SUPERPOSITION

Principle of Superposition: When two or more waves of the same type meet at a point, the resultant displacement is the algebraic sum of the individual displacements.

Interference and Coherence

Interference: Interference occurs when waves overlap and their resultant displacement is the sum of the displacement of each wave. This result is based on the principle of superposition and the resultant waves may be smaller or larger than either of the two individual waves.

- **Interference of two waves can either be:**

Constructive interference: The peaks and troughs line up on both waves. And the resultant wave has double the amplitude. This occurs when the wave are in **phase.**

Destructive interference: The peaks on one wave line up with the troughs of the other. And the resultant wave has no amplitude. This occurs when the wave are in **anti-phase**.

- **Conditions for Two-Source Interference:**
  - o Meet at a point
  - o Must be of the same type
  - o Must have the same plane of polarization

- **Demonstrating Two-Source Interference:**

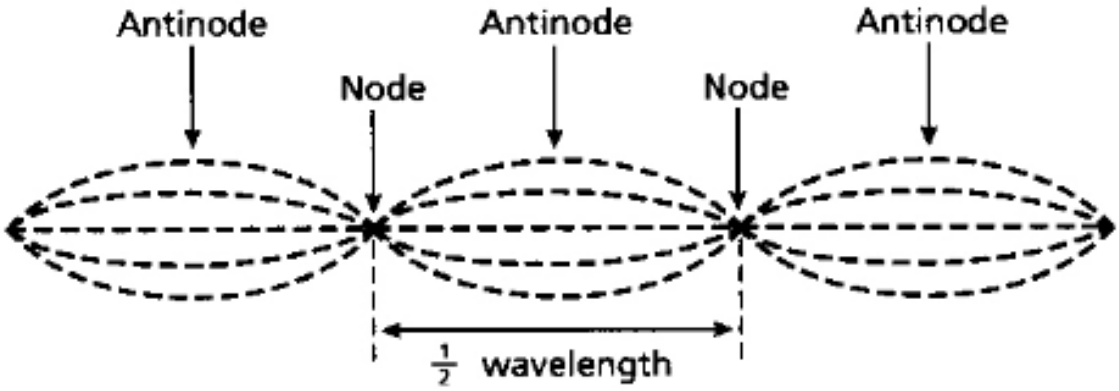
Water	Ripple generators in a tank
Light	Double slit interference
Microwaves	Two microwave emitters

Coherent: Waves are coherent if they have the same frequency and constant phase difference.

Stationary Waves

Stationary waves (Standing waves): Stationary are produced by the superposition of two waves of the same frequency and amplitude travelling in opposite directions. This is usually achieved by a travelling wave and its reflection.

- A stationary wave is made up of **nodes** and **antinodes**
  - **Nodes** are where there is no vibration
  - **Antinodes** are where the vibrations are at their maximum amplitude



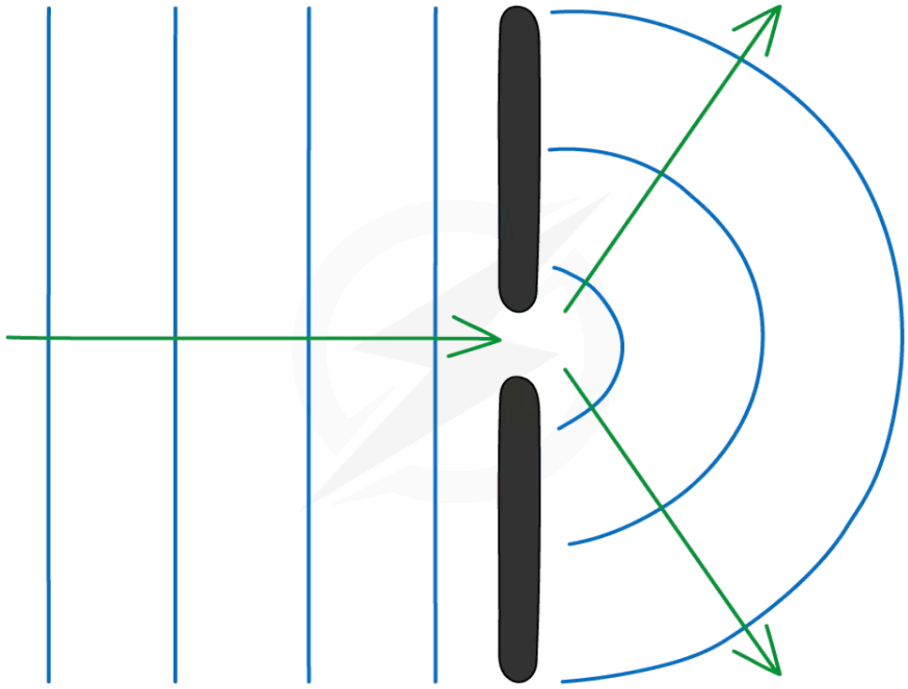
  - Neighbouring nodes & antinodes are separated by $\frac{1}{2}\lambda$.
  - Between 2 adjacent nodes, particles move in phase and they are out of phase with the next two nodes by π.

