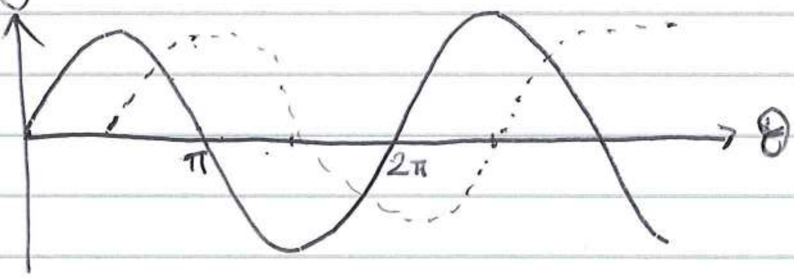
Waves

OSCILLATIONS

- Movement of particles in a wave back and forth (repeated motion)
- T (time period, s) - time taken for one full oscillation
- Amplitude (m) - maximum displacement
- Displacement (m) - distance of a particle from the equilibrium position.

All waves have a 'phase', dependent on the time at which the oscillations began ⇒ meaningless!

However, we can compare the point in a wave cycle with another wave ⇒ phase difference.



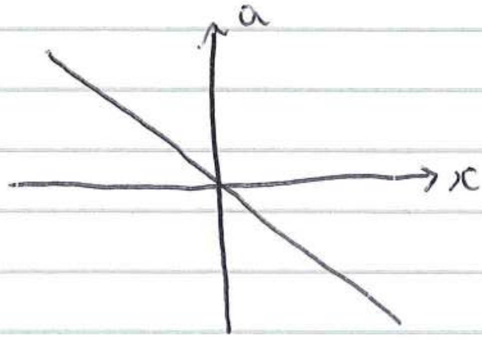
The dashed wave is one quarter λ ahead. ∴ this makes it $2\pi/4 = \pi/2$ radians ahead.

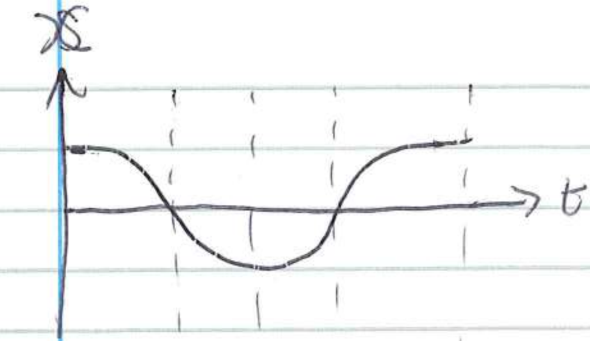
Simple Harmonic Motion

- Definition: the acceleration of a particle is proportional to the displacement and in the opposite direction.

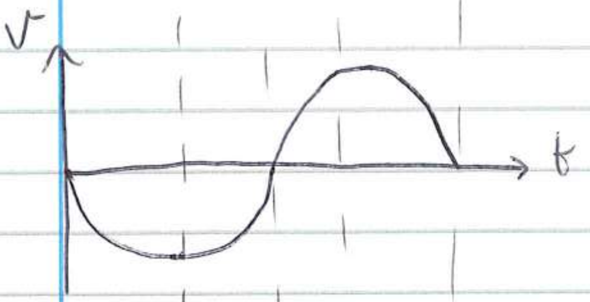
$a \propto -x$ ← displacement (m)

↑ acceleration (ms^{-2})

