UNIVERSITY OF KABIANGA

UNIVERSITY EXAMINATIONS

2016/2017 ACADEMIC YEAR

FIRST YEAR SECOND SEMISTER EXAMINATIONS

FOR THE DEGREE OF BSc (PHYSICS) AND

BACHELOR OF EDUCATION SCIENCE

MAIN CAMPUS REGULAR

COURSE CODE: PHY 104

COURSETITLE: WAVES AND GEOMETRICAL OPTICS.

DATE: APRIL 2017 TIME: 3 HOURS

INSTRUCTIONS: Answer Question ***ONE*** and any other ***THREE*** Questions.

Question one carries *28marks* and the rest *14marks* each

QUESTION ONE (28mks)

a) Differentiate between wave optics and geometrical optics (2mks)
b) State any two properties of rays. (2mks)
c) State Fermat's principle of least time and sketch a diagram to show how it can be applied on a flat surface (3mks)
d) Differentiate between specular and diffuse reflection (2mks)
e) Using the law of reflection, complete the ray-trace diagram for the four rays (a, b, c, d) incident on the curved surface shown at the left below, given the center of the curved surface is at point C (4mks)

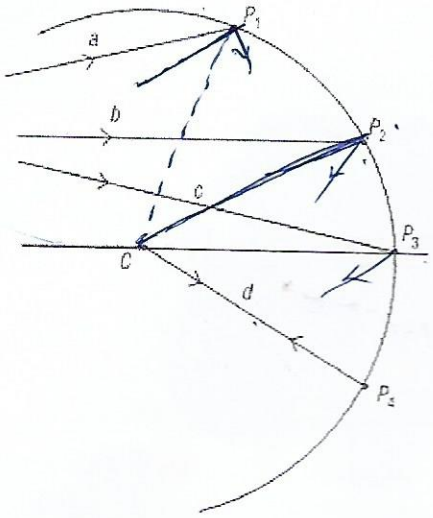


Fig.1

f) Sketch a graph to show the relationship between the angle of incidence and angle of deviation for a glass prism (2mks)

g) A glass of unknown index of refraction is shaped in the form of an isosceles prism with an apex angle of 25°. In the laboratory, with the help of a laser beam and a prism table, the minimum angle of deviation for this prism is measured carefully to be 15.8°. What is the refractive index of this glass material? (4mks)

h) The passenger-side mirror on an automobile is a convex mirror. It provides the driver with a wide field of view, but significantly reduced images. Use a ray diagram to show how this is achieved (3mks)

i) Define the term principal focus with reference to both converging and diverging lenses (2mks)

j) Distiquish between transverse and longitudinal motions. State examples in each case. (2mks)

k) Write the equation for the Lens makers formula and define all the terms in the equation (2mks)

QUESTION TWO (14mks)

a) A step-index fiber 0.0025 inch in diameter has a core index of 1.53 and a cladding index of 1.39. See Fig. 2. Such clad fibers are used frequently in applications involving communication, sensing, and imaging.

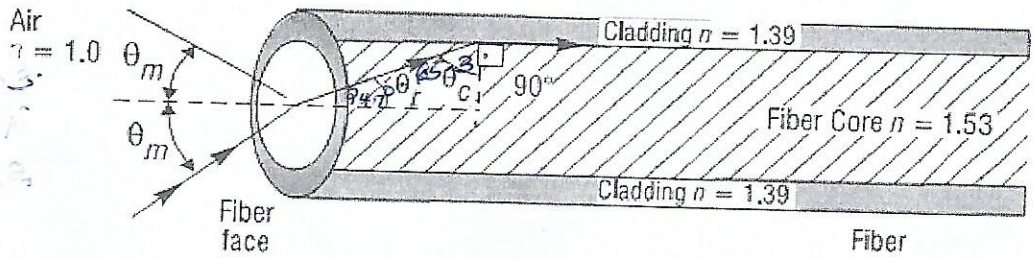


Fig. 2

What is the maximum acceptance angle θm for a cone of light rays incident on the fiber face such that the refracted ray in the core of the fiber is incident on the cladding at the critical angle? (6mks)

b) In a handheld optical instrument used under water, light is incident from water onto the plane surface of flint glass at an angle of incidence of 45° (Take the index of refraction of water and flint glass to be 1.33 and 1.63 respectively.

i) What is the angle of reflection of light off the flint glass? (2mks)

ii) Does the refracted ray bend toward or away from the normal? (2mks)

iii) What is the angle of refraction in the flint glass? (4mks)

QUESTION THREE (14mks)

