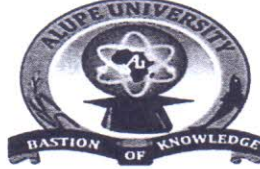


PHY 321



ALUPE UNIVERSITY

OFFICE OF THE DEPUTY VICE CHANCELLOR

ACADEMICS, RESEARCH AND STUDENTS AFFAIRS

UNIVERSITY EXAMINATIONS

2024 /2025 ACADEMIC YEAR

**THIRD YEAR SECOND SEMESTER REGULAR MAIN
EXAMINATION**

**FOR THE DEGREE OF BACHELOR OF
EDUCATION SCIENCE**

COURSE CODE: PHY 321

COURSE TITLE: PHYSICAL OPTICS

DATE: 07/04/2025

TIME: 2 PM - 5 PM

INSTRUCTION TO CANDIDATES

- SEE INSIDE

THIS PAPER CONSISTS OF 5 PRINTED PAGES

PLEASE TURN OVER

REGULAR – MAIN EXAM
PHY 321: PHYSICAL OPTICS

STREAM: BED (Scie)

DURATION: 3 Hours

INSTRUCTIONS TO CANDIDATES

- i. Answer the *TWO* question in *SECTION A* and any other *THREE* questions in *SECTION B*.

SECTION A (28 MARKS)**Question One (14 Marks)**

- a) What are the two conditions for interference to take place between two sources of light? (2 Marks)
- b) State any three differences between interference and diffraction. (6 Marks)
- c) Highlight three ways in which the phase difference between two waves can change (3 Marks)
- d) An oil film ($n = 1.45$) floating on water ($n = 1.33$) is illuminated by white light at normal incidence. The film is $2.8 \times 10^2 \text{ nm}$ thick. Find the wavelength of the light in the visible spectrum most strongly reflected ($m = 1$). (3 Marks)

Question Two (14 Marks)

- a) Why is it not practical to put the source of light and/or the screen at infinite distance from diffracting aperture in Fraunhofer diffraction? How are these obstacles overcome? (3 Marks)
- b) Light of wavelength 540nm passes through a slit of width 0.2 mm. Calculate the width of the central maximum on a screen located 1.5 m from the slit. (2 Marks)
- c) Using well labelled figure, describe linear polarization of light (2 Marks)
- d) The reflected ray in air is completely polarized when the angle of incidence is 48.0° . What is the index of refraction of the reflecting material? (2 Marks)
- e) State three conditions that must be satisfied for stimulated emission to result to laser light. (3 Marks)
- f) State Rayleigh's criterion applied to diffraction patterns (2 Marks)

SECTION B (42 MARKS)**Question Three (14 Marks)**

- a) What is the effect on spacing between fringes in a two-slit interference pattern, when the
- the screen is moved away from the plane of the slits (1 Mark)
 - the (monochromatic) source is replaced by another (monochromatic) source of shorter wavelength (1 Mark)
 - the separation between the two slits is increased (1 Mark)
- b) Two narrow slits are separated by 1.5 mm and are 3 m away from a screen. The slits are illuminated by a yellow light of wavelength 589 nm from a sodium-vapor lamp. Find the spacing between the bright fringes. (3 Marks)
- c) If the distance between the first and tenth minima of a double-slit pattern is 18.0 mm and the slits are separated by 0.150 mm with the screen 50.0 cm from the slits, what is the wavelength of the light used? (4 Marks)
- d) Coherent sources A and B emit electromagnetic waves with wavelength 2.0 cm. Point P is 4.86 m from A and 5.24 m from B. What is the phase difference at P between the two waves? (2 Marks)
- e) If mirror M_2 in a Michelson interferometer is moved through 0.233 mm, a shift of 792 bright fringes occurs. What is the wavelength of the light producing the fringe pattern? (2 Marks)

Question Four (14 Marks)

