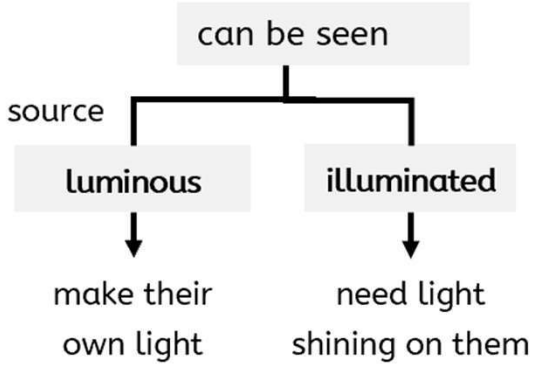
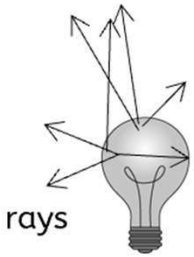
7.06: Sound and light

Describing light



- Light cannot be seen directly as it travels.

Light travels



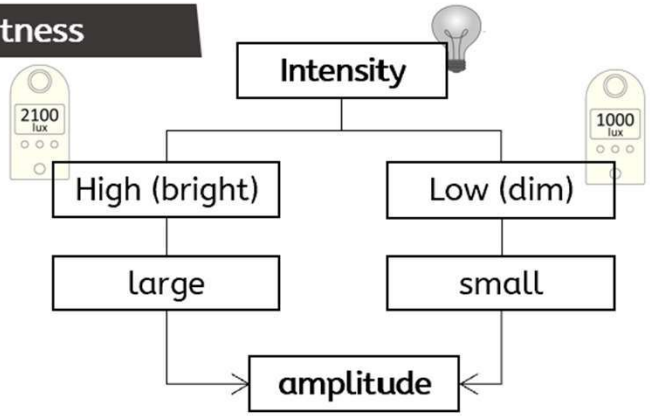
- away from source
- from every point
- in all directions
- very fast

Light is constantly emitted from a source that is 'on'.

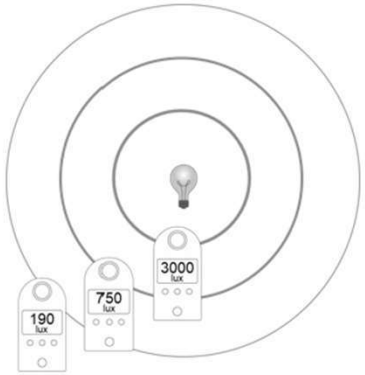
Light fills an enclosed space.

Darkness is the absence of light.

Brightness

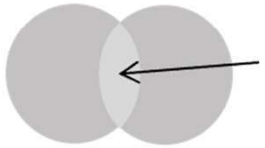


- Some sources transmit more energy away in a given time.
- Light spreads out from a source.
- Brightness decreases with distance.



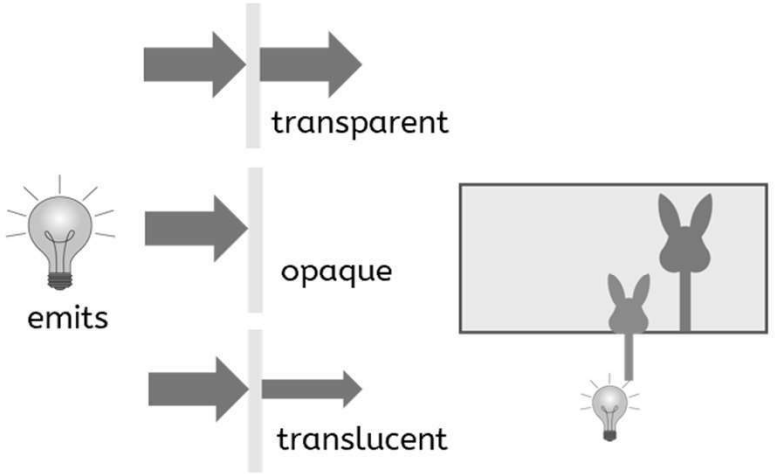
Light meter measures brightness in lux.

