



2023 Sec 3 Physics Chapter 3 Refraction
Answers to Examples and Exercises

3 Refraction

Example 1

Speed of light in **vacuum** = 1.33 times of speed of light in **water**.

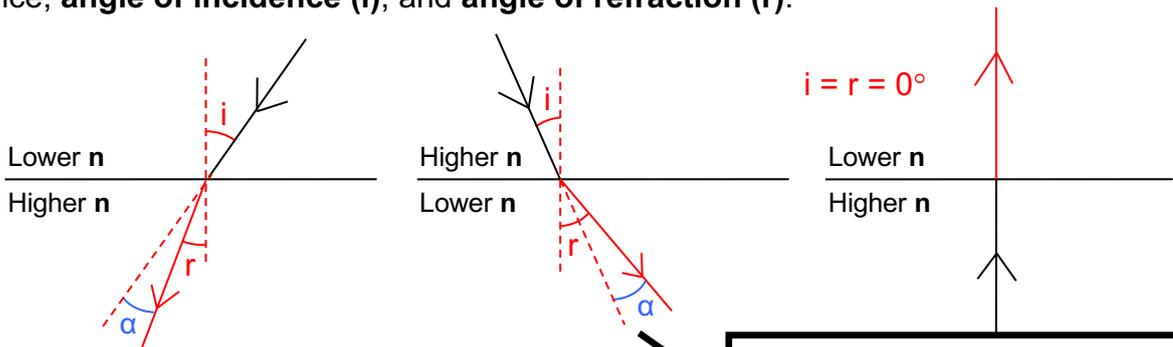
= 1.50 times of speed of light in **glass**.

speed of light in water = $3 \times 10^8 / 1.33 = 2.25 \times 10^8 \approx 2.3 \times 10^8 \text{ m s}^{-1}$

speed of light in glass = $3 \times 10^8 / 1.50 = 2.0 \times 10^8 \text{ m s}^{-1}$

Example 2

For each diagram below, label the **incident ray**, **refracted ray**, **normal** at the point of incidence, **angle of incidence (i)**, and **angle of refraction (r)**.

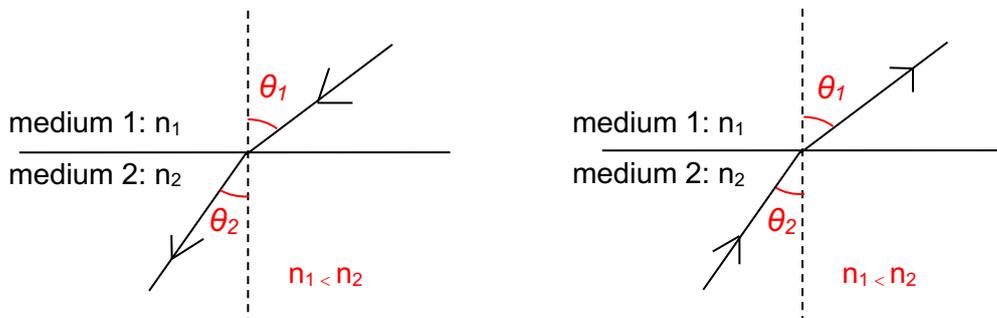


Note:

- α is the angle of deviation.
- Draw real light rays with continuous lines.
- Draw virtual rays & construction lines with dashed lines.

Check your knowledge of bending towards or away from normal. Also check which are angles of incidence, angles of refraction, etc.

