2.3.4 Consequences of energy transfer

- Metal spoon in a hot drink heats up because it conducts heat.
- Convection currents create sea breezes. During the day, the land is warmer and acts as a heat source. During the night, the sea acts as the heat source.
- A black saucepan cools better than a white one, white houses stay cooler than dark ones. (Thermal Radiation)

3. Properties of waves, including light and sound

3.1 General wave properties

Waves transfer energy without transferring matter.

Wavefront: the peak of a transverse wave or the compression of a longitudinal wave.

Speed: how fast the wave travels measured in m/s.

frequency: the number of waves passing any point per second measured in hertz (Hz).

Wavelength: distance between a point on a wave to the equivalent point on the next wave in meters.

Amplitude: maximum distance a wave moves from its rest position when a wave passes.

Velocity = frequency × wavelength
(m/s) (Hz) (m)

$V = f\lambda$

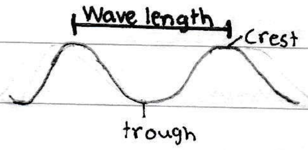
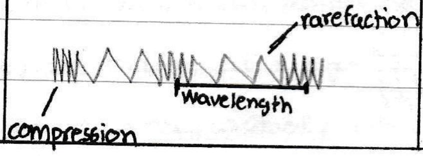
Frequency = $\frac{1}{\text{Period}}$
(Hz) (s)

* Period: time taken for 1 oscillation.

Wave Motion

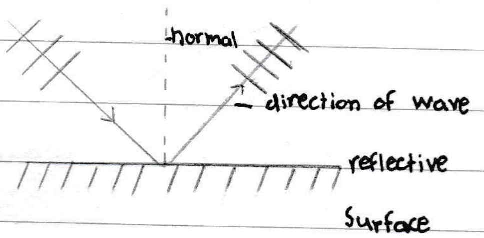
Wave Motion (periodic motion) is motion repeated at regular intervals. In ropes and springs, it is called as a ~~vibrations~~ vibration while in water waves, it is known as an oscillation.

Date

Transverse Waves	Longitudinal Waves
• Travelling waves in which Oscillation is perpendicular to the direction of travel. • Has crests and troughs. • Examples: light, water waves and vibrating string  	• Travelling waves in which oscillation is parallel to the direction of travel. • Has compressions and rarefactions. • Examples: sound waves 

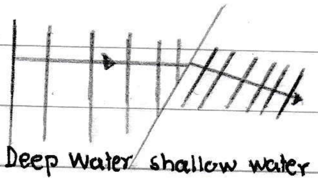
Reflection

- Waves bounce away from the surface at the same angle which they strike it with.
- Angle of incidence = angle of reflection
- Speed, wavelength and frequency aren't affected.



Refraction

- Speed and wavelength is decreased but frequency stays constant, and the wave changes direction.
- Waves slow down when they pass from a less dense medium to a more dense medium.
- When wave is slowed down, it is refracted towards normal ($i > r$)
- When wave is sped up, it is refracted away from normal ($i < r$)



☆ Deep water is denser than shallow water.

