3D. Light and sound

Speed of light = 3 x 10^8 m/s

Speed of sound = 343 m/s

Light Waves

Light = transverse electromagnetic wave (can be reflected + refracted)
Colours = different wavelengths.

Red = longest wavelength.
Violet = shortest wavelength.

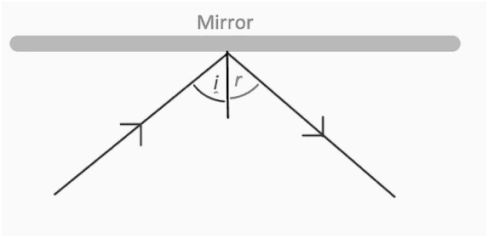
Reflection and refraction

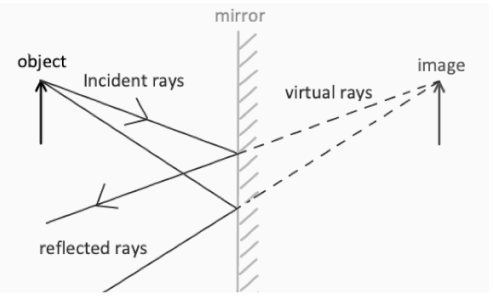
Law of reflection

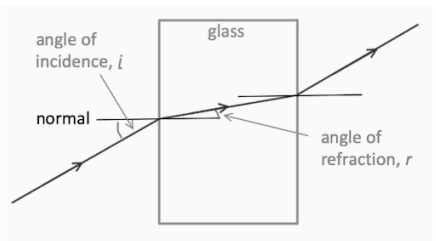
Law of reflection:
Angle of incidence = Angle of reflection

Virtual rays' crossing point = where the image of reflected object forms.

Ray diagrams







Practical: Refraction

Draw around a block on a sheet of paper.
Use a ray box to aim a ray of light through the block
Mark where the ray is:
Before it reaches, where it hits, where it leaves, and after it has left the block.
Draw straight lines connecting the dots. The line shows the ray of the path.

Replace the block and repeat at a different angle.

Snell's law (Refraction)

Snell's Law = describes relationship between angle of incidence and refraction.

$$n = \frac{\sin i}{\sin r}$$

Refractive index = ratio of velocity of light in a vacuum to its velocity in a medium.
Describes how much the medium slows light down compared to speed of light in a vacuum.

n = refractive index (the closer it is to 1, the less refraction)

Practical: Refractive index

Draw around a block on a sheet of paper.
Use a ray box to aim a ray of light through the block.

Mark where the ray is at the following locations:
before it reaches,
where it hits,
where it leaves,
and after it leaves the block.

Draw straight lines connecting the dots. The line shows the ray of the path.

Measure the angles of incidence and refraction.
Use the equation to find the refractive index of the block.

Uses of internal reflection

Optical fibres = light is totally internally reflected.

Made of two different types of glass.
The core has a high refractive index, surrounded by cladding with a low index.
The boundary has a low critical angle.

Usage (vision) = bundled together to carry light, and allows images to be seen.
E.G in endoscopes, to see into the body with small holes.

Usage (information) = telecommunication systems.
E.G electrical signals ➜ light pulses sent through optical fibres ➜ converted back by light sensitive detectors (less energy is lost)

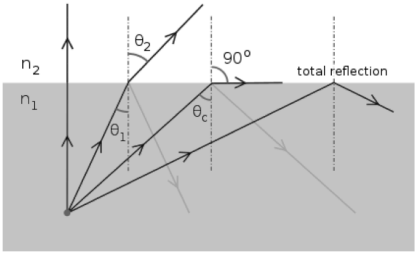
Prisms = light is totally internally reflected.

Usage (vision) = produces clearer and brighter images than mirrors.
E.G used in prismatic periscopes.

Usage (reflection) = used in reflectors such as bike / car reflectors.

Usage (magnification) = two prisms reflecting light can create large magnifications.
E.G binoculars.

Critical angle



Critical angle = smallest angle of incidence where light rays are totally internally reflected.

Total internal reflection is the complete reflection of a light ray reaching the boundary of a less optically dense medium when the angle of incidence exceeds the critical angle.

1: Angle of incidence must exceed the critical angle.
2: Light must travel from a more optically dense to a less optically dense medium.

Light travelling to less optically dense medium is refracted away from normal.
Angle of refraction increases when the angle of incidence increases.
Light is totally internally reflected when angle of incidence reaches critical angle, c.
(If i = c, light will travel along the boundary between mediums)

Refractive index and critical angle

The critical angle of a medium is related to its refractive index.

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

c represents the critical angle, and n represents the refractive index.
Larger refractive index = Smaller critical angle

Sound waves

Sound = longitudinal wave (can be reflected + refracted)
Frequency = pitch (increase = higher)
Amplitude = loudness (greater = louder)

Audible to humans = 20 - 20,000 Hz
Ultrasound = > 20,000 Hz

Practical: Speed of sound

Echo (speed of sound):

Make a noise at a large known distance from a wall.
Record time taken for sound to be heard.