The Open University of Sri Lanka
B.Sc. Degree Programme - Level 04
Final Examination – 2009/2010
PYU 2261 – Geometrical & Physical Optics
Duration: Three (3) hours

Date: 11th January 2010 **Time: 9.30 am to 12.30 pm**

ANSWER SIX QUESTIONS SELECTING THREE QUESTION FROM PART A AND B

PART A

1. (a) Show that the angle of deviation of a ray of light traversing through a prism of small angle A is given by $(\mu - 1)A$, where μ is the refractive index of the material of the prism.

(b) How do you define the dispersive power of a thin prism?

(c) Derive the condition for prism combination to be achromatic.

(d) If red, yellow and blue light have respective refractive indices of 1.644, 1.650 and 1.664 for flint glass and crown glass has refractive indices of 1.514, 1.517 and 1.523, respectively for the same colours,

(i) Calculate the dispersive power of flint and crown glass.

(ii) Find the refracting angle of thin prism of crown glass to produce achromatic combination with a thin prism of flint glass of refracting angle of 4°.

2. (a) Write down the cardinal points of an optical system.

(b) Show that the principle planes of an optical system consisting of two lenses of focal lengths f_1 and f_2 placed distance d apart on the common axis are $k_1 = -\frac{dF}{f_1}$ and $k_2 = \frac{dF}{f_2}$ from the first and the second lenses respectively, where F is the focal length of the lens system.

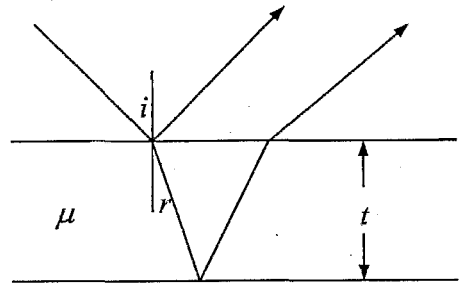
(c) An optical system consisting of a converging lens of the power -5 diopters and diverging lens of the power 10 diopters are placed 15 cm along their common axis. If the incident light falls first upon the converging lens, calculate (i) focal length of the lens system and (ii) distance to the first and second principle planes from the lenses.

(d) Mark the principle planes of the optical system drawing a diagram.

3. (a) How do two waves of light become coherent? Explain the importance of coherent sources of light to obtain interference patterns.

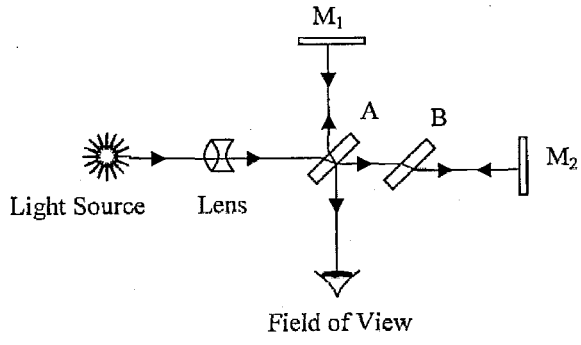
(b) Write down two methods of obtaining interference patterns by (i) division of wave fronts and (ii) division of amplitudes.

(c) A light ray incident on a parallel plate of glass of thickness t and refractive index μ with an angle i gets partially reflected and partially transmitted at the top surface as shown in the following figure. The transmitted ray again gets reflected at the bottom surface. Show that the path difference between the two rays emerged at the top surface is $2\mu t\cos r$ where r is the angle of refraction. Hence show that $2\mu t\cos r = (2m-1)\frac{\lambda}{2}$ for bright fringes and $2\mu t \cos r = m\lambda$ for dark fringes where m is an integer.



(d) A parallel beam of monochromatic light of wavelength 6560 Å normally incident on a parallel plate of glass of refractive index 1.6 and reflected light found to be with zero intensity. Explain how this can happen. When the angle of incident gradually increased, the first maximum occurs at an angle of 2°. Calculate the thickness of the glass plate.

4. (a) Briefly explain how fringes are obtained in the Michelson interferometer given in the following figure. What is the purpose of glass plate B placed in between A and M_2?



(b) Write down expression for the path difference of the fringe (i) at the center of the fringe pattern for normal incident and (ii) p^{th} fringe incident at an angle θ_p of the fringe system in Michelson interferometer.

