THE OPEN UNIVERSITY OF SRI LANKA

BACHELOR OF SCIENCE DEGREE PROGRAMME–LEVEL 04

FINAL EXAMINATION 2024/2025

OPTICS–PHU4302

Duration: TWO HOURS (2 hrs,)

Date: 30th November 2024 **Time 1.30 pm - 3.30 pm**

Answer Four (4) questions only

1. (a). Considering the superposition of two waves with identical amplitudes and frequencies propagating through a medium, estimate the ratio of intensities at two points where the path differences are 0 and $\lambda/4$. **(25 marks)**

(b). A Young's double-slit experiment setup has a screen 1.8 m away from the slits. Light with a wavelength of 500 nm passes through the slits separated by 0.3 mm. What is the angular position of the second-order bright fringe? **(25 marks)**

(c). In a double slit interference arrangement one of the slits is covered by a thin mica sheet whose refractive index is 1.58. The slits are 0.1 cm apart and the fringes are observed on a screen placed 50 cm away from the slit with a light of wavelength 500 nm. Due to the introduction of the mica sheet the central fringe gets shifted by 6 bands. Determine the thickness of mica sheet. **(25 marks)**

(d). A bi-prism is placed at a distance of 6 cm in front of a narrow slit, illuminated by sodium light with wavelength 589 nm and the distance between the virtual sources is found to be 0.05 cm. Find the width of the fringes observed with an eye-piece placed at a distance of 80 cm from the bi-prism. **(25 marks)**

2. (a). Explain how the path length differences between the interfering waves in double-slit and thin-film interference systems give rise to constructive or destructive interference. Discuss the main factor responsible for any variations in the interference patterns observed between these two systems. **(25 marks)**

(b). Briefly explain how thin film interference is utilized in optics and the lens industry. **(25 marks)**

(c). A soap film of 5×10^{-7} m thick and refractive index 1.33 is seen at an angle of 35° to the normal. Find the missing wavelengths in the visible spectrum. **(25 marks)**

(d). Monochromatic light with wavelength 580 nm is emitted by a broad source which is incident normally on two glass plates enclosing a wedge-shaped film. The plates are in contact at one end and are separated on the other end by a wire having a diameter of 0.05 mm and placed at 15 cm from the contacted end. Calculate the fringe width. **(25 marks)**

3. (a). Draw a clearly labeled diagram illustrating the setup of the apparatus used in Newton's ring experiment. **(25 marks)**

(b). Using the interference pattern formed in a thin air film between a convex lens and a flat glass plate, derive the mathematical relationship that demonstrates the diameter of Newton's rings is proportional to the square root of an integer. **(25 marks)**

(c). In a Newton's rings experiment, interference rings are observed in reflected light with a wavelength of 590 nm. The diameter of the 10^{th} dark ring is measured to be 0.5 cm. Calculate the radius of curvature of the lens and the thickness of the air film at this ring. **(25 marks)**

(d). In a Newton's rings experiment, the diameter of the 12^{th} dark ring changes from 1.50 cm to 1.35 cm when the air film is replaced with a drop of liquid. Determine the refractive index of the liquid. **(25 marks)**

4. (a). If the odd-numbered half-period zones are transparent, calculate the radii of the first two clear zones in a zone plate designed to focus a parallel beam of light with a wavelength of 600 nm at a focal distance of 2 m. **(25 marks)**

(b). A single slit with a width of 0.06 mm is illuminated by light with a wavelength of 700 nm. If a screen is placed 4.0 m away, calculate the distance between the first and second diffraction minima. **(25 marks)**

(c). In a double slit Fraunhofer diffraction pattern, the screen is placed 170 cm away from the slits. The width of the slits is 0.08 mm and they are 0.4 mm apart. Calculate the wavelength of light if the fringe width is 0.25 cm. Also find the missing orders. **(25 marks)**

(d). A grating has 1000 lines ruled on it. What is the difference between the two wavelengths that just resolved in the first order spectrum in the region of wavelength 600 nm? **(25 marks)**

5. (a). State the Brewster's law. It is required to determine the refractive index of an opaque dielectric. The polarizing angle is found to be 59.83°, when light is reflected from a flat polished surface of the dielectric. What is the refractive index of the dielectric material? **(25 marks)**

(b). An unpolarized beam of light is incident on a group of three polarizing sheets which are lined up so that the characteristic direction of each is rotated by 30° clockwise with respect to the preceding sheet. What fraction of the incident intensity is transmitted? **(25 marks)**

(c). Light enters a calcite crystal at an angle of incidence of 30°. Given the ordinary refractive index $n_o = 1.658$ and extraordinary refractive index $n_e = 1.486$, calculate the angle of refraction for both the ordinary and extraordinary rays inside the crystal. **(25 marks)**

(d). A ray of monochromatic light strikes a uniaxial crystal of mica with its optic axis aligned parallel to the crystal's surface. The ray is incident at a 45° angle with respect to the optic axis, and the crystal has a thickness of 2 mm. Given that $n_o = 1.600$ and $n_e = 1.605$ for this wavelength, calculate the separation between the ordinary and extraordinary rays at the exit face of the crystal. **(25 marks)**

6. (a). Explain followings in briefly,

(i). Optics axis of a crystal,

(ii). Nicol prism,

(iii). Double refraction of crystals. **(25 marks)**

(b). Consider a positive crystal with refractive indices of 1.310 for the extraordinary ray (e-ray) and 1.309 for the ordinary ray (o-ray). Determine the minimum thickness required for this crystal to function as a quarter-wave plate for light with a wavelength of 600 nm. **(25 marks)**

(c). What are optically active materials? Give two examples for optically active materials. A sample of a substance is placed in a polarimeter tube of length 10 cm. The observed rotation is 4.5° when the light passes through the substance. If the concentration of the substance is 0.5 g/ml, calculate the specific rotation of the substance. **(25 marks)**

(d). What is the basic principle behind the working of a laser? Explain briefly. **(25 marks)**

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