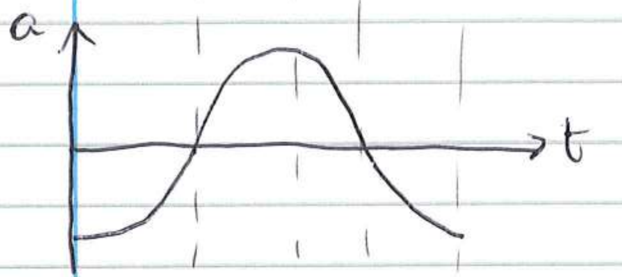




- displacement - time usually starts at the amplitude at time = 0



- velocity - time is the gradient of displacement - time



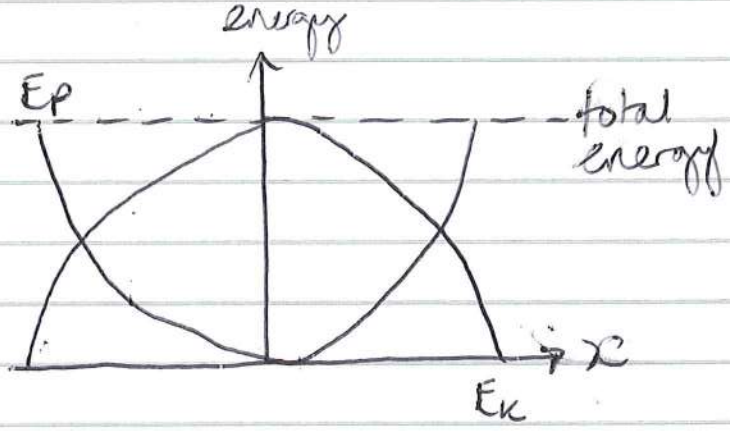
- acceleration - time is the opposite in direction to displacement time

$$T \propto \frac{1}{f}$$

$$T = \frac{1}{f}$$

(f:) Number of waves passing a point (or produced) per second!

Energy in SHM



TRAVELLING WAVES

- λ (wavelength, m) - distance between two equivalent points on adjacent waves
- wave speed ($m s^{-1}$): $v = \frac{\text{distance}}{\text{time}} = \frac{\lambda}{T} = f\lambda$

  e.g. 3×10^8 m/s for EM waves

  ~ 300 m/s for sound waves in air

- Transverse: oscillations of medium/particles are perpendicular to wave propagation (EM spectrum)
- Longitudinal: oscillations parallel to propagation (sound)

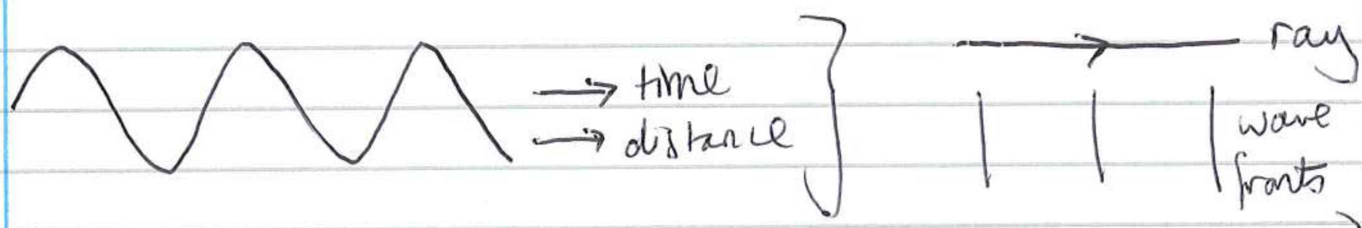
Radio
Microwaves
Infrared
Visible
Ultraviolet
X-ray
Gamma rays

↓ increasing frequency

↑ increasing wavelength

☐ Learn methods for finding speed of sound
☐ Learn the exact details of EM spectrum.

WAVE CHARACTERISTICS



- Intensity - power transferred per unit area (W/m^2)

→ intensity $\propto$ amplitude^2 $\quad \frac{I_1}{A_1^2} = \frac{I_2}{A_2^2}$

→ intensity follows an inverse square law, $I \propto \frac{1}{x^2}$ ← distance the wave has moved from source

→ can be reduced by polarisation (filter in a vector plane, only lets components through in certain orientation)

