KABARAK UNIVERSITY

UNIVERSITY EXAMINATIONS

2008/2009 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: PHYS 122

COURSE TITLE: GEOMETRICAL OPTICS

STREAM: SESSION II

DAY: THURSDAY

TIME: 2.00 – 4.00 P.M.

DATE: 12/08/2010

INSTRUCTIONS:

Answer question ONE and any TWO other questions.
Question ONE carries 40 marks while all the other questions carry 15 marks each.

Take: Free space permittivity constant, $\varepsilon_o = 8.85 \times 10^{-12}$ F/m; $k = 1/(4\pi\varepsilon_o) = 9 \times 10^9 Nm^2/C^2$
Electron charge, $q_e = -1.6 \times 10^{-19}C$ Mass of electron, $m_e = 9.11 \times 10^{-31}kg$
Free space permeability constant, $\mu_o = 4\pi \times 10^{-7} Tm/A$,
$1\mu C = 10^{-6}C$, $1nC = 10^{-9}C$, $1eV = 1.6 \times 10^{-19}J$

PLEASE TURN OVER

QUESTION ONE

(a) State the laws of reflection and refraction [2 marks]

(b) Define the *index of refraction* of a material medium. [1 mark]

(c) When an object is placed 20cm from a certain lens, its virtual image is formed 10cm from the lens. Determine the focal length and character of the lens. [3 marks]

(d) State Fermat's principle [1 mark]

(e) A man has a concave shaving mirror whose focal length is 40cm. How far should the mirror be held from his face in order to give an image of two fold magnification? [2 marks]

(f) Light passes from air into a liquid and is deviated 19° when the angle of incidence is 52°. What is the index of refraction of the liquid? [2 marks]

(g) Define optical path length and state Fermat's principle. [2 marks]

(h) state four characteristics of images formed in a plane mirror [2 marks]

(i) Distinguish between chromatic and spherical aberrations. [4 marks]

(j) A candle is held 3cm from a concave mirror whose radius is 24cm. where is the image of the candle? [2 marks]

(k) Define the following phenomena related to light emission

i) continuous spectra [1 mark]

ii) fluorescence [1 mark]

iii) band spetra [1 mark]

(l) At what angle of incidence should a beam of light strike the surface of a still pond if the angle between the reflected ray and the refracted ray is to be 90°? (n = 1.33 for water.) [3 marks]

(m) It is suspected that a gas mixture containing helium, neon, ans argon has been contaminated with carbon monoxide. Suggest a method using spectra to determine whether the CO impurity is present. [2 marks]

(n) The velocity of light in air is $3 \times 2.25 \times 10^8$ m/s. Calculate

i) the refractive index of water, [2 marks]

ii) the angle of refraction of light from air to water at an angle [2 marks]

(o) An astronomical telescope has an objective of focal length 120 cm and an eye piece of focal length 5 cm. If the telescope is in normal adjustment, what is

i) the angular magnification (magnifying power) [2 marks]

ii) the separation of the two lenses [2 marks]

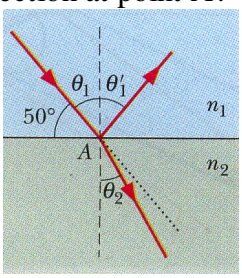
(p) A ray of light is incident along the normal in a plane mirror. The mirror is then rotated through an angle of 15^o. Calculate the angle between the first reflected ray and the second reflected ray. [3 marks]

QUESTION TWO

(a) Use Fermat's principle to arrive at the law of reflection. [5 marks]

(b) Apply Fermat's principle to the case of refraction in order to derive Snell's law: [5 marks]

(c) In Fig below, a beam of monochromatic light reflects and refracts at point A on the interface between material 1 with index of refraction $n_1 = 1.33$ and material 2 with index of refraction $n_2 = 1.77$. The incident beam makes an angle of 50° with the interface. What is the angle of reflection at point A? What is the angle of refraction there? [5 marks]



QUESTION THREE

(a) A point source S is located on the axis of, and 30 cm from, a plano-convex thin lens. Suppose that the glass lens is immersed in air ($n_{lm} = 1.5$) and that it has a radius of 5cm. Determine the location of the image

i. when the flat surface is toward S and [3 marks]