- Light from multiple sources falling on a screen is brighter than one.



Different media

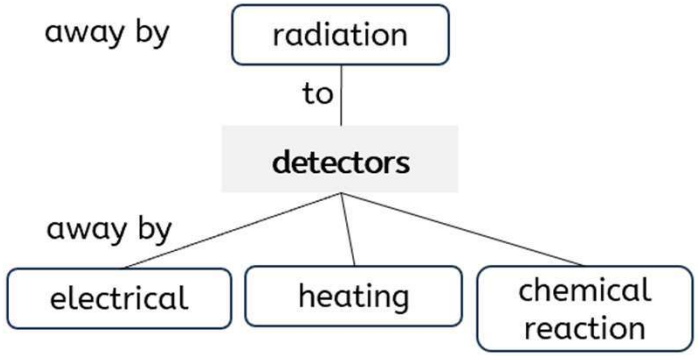
- Light is transmitted through any transparent media, including a vacuum.



- All materials absorb some energy from light.
- Opaque objects transmit nothing (forming shadows)

Energy pathways

- From a source, light travels …



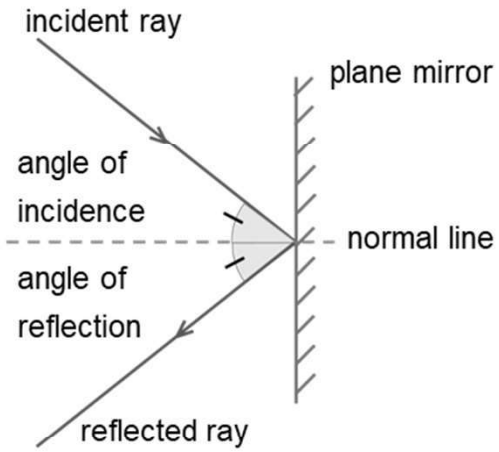
Light is the transfer of energy by the radiation pathway to its surroundings so that a region is lit up.

7.06: Sound and light

Light reflecting

- **All** surfaces reflect light and obey the **law of reflection**.

the angle of incidence	=	the angle of reflection



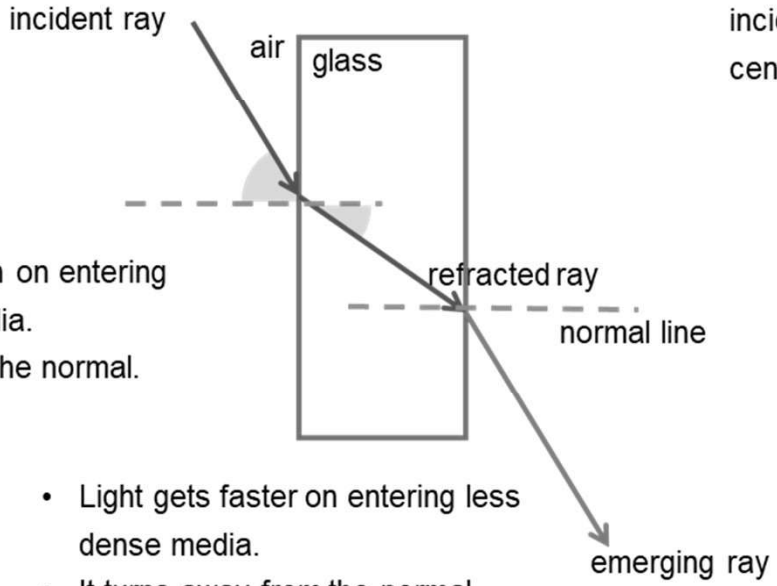
specular reflection

diffuse reflection

- **Most** surfaces reflect light **diffusely** (scatter it).

Light refracting

As the angle of incidence increases, there is more refraction.

