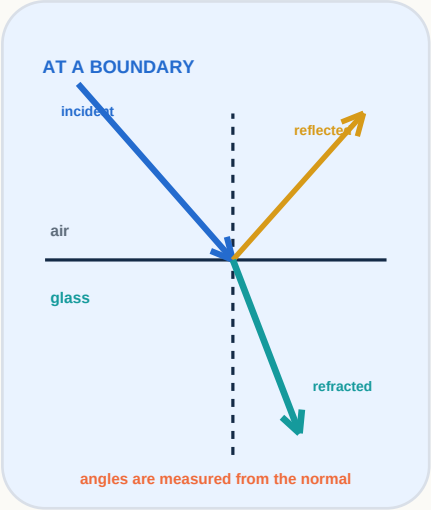
PEARSON EDEXCEL IAL PHYSICS | UNIT 2

LESSON 2.1.2

Reflection, Refraction and Refractive Index

At an interface, a wave may be reflected and transmitted. A change in wave speed changes wavelength and can change direction.



THE CORE RELATIONSHIPS

REFLECTION

$i = r$

angle in = angle out

REFRACTIVE INDEX

$n = c/v$

dimensionless

SNELL'S LAW

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

angles from normal

WHAT CHANGES AT THE INTERFACE?

FREQUENCY

Set by the source, so it stays constant across the boundary.

SPEED

Changes because wave speed depends on the medium.

WAVELENGTH

Changes with speed because frequency remains constant.

BENDING RULES

INTO HIGHER n / SLOWER MEDIUM

The ray bends towards the normal, so the refracted angle is smaller.

INTO LOWER n / FASTER MEDIUM

The ray bends away from the normal, so the refracted angle is larger.

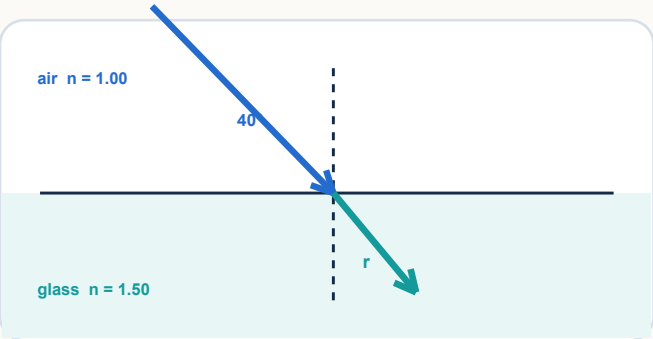
ANGLE TRAP

Measure every incidence, reflection and refraction angle from the normal, never from the surface.

1 A complete refraction calculation

Use both refractive indices when neither medium is assumed to be vacuum. Check the bending direction against your numerical answer.

AIR TO GLASS



FIND THE REFRACTED ANGLE

$n_1 = 1.00$

$n_2 = 1.50$

$\theta_1 = 40°$

CALCULATE IN THREE STEPS

1 SUBSTITUTE

$1.00 \sin 40°$

$= 1.50 \sin r$

2 ISOLATE

$\sin r = 0.4285$

$r = \sin^{-1}(0.4285)$

3 ANSWER

$r = 25.4°$

towards the normal

SPEED AND WAVELENGTH IN GLASS

$v = c/n = (3.00 \times 10^8)/1.50 = 2.00 \times 10^8 \text{ m s}^{-1}$

for $f = 5.0 \times 10^{14}$ Hz, $\lambda = v/f = 4.0 \times 10^{-7}$ m

Frequency stays constant; lower speed therefore gives a shorter wavelength.

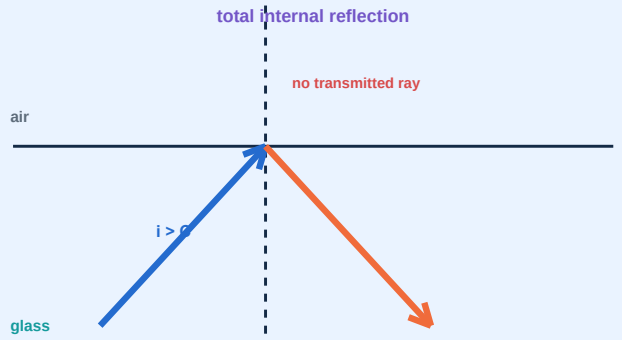
SENSE CHECK

Glass has the larger refractive index and the lower wave speed. The refracted angle must be smaller than 40 degrees.

2 Critical angle, TIR and measuring n

Total internal reflection occurs only from higher refractive index to lower refractive index, with incidence above the critical angle.

CRITICAL ANGLE AND TOTAL INTERNAL REFLECTION



GLASS TO AIR

$\sin C = n_{air}/n_{glass}$

$= 1.00/1.50 = 0.6667$

$C = 41.8°$

At i = C, the refracted ray travels along the boundary.

TWO CONDITIONS FOR TIR

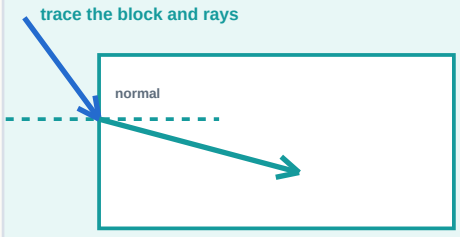
1 DIRECTION

The wave travels from higher n to lower n.

2 ANGLE

The angle of incidence is greater than C.

MEASURING THE REFRACTIVE INDEX OF A SOLID



1. Trace the block and mark the incident and refracted rays.
2. Remove the block, draw the normal and measure i and r.
3. Repeat for several angles and calculate sin i and sin r.
4. Plot sin i against sin r; for air, gradient is n of the solid.

QUALITY

Use a narrow ray, mark points far apart, repeat several angles and use a best-fit gradient instead of one angle pair.