Cambridge IGCSE Physics Review

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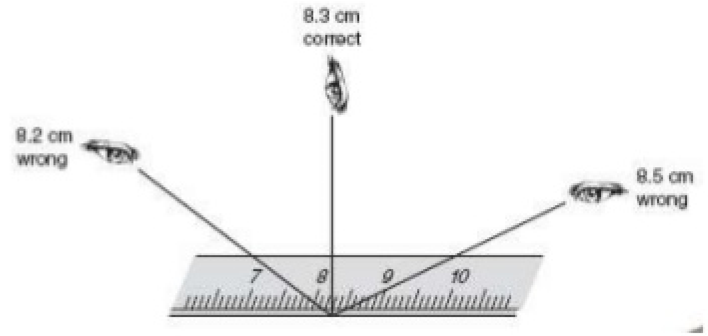
General Physics

Measurement



- Correct way to read the scale on a ruler
- Position eye perpendicularly at the mark on the scale to avoids parallax errors
- Another reason for error: object not align or arranged parallel to the scale

How to read the scale on the ruler

The correct way to measure with a ruler:

eye must be **directly over the mark on the scale** or the thickness of the ruler causes a parallax error.

Equations for motion with a constant acceleration

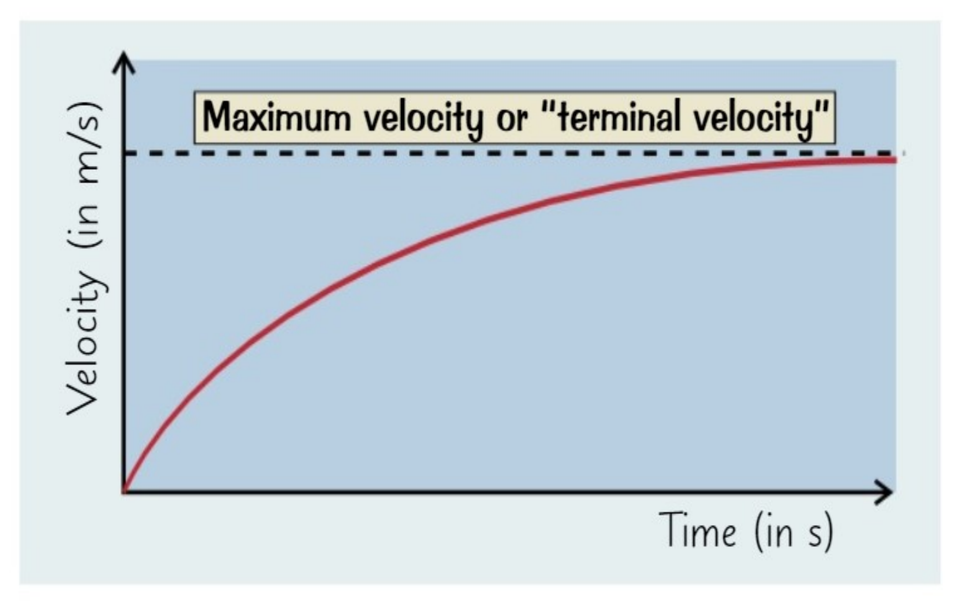
$$v = u + at$$

$$s = \frac{(v+u)}{2}t$$

$$s = \frac{1}{2}at^2 + ut$$

$$v^2 = u^2 + 2as$$

● Terminal velocity

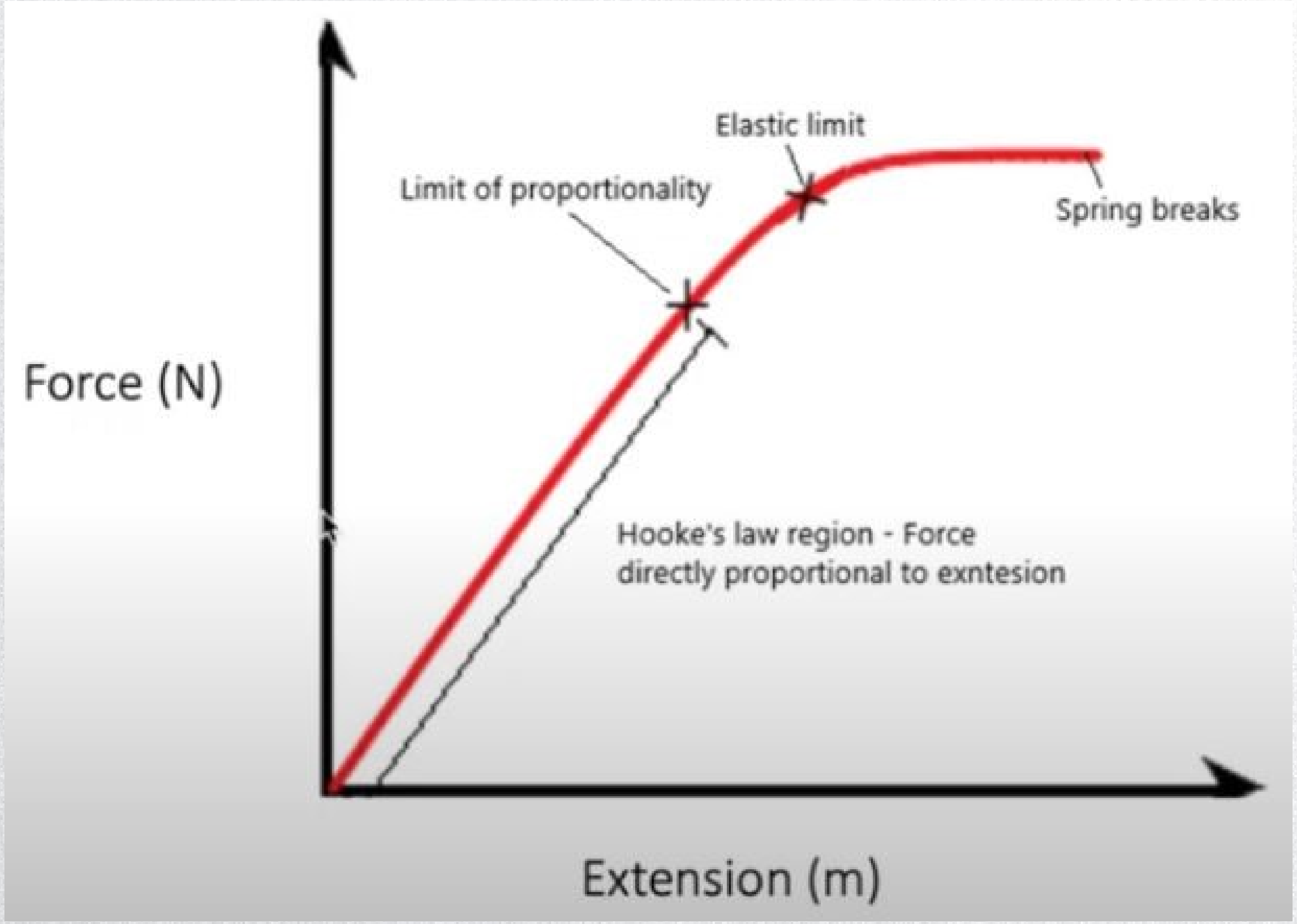


Falling objects can reach a **terminal velocity**.

Frictional forces (ex. air resistance) increase with speed, but only up to a certain point.

The resistance force gradually reduces the acceleration until eventually the **resistance force** is equal to **accelerating force**.

Hooke's Law



Elastic limit
Limit of proportionality
Spring breaks
Force (N)
Hooke's law region - Force directly proportional to exntesion
Extension (m)

Newton's second law

$$F = ma$$

$$F = m\frac{v-u}{t}$$

$$F = m\frac{\Delta v}{t}$$

$m \times \Delta v$

Changes in momentum

$F \times t = m \times \Delta v$

Impulse

$m \times v$

Momentum

Conservation of momentum: when 2 or more objects act on each other, their total momentum remains constant.