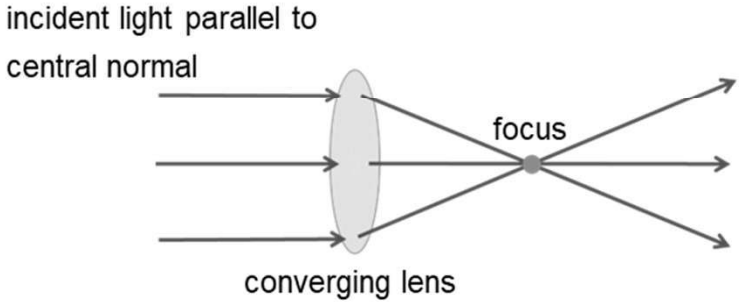


- Light slows down on entering more dense media.
- It turns towards the normal.

- Light gets faster on entering less dense media.
- It turns away from the normal.

and Lenses

Converging lenses form a focus can form a clear image.

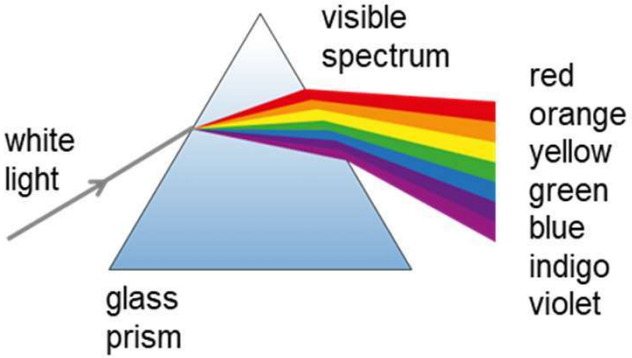


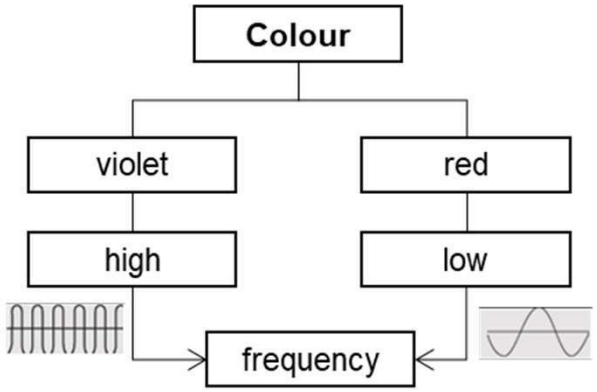
- **The focal length is the distance from lens to focus,**
- **or lens to image.**
- **Thicker lenses (more curved) refract more, have a closer focus and longer focal length.**

7.06: Sound and light

Coloured light

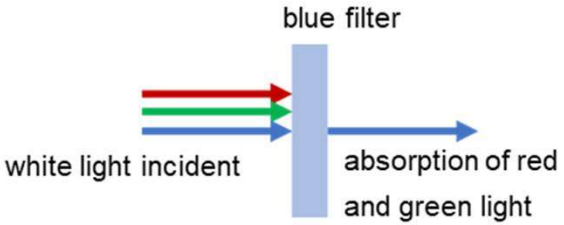
- Luminous objects emit light of particular colours.
- Most common sources emit white light.





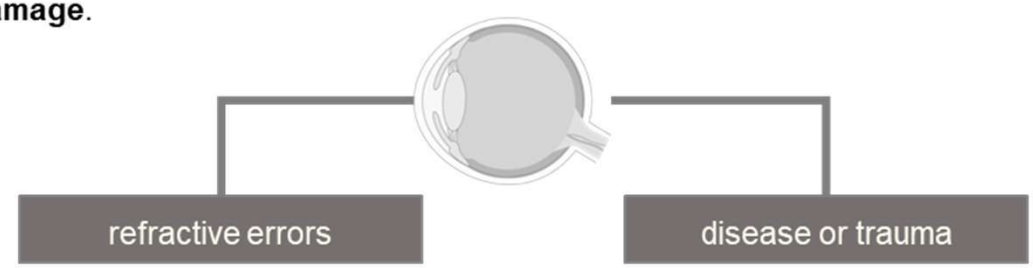
Coloured filters:

- transparent objects
- transmit own colour
- selectively absorb any other colour of incident light



Seeing differences

Many problems with our vision are caused by parts of the eye that are not the right **shape** or **size**, that have become **cloudy,** or due to **cell damage**.



not preventable but treatable

may be preventable and treatable

People with low vision may use:

Long canes, guide dogs, talking books, Braille or other assisted devices.