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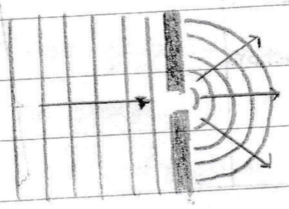
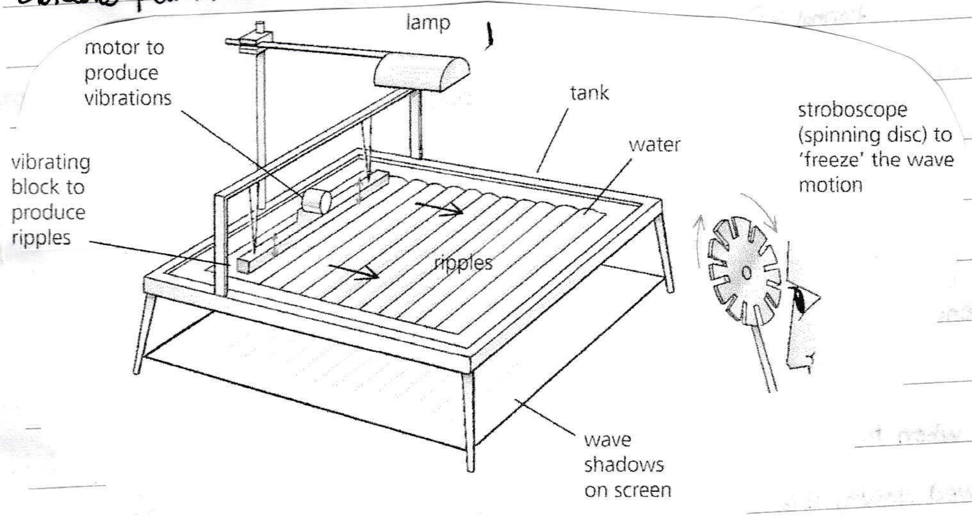
Diffraction

- Waves bend round the sides of an obstacle, or spread out as they pass through a gap.
- Wider gaps produce less diffraction.
- Only significant if the size of the gap is about the same as the wavelength.
- At an edge, longer wavelengths would produce more diffraction.



Water Waves

- Ripple tank is used for experiments.
- Ripples (tiny waves) are sent across the surface of water.
- Obstacles put in their path to observe the produced effect.

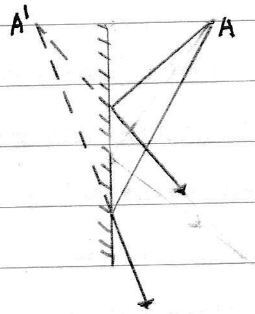


3.2 Light

3.2.1 Reflection of light

- Plane (flat) mirrors create a reflection.
- Rays from an object reflect off the mirror into our eye but we see them behind the mirror.

Image properties:
- Same size as object
- Same distance from mirror as the object.
- A line joining equivalent points of the image and the object meet the mirror at a right angle.
- Image is virtual: no rays actually pass through the image; the image cannot be formed on a screen.



★ Angle of incidence = Angle of reflection

3.2.2 Refraction of light

Experimental Demonstration

1. Using the ray box, pass a ray through a glass slab on a white sheet of paper.
2. Mark two points on the incident ray, refracted ray, emergent ray and draw an outline of the glass slab with a pencil on the paper.
3. Connect the dots to create a diagram; a protractor is used to find the angles.

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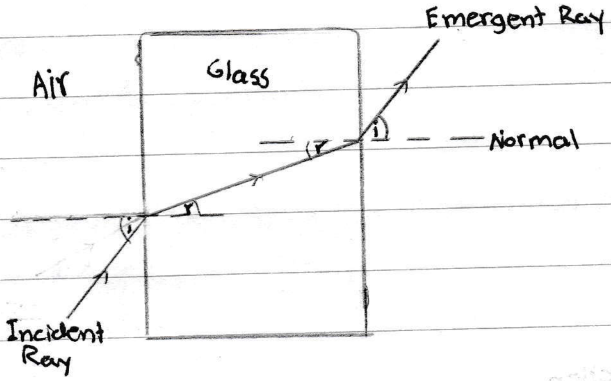
Passage of light through a parallel-sided transparent material.

1. Rays of light travelling from air into glass strike the glass with the angle of incidence (i) and are refracted towards the normal. The angle between the refracted ray and the normal is the angle of refraction (r). [less dense to denser medium]

2. Refracted ray escapes the material by striking the opposite side with an angle equivalent to r.

3. Emergent rays travelling from glass into air are refracted away from the normal by an angle of refraction equivalent to i. [denser to less dense medium]

★ The emergent ray is parallel to the incident ray because the change in angle of the light ray is the same as it enters and leaves the glass.



