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OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2019 /2020 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: 5TH NOVEMBER, 2020 TIME: 0900 – 1200 HRS

INSTRUCTION TO CANDIDATES

- SEE INSIDE

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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.***

ii. *The following constants maybe useful*

SECTION A (28 MARKS)

Question One (14 Marks)

a) What conditions are necessary for interference to take place between two sources of light? (2 Marks)

b) A pair of narrow, parallel slits separated by 0.250 mm is illuminated by green light ($\lambda = 546.1nm$). The interference pattern is observed on a screen 1.20 m away from the plane of the parallel slits. Calculate the distance

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

ii. between the first and second dark bands in the interference pattern. (2 Marks)

c) Interference effects are produced at point P on a screen as a result of direct rays from a 500-nm source and reflected rays from the mirror as shown in Figure 1. Assume the source is 100 m to the left of the screen and 1.00 cm above the mirror. Find the distance y to the first dark band above the mirror. (3 Marks)

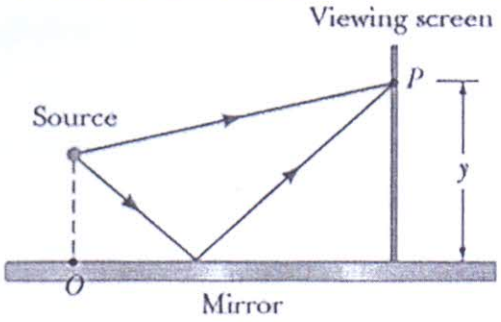


Figure 1

d) Two microscopic slides 10.0 cm long are in contact at one end; at the other end they are separated by a piece of paper 0.02 mm thick. Suppose the slides have refractive index, $n = 1.52$ and the space between them contains water ($n = 1.33$). What is the spacing of the interference fringes seen by reflection? (2 Marks)

e) Identify any three classes of lasers. (3 Marks)

Question Two (14 Marks)

a) Describe the difference between Fresnel diffraction and Fraunhofer diffraction. (2 Marks)

b) Why is a diffraction grating better than a two-slit setup for measuring wavelengths of light? (2 Marks)

c) Light of wavelength 587.5 nm illuminates a slit of width 0.75 mm.

i) At what distance from the slit should a screen be placed if the first minimum in the diffraction pattern is to be 0.85 mm from the central maximum? (3 Marks)

ii) Calculate the width of the central maximum. (1 Mark)

d) Distinguish between dichroic and birefringent polarizers. (2 Marks)

e) Unpolarized light passes through two polaroid sheets. The transmission axis of the analyzer makes an angle of 35.0° with the axis of the polarizer.

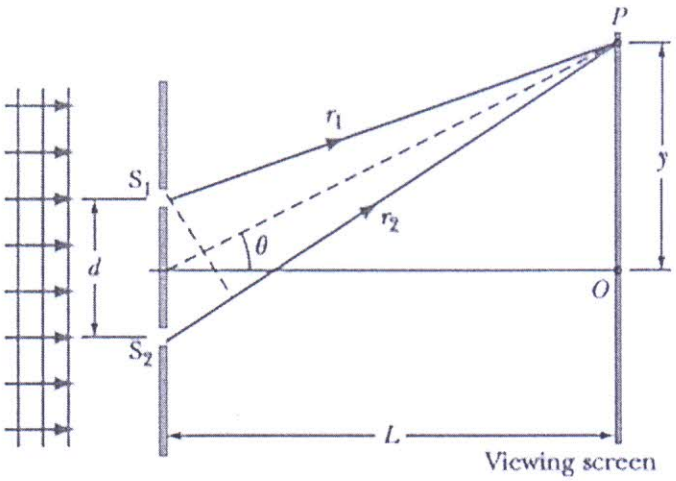
i) What fraction of the original unpolarized light is transmitted through the analyzer? (2 Marks)

ii) What fraction of the original light is absorbed by the analyzer? (2 Marks)

SECTION B (42 MARKS)

Question Three (14 Marks)

a) Let L=1.20 m and d = 0.120 mm and assume the slit system is illuminated with monochromatic 500 nm light as shown below.



