Exercise walk-through

Refraction ▪ 13.3

eXercise

You must be able to

- explain **refraction 折射** as a change in the speed and direction of light at a boundary
- apply **Snell's law 斯涅尔定律** $n_1 \sin\theta_1 = n_2 \sin\theta_2$ using the index of refraction
- describe **total internal reflection 全内反射** and calculate the critical angle

Method — Refraction

Light changes **speed** at a boundary, so its direction bends — toward the normal entering a **denser** medium (higher n).

Method — Snell's law

$n_1 \sin\theta_1 = n_2 \sin\theta_2$, with the angles measured from the normal.

Method — Total internal reflection

Going from dense to less dense, beyond the **critical angle** ($\sin\theta_c = n_2/n_1$) all the light reflects back inside.

Practice 2.1 ▪ 2 marks

Light passes from air ($n = 1.0$) into glass ($n = 1.5$) at 40° to the normal. Find the angle of refraction.

Solution 2.1

Method: Refraction

Worked steps

$$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2} = \frac{1.0 \sin 40^\circ}{1.5} = 0.428 \Rightarrow \theta_2 = 25^\circ$$ M1 A1.

Practice 2.2 ▪ 1 mark

State what happens to the speed of light entering a denser medium.

Solution 2.2

Method: Refraction

Worked steps

it decreases B1.

Practice 2.3 ▪ 1 mark

State the condition for total internal reflection to occur.

Solution 2.3

Method: Total internal reflection

Worked steps

the light must go from a denser to a less dense medium at an angle above the critical angle B1.

Exam-style 3.1 ▪ 1 mark

Snell's law is

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

B $n_1\theta_1 = n_2\theta_2$

C $\sin\theta = n$

D $n = c/v$ only

Solution 3.1

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

B $n_1\theta_1 = n_2\theta_2$

C $\sin\theta = n$

D $n = c/v$ only

Worked steps

A.

Exam-style 3.2 ▪ 1 mark

Total internal reflection occurs when light travels

A from less dense to more dense at any angle

B from more dense to less dense above the critical angle

C exactly along the normal

D through a vacuum

Solution 3.2

Method: Total internal reflection

A from less dense to more dense at any angle

B from more dense to less dense above the critical angle ✓

C exactly along the normal

D through a vacuum

Worked steps

B.

Exam-style 3.3 ▪ 3 marks

Light passes from water ($n = 1.33$) toward air ($n = 1.0$).
(a) Find the critical angle.
(b) State what happens to light striking the surface above this angle.

Solution 3.3

Method: Total internal reflection

Worked steps

(a) $\sin\theta_c = \dfrac{n_2}{n_1} = \dfrac{1.0}{1.33} = 0.752 \Rightarrow \theta_c = 48.8^\circ$ M1 M1 A1. (b) it is totally internally reflected B1.