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OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2021 /2022 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: 9TH JUNE, 2022 **TIME: 1400 – 1700 HRS**

INSTRUCTION TO CANDIDATES

- **SEE INSIDE**

THIS PAPER CONSISTS OF 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) Why is it so much easier to perform interference experiments with a laser than with an ordinary light source? (2 Marks)

b) What is the effect on spacing between fringes in a two-slit interference pattern, when the

i) the screen is moved away from the plane of the slits (1 Mark)

ii) the (monochromatic) source is replaced by another (monochromatic) source of shorter wavelength (1 Mark)

iii) the separation between the two slits is increased (1 Mark)

c) State three characteristics of interference pattern formed by Wedged thin films (3 Marks)

d) In a double slit experiment, the distance between slits is 5 *mm* and the slits are 1.0 m from the screeen. Two interference patterns are seen on the screen: one due to light of wavelength 480 *nm* and the other due to light of wavelength 600 *nm*. Calculate the position of third order $(m = 3)$ bright fringes on the screen due to each wavelegth and determine separation of the interference patterns. (3 Marks)

e) Light of wavelength 624nm is incident perpendicularly on a soap film (n=1.33) suspended in air. What are the least (m=1) and second least (m=2) thickness of the film for which the reflection from the film will undergo fully constructive interference. (3 Marks)

Question Two (14 Marks)

a) With the help of well labelled figures, state the difference between Fresnel diffraction and Fraunhoffer diffraction. (4 Marks)

b) Using figures, distinguish between horizontally polarized, vertically polarized and unpolarized light. (3 Marks)

c) Give a brief description of Carbon dioxide (CO_2) gas laser. (2 Marks)

d) Coherent laser light of wavelength 633nm is incident on a single slit of width 0.25 mm. The viewing screen is 2.0 m from the slit. What is the width of the central bright fringe? (2 Marks)

e) A light beam is incident on a piece of fused quartz (n=1.458) at Brewster's angle. Find

i) The value of Brewster's angle and (2 Marks)

ii) The angle of refraction for the transmitted ray (1 Mark)

SECTION B (42 MARKS)

Question Three (14 Marks)

a) A pair of narrow, parallel slits separated by 0.25 mm is illuminated by green light (($\lambda = 546.1\,nm$). The interference pattern is observed on a screen 1.2 m away from plane of parallel slits.

i) Calculate the distance from central maximum to the first bright region on either side of the central maximum and (2 Marks)

ii) Determine the distance between the first and second dark bands in the interference pattern. (3 Marks)

b) Monochromatic light falls on a screen 1.75 m from two slits separated by 2.10 mm. The first and second order bright fringes are separated by 0.552 mm. What is the wavelength of light?

(3 Marks)

c) Coherent light with wavelength 500 nm passes through narrow slits separated by 0.34 mm. What is the phase difference in light from the two slits at an angle of 23.0° from the centerline. (2 Marks)

d) A thin film of transparent material of thickness d and index n_f where $n_2 > n_f > n_1$ is shown in Figure 1. For what three smallest gap thicknesses will reflected light rays 1 and 2 interfere totally i) constructively and ii) destructively? Assume the light has wavelength in the film of 600 nm and $n_f = 1.40$. (4 Marks)

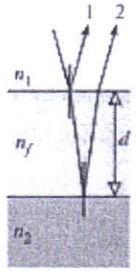

Figure 1

Question Four (14 Marks)

a) State three factors that affect diffraction patterns. (3 Marks)

b) The distance between the first and fifth minima of a single slit diffraction pattern is 0.35 mm with the screen 40 cm away from the slit, when light of wavelength 550 nm is used.

i) Find the slit width (2 Marks)

ii) Calculate the angle θ of the first diffraction minimum (2 Marks)

c) A helium-neon laser (λ=632.8 nm) is used to calibrate a diffraction grating. If the first order maximum occurs at 20.5°, what is the spacing between adjacent grooves in the grating? (2 Mark)

d) Intense white light is incident on a diffraction grating that has 600 lines/mm.

i) What is the highest order in which the complete visible spectrum (longest wavelength, 700 nm) can be seen with this grating? (2 Marks)

ii) What is the angular separation between the violet edge (400 nm) and the red edge (700 nm) of the first order spectrum produced by the grating? (3 Marks)

Question Five (14 Marks)

a) A plano-convex lens has index of refraction n. The curved side of the lens has radius of curvature R and rests on a flat glass surface of the same index of refraction, with a film of air between them, as shown in Figure 2. The lens is illuminated from above by light of wavelength λ.

i) Show that the Newton's bright rings have radii given approximately by $r \approx \sqrt{\left(m+\frac{1}{2}\right)\lambda R}$ Where $r << R$ and m is an integer. The symbols have their usual meaning.

(4 Marks)

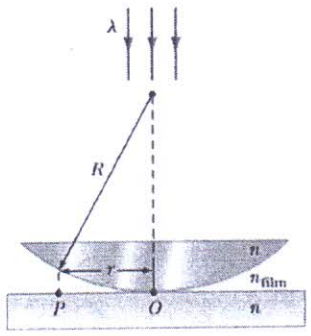

Figure 2

ii) Find the air-gap thickness t at i) the second bright ring (m=1) and ii) the third dark ring. (2 Marks)

iii) State one application of newton's rings (1 Mark)

b) Two rectangular optically flat plates (n =1.52) are in contact along one end and separated along the other end by a $2.0\mu m$ thick spacer. The top plate is illuminated by monochromatic light of wavelength 546.1 nm.

i) How many dark fringes will be observed crossing the top plate? (3 Marks)

ii) When the plates, of length 14.0 cm are illuminated from above with light of wavelength 650 nm, a person observes bright bands separated by 0.58 mm. What is the thickness of the spacers separating the plates at the other end? (4 Marks)

Question Six (14 Marks)

a) Using well labelled diagrams, state the difference between circular polarization and elliptical polarization. (2 Marks)

b) Distinguish between dichroic materials and birefringent materials and give examples of each. (4 Marks)

c) Briefly describe the following mechanisms of producing plane polarized light.

i) Reflection (2 Marks)

ii) Scattering (2 Marks)

d) State Malu's law (1 Mark)

e) Light of intensity I_o and polarized parallel to the transmission axis of a polarizer is incident on an analyzer.

i) If the transmission axis of the analyzer makes an angle of 45° with the axis of the polarizer, what is the intensity of the transmitted light? (2 Marks)

ii) What should the angle between the transmission axes be to make $I/I_o = \frac{1}{3}$. (1 Mark)

Question Seven (14 Marks)

a) State three characteristics of lasers (3 Marks)

b) A helium-neon laser emits laser light at wavelength of 632.8 nm and a power of 2.3 mW. At what rate are phonons emitted from this device. (3 Marks)

c) State any four applications of lasers (4 Marks)

d) Sodium light of wavelength 589 nm is used to view an object under a microscope. The aperture of the objective has a diameter of 0.90 cm.

i) Find the limiting angle of resolution for this microscope. (2 Marks)

ii) Suppose oil with $n = 1.50$ fills the space between the object and objective for this microscope. Calculate the limiting angle θ_{min} for sodium light of wavelength 589 nm in air. (2 Marks)

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