(collision problems)

Momentum before = momentum after

Work & Energy

$$W = \Delta E$$

$$W = F \times d$$

Efficiency

$$(\%)\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy output}} \times 100\%$$

$$(\%)\text{Efficiency} = \frac{\text{useful power output}}{\text{total power output}} \times 100\%$$

Power

$$\text{Power} = \frac{\text{work done}}{\text{time taken}}$$

$$P = \frac{W}{t}$$

$$P = \frac{\Delta E}{t}$$

Electric Power

$= V \times I$

The **force exerted per unit area**

$$P = \frac{F}{A}$$

Pressure

The change in pressure beneath the surface of a **liquid**:

$$\mathbf{P = \rho g h}$$

Manometer

Barometer

Pressure due to **gas** = atm. + $\rho g h$

Thermal Physics

Kinetic (Particle) Model of Matter

Kinetic model of matter:

- Kinetic means ‘related to movement’
- In this model, the things that are moving are the particles of which matter is made
- The model thus has an alternative name: **the particle model of matter**.
- The matter is made up of **identical particles**, each is considered as **a small, solid, inelastic sphere**.

Thermal Capacity

Thermal capacity:

- Thermal capacity is defined as **the amount of heat to be supplied to an object to produce a unit change in its temperature.**
- High thermal capacity means it takes a lot of energy to raise their temperature by a certain amount.
- The thermal capacity of an object depends on the material from which it is made and its mass.
- Objects made of non-metals and liquids have higher thermal capacities.
- $Thermal\ capacity = \frac{E}{\Delta T}$
- The **SI unit** of heat capacity is **joule per kelvin (J/K), non-SI unit** would be **J/°C**.

Specific Heat Capacity

The specific heat capacity of a substance is **the energy required to change the temperature of an object by 1 ◦C per Kg of mass.**

Energy required = mass × specific heat capacity × temperature change

$$\Delta E = m \times c \times \Delta T$$

	ΔE (J)	m (kg)	ΔT (◦ C)
Water	4200	1	1
Mercury	139	1	1

Specific Heat Capacity

- The **specific heat capacity** of a material is the energy required to raise the temperature of 1 Kg of the material by 1 ◦C .
- Some materials need more energy to increase the temperature than the others (e. g. you need 4200 J to warm 1 kg of water by 1 ◦C , but only 139 J to warm 1 kg of mercury by 1 ◦C).
- Materials that need to gain lots of energy to warm up also release lots of energy when they cool down again. They store a lot of energy for a given change in temperature.
- Unit: **J/(kg °C)**

Specific latent heat

- **Specific latent heat of fusion (fusion means melting):**
  - ✓ Energy required to **melt** 1 kg of **solid** at its **melting point** with no change in temperature (energy per kilogram required to cause a substance to change state from **solid to liquid** at its **melting** point)
- **Specific latent heat of vaporization**:
  - ✓ Energy required to **vaporize** 1 kg of **liquid** at **boing point** with no change in temperature (energy per kilogram required to cause a substance to change state from **liquid to gas** at its **boiling** point)

$$Energy\ required = \text{mass} \times specific\ latent\ heat$$

$$\text{Energy} = \text{m} \times \text{L}$$

Thermal Expansion

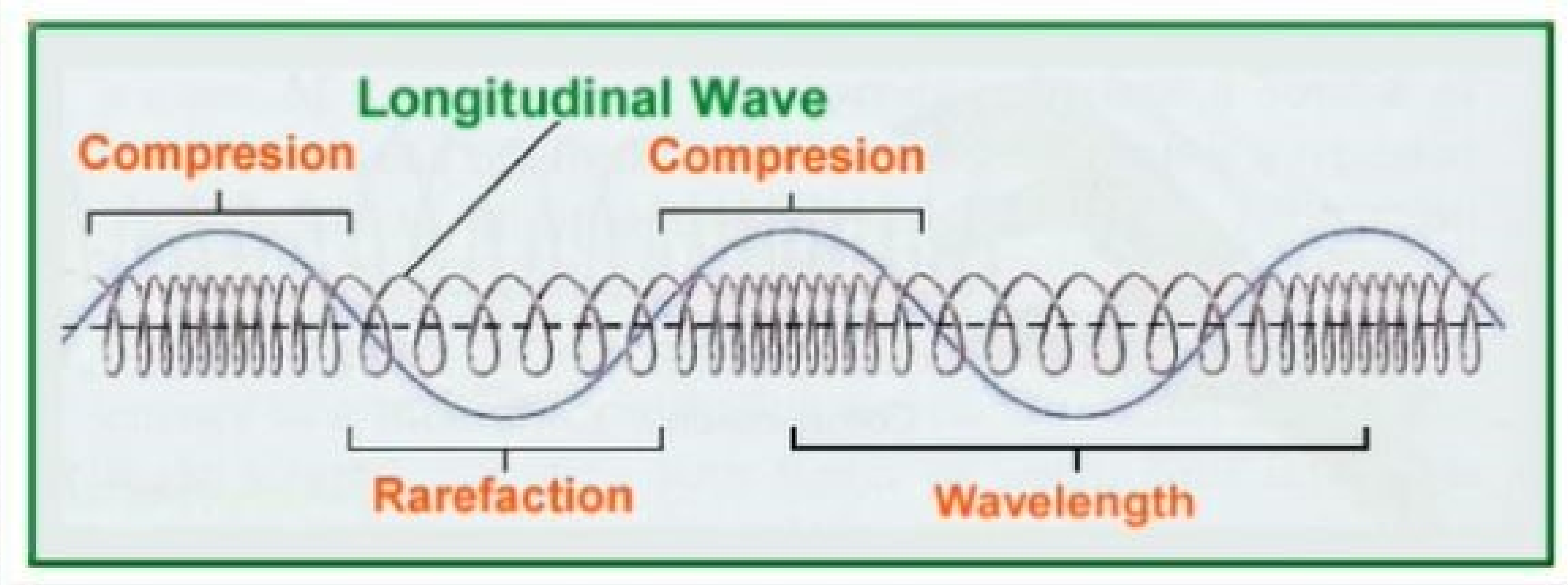
- Solids, liquids, and gases expand when **heating**
- This is because particles **gain more kinetic energy** when heated, and therefore **gain more separation** from neighboring particles
- The extend of expansion varies:
  - ✓ Solids expand the least
  - ✓ Liquids expand more than solids
  - ✓ Gases expand more than liquids

Boiling vs. Evaporation

Boiling vs. Evaporation	
Common	Change in state from liquid to gas
Differences	- Boiling occurs at a fixed temperature; Evaporation can occur at all temperatures, including below the boiling point - Evaporation decreases the temperature of the remaining liquid; During boiling the temperature remains constant

