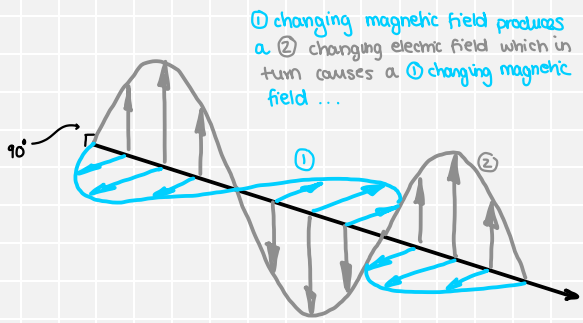
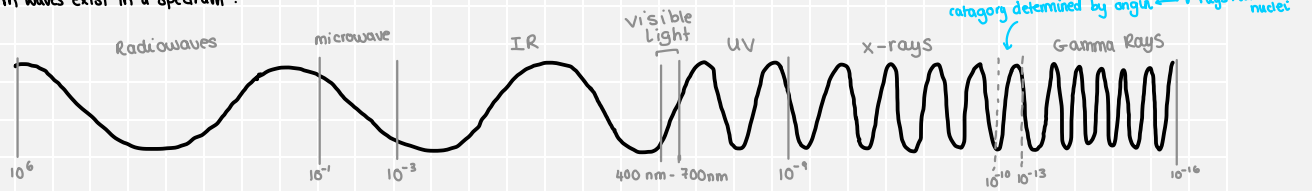
ELECTROMAGNETIC WAVES

What is an Electromagnetic Wave?



- 1865 - James Clerk Maxwell publishes 'a dynamic theory of the electromagnetic field'.
  - ↳ presented equations linking oscillating electric and magnetic fields
  - ↳ predicted existance of electromagnetic waves
  - ↳ behaviour of such waves (see diagram) led to a self-sustaining wave that could travel in a vacuum.
  - ↳ The EM wave was transverse with the electric and magnetic components oscillating in phase at 90° to each other.

EM waves exist in a spectrum :



x-rays : e⁻ transitions
γ-rays : unstable nuclei
catagory determined by origin

NB: See collins TB for details on uses / origins! [pages 24-25]

Maxwell's Prediction

His theory led to the following equation for the speed of EM waves (in a vacuum) :

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

- c : speed of EM waves
- ε_0 : permittivity of free space, $8.85 \times 10^{-12}\ Fm^{-1}$
  - ↳ relates Electric field strength to Q that creates it
- μ_0 : permeability of free space, $4\pi \times 10^{-7}\ Hm^{-1}$
  - ↳ relates B to the I that creates it

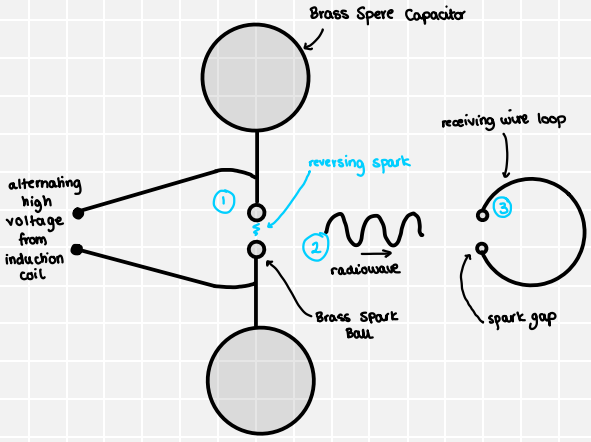
Maxwell predicted this BEFORE there was any experimental evidence

This equation leads to a predicted value for the speed of EM waves as $3.00 \times 10^{8}\ ms^{-1}$

↳ very close to Fizeau's speed of light measurement

As a result of this, Maxwell suggested that light was in fact an electromagnetic wave.

Hertz and EM waves (1885 - 1889)



Hertz set out to test Maxwell's theory of electromagnetism

① Hertz discovered that em waves (radiowave) can be produced by a spark (due to electrical discharge)
  - ↳ created by high voltage - direction keeps changing

② This reversing spark produced radiowaves of frequency f
  - ↳ f depended on size of inductance / capacitance

③ Radiowaves were detected by 2 tiny brass spheres seperated by a small gap.
  - ↳ as radiowaves pass through gap, emf is induced
  - ↳ results in current in wire loop ← creates a detector!

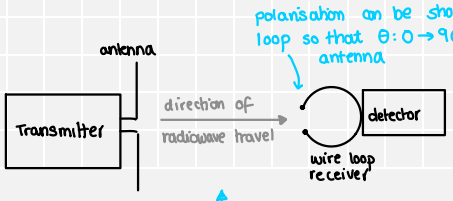
accidental discovery of photo-electric effect!

Later experiments by Hertz showed that these radiowaves (em waves) could be:

- reflected / focused by a concave reflector
- pass through some insulators
- create stationary waves (used to determine λ)
- Polarised

Hertz then confirmed c using: $c = f\lambda$

$c = 299\ 792\ 458\ ms^{-1}$



Polarisation can be shown by rotating loop so that $\theta: 0 \rightarrow 90°$ from plane of antenna

$\theta = 0°$: full strength signal

$\theta = 90°$: no signal