

# KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS  
2021/2022 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER  
MAIN EXAMINATIONS

FOR THE DEGREE OF BSc (PHYSICS)

**COURSE CODE:** SPC 122

**COURSE TITLE:** WAVES & GEOMETRICAL PHYSICS

**DURATION:** 2 HOURS

**DATE:** 13/05/2022

**TIME:** 2:00PM-4:00PM

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## 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

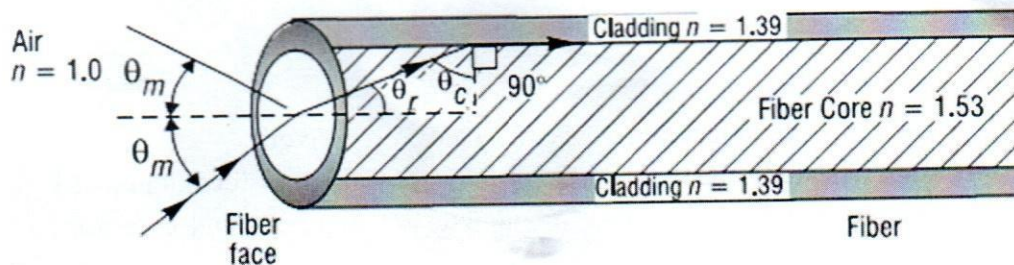
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### QUESTION ONE (30 MARKS)

- 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  $25^\circ$ . 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  $15.8^\circ$ . 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  $\theta_m$  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  $45^\circ$  (Take the index of refraction of water and flint glass to be 1.33 and 1.63 respectively.
- What is the angle of reflection of light off the flint glass? (2mks)
  - Does the refracted ray bend toward or away from the normal? (2mks)
  - 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;

$$y = 0.1m \left( \sin \frac{\pi x}{2} \right) \sin 12\pi t$$

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)

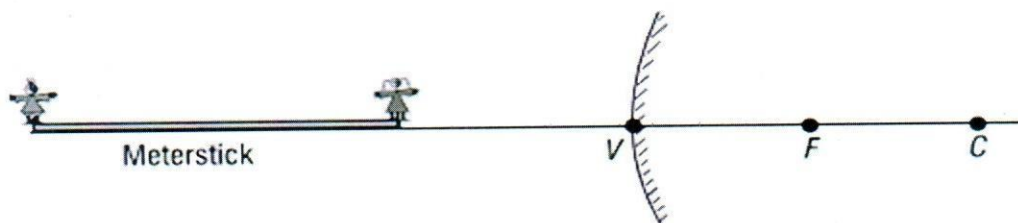
### QUESTION FOUR (20 MARKS)

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

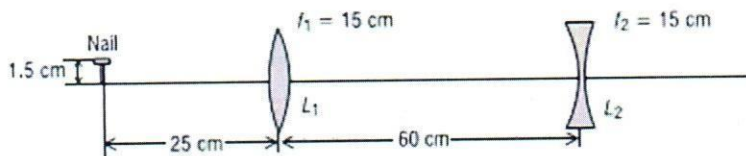


**Fig. 2**

- (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.
- What is its focal length in air? (2mks)
  - What is its focal length in water ( $n= 1.33$ )? (2mks)
  - Does it matter which lens face is turned toward the light? (2mks)
  - 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)