Waves

Production of Sound Waves



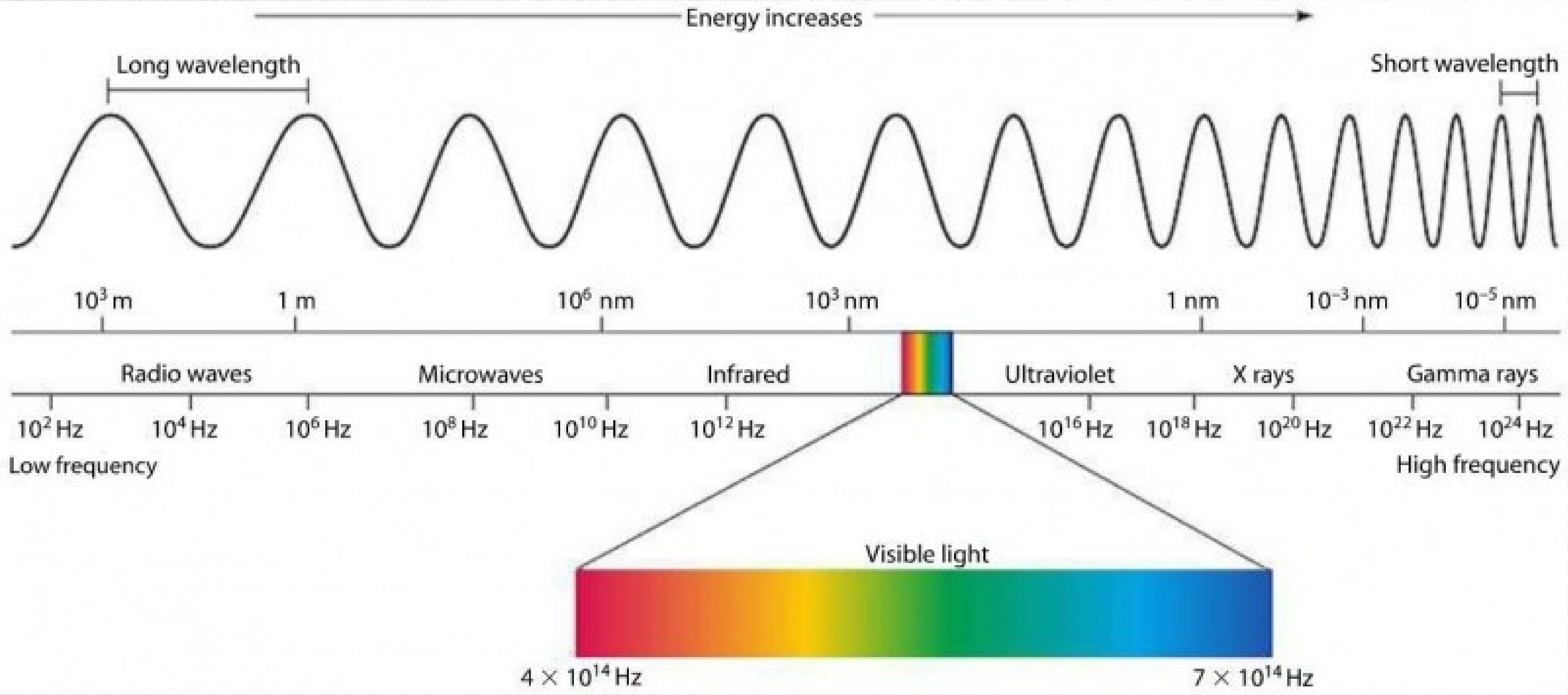
Speed of Sound

- Sound cannot travel through **vacuum**
- Sound must be transmitted through vibrations of particles within a medium
- **The closer the particles are within the medium, the faster sound will travel**
  - ✓ Air particles are very spread out, so sound does not travel very fast
  - ✓ Metals on the other hand are usually solids, and particles are much closer together allowing quicker transmission of sound waves
  - ✓ Sound speed in air = 330 m/s (approximately 330–350 m / s)

    Sound in water = 1500 m/s

    Sound in metals = 5000 m/s

Electromagnetic (EM) waves



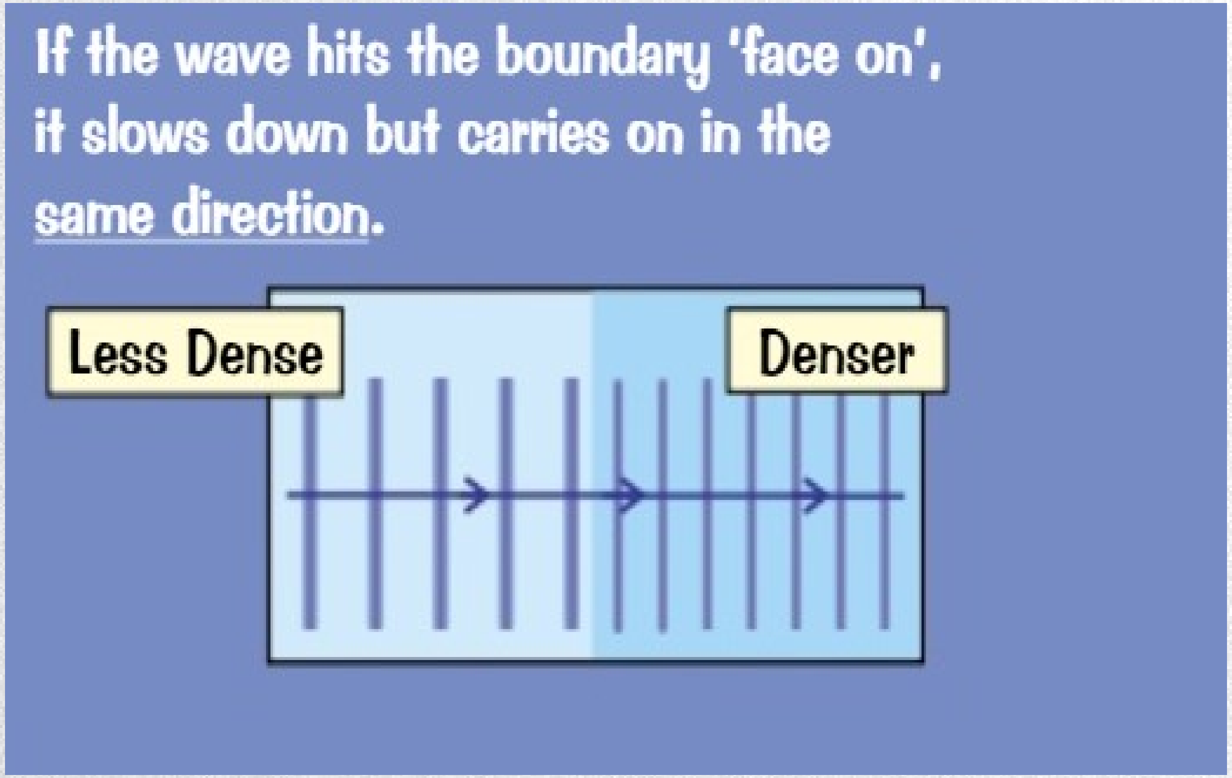
Electromagnetic (EM) waves

- All electromagnetic waves are **transverse**.
- The speed of electromagnetic waves in a vacuum is **3.0×10^8 m/s** and is approximately the same in air.
- The higher the frequency, the higher the energy of radiation.

