is a critical piece of information needed for the experiment with a grating spectrometer. The transmission grating is to be illuminated at normal

QUESTION FOUR (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:

$$y_B = \frac{\lambda s}{a} m \text{ where } m = 0, \pm 1, \pm 2, \ldots\ldots$$ (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 FIVE (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) Kabilile, 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) incidence with the red light at $\lambda = 632.8nm$ and blue light at $\lambda = 420.0nm$. Printed on the frame surrounding the ruled grating, Joyce sees that there are 5000 slits (line) per centimeter on this grating. Joyce decides she must, in turn:

(i) Determine the distance l between the slit centers (3mks)

(ii) Determine the angular deviation in 2nd order for both the red and the blue light (8mks)

(iii) Determine the separation distance on the screen between the red and blue fringes (5mks)

(c) Determine the size of the airy disk at the center of the diffraction pattern formed by a lens of diameter 4cm and focal length 15cm. assume a wavelength of 550nm incident on the lens. (3mks)

QUESTION THREE (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)