Calculate the phase difference between the two wave fronts arriving at P when

i. $\theta = 0.500°$ (2 Marks)

ii. $y = 5.00\ mm$ (2 Marks)

iii. What is the value of θ for which the phase difference is 0.333 rad? (2 Marks)

iv. What is the value of θ for which the path difference is $\lambda/4$ (2 Marks)

b) i) Calculate the minimum thickness of a soap-bubble film, $n = 1.33$, that will result in constructive interference in the reflected light if the film is illuminated by light with wavelength 602 nm in free space. (2 Marks)

ii) Recalculate the minimum thickness for constructive interference when the soap-bubble film is on top of a glass slide with $n = 1.5$. (2 Marks)

iii) What other film thicknesses (atleast) in part (i) will produce constructive interference? (2 Marks)

Question Four (14 Marks)

a) What is the difference between transmission grating and reflection grating? (2 Marks)

b) Monochromatic light from a helium–neon laser ($\lambda = 632.8nm$) is incident normally on a diffraction grating containing (6×10^3 lines/cm). Find the angles at which one would observe the first-order maximum, the second-order maximum, and so forth. (4 Marks)

c) 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 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)

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

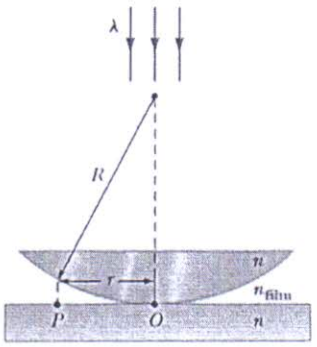
Question Five (14 Marks)

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 index n_{film} between them, as shown below. The lens is illuminated from above by light of wavelength λ.

i) Show that the dark Newton's rings have radii given approximately by

$r \approx \sqrt{\frac{m\lambda R}{n_{film}}}$ Where $r << R$ and m is an integer. The symbols have their usual meaning.

(4 Marks)



ii) Show that the diameter of consecutive dark fringes in Newton's rings are separated by $d_{m+s}^2 - d_m^2 = 4s\lambda R$, where the medium between the glass plate and the lens is air ($n_{film} = 1$). (3 Marks)

b) A Plano convex lens of radius 1.0m is placed on an optically flat glass plate and is illuminated by an extended monochromatic source. Assume that the point of contact is

perfect. The diameters of the 15th and 5th dark rings in the reflected light are $5.90\times10^{-3}\,m$ and $3.36\times10^{-3}\,m$, respectively. Calculate the wavelength of light used.

(2 Marks)

c) Two 0.15m long glass plates are made to touch at one end. A sheet $6\times10^{-5}\,m$ thick separates the other end. How many bright fringes will be observed over the entire plate, if light of wavelength $720nm$ is reflected normally from it. (3 Marks)

d) State two characteristics of interference fringes formed by wedge shaped thin films. (2 Marks)

Question Six (14 Marks)

a) Explain briefly the following methods for producing plane polarized light.

i) Polarization by Selective Absorption (2 Marks)

ii) Polarization by Reflection (2 Marks)

iii) Polarization by Double Refraction (2 Marks)

iv) Polarization by Scattering (2 Marks)

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

c) The angle of incidence of a light beam in air onto a reflecting surface is continuously variable. The reflected ray is found to be completely polarized when the angle of incidence is 48.0°.

i) What is the index of refraction of the reflecting material? (1 Marks)

ii) If some of the incident light (at an angle of 48.0°) passes into the material below the surface, what is the angle of refraction? (2 Marks)

Question Seven (14 Marks)

a) 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. (1 Mark)

ii) Using visible light of any wavelength you desire, find the maximum limit of resolution for this microscope. (1 Mark)

iii) Water of index of refraction 1.33 now fills the space between the object and the objective. What effect would this water have on the resolving power of the microscope, using 589-nm light? (2 Marks

b) Two bright lines in the spectrum of sodium have wavelengths of 589.00 nm and 589.59 nm, respectively.

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

ii) To resolve these lines in the second-order spectrum, how many lines of the grating must be illuminated? (2 Marks)

c) State three properties of lasers. (3 Marks)

d) Outline three applications of lasers (3 Marks)

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