Stationary and Progressive Waves:

Stationary Waves	Progressive Waves
• Stores energy • Have nodes & antinodes Amplitude • Increases from node to antinode • Phase change of π at node	• Transmits energy • No nodes & antinodes • Amplitude constant along length of the wave • No phase change

Diffraction

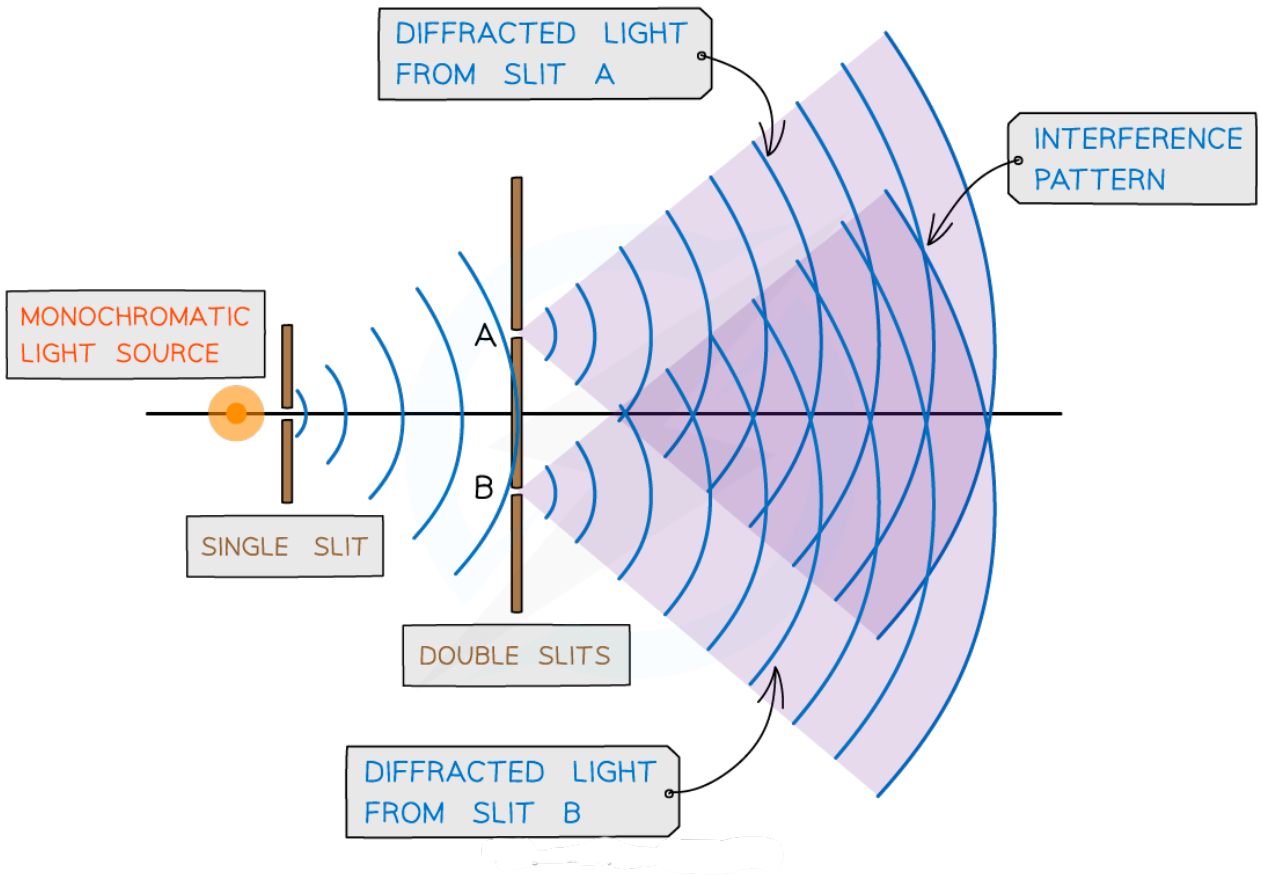
Diffraction: Diffraction is the spreading out of waves when they pass an obstruction. This obstruction is typically a narrow slit (an aperture).The extent of diffraction depends on the width of the gap compared with the wavelength of the waves



