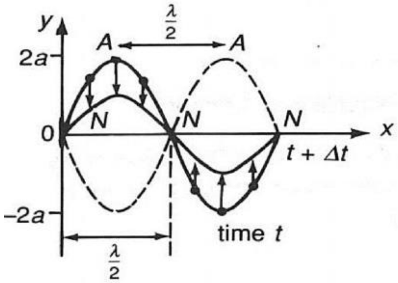
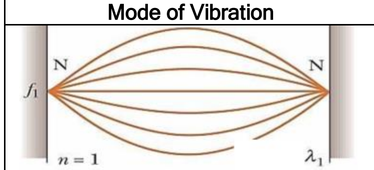
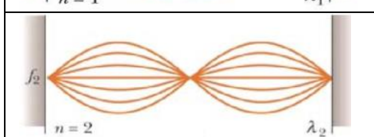
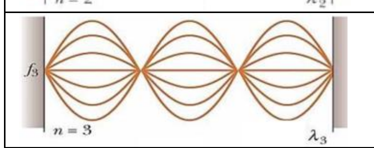
Principle of Superposition: when two or more waves of the same kind overlap, the resultant displacement at any point at any instant is given by the vector sum of the individual displacements at that point at that instant.

Stationary (Standing) Waves: form when two similar waves with the **same speed, frequency and amplitude,** travelling towards each other in opp. directions superimpose.



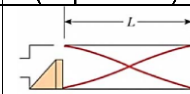
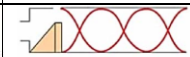
Wave:	Stationary	Progressive
Amplitude	Varies from max. at the anti-nodes 2A to 0 at the nodes.	Same amplitude (A) for all the particles in the wave motion.
Frequency	All particles vibrate with SHM at the frequency of the component waves.	All particles vibrate with SHM at the frequency of the progressive wave.
Wavelength	Twice the distance between a pair of adjacent nodes or antinodes.	Distance between any two consecutive points on the wave vibrating in phase.
Phase	All particles within a loop vibrate in phase. They are in anti-phase with all particles in the adjacent loops.	All particles within one wavelength have different phase.
Wave Profile	The wave profile does not advance.	The wave profile advances with the speed of the wave.
Energy	No translation of energy: Energy is retained within the vibratory motion of the stationary wave.	Energy is transported in the direction of propagation of the wave.

First Standing Wave Experiments (Stretched String with 2 ends fixed)

Mode of Vibration	Wavelength	Frequency	Harmonic	Overtone
	$\lambda_1 = 2L$	$f_1 = \frac{v}{\lambda_1} = \frac{v}{2L}$	1st	-
	$\lambda_2 = L$	$f_2 = \frac{v}{\lambda_2} = \frac{v}{L} = 2(\frac{v}{2L})$	2nd	1st
	$\lambda_3 = \frac{2}{3}L$	$f_3 = \frac{v}{\lambda_3} = \frac{3v}{2L} = 3(\frac{v}{2L})$	3rd	2nd

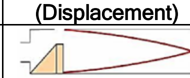
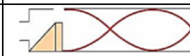
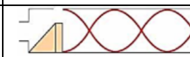
The nth harmonic can be expressed as: $f_n = n(\frac{v}{2L})$
where n = 1, 2, 3, 4, ...

Second Standing Wave Experiments (Air Column - Open Pipe)

Mode of Vibration	Wave profile (Displacement)	Wave-length	Frequency	Har-monic	Over-tone
		$\lambda_1 = 2L$	$f_1 = \frac{v}{\lambda_1} = \frac{v}{2L}$	1st	-
		$\lambda_2 = L$	$f_2 = \frac{v}{\lambda_2} = 2(\frac{v}{2L})$	2nd	1st
		$\lambda_3 = \frac{2}{3}L$	$f_3 = \frac{v}{\lambda_3} = 3(\frac{v}{2L})$	3rd	2nd

The nth harmonic can be expressed as: $f_n = n(\frac{v}{2L})$ where n = 1, 2, 3, 4, ...

Third Standing Wave Experiments (Air Column - Closed Pipe)

Mode of Vibration	Wave profile (Displacement)	Wave-length	Frequency	Har-monic	Over-tone
		$\lambda_1 = 4L$	$f_1 = \frac{v}{\lambda_1} = \frac{v}{4L}$	1st	-
		$\lambda_3 = \frac{4}{3}L$	$f_3 = \frac{v}{\lambda_3} = 3(\frac{v}{4L})$	3rd	1st
		$\lambda_5 = \frac{4}{5}L$	$f_5 = \frac{v}{\lambda_3} = 5(\frac{v}{4L})$	5th	2nd

The nth harmonic can be expressed as: $f_n = n(\frac{v}{4L})$ where n = 1, 3, 5, ...