(c) Hence show that $2d\,(1-\cos\theta_p) = p\lambda$ where d is the distance between the two mirrors and λ is the wavelength of the light.

(d) Calculate the radius of the 6^{th} bright fringe of the fringe system in Michelson interferometer when the distance between the two mirrors is 4 mm. Assume that the interferometer is adjusted to get a bright fringe at the center and $\lambda = 4358$ Å.

PART B

5. (a) Write down the types of wave fronts associated with (i) Fresnel diffraction and (ii) Fraunhofer diffraction.

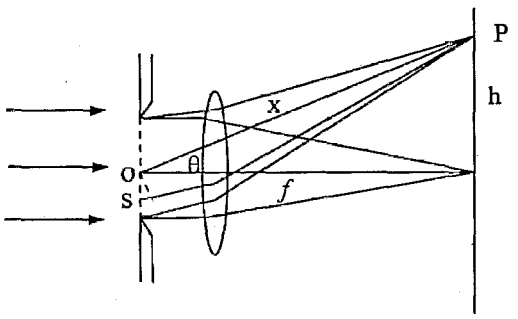
(b) Explain how you obtain a vibration curve with the half zones of spherical wave front.

(c) What is meant by a zone plate? Show that a zone plate can be made in practice by drawing concentric circles with radii proportional to the square root of whole numbers.

(d) A parallel beam of micro waves having a wavelength λ cm passes through a circular opening. A detector is placed d cm behind on the axis of the hole. If the opening gradually increases its radius r, show that the detector record maximum intensity when $r^2 = (2n-1)^2\lambda^2 + 2d(2n-1)\lambda$ and minimum intensity when $r^2 = n^2\lambda^2 + 2dn\lambda$, where n is an integer.

6. (a) Write down the assumptions made in the Fresnel diffraction.

(b) Based on those assumptions, show that the disturbance at point P is $dy_o = a\frac{ds}{x}\sin(\omega t - kx)$, if the wavelet coming from element ds from origin, o is $y_0 = a\sin\omega t$ referring to the following figure.



(c) If the overall displacement due to the whole slit is $y = \frac{ab}{x}\left(\frac{\sin\beta}{\beta}\right)\sin(\omega t - kx)$, where $\beta = \frac{kb}{2}\sin\theta$, show that $h = \frac{n\lambda f}{b}$ gives the positions of the nth minima from the axis of the lens.

(d) Parallel light of wavelength 6560 Å incident normally on a slit of 0.38 mm width. A lens with a focal length of 50 cm is placed just behind the slit to bring the diffraction pattern focus on a screen. Calculate the distance from the centre of the principal maximum to the 3rd minimum.

7. (a) What is the difference between unpolarized and polarized light? Explain the nature of plane polarized, circularly polarized and elliptically polarized light.

(b) How do you produce plane polarized light by reflection?

(c) Write down the Brewster's law and show that tan $\alpha = \mu$, where α is the Brewster's angle of incidence and μ is the refractive index.

(d) A Light beam is reflected from a surface of a glass plate and reflected light found to be plane polarized when the angle of incidence is 57°. Find the refractive index of the glass plate. If the reflected light is viewed through a calcite crystal which can be rotated about the direction of the reflected beam, when do you observe the intensity of transmitted light through calcite crystal to be zero?

8. (a) What is meant by optical activity of solids and liquids? Briefly discuss the practical applications of optical activity of materials in nature?

   (b) How do you define the specific rotation (i) in crystals and (ii) in liquids?

   (c) Describe the Fresnel's explanation of specific rotation in crystals.

   (d) 14.5 g from mixture of sugar and salt is dissolved in 60 cm^2 of water. When this solution is placed in polarimeter tube of 15 cm long, it rotates the plane of polarization of sodium light by 16.8° to the right. If the specific rotation of sugar is 66.5° find the fraction of sugar in the mixture.

9. Answer any two of the following.

   (a) Classify the types of aberrations and briefly explain one of them.

   (b) Explain two industrial applications of interference of light due to the optical wedge.

   (c) Discuss the differences between Newton's rings and Fabry-Perot rings.

   (d) Find out the intensity distribution after diffracting at a straight edge using the Cornu's spiral.

   (e) Write down the experimental procedure to identify unpolarized, plane polarized, circularly polarized and elliptically polarized light.