

REFRACTION CALCULATIONS

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Lesson Description

In this lesson we :

- Use Snell's Law to complete refraction calculations



Summary

Total Internal Reflection

Refractive index: The refractive index n of a material is the ratio of the speed c of light in a vacuum to the speed v of light in the material.

$$n = \frac{\text{speed of light in a vacuum}}{\text{speed of light in the material}}$$

Refractive index of some common materials

Substance	Refractive index	Substance	Refractive index
Air	1,0	Perspex	1.50
Ice	1,31	Glass	1,52
Water (20°)	1.33	Ruby	1,76
Ethanol	1,36	Cubic zirconia	2,18
Plastic	1,46	Diamond	2,42
Sapphire	1,76	Amber	1,55

Snell's Law of Refraction: When light travels from a material with refractive index n_1 into a material with refractive index n_2 , the refracted ray, the incident ray and the normal to the interface between the materials all lie in the same plane. The angle of refraction, θ_r , is related to the angle of incidence, θ_i , by:

$$n_1 \sin \theta_i = n_2 \sin \theta_r$$



Test Yourself

Question 1

A beam of light is shone through a perspex block and directed towards a second block. If you want the light to slow down, the second block could be made of:

- A water
- B air
- C glass
- D ethanol

Question 2

A beam of light is shone through a perspex block and directed towards a second block which causes the light to slow down. If the angle of incidence is 25° , then the angle of refraction in the 2nd block could be:

- A 0°
- B 20°
- C 25°
- D 90°

Question 3

When a ray of light moves from air into a perspex block which has a refractive index of 1,5, the ray of light will

- A continue to move at the same speed
- B slow down
- C speed up
- D always change direction

Question 4

When a ray of light strikes the boundary between a perspex block ($n = 1,5$) and air at an angle of incidence of 0° , the ray of light will

- A continue to move at the same speed
- B slow down
- C speed up
- D undergo total internal reflection

Question 5

When a ray of light moves from glass ($n = 1,5$) into water ($n = 1,33$), at an angle of incidence of 30° , the ray of light will emerge from the glass at an angle of

- A 0°
- B $26,32^\circ$
- C 30°
- D $34,33^\circ$

Question 6

A ray of light moves from water ($n = 1,33$) into an unknown substance. The angle of refraction is 90° . What is the angle of incidence?

- A 0°
- B 30°
- C 42°
- D $48,75^\circ$

Question 7

A ray of light moves from water ($n = 1,33$) into an unknown substance. The angle of refraction is 90° . What could the unknown substance be?

- A ice
- B ethanol
- C glass
- D perspex

Question 8

When a ray of light moves from air to glass ($n = 1,5$) to water ($n = 1,33$), the speed of light undergoes the following changes:

- A slows down in glass and speeds up in water
- B slows down in glass and slows down more in water
- C speeds up in glass and slows down in water
- D no change in glass but speeds up in water

Question 9

What is the speed of light when it travels through glass?

- A $3 \times 10^8 \text{ m.s}^{-1}$
- B $4 \times 10^8 \text{ m.s}^{-1}$
- C $2 \times 10^8 \text{ m.s}^{-1}$
- D $1,5 \times 10^8 \text{ m.s}^{-1}$

Question 10

When light strikes a diamond with an angle of incidence of 0° , the beam of light....

- A speeds up and bends away from the normal
- B speeds up without changing direction
- C slows down without changing direction
- D slows down and bends towards the normal



Improve your Skills

Question 1

A ray of light is shone through a ruby. Calculate the speed of light through the sapphire.

Question 2

Calculate the refractive index of a cubic zirconia if an angle of incidence of 30° causes an angle of refraction of $13,26^\circ$ when light moves from air into a cubic zirconia.

Question 3

The refractive index of gallium phosphide is 3.5. If a ray of light moves from air through the gallium phosphide with an angle of incidence of 40° , calculate the angle of refraction.

Question 4

A layer of oil ($n = 1,45$) floats on water ($n = 1,33$). The angle of refraction of a ray of light moving from the oil into the water is 35° .

- Calculate the angle of incidence with which the light hits the oil.
- Under what conditions will total internal reflection take place for these materials. Support your answer with a calculation.

Question 5

A transparent rectangular block lies under water. A diver shines a laser onto it so the beam of light has an angle of incidence equal to 34° . The resulting angle of refraction is $21,89^\circ$. Identify the material that the block is made of.

Question 6

A ray of light moves from medium 1 to medium 2. The refractive index of medium 1 is double that of medium 2. If the angle of incidence is 15° , calculate the angle of refraction.