Refractive Index (n)

$$\text{refractive index} = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}}$$

$\frac{\sin i}{\sin r} = n$ $\quad$ $n_1 . \sin i = n_2 . \sin r$

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

Critical angle (C)

Maximum angle a light ray can pass through from a high dense medium to a low dense medium. ★ $r > i$

$C = \sin^{-1}\left(\frac{1}{n}\right)$

Internal reflection: When rays are reflected back into the medium instead of getting refracted out into a less dense medium.

Total internal reflection: When all the light is reflected back into the medium because the angle of incidence was greater than the critical angle. $(i > C)$

Optical fibres.

- Light put in at one end is totally internally reflected until it comes out of the other end.
- Used in communications: signals are coded and sent along the fibre as pulses of laser light.
- Used in medicine: an endoscope, an instrument used by surgeons to look inside the body, contains a long bundle of optical fibres.

3.2.3 Thin converging lens

A converging lens collects light rays together.

principal focus: the point where rays parallel to the principal axis converge with a converging lens.

*centre of the lens

focal length: distance from the principal focus and the optical centre.

Nature of an image

Object Position	Image Characteristics			
(Principle points)	Type	Orientation	Size	Position
Infinity	Real	Indeterminate	infinitely diminished	At F
between infinity and 2F'	Real	Inverted	Diminished	between F and 2F
at 2F'	Real	Inverted	same size	At 2F
between 2F' and F'	Real	Inverted	Enlarged	between infinity and 2F
at F'	none	Indeterminate	Infinitely enlarged	at infinity
between F' and lens	Virtual	Upright	Enlarged	between lens and infinity
next to lens	Virtual	Upright	Same size	next to the lens

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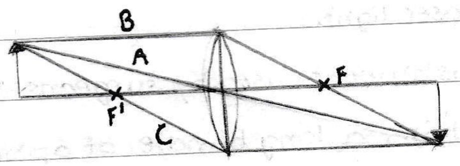
Magnifying glass

When an object is closer to a converging lens than the principal focus, the rays never converge. Instead, they appear to come from a position behind the lens. The image is upright and magnified, thus the lens is used this way as a magnifying glass. It is a virtual image.

Real Image

• When object is further away from the optical centre than F'.



★as object is moved towards the, the image becomes bigger and further away.

A) A ray through centre of the lens. Passes through the lens.

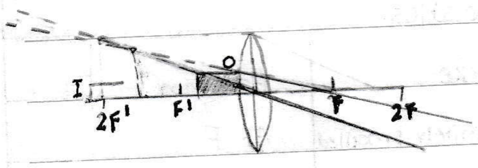
B) A ray parallel to the principal axis. Passes through the focus on the other side of the lens.

C) A ray through F' which will leave the lens, parallel to the principal axis.

• Image can be ~~placed~~ picked up on a screen.

Virtual Image

• When object is closer to the optical centre than F'.



★ used for magnifying glass

• no rays meet to form the image.

• Image can't be picked up on screen.

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3.2.4 Dispersion of light

- When light is refracted by a prism, the incidence ray is not parallel to the emergent ray, since the prism's sides are not parallel.
- White light is a mixture of colours, and the prism refracts each by a different amount - red is deviated least and violet is deviated most. This causes the white light to disperse into a spectrum.

Monochromatic: A light of a single wavelength and colour. (Ex: lasers)

Light Spectrum: Red

Orange

Yellow

Green

Blue

Indigo

violet

3.3 Electromagnetic spectrum

long wavelength, low frequency — Short wavelength, high frequency

Radio waves | Microwaves | Infra-red | visible Light | Ultra-violet | X-rays | Gamma rays

- all e.m. waves travel with the same high speed in a vacuum.
- Speed of electromagnetic waves in a vacuum is 3.0×10^8 m/s and is approximately the same in air.

