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OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2020 /2021 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: PHY 321

COURSE TITLE: PHYSICAL OPTICS

DATE: 15/07/2021 **TIME: 1300 – 1600HRS**

INSTRUCTION TO CANDIDATES

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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) Using well labelled diagrams, distinguish between constructive interference and destructive interference. (2 Marks)

b) Two slits spaced 0.45 mm apart are placed 75.0 cm from a screen. What is the distance between the second and the third dark fringe on the screen when the slits are illuminated with coherent light of wavelength 500 nm? (4 Marks)

c) State two characteristics formed by Newton's rings interference patterns. (2 Marks)

d) Coherent sources A and B emit electromagnetic waves with wavelength 2.00 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) State two applications of Michelson interferometer. (2 Marks)

f) Plot light intensity I against $d\sin\theta$ for double slit interference pattern when $L >> d$. (2 Marks)

Question Two (14 Marks)

a) State two reasons, why it's not practical to put the source of light and/or the screen at infinite distance from diffracting aperture in Fraunhofer diffraction. (2 Marks)

b) Why can you hear around corners, but not see around corners? (2 Marks)

c) Light of wavelength 600 nm falls on a 0.40-mm-wide slit and forms a diffraction pattern on a screen 1.5 m away.

(i) Find the position of the first dark band on each side of the central maximum. (2 Marks)

(ii) Find the width of the central maximum. (2 Marks)

d) i) Explain what is meant by the statement, the beam of light is plane polarized? (1 Mark)

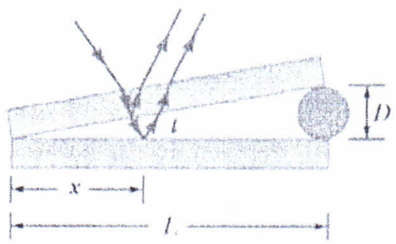
ii) The index of refraction of a glass plate is 1.52. What is the Brewster's angle when the plate is in air and in water? (2 Marks)

e) State the three types of gas lasers. (3 Marks)

SECTION B (42 MARKS)

Question Three (14 Marks)

a) A pair of glass slides 10.0 cm long and refractive index, $n = 1.52$ are separated on one end by a hair, forming a triangular wedge of air, as illustrated below.



When coherent light from a helium–neon laser with wavelength 633 nm is incident on the film from above and dark fringe is at distance $x = md$ where m is the order of the fringe and $d = 6.67 \times 10^{-4}\, m$.

i) How thick is the hair? (4 Marks)

ii) The air wedge is replaced with water, with $n = 1.33$. Find the distance between dark bands when the helium– neon laser light hits the glass slides. (3 Marks)

b) In a Newton's-rings experiment, a plano-convex glass ($n = 1.52$) lens having radius $r = 5.00cm$ is placed on a flat plate. When light of wavelength $\lambda = 650nm$, is incidentally normal, 55 bright fringes are observed, with one precisely on the edge of the lens.

i) What is the radius R of curvature of the convex surface of the lens (4 Marks)

ii) What is the focal length of the lens (3 Marks)

Question Four (14 Marks)

a) Monochromatic light from a helium–neon laser ($\lambda = 7.8 \times 10^2 nm$) is incident normally on a diffraction grating containing 3.3×10^3 lines per centimeter. Find the angles at which one would observe the first-order maximum, the second-order maximum, and third-order maximum. (4 Marks)

b) Light of wavelength 500 nm is incident normally on a diffraction grating. If the third-order maximum of the diffraction pattern is observed at 32.0°.

i) What is the number of rulings per centimeter for the grating? (2 Marks)

ii) Determine the total number of primary maxima that can be observed in this situation. (2 Marks)

c) Light from an argon laser strikes a diffraction grating that has 5310 grooves per centimeter. The central and first-order principal maxima are separated by 0.488 m on a wall 1.72 m from the grating. Determine the wavelength of the laser light. (3 Marks)

d) State three applications of diffraction gratings. (3 Marks)

Question Five (14 Marks)

a) Two narrow, parallel slits separated by 0.85mm are illuminated by 600-nm light, and the viewing screen is 2.80 m away from the slits.

  i) What is the phase difference between the two interference waves on a screen at a point 2.50 mm from the central bright fringe? (3 Marks)

  ii) What is the ratio of intensity at this point to the intensity at the center of a bright fringe? (3 Marks)

b) A pair of slits, separated by 0.150 mm, is illuminated by light having a wavelength of $\lambda = 643nm$. An interference pattern is observed on a screen 140 cm from the slits. Consider a point on the screen located at $y = 1.80cm$ from the central maximum of this pattern.

  i) What is the path difference d for the two slits at the location y? (2 Marks)

  ii) Express this path difference in terms of the wavelength. (1 Mark)

  iii) Will the interference correspond to a maximum, a minimum, or an intermediate condition? (1 Mark)

c) A plane wave of monochromatic light is incident normally on a uniform thin film of oil that covers a glass plate. The wavelength of the source can be varied continuously. Fully destructive interference of the reflected light is observed for wavelengths of 500 nm and 700 nm and for no wavelengths in between. If the index of refraction of the oil is 1.30 and that of the glass is 1.50, find the thickness of the oil film. (4 Marks)

Question Six (14 Marks)

a) Briefly describe the following methods of producing plane polarized light.

  i) by passing light through dichroic materials (2 Marks)

  ii) by passing light through birefringent materials (2 Marks)

b) Distinguish between polarization by reflection and scattering. (4 Marks)

c) Plane-polarized light is incident on a single polarizing disk with the direction of E_o parallel to the direction of the transmission axis. Through what angle should the disk be rotated so that the intensity in the transmitted beam is reduced by a factor of 5.00? (3 Marks)

d) Light with a wavelength in vacuum of 546.1 nm falls perpendicularly on a biological specimen that is 1.000 mm thick. The light splits into two beams polarized at right angles, for which the indices of refraction are 1.320 and 1.333, respectively. Calculate the wavelength of each component of the light while it is traversing the specimen. (3 Marks)

Question Seven (14 Marks)

a) The doublet in the hydrogen spectrum has wavelengths of 656.272 nm and 656.285 nm.

   i) What must be the resolving power of a grating so as to distinguish these wavelengths? (2 Marks)

   ii) How many lines of the grating must be illuminated to resolve these lines in the third order spectrum? (2 Marks)

b) The Hubble Space Telescope has an aperture of diameter 2.40 m.

   i) What is its limiting angle of resolution at a wavelength of 6.00×10^2 nm ? (2 Marks)

   ii) What's the smallest crater it could resolve on the Moon? (The Moon's distance from Earth is ($3.84 \times 10^8 m$) (2 Marks)

c) Using well labelled diagram, distinguish between spontaneous and stimulated emission of a laser. (6 Marks)

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