KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2020 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGRE OF BSc (PHYSICS)

COURSE CODE: SPC 122

COURSE TITLE: WAVES & GEOMETRICAL PHYSICS

DURATION: 2 HOURS

DATE: 15/07/2021 **TIME: 2:00-4:00PM**

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.

Start every question on a new page and make sure question's number is written on each page
This paper consists of **3** printed pages. Please Turn Over

QUESTION ONE (30 MARKS)

a) A transverse sinusoidal wave is moving along a string in the positive direction of an x axis with a speed of 80 m/s. At t=0, the string particle at x=0 has a transverse displacement of 4.0 cm from its equilibrium position and is not moving. The maximum transverse speed of the string particle at x=0 is 16 m/s.

(i) What is the frequency of the wave? (2mks)

(ii) What is the wavelength of the wave? (2mks)

b) State Fermat's principle of least time and sketch a diagram to show how it can be applied on a flat surface (3mks)

c) Differentiate between specular and diffuse reflection (2mks)

d) Briefly explain the following terms (3mks)

i) Standing wave

ii) Interference

iii) Doppler effect

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

f) 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)

g) 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)

h) A concave mirror has a radius of curvature of 25 cm. A 2 cm tall object is placed 20 cm from the mirror along its axis. Find the location of the image and its size (3mks)

i) A string fixed at both ends is 8.40 m long and has a mass of 0.120 kg. It is subjected to a tension of 96.0 N and set oscillating. (i) What is the speed of the waves on the string? (ii) What is the longest possible wavelength for a standing wave? (iii) Find the frequency of the wave. (6mks)

QUESTION TWO (20 MARKS)

a) State and explain two factors that affect the critical angle (4marks)

b) Using a diagram explain how a mirage is formed (4marks)

c) 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. 1. Such clad fibers are used frequently in applications involving communication, sensing, and imaging.

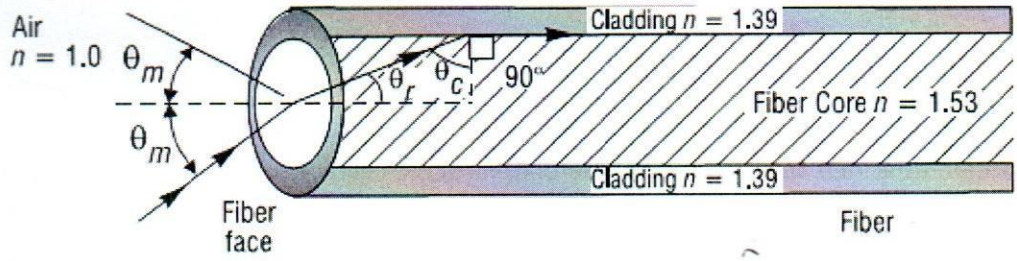

Fig. 1

What is the maximum acceptance angle θ_m 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)

d) 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? (2mks)

QUESTION THREE (20 MARKS)

a) A rope, under a tension of 200N and fixed at both ends, oscillates in a second harmonic standing wave pattern. The displacement of the rope is given by;

$$y = 0.1m\left(sin\frac{\pi x}{2}\right) sin12\pi t$$

where x=0 at one end of the rope, x is in meters, and t is in seconds. What are; (i) the length of the rope, (ii) the speed of the wave on the rope, and (iii) the mass of the rope? (iv) If the rope oscillates in a third harmonic standing wave pattern, what will be the period of oscillation (8mks)

a) The equation of a transverse wave traveling along a very long string is,

$$y(x,t) = 6.0\sin(0.020\pi x + 4.0\pi t)$$

Where x and y are expressed in centimeters and t is in seconds. Determine; (a) the amplitude, (b) the wavelength, (c) the frequency (d) the speed, (e) the direction of propagation of the wave, and (f) the maximum transverse speed of a particle in the string. (9mks)

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. (3mks)

QUESTION FOUR (20 MARKS)

a) Use Fermat's principle to derive the law of reflection and refraction (6mks)

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

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

Where p and q are the object and image distances respectively.

c) A meter stick 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 meter stick as shown in Fig. 2.

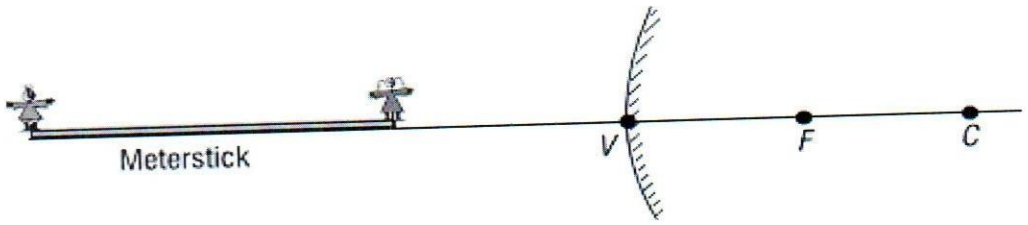

Fig. 2

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

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

QUESTION FIVE (20 MARKS)

a) An object is placed 20cm from (a) a converging lens, (b) a diverging lens, of focal length 15cm. calculate the image position and magnification in each case. (4mks)

b) 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)

c) 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. 3.

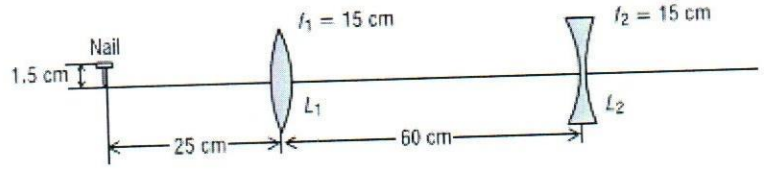

Fig.3

Locate the final image, determine its size, and state whether it is real or virtual, erect or inverted. (8mks)