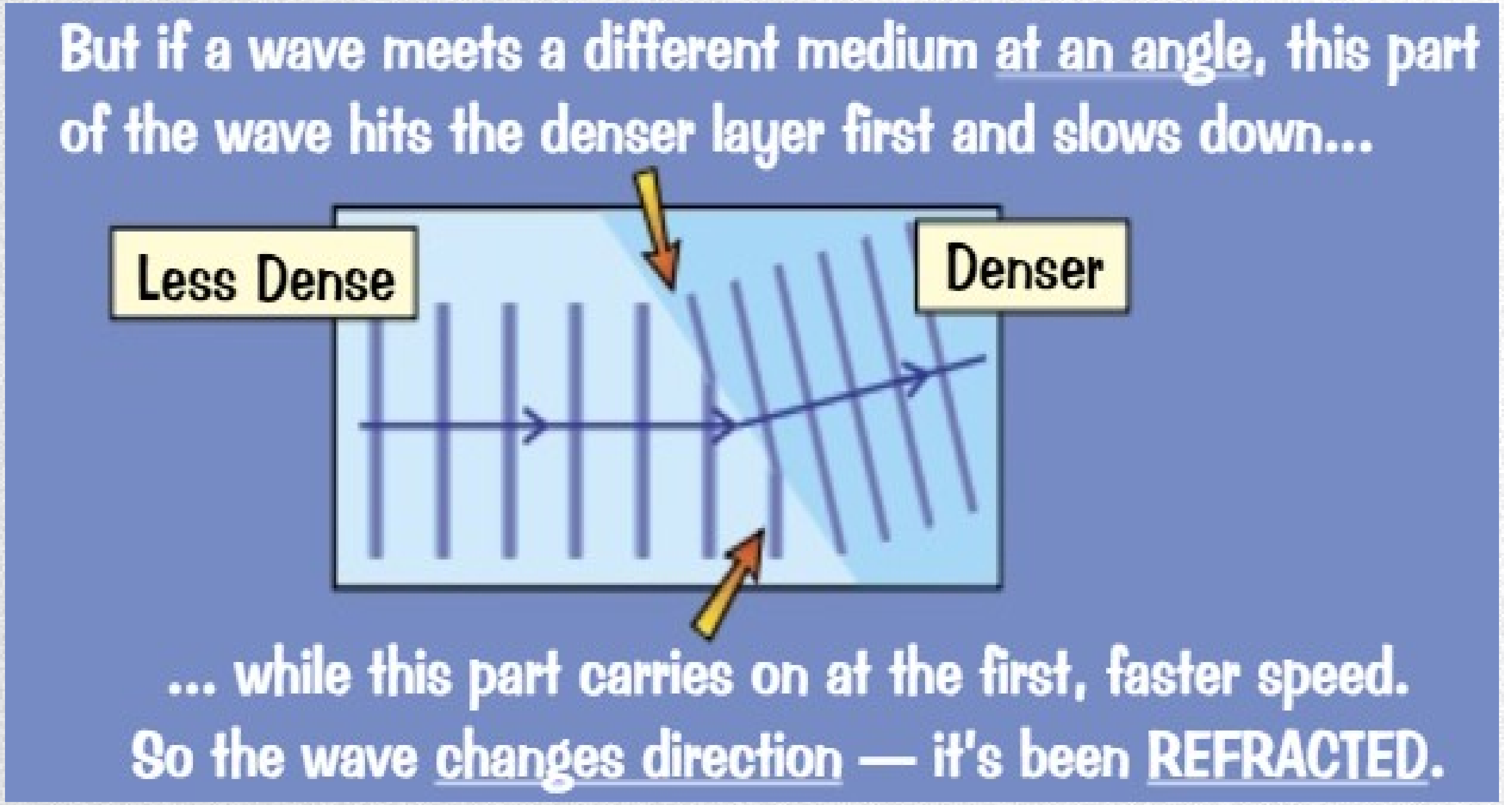
Refraction

- Waves travel at **different speeds** in substances which have **different densities**.
  - ✓ EM waves travel more slowly in denser substances.
  - ✓ Sound waves travel faster in denser substances.
- When a wave cross a boundary between substances, e.x. from glass to air, it changes speed.
- If a wave is travelling along (or parallel to) the normal when it crosses a boundary between materials, it doesn’t refract.

Refraction of Light



Refraction of Light



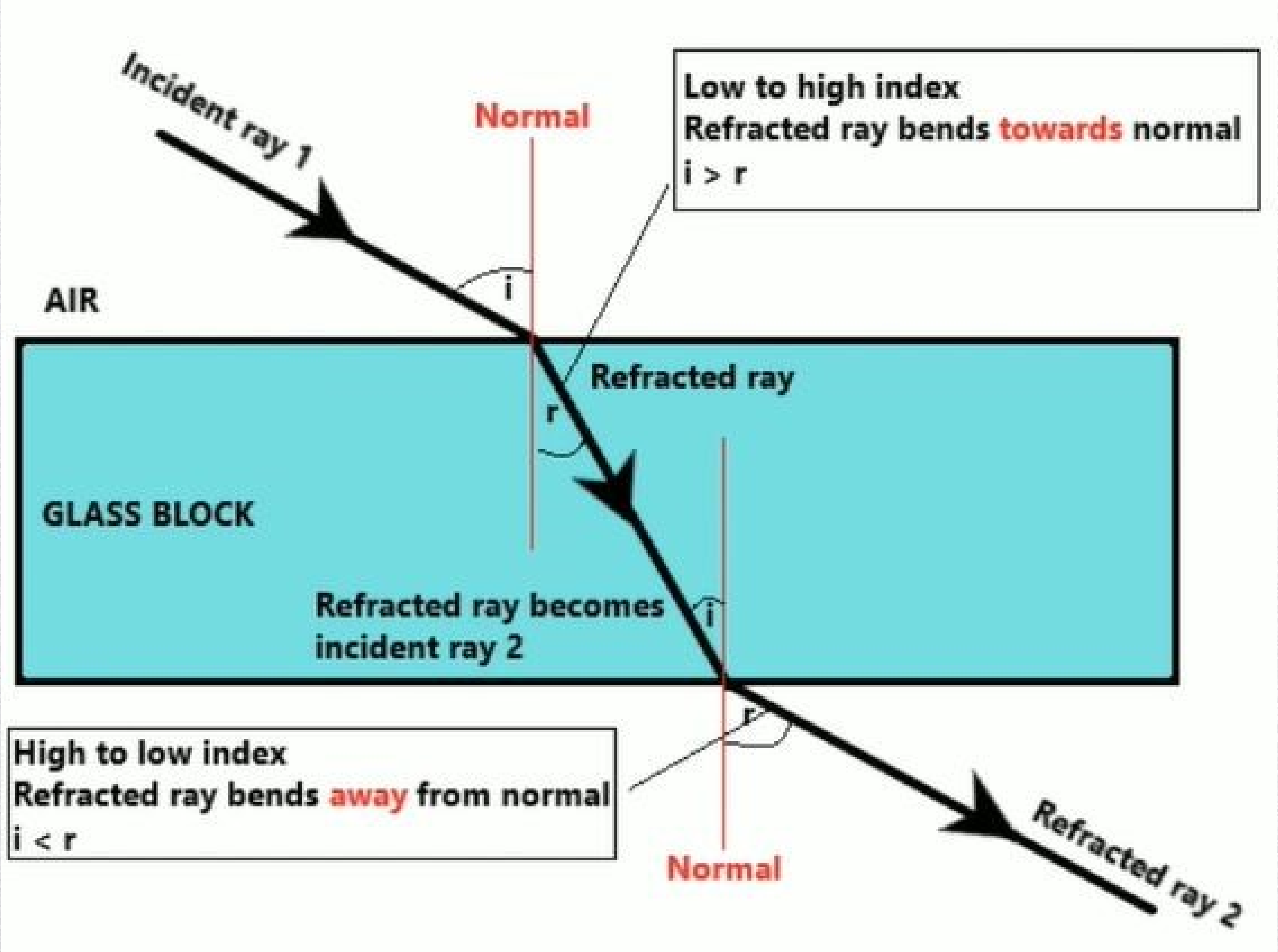
Refraction of Light

A ray diagram for a refracted wave:

- Draw the **boundary** between two materials
- Sketch the **normal**: a line that is at 90° to the boundary
- Draw an **incident ray** that meets the normal at the boundary
- Draw the angle of incidence, i
- Draw the **refracted ray** on the other side of the boundary:
  - ✓ If the 2nd material is denser than the 1st → the refracted ray **bends towards** the normal → $i > r$
  - ✓ If the 2nd material is less dense than the 1st → the refracted ray **bends away** the normal → $i < r$

C. Chu

Refracted twice



Refractive Index (Index of Refraction)

- Every transparent material has a refractive index
- The refractive index of a transparent material tells you **how fast light travels in that material**.

$$refractive\ index, n = \frac{speed\ of\ light\ in\ a\ vacuum, c}{speed\ of\ light\ in\ that\ material, v}$$

$$\boldsymbol{n = \frac{c}{v}}$$

✓ The speed of light in air is about the same as in a vacuum, so the refractive index of air is 1.00 (to 2 d.p.).