Example 3



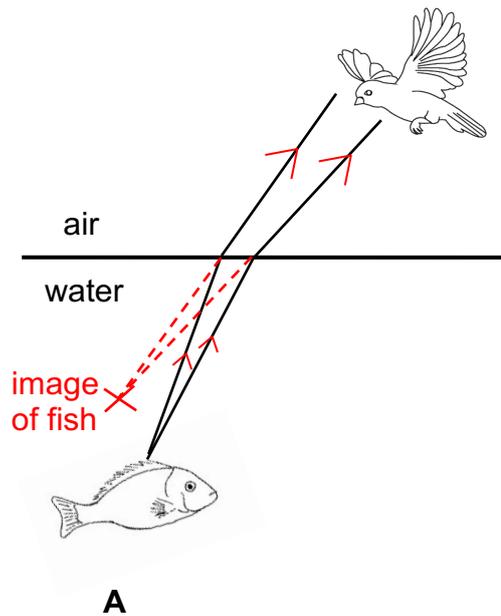
Example 8

Total internal reflection can only happen when the incident ray travels from an optically denser medium to an optically less dense medium. The optically less dense cladding makes sure that this condition is always present each time the light beam hits the boundary between the glass core and the cladding.

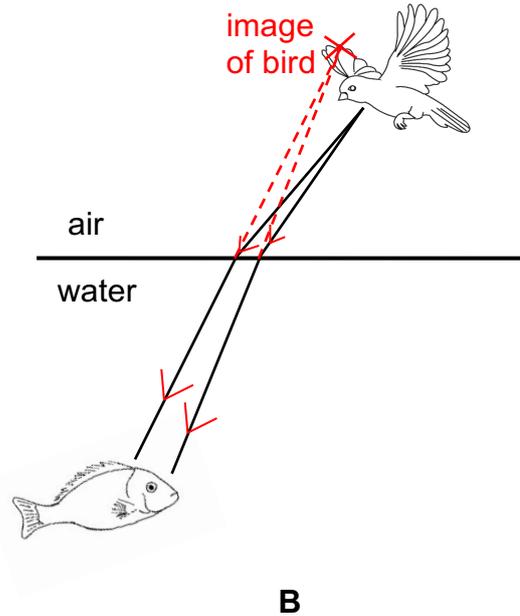
This enables the transmission of signal between two ends of the fibre by total internal reflection.

Example 9

(a)



(b)