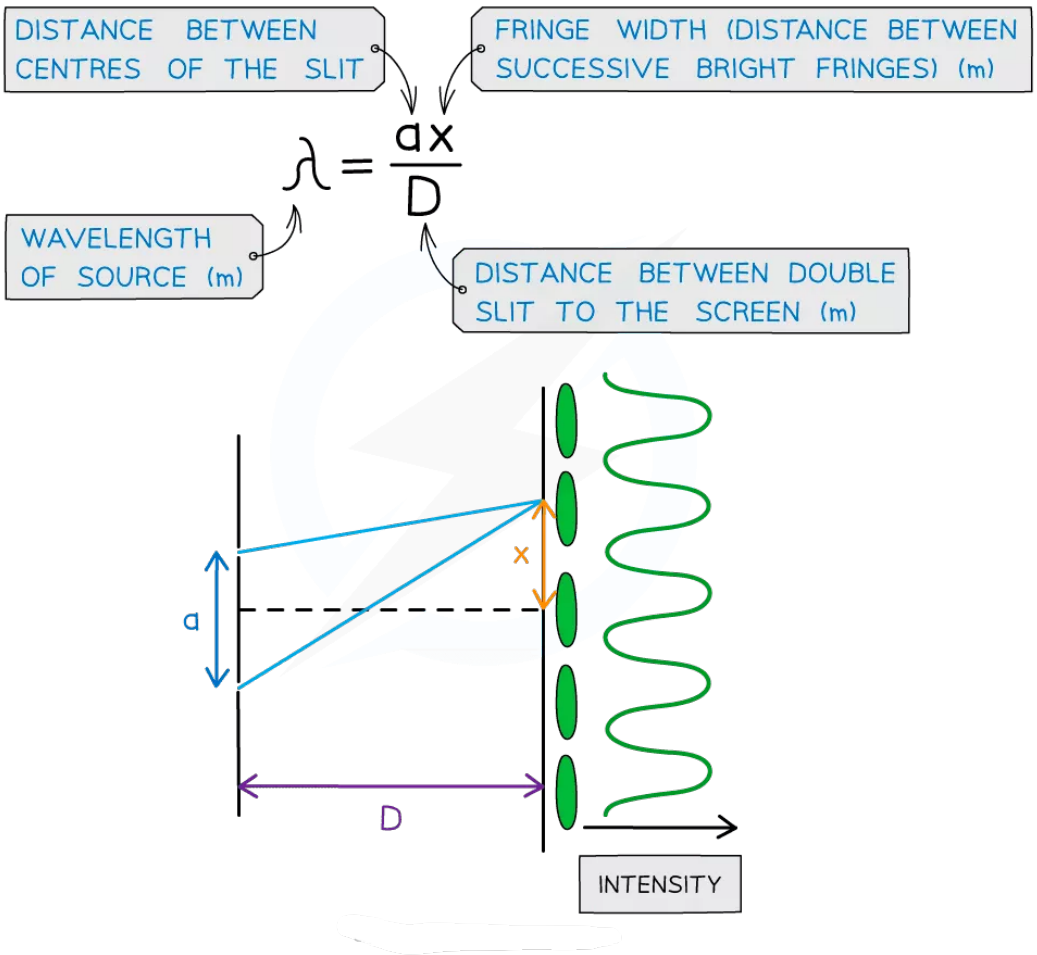
Diffraction: when a wave passes through a narrow gap, it spreads out

Double-Slite Interference

- Young's double slit experiment demonstrates how light waves produced an interference pattern. The experiment is shown below:



