2020 Sec 3 Physics Chapter 8 Refraction

Answers to Examples and Exercises

8 Refraction

Example 8.1

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

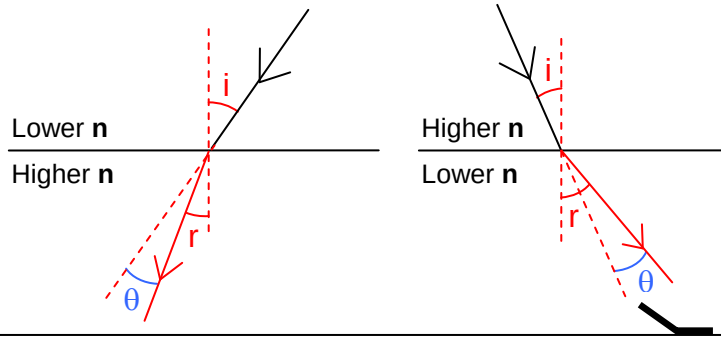
= 1.50 **times** of speed of light in **glass**.

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

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

Example 8.2

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)**.

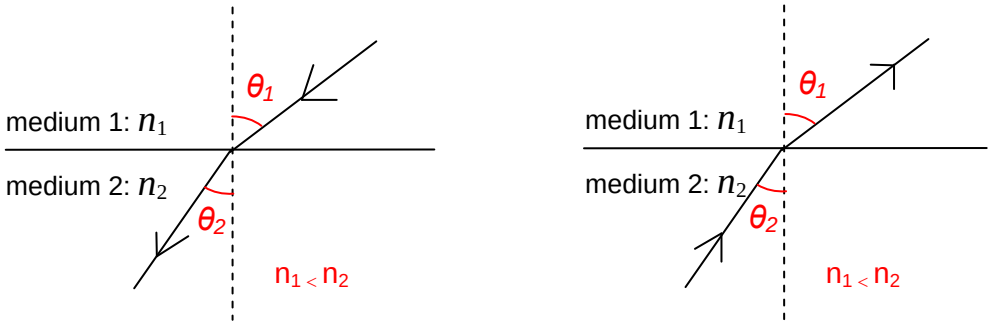


Check your knowledge of bending towards or away from normal. Also check which are angles of incidence, angles of refraction, etc.

Note:

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

Example 8.3



Example 8.4

Using $n_1 \sin \theta_1 = n_2 \sin \theta_2$

$1.0 \times \sin (90 - 55)^\circ = n \sin (90 - 70)^\circ$

$$n = \frac{\sin 35^\circ}{\sin 20^\circ}$$

$= 1.68$

Example 8.5

Applying Snell's law, $n_1 \sin \theta_1 = n_2 \sin \theta_2$

$n_1 = n$, $\theta_1 = c$ and $n_2 = 1.0$, $\theta_2 = 90^\circ$

Hence, $n \sin c = 1.0 \sin 90° = 1$

$n = 1 / \sin c$

Example 8.6

(a) 90°

(b) Using $n = \frac{1}{\sin \mathbf{c}}$

$$\sin \mathbf{c} = \frac{1}{n} = \frac{1}{1.5}$$

$c = 41.8^\circ$

Example 8.7

- *Draw the path of the rays in the diagram until it emerges out of the prism.*
- *Mark all relevant angles and show clearly all necessary calculations.*

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

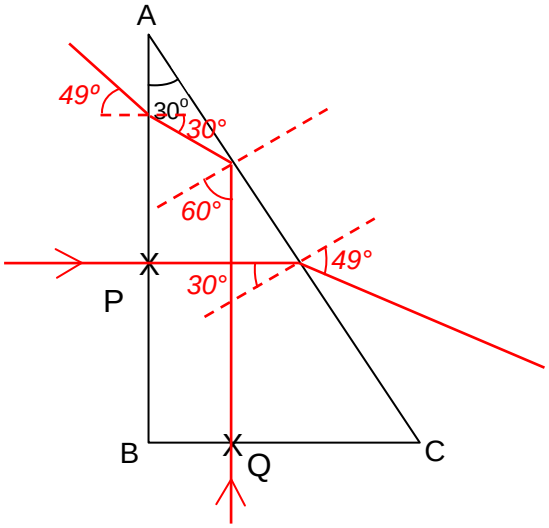
$1.5 \sin c = 1.0 \sin 90°$

$c = 42°$ (2 sf)

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

$1.5 \sin 30° = 1.0 \sin \theta_2$

$\theta_2 = 49°$ (2 sf)

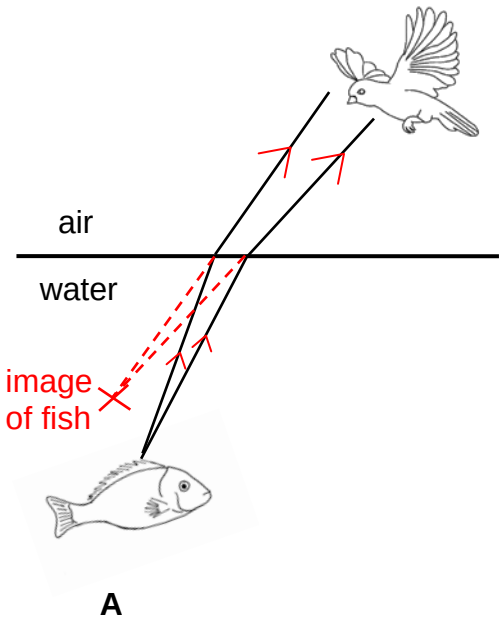


Approach:

