revisely

Progressive and Stationary Waves

Progressive waves

- A progressive wave carries energy from one place to another without transferring any material.
  - Transverse - direction of oscillation is perpendicular to direction of energy transfer
  - Longitudinal - oscillation is parallel to energy transfer
- Displacement - how far a point on the wave has moved from the undisturbed position
- Amplitude — maximum magnitude of displacement
- Phase — measurement of the position of a certain point along the wave cycle

$$\text{phase difference in radians} = \frac{2\pi d}{\lambda} \text{ for distance d apart}$$

- **Polarised** waves oscillate in only one direction
  - Polarisation can only happen for **transverse** waves
  - A polarising filter only transmits waves in one plane
- **Superposition** occurs when two or more waves pass through each other - the displacements due to each wave combine.
  - Principle of superposition: "when two or more waves cross, the resultant displacement equals the vector sum of the individual displacements"

Stationary waves

- Stationary wave = "superposition of two progressive waves with the same frequency/ wavelength". Unlike progressive waves no energy is transferred by a stationary wave.
  - Stationary waves vibrating freely do not transfer any energy to their surroundings
- Stationary waves on strings and pipes are similar:
  - f_0: $l = \frac{\lambda}{2}$ $2f_0$: $l = \lambda$ $3f_0$:c $l = \frac{3\lambda}{2}$ where l is a fixed length of string or open pipe.
  - The distance between adjacent nodes is $\frac{\lambda}{2}$
  - A node is a point of zero displacement, an antinode a point of maximum displacement
- The longer/heavier/looser the string, the lower the resonant frequency μ = mass per unit length, T = tension

$$f_0 = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

- When in phase the two progressive waves reinforce each other to create a larger wave
- $\frac{1}{4}$ of a cycle later the waves have moved $\frac{\lambda}{4}$ in opposite directions so are now in antiphase and cancel each other out
- After another $\frac{1}{4}$ of a cycle they are back in phase with the same resultant as before, but reversed.

The points of zero displacement remain in constant positions throughout. Between these points (nodes) the stationary wave oscillates.

- Phase difference:
    - 0 / 2π if two particles are between adjacent nodes or separated by an even number of nodes
    - π if separated by an odd number of nodes

In a stationary wave all particles except those at the nodes vibrate at the same frequency. The amplitude varies from zero at nodes to maximum at antinodes (whereas in a progressive wave it would be the same for all particles).

Phase difference between two particles is $n\lambda$ where n is the number of nodes between the particles - for a progressive wave phase difference = $\frac{2\pi d}{\lambda}$