(c) Further

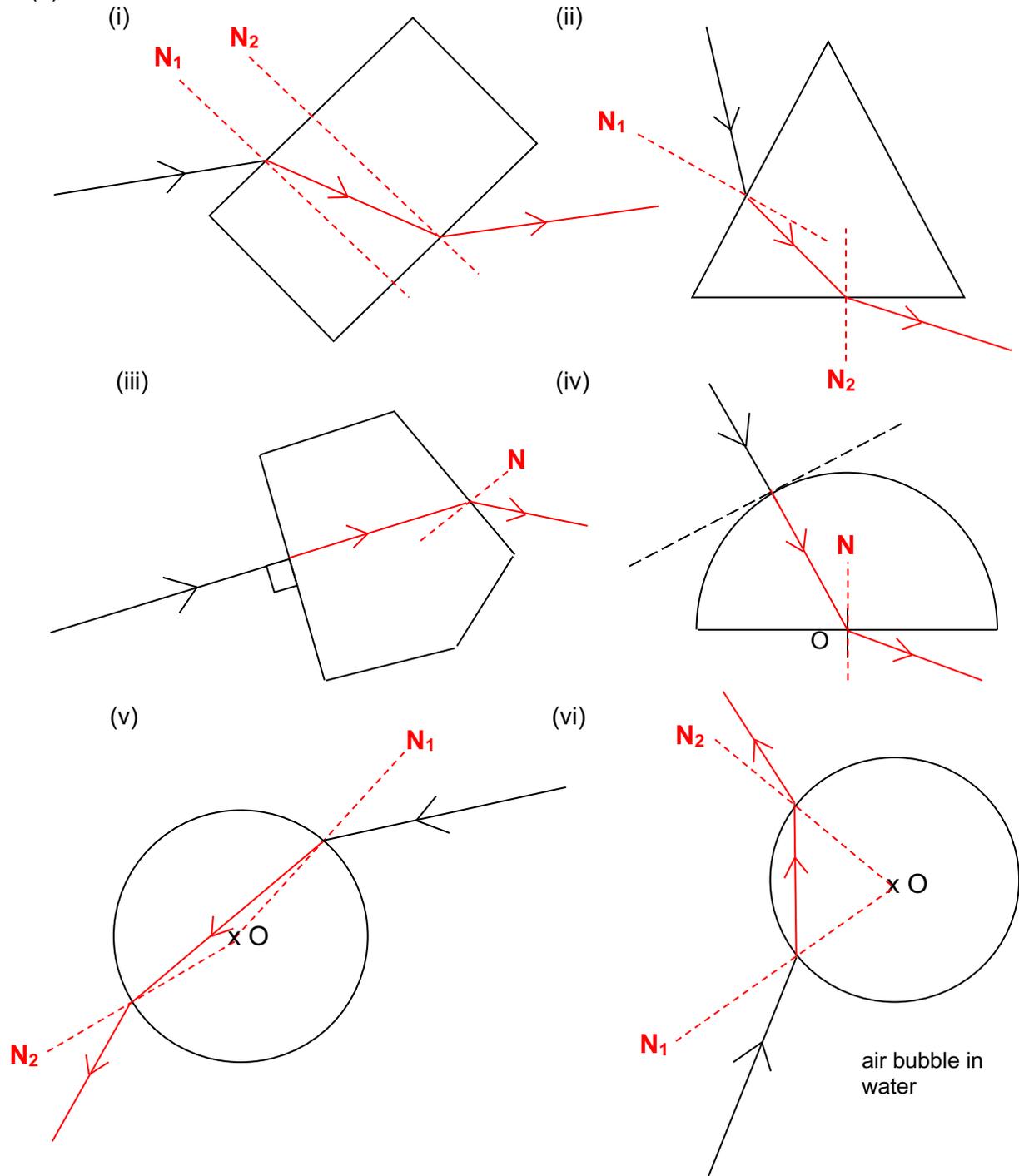
Exercises

Refraction

1 (a) Monochromatic light refers to light of a single frequency (or wavelength).

[mono: single; chroma: colour]

1 (b)

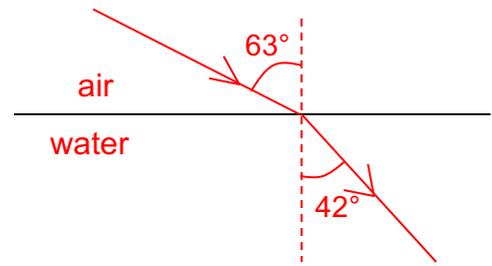


2. $n = c / v$

$$2.4 = 3.0 \times 10^8 \text{ m s}^{-1} / v_{\text{diamond}}$$

$$v_{\text{diamond}} = 1.25 \times 10^8 \approx 1.3 \times 10^8 \text{ m s}^{-1} \text{ (2 s.f.)}$$

3. Using $n_{\text{air}} \sin \theta_{\text{air}} = n_{\text{water}} \sin \theta_{\text{water}}$
 $1.00 \times \sin \theta_{\text{air}} = 1.33 \times \sin 42^\circ$
 $\sin \theta_{\text{air}} = 0.88994$
 $\theta_{\text{air}} = 62.9^\circ (3 \text{ s.f.}) \approx 63^\circ (2 \text{ s.f.})$

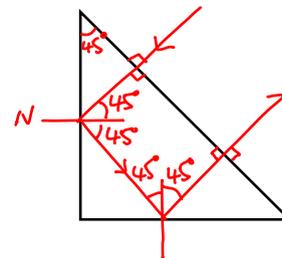
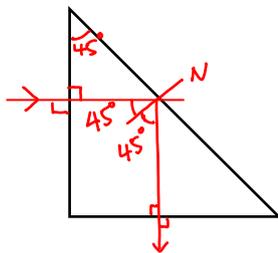