Light from the Sun can be dangerous:

- Never look directly at the Sun.
- Wear sunglasses in bright sunlight.
- Protect the skin too.

7.06: Sound and light

Images

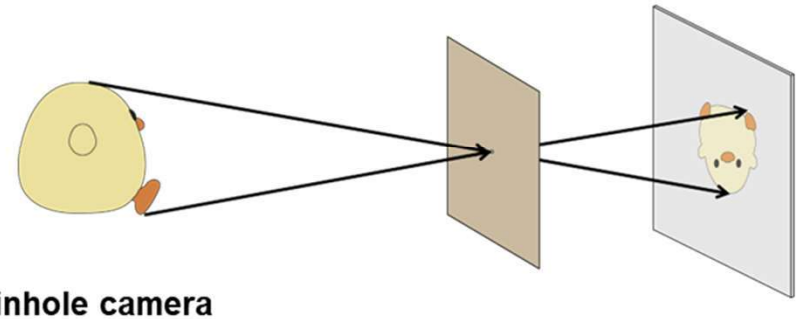


Image is:

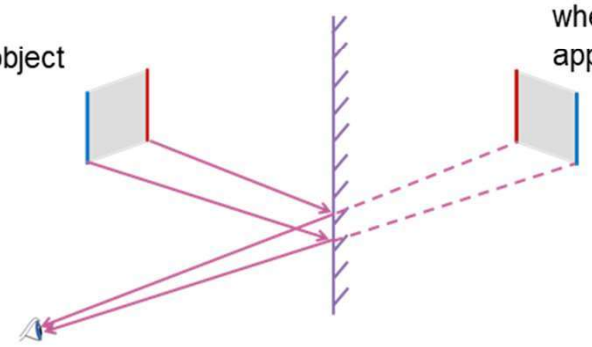
- inverted
- dim
- diminished.

Pinhole camera

- Some light from each point of the object facing, passes through the pinhole.
- The pinhole only allows a narrow beam through, from each point.
- Light from each point crosses over as it passes through the pinhole.
- Light from every point falls on the screen forming a complete image.

Mirror image

- Light from every point of real object reflects into eye.
- Brain interprets reflected light as originating from behind mirror.



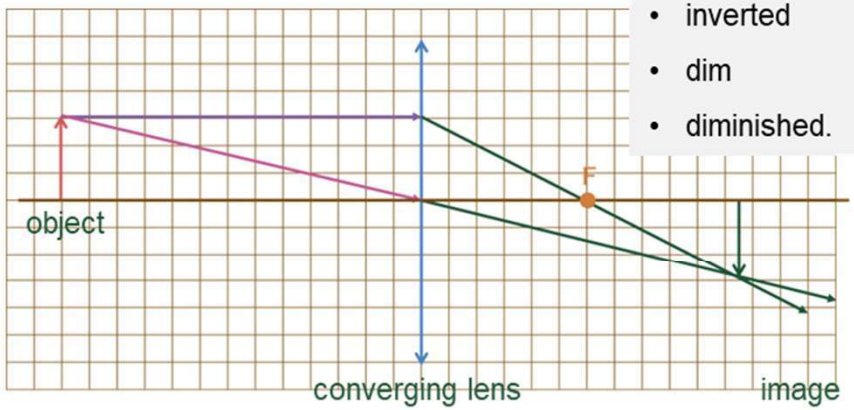
- right way up
- same size
- same distance

Images from lenses

- Some light from each point refracts through the lens.
- Light from each point arrives at specific points on the surface forming an image.

