

Solutions

Each answer shows the steps, then the **result**.

2.1

- the angle of incidence equals the angle of reflection, both measured from the normal

2.2

- any three of: virtual; the same size as the object; 5 cm behind the mirror (the same distance as the object is in front); laterally inverted

2.3

- $n = \sin i / \sin r$

$$n = \frac{0.80}{0.50} = \mathbf{1.6}$$

2.4

- $\sin r = \sin i / n$

$$\sin r = \frac{0.766}{1.4} = 0.547$$

- $r = \mathbf{33^\circ}$

2.5

- $\sin c = 1/n$

$$\sin c = \frac{1}{2.4} = 0.417 \Rightarrow c = \mathbf{25^\circ}$$

2.6

- it is totally internally reflected: none of the light leaves the glass and the angle of reflection equals the angle of incidence
- use: optical fibres (or prisms in binoculars, or road and bicycle reflectors)

2.7

- focal length: the distance from the centre of the lens to the principal focus
- principal focus: the point on the principal axis where rays parallel to the axis meet after passing through the lens

2.8

- between the lens and its principal focus (closer to the lens than F)
- the image is enlarged, upright and virtual

2.9

- violet, indigo, blue, green, yellow, orange, red
- monochromatic light is light of a single frequency (a single colour)

3.1 D

- the critical angle is $\sin^{-1}(1/1.5) = 42^\circ$, and 45° is larger, so the ray cannot escape
- A** describes light entering glass; **B** is refraction below the critical angle; **C** happens only exactly at 42°

3.2 A

- a plane mirror image is virtual, the same size, and laterally inverted
- it is never real (**B**, **D**) and never diminished (**C**)

3.3

- (a) $\sin c = 1/n$

$$\sin c = \frac{1}{1.5} = 0.667 \Rightarrow c = \mathbf{42^\circ}$$

- (b) the ray is totally internally reflected at the flat face

- because 50° is greater than the critical angle of 42°

- (c) $\sin r = \sin i / n$

$$\sin r = \frac{0.643}{1.5} = 0.429$$

- $r = \mathbf{25^\circ}$

- (d) any two of: optical fibres for telephone and internet signals; prisms in binoculars or periscopes; reflectors on bicycles and roads; endoscopes in medicine

- (e) it slows down

3.4

- (a) ray from the top of the object parallel to the axis, refracting at the lens through the far F

- ray from the top of the object through the centre of the lens, undeviated
- the two rays cross 12 cm beyond the lens, 4 cm below the axis, so the image I is 12 cm from the lens

- (b) real, inverted and enlarged

- (c) the object is now inside F, so the image becomes virtual and upright, on the same side of the lens as the object

- it is still enlarged

- (d) the eye focuses light from a distant object in front of the retina

- the diverging lens spreads the rays out before they enter the eye, so they now meet on the retina

3.5

- (a) a band of colours (a spectrum) from red to violet

- the effect is dispersion

(b) violet

- it has the highest frequency (shortest wavelength), and the glass slows and bends higher-frequency light more

(c) the image is virtual

- the reflected rays only appear to come from behind the mirror, so no light actually passes through the image position and none can fall on a screen there