Refractive Index (Index of Refraction)

- Light travels at different speeds depending on the refractive index of the material.
- Every material (medium) has a different refractive index
  - ✓ The higher the refractive index (n), the slower light travels (v)
  - ✓ The lower the refractive index (n), the faster light travels (v)
- In general, the denser the material the higher the refractive index

Refractive Index (Index of Refraction)

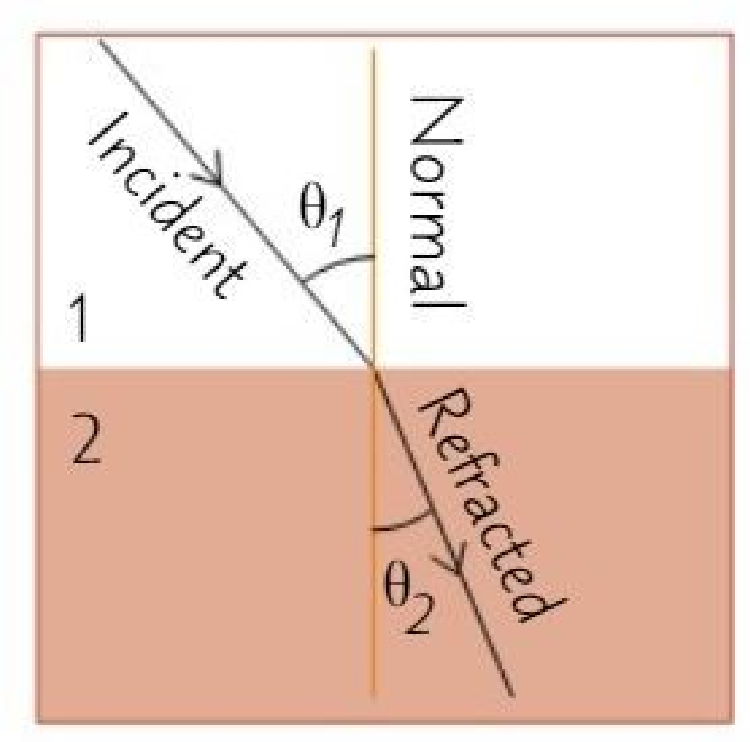
In optics, the **refractive index** (also known as index of refraction, n) of a material is a *dimensionless* number that describes how fast light travels through the material.

Material	n
vacuum	1
air	1.000293 ≈ 1.00
water	1.33
glass	1.52

Snell's law

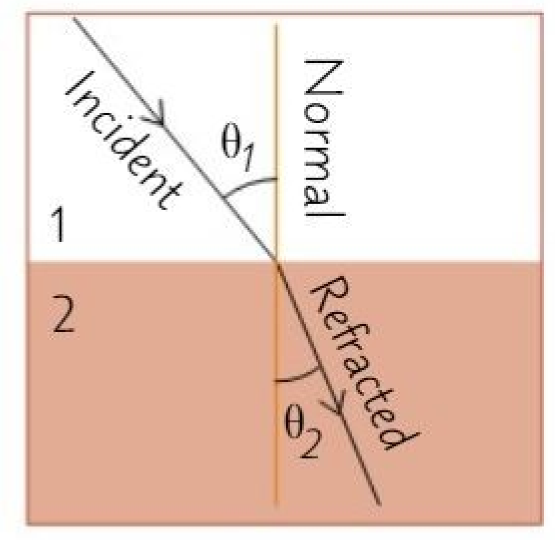
$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

Where
n_1 is the refractive index in medium 1;
n_2 is the refractive index in medium 2;
θ_1 is the angle of incidence;
θ_2 is the angle of refraction.



Snell's law

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



Where
n_1 is the refractive index in medium 1;
n_2 is the refractive index in medium 2;
θ_1 is the angle of incidence;
θ_2 is the angle of refraction.

In the case if medium 1 is air, and it is known that the refractive index of air is 1; the formula above could be arranged as :

$$1 \times \sin\theta_1 = n_2 \sin\theta_2$$

Now θ_1 is the angle of incidence (i) , θ_2 is the angle of refraction (r), n_2 can be simply written as n. Thus, the formula can be simplified as $\boldsymbol{n = \frac{\sin i}{\sin r}}$

The critical angle & Total internal reflection

- Consider light rays going **from a medium of higher to lower refractive index (*density from high to low*)**
- Light bends away from the normal
- As the **angle of incidence (i) increases**, angle of refraction (r) **increases** as well
- If the angle of refraction (r) is larger than 90°, the entire light is reflected back into the medium (***total internal reflection***)
- The critical angle is this limit – It is the angle of incidence that causes **an angle of refraction of 90°**
- When **the angle of incidence (i) is larger than the critical angle (C)**, then we get **total internal reflection**

The critical angle & Total internal reflection

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

From glass to air:

$$n_{glass} \sin i = 1 \times \sin r$$

Since refractive angle = 90° when total internal reflection happens

$$n_{glass} \sin i = 1 \times \sin 90°$$

$$\sin i = \frac{1}{n_{glass}}$$

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

Therefore, $\boldsymbol{n = \frac{1}{\sin C}}$ *where* ***C is the critical angle.***

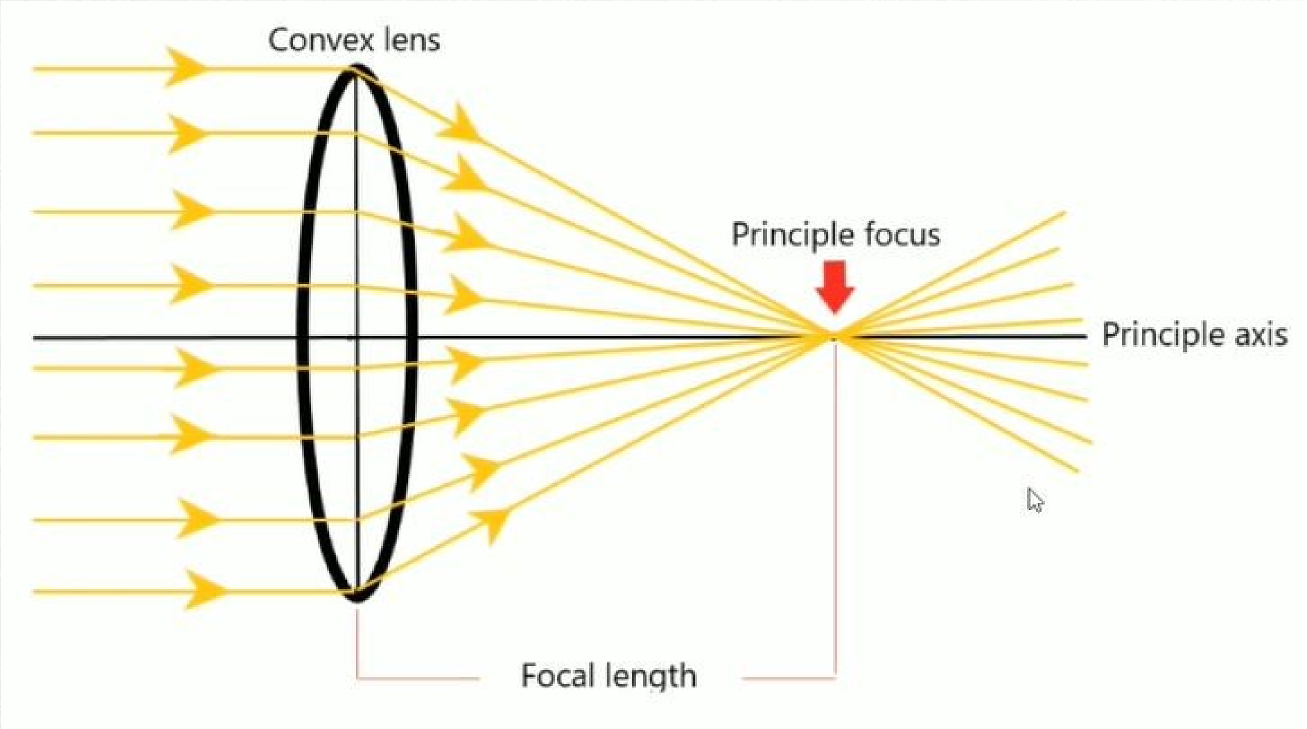
The critical angle & Total internal reflection