Image is:

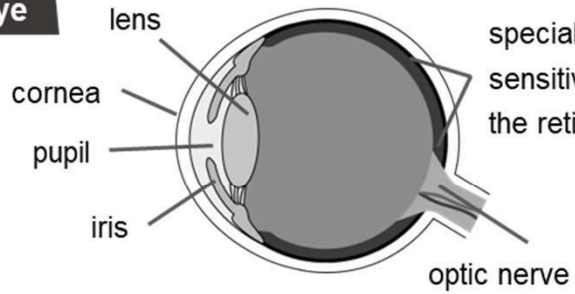
- inverted
- dim
- diminished.



- A partially covered lens still forms an image, but dimmer.

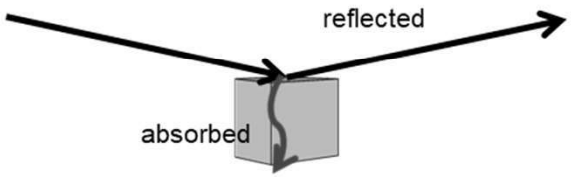
7.06: Sound and light

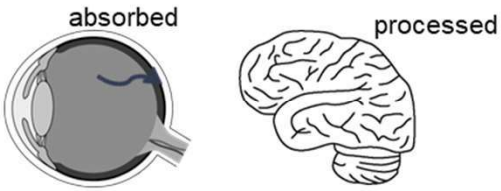
The human eye



cornea	refracts light before it enters the eye
iris	controls the size of the pupil
pupil	lets light enter the eye
lens	refracts light to form an image
retina	made up of cells that detect light
optic nerve	carries electrical signals to the brain

Seeing objects

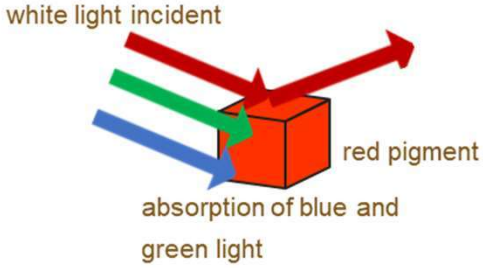




incident light → object → reflected light → eye → brain

Seeing coloured objects

- If an opaque object is coloured, it has pigments which absorb specific colours.
- absorbs any colour different not in the pigment
- appears the colour of any scattered light



Seeing at different distances

- The lens shape changes as needed.

Refraction errors of the eye

short-sightedness

- eye too long or the cornea too extended: focus in front of retina

Glasses to spread out the light before it enters the eye.

long-sightedness

- eye too short or the cornea too rounded: focus behind the retina

Glasses to converge the light before it enters the eye.

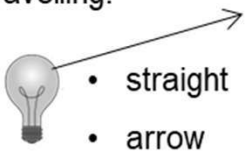
7.06: Sound and light

Scientific models

Representations of reality that can be used to explain observations

The ray model of light

- Rays are imaginary lines, **drawn to represent** the path light is travelling.
- From an infinite number, **a few** are chosen to be drawn.



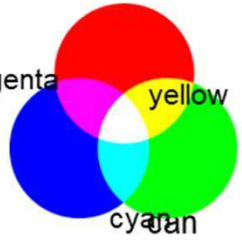
- straight
- arrow

The 'passive-eye' model of vision

- Objects emit or reflect light into the eye.

The 'three primary colours' model of human colour vision

- eye has three types of sensor cell
- detect: red, green and blue, the primary colours of light
- directed at a white screen, combinations of primary colours appear as secondary colours or white (and more)



The pinhole camera as a model for the eye

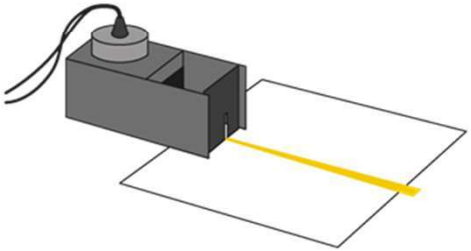
- Light enters through the pinhole similar to the pupil.

- Light 'crosses over' at the pinhole, similar to the lens.
- Light from the object falls on the screen, similar to the back of the eye.