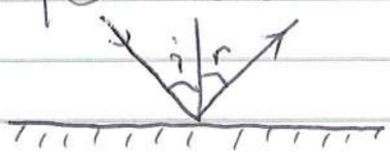
$$I = I_0 \cos^2 \theta$$

- polarizing filter
- reflection on a surface

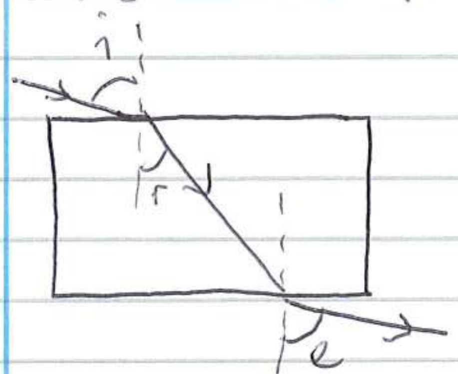
- Superposition - the displacements of waves meeting at a point sum as vectors.
  - → constructive (e.g. crest meets crest)
  - → destructive (e.g. crest meets a trough)
  - → consequence of interference (phenomenon of waves combining)

WAVE BEHAVIOUR

- Reflection - angle of incidence = angle of reflection



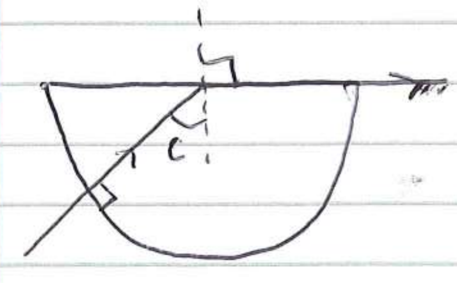
- Refraction - change in direction of a wave caused by a change of speed when crossing a boundary between two media.



$$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$$

→ $n_{vacuum} = n_{air} = 1$

→ n_{glass} between 1 and 2.5

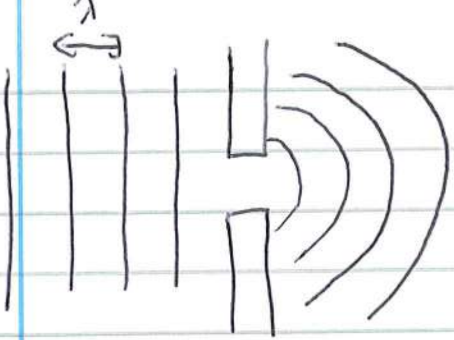


Critical angle gives angle of refraction of 90° for light <u>from</u> more dense <u>to</u> less dense material.

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

☐ Learn a method of investigation!

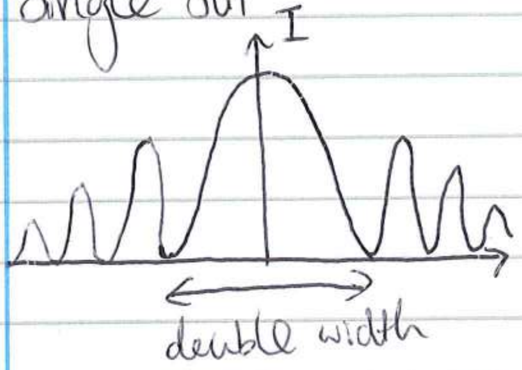
- Diffraction - spreading out of a wave when passing through a gap in a boundary.



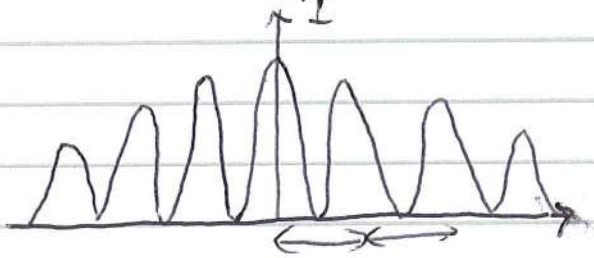
Diffraction is optimised if wavelength ≈ gap size.

NB: Since visible light $\lambda \approx 10^{-7}$ m, reducing the gap optimises diffraction spread.

Single slit



Double slit



⇒ distance between peaks

"fringe spacing" ← $S = \frac{\lambda D}{d}$

S (m); d = distance between slits (m); D = distance from slits to screen (m)

Bright fringes
→ constructive interference
→ path difference = $n\lambda$ (n ← integer)

Dark fringes
→ destructive interference
→ path difference = $\left(n + \frac{1}{2}\right)\lambda$

STANDING WAVES