- *Whenever a light ray reaches a boundary, draw the normal & determine its angle of incidence.*
- *Compare the refractive indices of the 1st & 2nd medium and check how this ray should refract (bend).*
- *If the 1st medium is optically denser (higher refractive index), compare angle of incidence i with critical angle c. If i > c, total internal reflection occurs.*
- *Else, normal refraction occurs.*

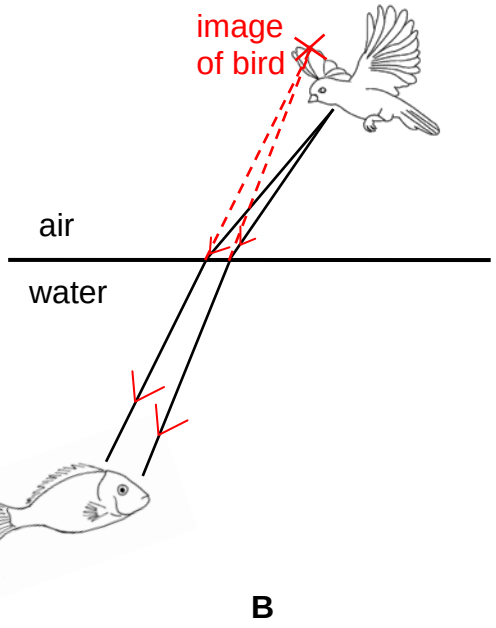
Example 8.8

(a)



A

(b)