Observing light

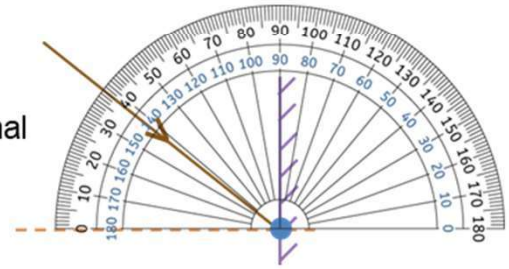
Using a raybox

- Raybox and comb, connected to a power supply
- Draw crosses (avoiding likely measurement errors).
- Plot and label rays.



Measuring angles

- centre at vertex
- scale starting at 0° on normal line
- read up from 0°



Trusted scientific research

High-quality data

- Well-chosen method
- Appropriate resolution
- Multiple measurements
- Repeatable
- Reproducible
- Appropriate range
- Systematic intervals

Trustworthy conclusions

Process and display collected data

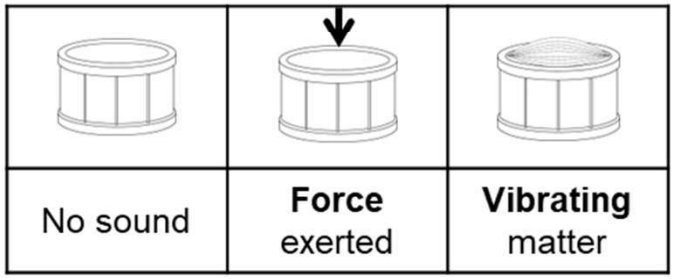
Describe data from table or chart

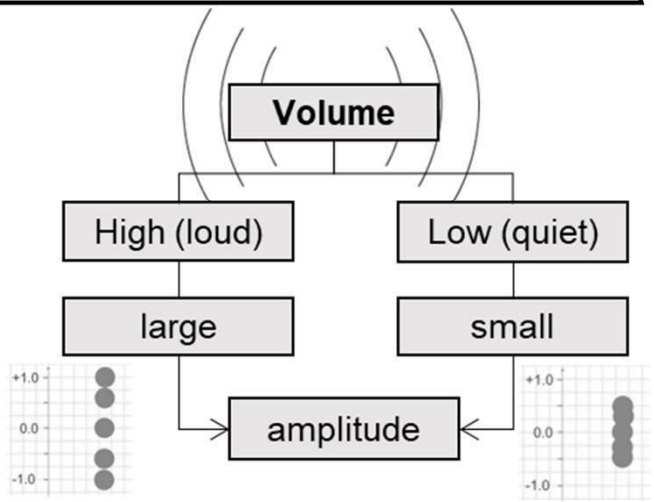
Explain interpreted data

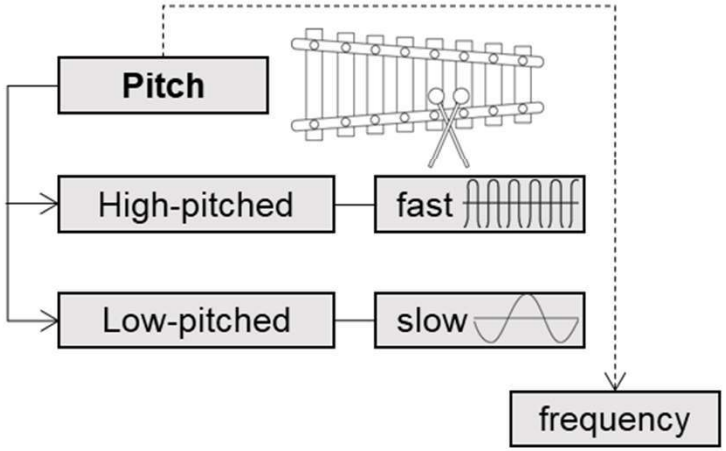
7.06: Sound and light

Describing sound

Sources of sound

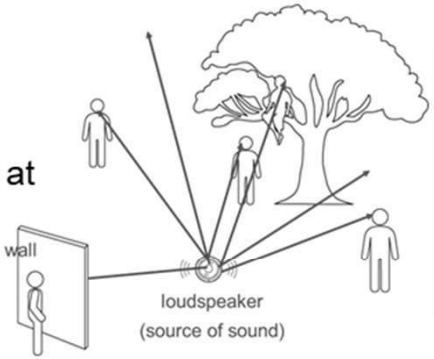






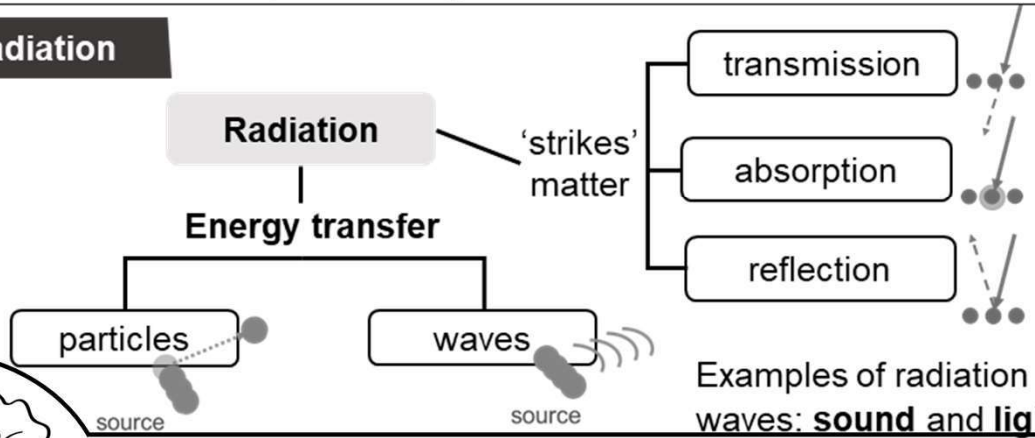