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

where i is the angle of incidence ***in air****, when total internal reflection happens, the angle of refraction = 90°*

Therefore, $n = \frac{\sin 90^\circ}{\sin C}$ *which gives* $\boldsymbol{n = \frac{1}{\sin C}}$ *where* ***C is the critical angle****.*

Thin Converging Lenses

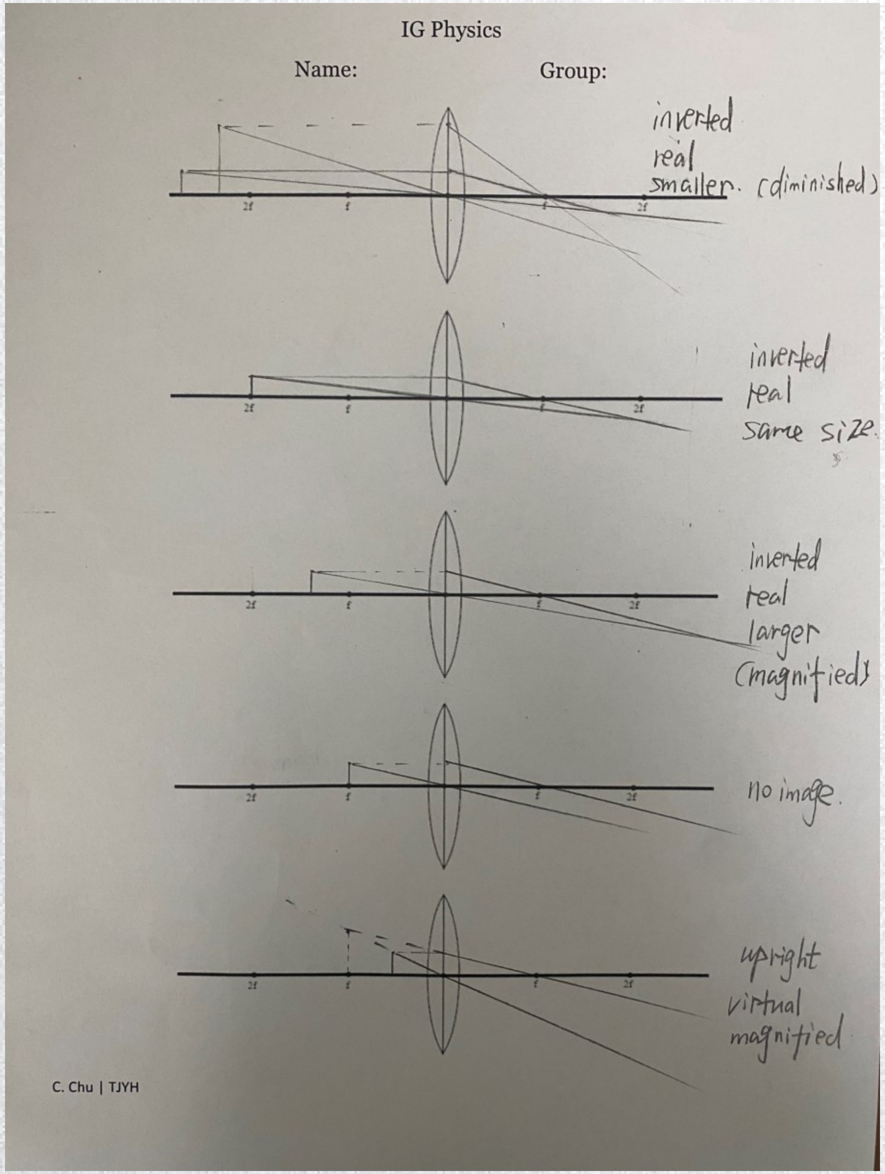


- Light coming from **a very distance** object are considered **parallel rays**
- When parallel rays pass a **convex (converging)** lens, light rays are focused at a single point called the **principle focus** (or **focal point**).
- The **imaginary horizontal line** at right angles to the lens is the **principle axis.**
- The distance from **the lens center to the principle focus** is the **focal length**

Ray tracing: between F & the lens

Position	Description of images
beyond 2F	real, inverted, and diminished (smaller)
at 2F	real, inverted, and same size
between 2F and F	real, inverted, and magnified (larger)
at F	no image
between F and the lens	virtual, upright, beyond 2F, larger

Ray diagrams

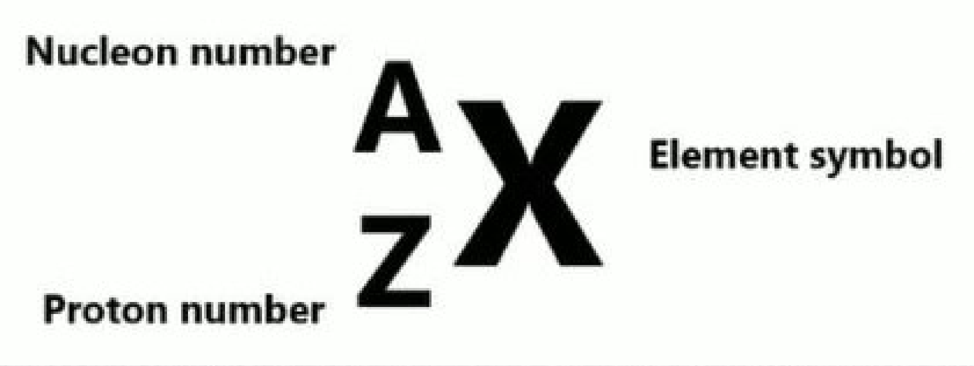


Atomic Physics

Nuclide

- For any given atom:
  - ✓ **Proton number (Z)** is the number of protons in the nucleus
  - ✓ **Nucleon number (A)** is the sum of protons and neutrons

- The nuclide of an atom represents these values in the form of :



Nuclide

The nucleus of an atom of element X is written as

$${}^{A}_{Z}\mathrm{X}$$

where Z is the proton number and A is the nucleon number.

$$\begin{aligned}\text{proton number} + \text{neutron number} \\ = \text{nucleon number}\end{aligned}$$

$$Z + N = A$$

Radioactive decay equations

Here is an example of an equation for **beta decay**:

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e + \text{energy}$$

This is the decay that is used in **radiocarbon dating**.

