JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

1ST YEAR 2ND SEMESTER 2021/2022

MAIN REGULAR

COURSE CODE: SPB 9108/SPH 103

COURSE TITLE: OPTICS

EXAM VENUE: **STREAM: (BED SCI)**

DATE: **EXAM SESSION:**

TIME: 3:00HRS

Instructions:

1. **Answer question 1 (Compulsory) in Section A and ANY other 2 questions in Section B.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room**

Question 1 (30 marks)

(a) State the laws of refraction of light. A ray diagram should form a part of your answer. (2 mks)

(b) A small object is placed between the principal focus of a concave mirror and the pole of the mirror. Use a ray diagram to show the position of the image, hence describe the image as fully as you can. (3 mks)

(c) A biconvex lens is to be made of glass with refractive index of 1.5. One surface is to have twice the radius of curvature of the other and the focal length is to be 60 mm. Find the smaller radius. (3 mks)

(d) A wavefront is circular in shape. Explain how Huygens principle can be used to determine its position after a time interval Δt. (2 mks)

(e) In Michelson's interferometer, 100 fringes cross the field of view when the movable mirror is displaced through 0.02948 mm. Calculate the wavelength of the monochromatic light used. (3 mks)

(f) Light of wavelength 600 nm is incident normally on a slit of width 0.1 mm. Find the angular position of the first minimum. (2 mks)

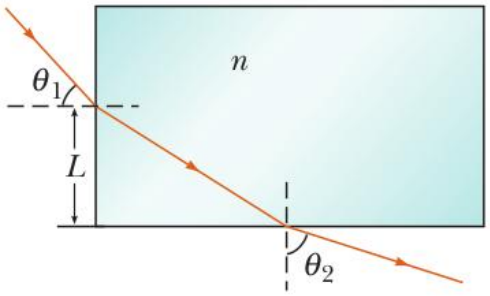
(g) The image of a real object in a diverging lens of focal length 10 cm is formed 4 cm from the lens.

i. Find the object distance and the magnification. (3 mks)

ii. Draw a sketch to illustrate the formation of the image. (1 mk)

(h) Explain how the eye is focused for viewing objects at different distances. State any two eye defects and explain how each can be corrected. (3 mks)

(i) A ray of light enters a rectangular block of plastic at an angle $\theta_1 = 45.0^o$and emerges at an angle $\theta_2 = 76.0^o$,as shown in the figure below.



Determine the refractive index of the plastic. (3 mks)

(j) A concave makeup mirror is designed so that a person 25 cm in front of it sees an upright image magnified by a factor of two. What is the radius of curvature of the mirror? (3 mks)

(k) State and explain what is observed when light rays pass through a narrow slit. (2 mks)

Question 2 (20 marks)

(a) Define optical path length and state Fermat's principle. Using Fermat's principle, derive Snell's law of refraction at the plane interface between two materials of refractive indices n_1 and n_2. (6 mks)

(b) A thin biconvex lens is placed with its principal axis first along a beam of parallel red light and then along a beam of parallel blue light. If the refractive indices of the lens for red and for blue light are respectively 1.514 and 1.524, and if the radii of curvature of its faces are 30 cm and 20 cm, calculate the separation of the foci for red and blue light. (5 mks)

(c) State Huygens principle, hence show that the refractive index of light moving from medium 1 to medium 2 is given by $n = \frac{v_1}{v_2}$where $v_1$and $v_2$are the velocities in the respective media. (4 mks)

(d) Explain the principle of operation of the Michelson interferometer, indicating how the final measurements are obtained. (5 mks)

Question 3 (20 marks)

(a) Where should the final image be formed when (i) a telescope (ii) a microscope is in normal use? Define the magnifying power (angular magnification) of a telescope and microscope. (4 mks)

(b) A telescope is made of an object lens of focal length 20 cm and an eyepiece of 5 cm, both converging lenses. Find the magnifying power in the case where: (i) the eye is focussed to see parallel rays, (ii) when the eye sees the image situated at a distance of 25 cm (near vision). (6 mks)

(c) The focal length of a diverging lens is 20 cm. Determine the position of the object given that the image is virtual, erect and 20% of the size of the object. (5 mks)

(d) (i) A ray of light is incident at a small angle to the face of a thin glass prism. Derive an expression for the angle of deviation of the ray. (4 mks)

(ii) Why is the deviation of yellow light usually used as that of white light? (1 mk)

Question 4 (20 marks)

(a) (i) Give an account of the theory of the production of a spectrum by means of a plane diffraction grating. (4 mks)

(ii) How does the spectrum in (a)(i) differ from the spectrum produced using a prism? (1 mk)

(b) Parallel light consisting of two monochromatic radiations of wavelengths 6×10^{-5}cm and 4×10^{-5}cm falls normally on a plane diffraction grating ruled with 5000 lines per cm. Find the angular separation of the second-order spectra of the two wavelengths. (5 mks)

(c) Light of wavelength 5.40×10^2 nm passes through a slit of width 0.200 mm.

(i) Find the width of the central maximum on a screen located 1.50 m from the slit. (3 mks)

(ii) Determine the width of the first-order bright fringe. (2 mks)

(d) Light of wavelength 550 nm is incident normally on a grating that has 400 lines per mm. Find the total number of maxima that are observable. (5 mks)

Question 5 (20 marks)

(a) (i) Explain what is meant by the statement that a beam of light is plane polarized. (1 mk)
(ii) State and explain any two methods by which light may be polarized. (6 mks)
(iii) The refractive index of diamond for sodium light is 2.417. Find the angle of incidence for which the light reflected from diamond is completely plane polarized. (3 mks)

(b) (i) Using suitable rays of light that pass through a point object lying on the principal axis of a concave mirror and get reflected to form its image, derive the mirror formula. (5 mks)
(ii) Explain the sign convention that is used alongside the formula. (1 mk)

(c) (i) State the laws of reflection of light. (2 mks)
(ii) Two plane mirrors M_1 and M_2 are placed in contact at an angle of 120° to each other. A ray of light is incident at an angle of incidence of 52° to M_1. Find the angle of reflection at M_2. (2 mks)