Vibrations travel through matter

- Travel in **all directions** from a source.
- Can be observed by **detectors** placed at a distance.
- If blocked, a **shadow region** occurs.
- Fastest in solids, slowest in gases.



- Gas ✓
- Liquid ✓
- Solid ✓
- Vacuum ×

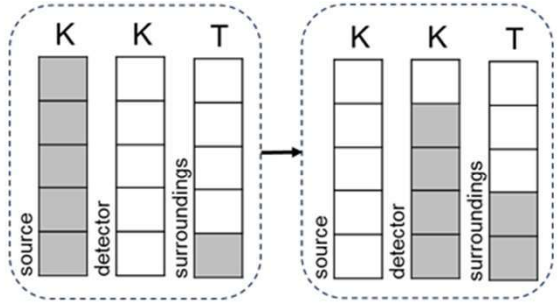
Radiation



Examples of radiation by waves: **sound** and **light**.

Energy transfer

- As vibrations travel, the energy store of the source decreases.
- The energy store of the matter increases.
- The kinetic store of any detector increases.
- By the **mechanical** pathway.



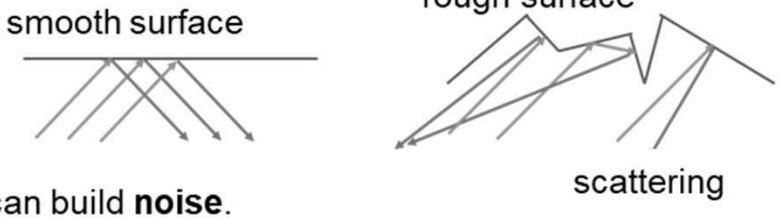
- The thermal store of the surroundings also increases.

7.06: Sound and light

Vibrations get less with distance

- Energy **spreads out** among more particles.
- Each **particle absorbs** some energy, not passing it all on.
- If **all energy** is absorbed, a shadow region occurs.