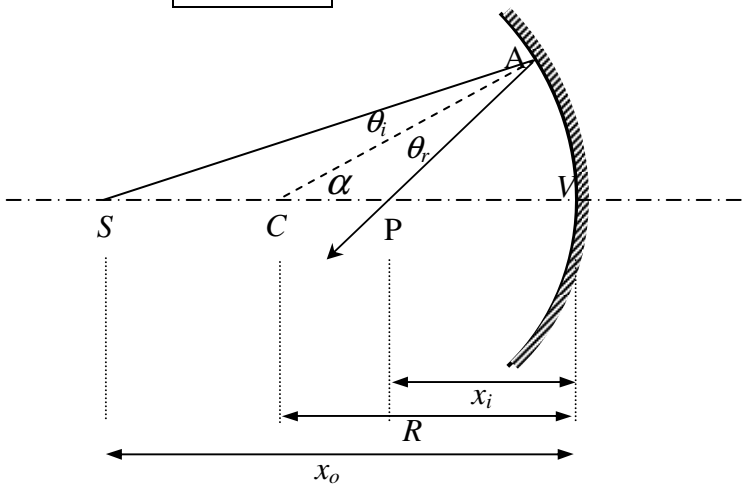
ii. when the curved surface is toward S. [3 marks]

(b) Derive the thin lens equation using geometrical arguments and the fact that a spherical wave enters and a spherical wave leaves the lens. [4 marks]

(c) A double convex lens has radii of curvature of 10cm and 15cm, respectively, for its first and second surfaces, and is 40cm thick at the center. The index of refraction of the glass is 1.60. Find the image of the object placed 14cm from the first surface (Do not neglect the thickness of the lens). [5 marks]

QUESTION FOUR

(a) In the figure light from a source S is reflected off the spherical concave mirror radius R centered on C. show that $\boxed{\frac{1}{x_o}+\frac{1}{x_i}=\frac{2}{R}}$ [5 marks]



(b) Tarantula of height h sits cautiously before a spherical mirror whose focal length has absolute value of focal length = 40 cm. The image of tarantula produced by the mirror has the same orientation as tarantula and has height h' = 0.20h.

i) Is the image real or virtual, and is it on the same side of the mirror as the tarantula or the opposite side? [3 marks]

ii) Is the mirror concave or convex, and what is its focal length f? [2 marks]

(c) Praying mantis preys along the central axis of a thin symmetric lens, 20 cm from the lens. The lateral magnification of the mantis provided by the lens is m = - 0.25, and the index of refraction of the lens material is 1.65.

i) Determine the type of image produced by the lens; the type of lens; whether the object (mantis) is inside or outside the focal point; on which side of the lens the image appears; and whether the image inverted. [3 marks]

ii) What are the two radii of curvature of the lens? [2 marks]

QUESTION FIVE

(a) In practice, optical fibers have a coating of glass of refractive index 1.512 which protect the optical surface of the fiber. If the fiber itself has an index of refraction 1.700, what is the critical angle for total reflection of a ray inside the fiber? [5 marks]

(b) Figure 1 shows a ray of light incident at an angle θ_1, on one end of an optical fiber. Its angle of refraction is θ_2, and it strikes the side of the fiber at an angle of Φ_2. If the index of refraction of the fiber is 1.30, what is the largest angle of incidence θ_1 that a ray can have and still be totally reflected from the side of the fiber? [5 marks]

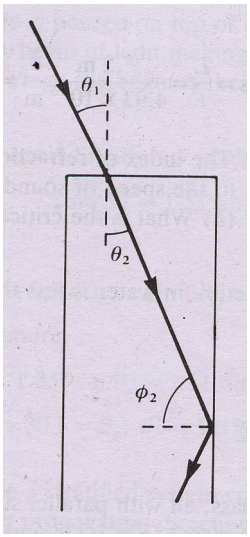


Figure 1

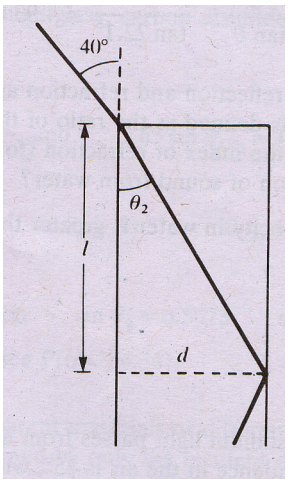


figure 2

(c) The optical fiber in Figure 2 is 2 m long and has a diameter of 20 μm. If a ray of light is incident on one end of the fiber at an angle $\theta_1 = 40°$, how many reflections does it make before emerging from the other end? (The index of refraction of the fiber is 1.30.) [5 marks]