A carbon-14 nucleus decays to become a nitrogen-14 nucleus. If we could see inside the nucleus, we would see that **a single neutron has decayed to become a proton**.

$$^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e$$

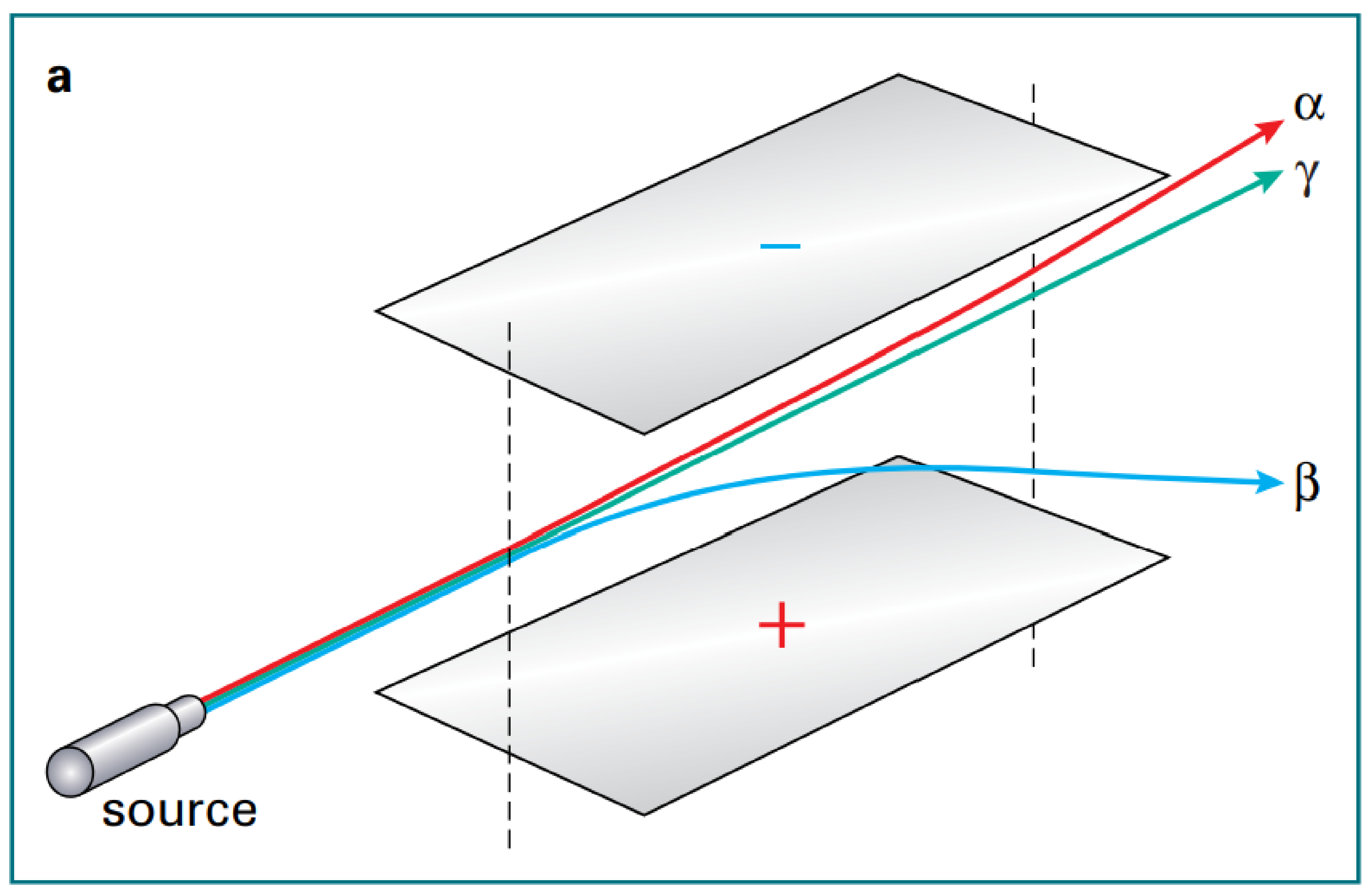
Deflecting radiation

Alpha and beta particles are deflected in opposite directions when they pass through an **electric field**, because they have opposite charges.

Alpha particles are attracted towards a negatively charged plate, while **beta particles** are attracted towards a positively charged plate.

Gamma rays are not deflected because they are uncharged.

Deflecting radiation



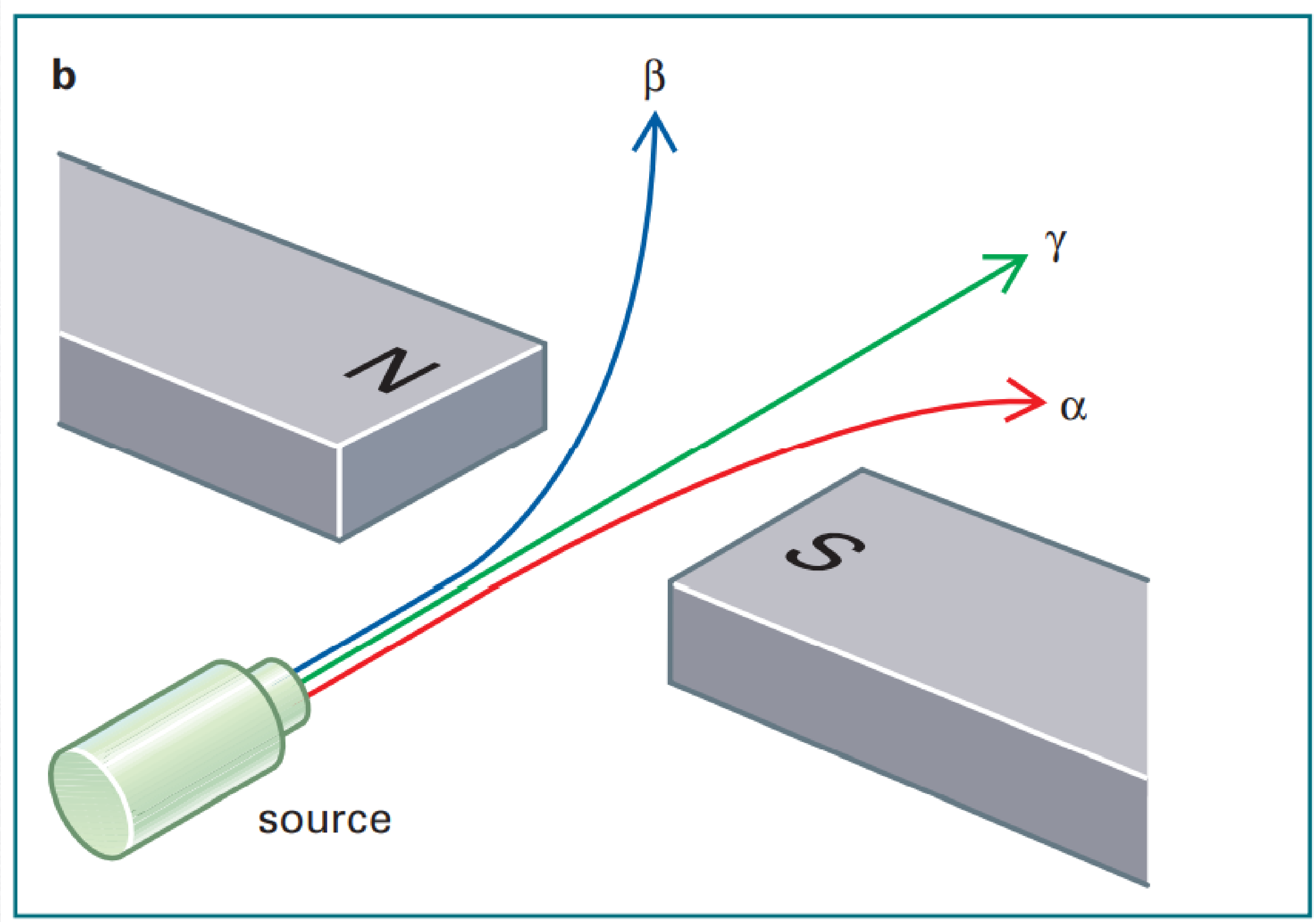
Alpha and beta radiations are deflected in opposite directions: a) in an electric field

Deflecting radiation

Alpha and beta particles are charged, so, when they move, they constitute an electric current. Because of their opposite signs, the forces on them in a **magnetic field** are in opposite directions.