- a) Plot a well labelled light intensity I versus $(\pi/\lambda)a \sin \theta$ for the single-slit Fraunhofer diffraction pattern. (3 Marks)
- b) A beam of monochromatic light is diffracted by a slit of width 0.600 mm. The diffraction pattern forms on a wall 1.30 m beyond the slit. The width of the central maximum is 2.00 mm. Calculate the wavelength of the light. (3 Marks)
- c) A diffraction grating has 4.2×10^3 rulings per centimeter. The screen is 2.0 m from the grating.
- Compute the value of d , the distance between adjacent rulings. Express the answer in meters. (2 Marks)
 - Calculate the angle of the second-order maximum made by the 589.0-nm wavelength of sodium. (2 Marks)
 - Find the position of this second-order maximum on the screen. (2 Marks)

- d) A bright spectral line occurs at an angle of 14.8° in the first-order spectrum of a diffraction-grating spectrometer. If the grating has 3 660 slits/cm, what is the wavelength of the light? (2 Marks)

Question Five (14 Marks)

- a) The radius of curvature of the convex surface of a plano-convex thin lens is $R = 5 \text{ m}$. The convex surface is placed down on a plane glass plate and illuminated from above by light of wavelength $\lambda = 450 \text{ nm}$, see Fig. 1.

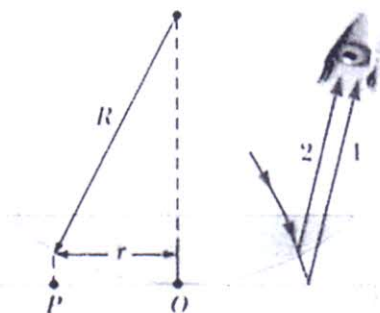


Figure 1

- i) What is the change in thickness of the air film at the position of sixth dark fringe (3 Marks)
 - ii) What is the radius of the fourth bright fringe? (3 Marks)
- b) Two glass plates 10.0 cm long are in contact at one end and separated at the other end by a thread with a diameter $d = 0.05 \text{ mm}$ (Fig. 2).

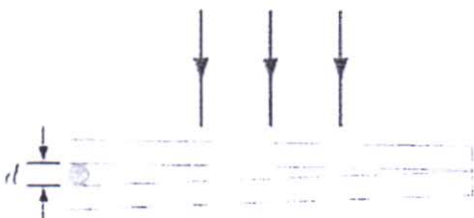


Figure 2

Light containing wavelength 600 nm is incident perpendicularly and viewed by reflection.

- i) What is the thickness of the air wedge at the first dark fringe (3 Marks)
 - ii) At what distance from the contact point is the first dark fringe ($m = 1$)? (3 Marks)
- c) State any two characteristics of fringes formed by coherent sources obtained using plane mirror with a point single light source placed close to the mirror. (2 Marks)

Question Six (14 Marks)

- a) Differentiate between vertically polarized and horizontally polarized light (2Marks)
- b) What is the difference between ideal polarizer and dichroic polarizer? (2 Marks)
- c) Using well labelled diagram, describe briefly how double refraction can produce plane polarized light. (2 Marks)
- d) Using well labelled diagram showing incident light from medium n_1 onto medium of index n_2 , prove that Brewster law can be expressed as $\tan \theta_p = n_2/n_1$. (4 Marks)
- e) The polarizers are rotated so that the second polarizer has a transmission axis of 40.0° with respect to the first polarizer, and the third polarizer has an angle of 90.0° with respect to the first. If I_b is the intensity of the original unpolarized light, what is the intensity of the beam after it passes through
- the second polarizer and (2 Marks)
 - the third polarizer? (2 Marks)

Question Seven (14 Marks)

- a) Using well labelled diagram, distinguish between spontaneous emission and stimulated emission (4 Marks)
- b) With help of well labeled energy levels for helium and neon atoms in a helium–neon gas laser. Briefly describe the lasing action in this laser. (2 Marks)
- c) Highlight any two applications of lasers (2 Marks)
- d) A diffraction grating 1 cm wide has $N = 1,000$ equally spaced slits across its width. The diffraction grating is illuminated at normal incidence by sodium doublet which contains two colors, one with wavelengths $\lambda_1 = 589.0 \text{ nm}$ and the other with wavelength $\lambda_2 = 589.6 \text{ nm}$.
- What is the separation between the slits of the grating? (1 Mark)
 - How many bright fringes are seen for both colors? (2 Marks)
 - What must the resolving power of the grating be if the two colors are to be resolved (distinguished)? (2 Marks)
 - How many slits of this grating must be illuminated in order to resolve these two colors in the fourth-order? (1 Mark)