Reflections

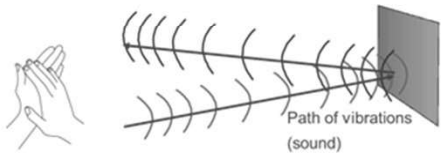


Surfaces

- Smooth surfaces can build **noise**.
- Rough surfaces scatter sound so that it spreads out and quietens.
- Noise can be made worse by many reflections interacting, and better by using rough surfaces.

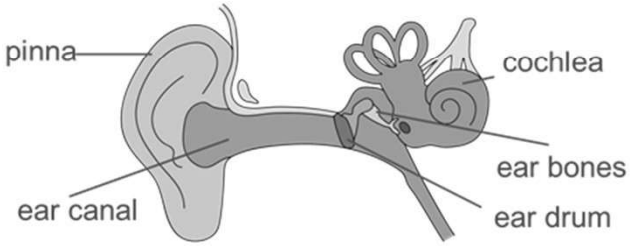
Echoes

- A reflected sound is an echo.
- Some animals use echoes.



Hearing

The ear



Sound in the ear

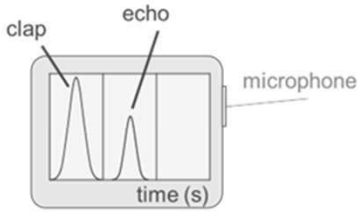
- The function:
  - **transfer energy** to the nervous system, as much as possible
  - from the vibrations in the air
  - to the inner ear,
  - so that the brain can perceive and interpret it.
- Energy transfer from the tiny hairs in the cochlea to the nerves is by the **electrical** pathway.

Differences in hearing

- The **audible range** of human hearing is from about 20 Hz to 20 000 Hz.
- Above this is **ultrasound** and below this is **infrasound**.
- Different animals have different ranges of hearing.
- Exposure to loud sounds and ageing can contribute to hearing differences, e.g. deafness.

7.06: Sound and light

Using technology to improve data quality



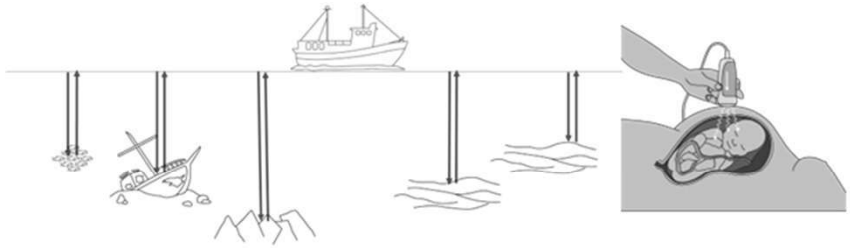
Measuring short times

- **Digital** clock reduces systematic error (no scale).
- **Datalogging** equipment:
  - reduces difficulty observing quiet sounds e.g. echoes
  - reduces difficulty judging when sound arrives (measures directly)
  - reduces reflex action delays
  - allows 'zoom in' on time scale.

Using scientific knowledge

Echolocation

- Finding an object



Acoustic imaging

- Deep in the sea
- Inside living organisms (foetal scan)
- Inside solid objects

We have more information, of better quality, with much less risk.

Hearing technology examples

- Hearing aids
- Hearing implants
- Hearing loops

Reduce the chance of hearing damage by wearing ear protection and reducing volume of sounds.

Observing by measurement

Quantities: and their units

Base quantities: length (m), mass (kg), time (s), temperature (K).

Derived quantities include force (N), **frequency (Hz)**, **loudness (dB)**.

Measuring instruments

- Include rulers, balances, clocks and thermometers.
- Measuring tapes are used to measure distances longer than a few metres.

Unit prefixes

- Standard prefixes change a number by multiples of 1 000, e.g. one *kilo*metre is equal to 1 000 metres.
- The prefix ***milli-*** uses a multiple of 0.001, it means one thousandth:
  - one **millisecond** is one thousandth of a second (1 ms is easier to use than 0.001 s).
- A non-standard but common prefix is ***centi-***, to mean one hundredth.
  - one centimetre is one hundredth of one metre (1 cm is easier to use than 0.001 m).