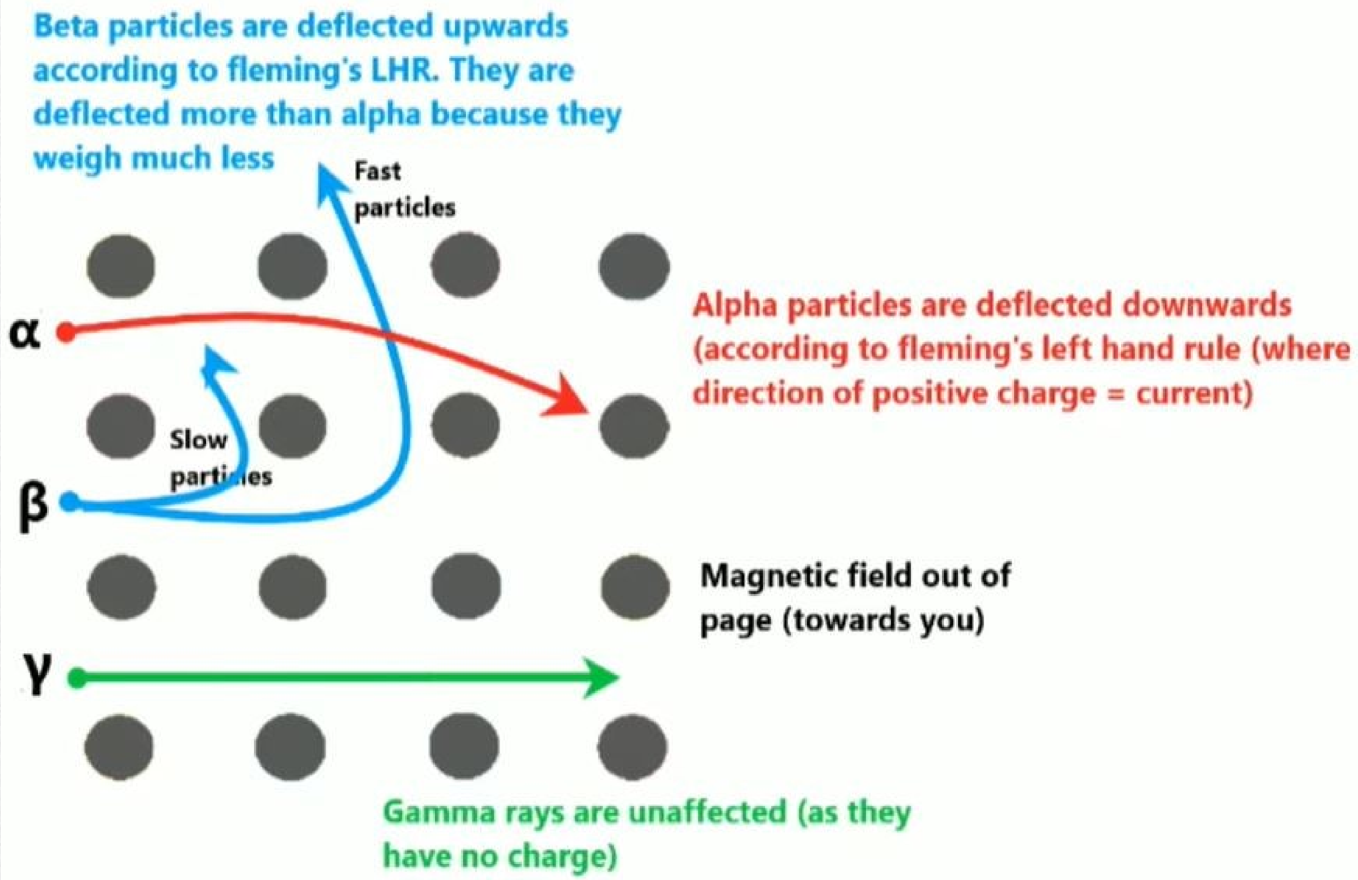
The direction in which the particles are deflected can be predicted using **Fleming's left-hand rule**. As in an electric field, gamma rays are not deflected because they are uncharged.

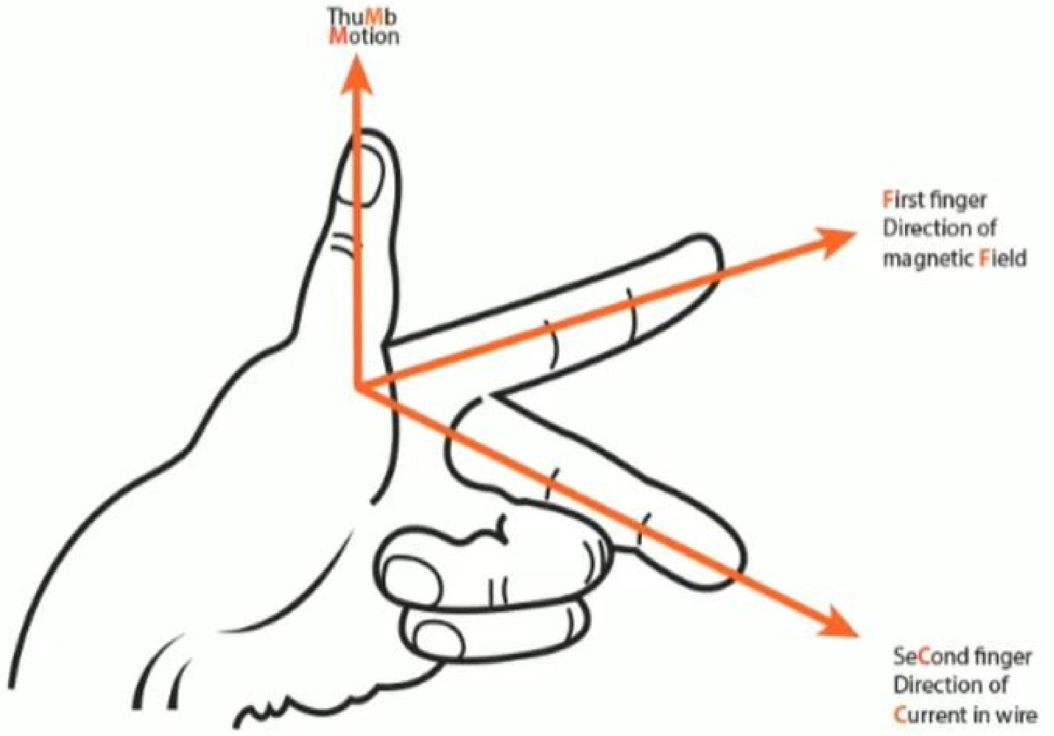
Deflecting radiation



Alpha and beta radiations are deflected in opposite directions: b) in a magnetic field.

Effect of magnetic fields





Half-life

Half-life:

The time taken for half of the radioactive atoms now present to decay.

The time taken for the activity (or count rate) to fall by half.

- A short half-life means the activity falls quickly, because lots of the nuclei decay quickly.
- A long half-life means the activity falls more slowly because most of the nuclei don't decay for a long time.
- **For any particular isotope, the half-life is always the same.**

Half-life

- Usually, we cannot measure the numbers of atoms in a sample. Instead, we measure the **counter rate** (the amount of radioactivity) using a Geiger counter or some other detector.

- We might also determine **the activity of a sample:**
  - ✓ **Activity**: the rate at which **nuclei decay** in a sample of a radioactive substance.
  - ✓ The unit of activity is **Becquerel (Bq)**.
  - ✓ **1 Bq = 1 decay per second.** This is the number of atoms that decay each second. As number of unstable nuclei decreases, the number of emitted particles become reduced, too.

The **count rate** and **activity** both decrease following the same pattern as the number of undecayed atoms.

THANK YOU