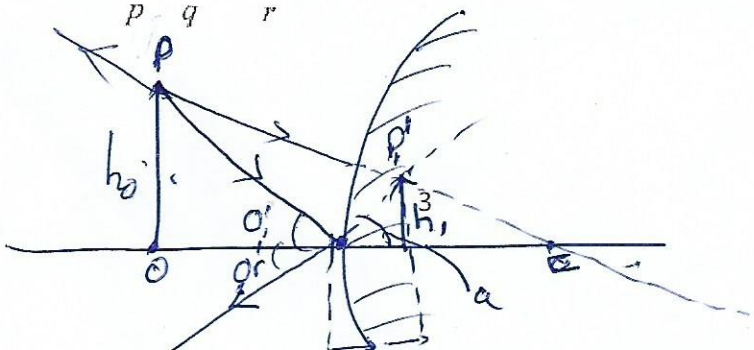
a) A travelling wave is described by $y(x, t) = 0.2\, e^{-x-3t}\sin(x + 3t)$ for x and y measured in centimetres and t in seconds. (a) Show explicitly that y(x, t) satisfies the one-dimensional wave equation. Deduce the wave speed from this. What is the direction of propagation? (8mks)

b) Use the work from part (a) to show that the "equation of motion" at any fixed x is $\partial^2 y/\partial t^2 + 6\,\partial y/\partial t + 18\, y = 0$. Thus, what kind of oscillation is associated with the wave? (6mks)

QUESTION FOUR (14mks)

a) By drawing the basic ray diagram of a spherical convex mirror, show that the mirror formula is; (6mks)

$$\frac{1}{p} + \frac{1}{q} = -\frac{2}{r}$$



b) A meterstick lies along the optical axis of a convex mirror of focal length 40 cm, with its near end 60 cm from the mirror surface. Five-centimeter toy figures stand erect on both the near and far ends of the meterstick as shown in Fig. 3.

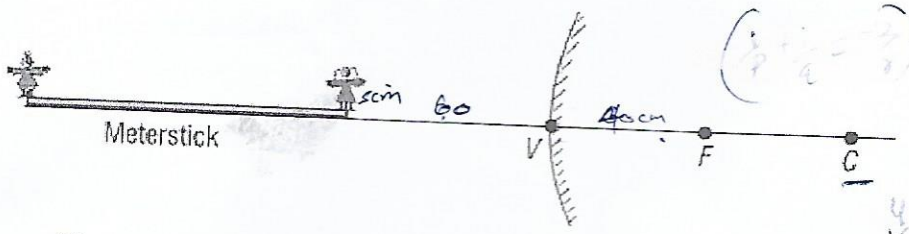


Fig. 3

(i) How long is the virtual image of the meterstick? (4mks)

(ii) How tall are the toy figures in the image, and are they erect or inverted? (4mks)

QUESTION FIVE (14mks)

a) A double-convex thin lens can be used as a simple "magnifier." It has a front surface with a radius of curvature of 20 cm and a rear surface with a radius of curvature of 15 cm. The lens material has a refractive index of 1.52.

i) What is its focal length in air? (2mks)

ii) What is its focal length in water (n= 1.33)? (2mks)

iii) Does it matter which lens face is turned toward the light? (2mks)

iv) How far would you hold an index card from this lens to form a sharp image of the sun on the card? (2mks)

b) A two-lens system is made up of a converging lens followed by a diverging lens, each of focal length 15 cm. The system is used to form an image of a short nail, 1.5 cm high, standing erect, 25 cm from the first lens. The two lenses are separated by a distance of 60 cm as shown in Fig. 4.

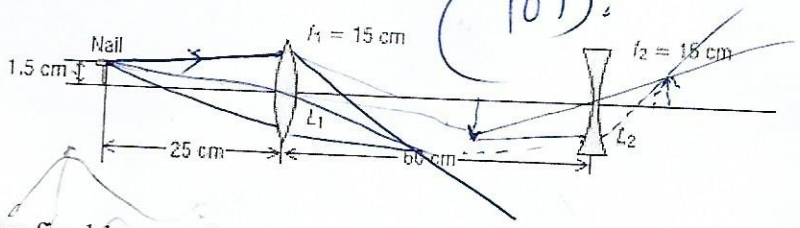


Fig.4

Locate the final image, determine its size, and state whether it is real or virtual, erect or inverted. (6mks)

QUESTION SIX (14mks)

a) Define the term Doppler effect (2mks)

b) What happens to velocity of the wave, wavelength and frequency by moving a source in the absence of dispersion. (3mks)

c) What is a standing wave and how does it come about. (2mks)

b) As you stand by the side of the road, a car approaches you at a constant speed, sounding its horn, and you hear a frequency of 76 Hz. After the car goes by, you hear a frequency of 65 Hz. What is the speed of the car? The speed of sound in air is 343 m/s.

(7mks)