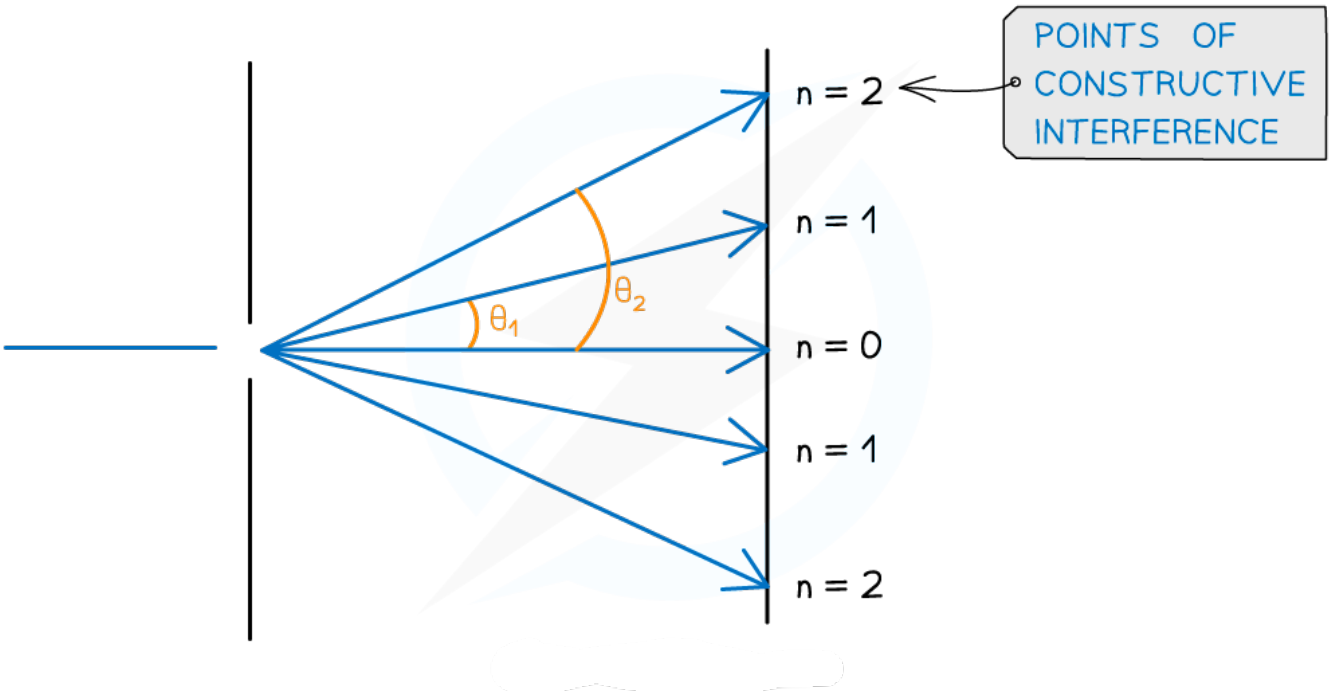
- When a monochromatic light source is placed behind a single slit, the light is diffracted producing two light sources at the double slits A and B
- Since both light sources originate from the same primary source, they are **coherent** and will therefore create an observable interference pattern
- Both diffracted light from the double slits create an interference pattern made up of bright and dark fringes
- The wavelength of the light can be calculated from the interference pattern and experiment set up. These are related using the double-slit equation



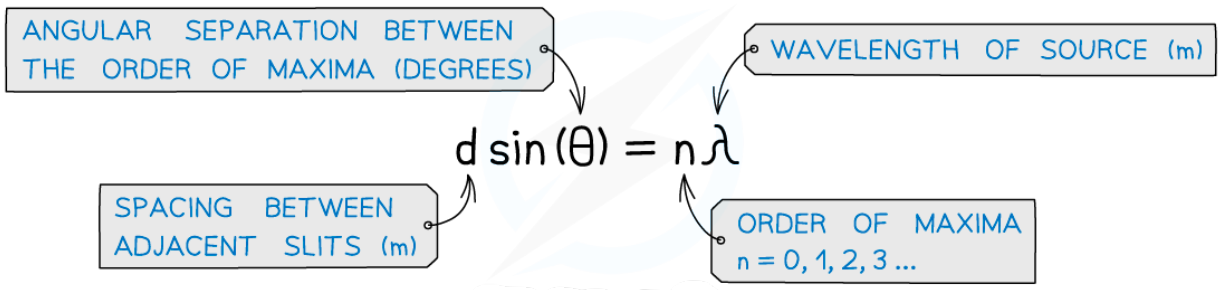
- The interference pattern on a screen will show as 'fringes' which are dark or bright bands
- **Constructive** interference is shown through **bright** fringes with varying intensity (most intense in the middle)
- **Destructive** interference is shown from **dark** fringes where no light is seen.

Diffraction Grating

- A diffraction grating is a plate on which there is a very large number of parallel, identical, close-spaced slits
- When monochromatic light is incident on a grating, a pattern of narrow bright fringes is produced on a screen.



- The angles at which the maxima of intensity (constructive interference) are produced can be deduced by the diffraction grating equation



- The maximum angle to see orders of maxima is when the beam is at right angles to the diffraction grating. This means $\theta = 90^\circ$ and $\sin(\theta) = 1$