Uses

Radio waves: radio and television communications.

Microwaves: Satellite television and telephones

Infrared: electrical appliances (radiant heaters and grills), remote controllers for televisions and intruder alarms.

X-rays: medicine (X-ray photography and killing cancer cells) and security.

Safety issue: is a mutagen; it causes cancer (mutations)

3.4 Sound

Production

- Sound waves come from a vibrating source e.g. loudspeaker
- As the loudspeaker cone vibrates, it moves backwards and forwards, squashing and stretching the air infront.
- As a result, a series of compressions (squashes) and rarefactions (stretches) travel through the air as sound waves.

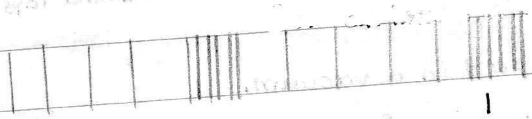
Properties

- Sound waves are longitudinal: they have compressions and rarefactions, and they oscillate back and forth.

  Compression: high pressure region of the wave

  Rarefaction: low pressure region of the wave
- The approximate range of audible frequencies for a healthy human ear is 20 Hz to 20 000 Hz.

  Ultrasound waves: Sounds above the range of human hearing.
- Sound waves need a medium to ~~travel~~ through.



Speed of sound

concrete	Solid	5000 m/s
water (pure) at 0°c	liquid	1400 m/s
air (dry) at 30°c	gas	350 m/s
air (dry) at 0°c	gas	330 m/s

V solid > V liquid > V gas

Experiment: 1. A sound will come back to you when reflected off a wall. Make a sharp sound.

2. Measure time taken for echo and distance from wall.

3. Calculate speed of sound. $\frac{2 \times \text{Distance to wall}}{\text{echo time}}$

Loudness and pitch

- The higher the frequency, the higher the pitch.
- The higher the amplitude, the louder the sound.

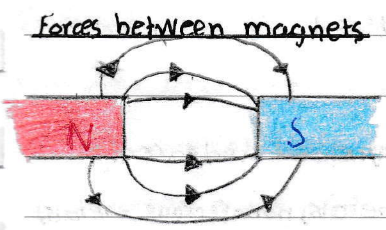
Echoes

Hard surfaces reflect sound waves, creating echoes.

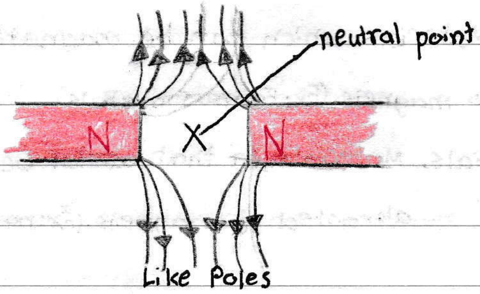
4. Electricity and magnetism

4.1 Simple phenomena of magnetism

Forces between magnets



Unlike Poles



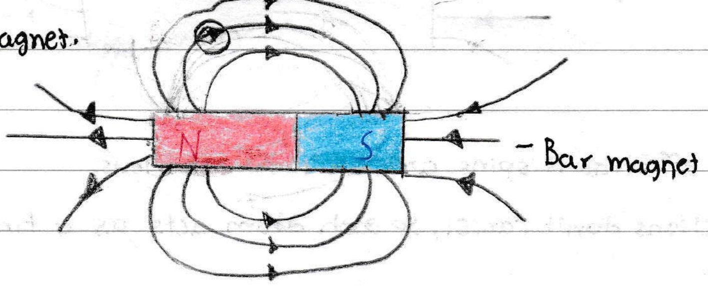
Like Poles

The combined field is almost uniform(even) in strength.

Between like poles, there is a neutral point where the combined field strength is zero.

Forces between magnets and magnetic materials

The magnetic materials are pulled into position by forces from the poles of the magnet.



★ Magnetic forces are due to interactions between magnetic fields.