B

(c) Further

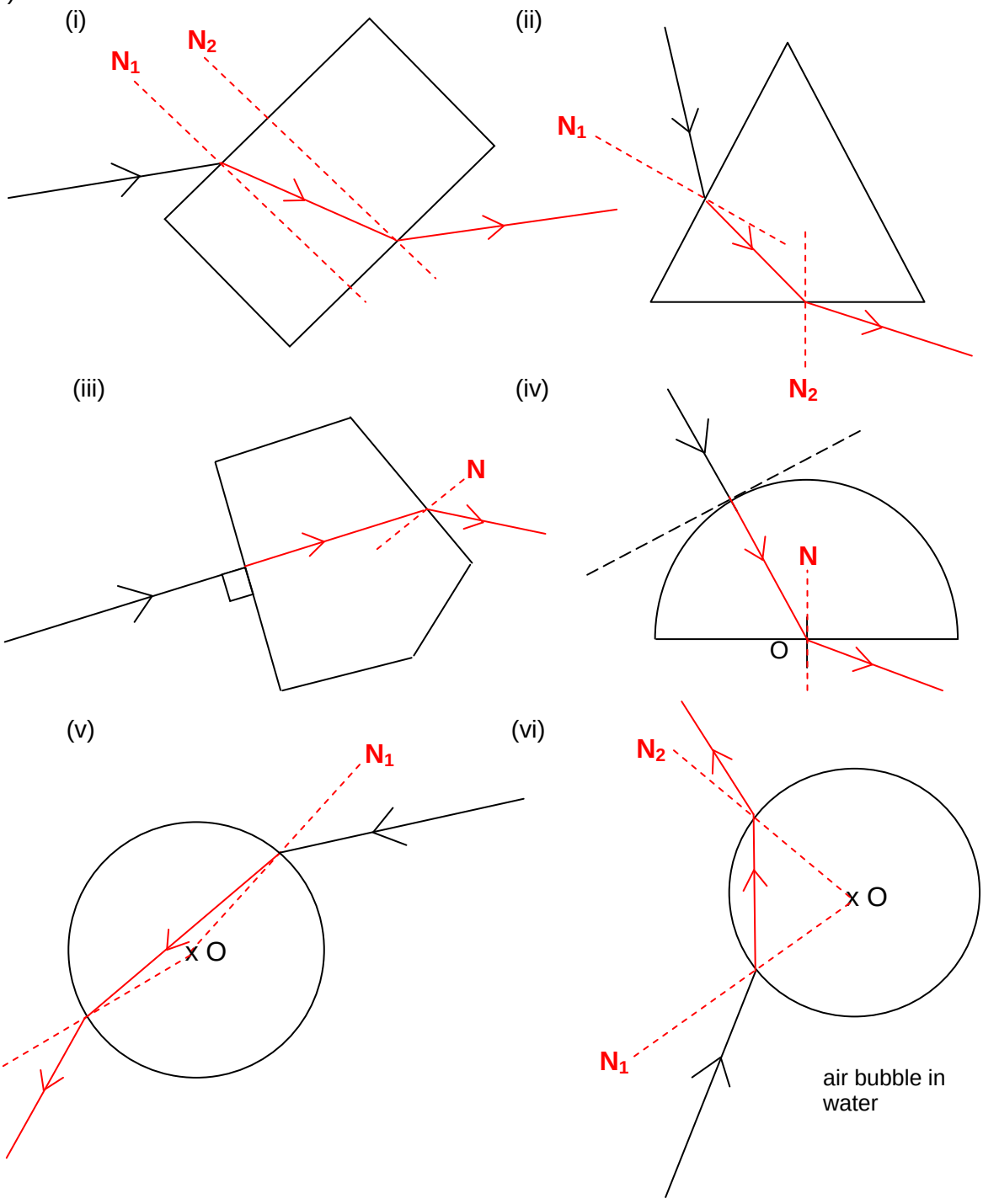
Exercises

Refraction

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

[mono: single; chroma: colour]

1 (b)



2. $n = c / v$

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

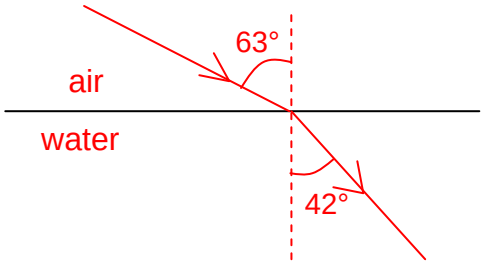
$v_{diamond} = 1.25 \times 10^8 \approx 1.3 \times 10^8 \text{ m s}^{-1}$ (2 s.f.)

3. Using $n_{air} \sin \theta_{air} = n_{water} \sin \theta_{water}$

$1.00 \times \sin \theta_{air} = 1.33 \times \sin 42^o$

$\sin \theta_{air} = 0.88994$

$\theta_{air} = 62.9^o (3 \text{ s.f.}) \approx 63^o (2 \text{ s.f.})$



Critical Angle and Total Internal Reflection

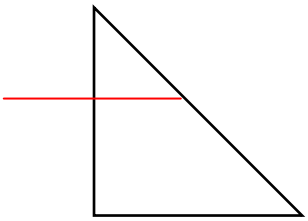
4. Using $n_1 \sin \theta_1 = n_2 \sin \theta_2$

$1.33 \sin c = (1.0) \sin 90°$

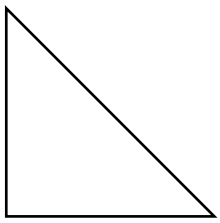
$\mathbf{c = 49°}$

OR $n = 1 / \sin c$ ➔ $\sin c = 1 / n$ ➔ Calculate c

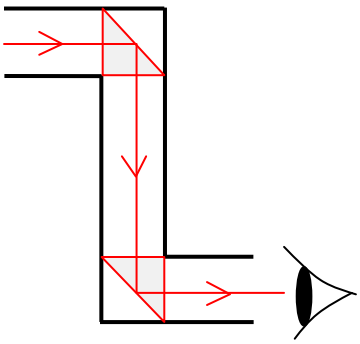
5. (a) deviate the ray of light through 90°



(b) deviate the ray of light through 180°



(c) Complete the diagram to show how two 45^o 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.

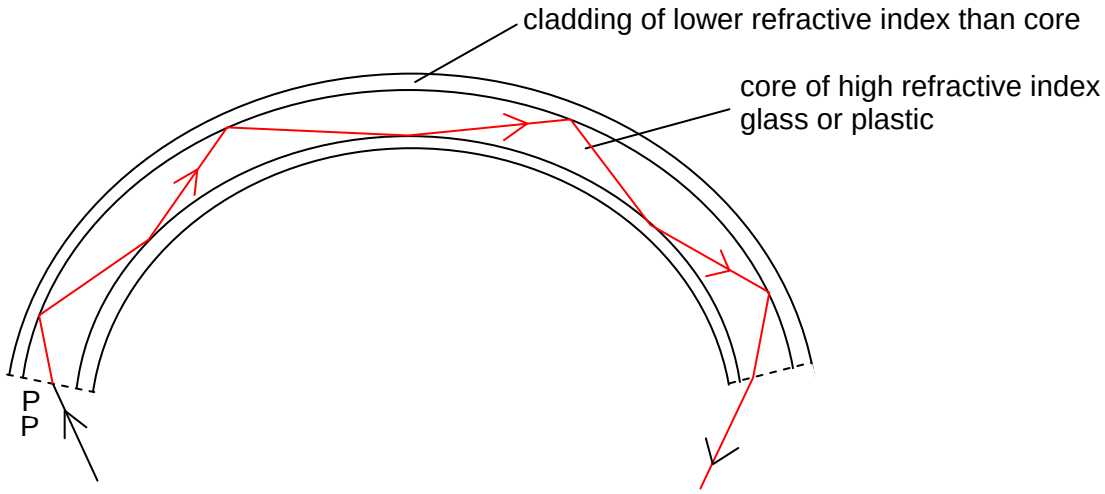


6. Optical fibres are rapidly replacing copper wires in telecommunications and computer networks.

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

- The speed of data transmission (by light) is much faster (speed of light versus speed of electric current).
- 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.



(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.