Critical Angle and Total Internal Reflection

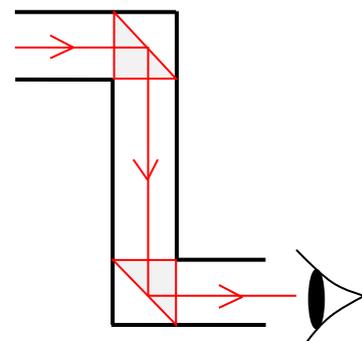
4. Using $n_1 \sin \theta_1 = n_2 \sin \theta_2$
 $1.33 \sin c = (1.0) \sin 90^\circ$
 $c = 49^\circ$

OR $n = 1 / \sin c \rightarrow \sin c = 1 / n \rightarrow \text{Calculate } c$

5. (a) deviate the ray of light through 90° (b) deviate the ray of light through 180°



(c) Complete the diagram to show how two 45° right-angled glass prisms may be used in a periscope. Draw the path of a ray through the periscope to show how it reaches the eye.

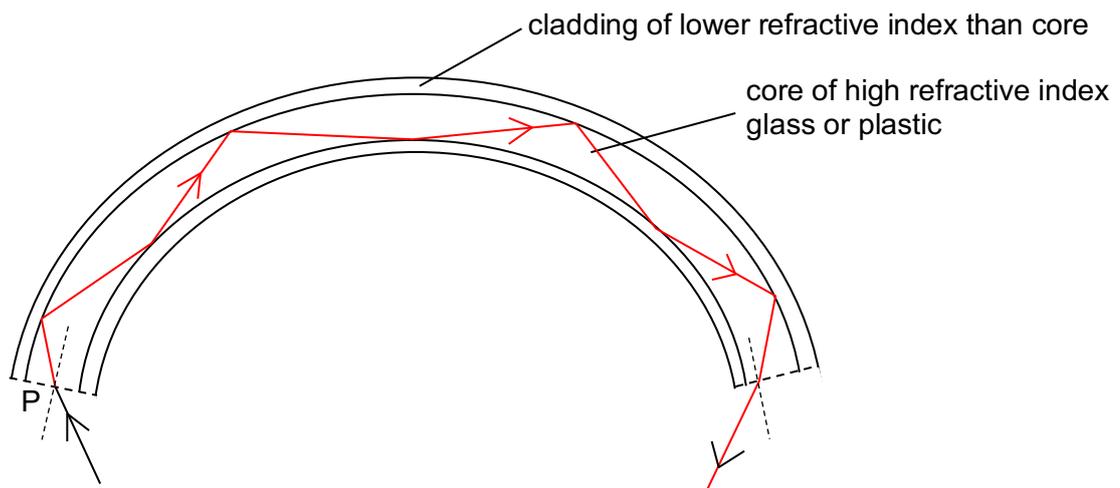


6. Optical fibres are rapidly replacing copper wires in telecommunications and computer networks.

(a) State 3 advantages optical fibres have over copper wires in telecommunications.

- The speed of data transmission (speed of light) is much faster
- There is less signal loss as compared to copper wires
- Optical fibres are lighter and cheaper as compared to copper wires of the same length
- The data transmission is not affected by electric and magnetic fields in the surroundings.
- The bandwidth and capacity for data is much greater.
- Optical fibres are not affected by corrosion (unlike copper wires).

(b) The diagram below shows a simple structure of an optical fibre with a ray of light incident at point P.



Note:

- At the entrance, the angle of refraction should be smaller than the angle of incidence
- At each reflection, check that the angle of incidence and angle of reflection look reasonably equal
- At the exit, the angle of refraction should be larger than the angle of incidence

(i) Explain the advantage of cladding the core.

- Since optical fibre can only transmit light when it travels from an optically denser to less dense medium (by total internal reflection), the cladding ensures that this condition is always present i.e. even when the optical fibre is placed in a medium denser than the core.