Interference: superposition of two or more waves to give a resultant wave whose displacement at every point at any time is given by the P of Superposition.

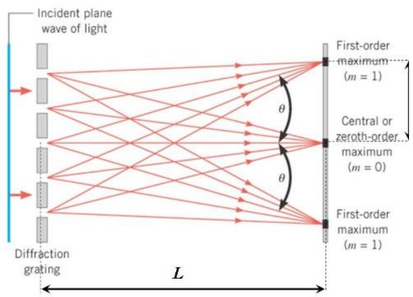
Conditions: same kind of waves and the waves must overlap.

Conditions to Observe Interference Pattern:

1. Coherence
2. Similar amplitude
3. Unpolarised, or polarized (in same plane transverse waves)

Diffraction Grating (N-slits):

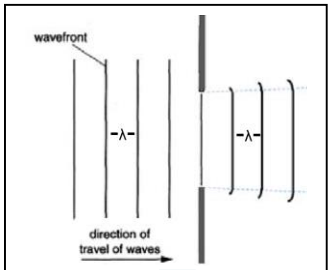
d: grating spacing, n: order of maxima.

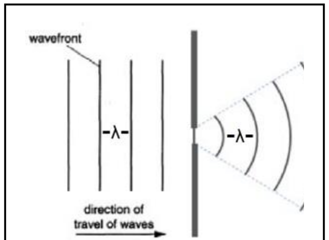


$$d\sin\theta_d = n\lambda$$

Maximum order detectable obtained by putting θ = 90° thus $n_{max} = d/\lambda$

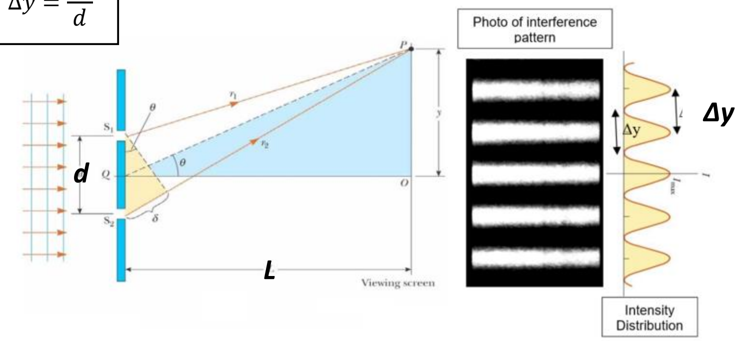
Diffraction: spreading of waves into "geometrical" shadows, after passing through small apertures of the spreading of waves round an obstacle (due to a redistribution of energy)





Young's Double Slit Experiment

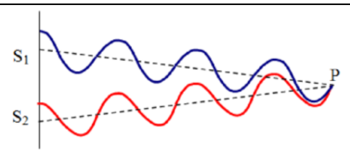
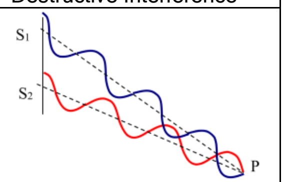
$$\Delta y = \frac{\lambda L}{d}$$



Constructive Interference (CI) occurs where two waves meet in phase. Oscillation at that point has max. resultant amplitude and max. intensity.

Destructive Interference (DI) occurs where two waves meet in anti-phase. Oscillation at that point has min. resultant amplitude and min. intensity.

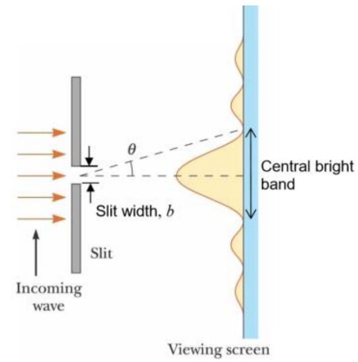
If S_1 and S_2 generate waves of same amplitude in phase.

	Constructive Interference	Destructive Interference
		
Resultant amplitude	2A	Zero (No oscillation)
Intensity	Max.	Min.
Path difference	$S_1P - S_2P = n\lambda$ Integer multiple of λ	$S_1P - S_2P = \frac{(2n+1)\lambda}{2}$ Odd integer multiple of ½ λ
Phase difference	$2n\pi\ rad$	$(2n+1)\pi\ rad$

If S_1 and S_2 operate in anti-phase, then path difference requirements for CI and DI are switched.

Single Slit Diffraction of Light:

light waves of wavelength λ passing through a single slit of width *b* undergoes diffraction.



The first minimum intensity of the single slit diffraction pattern occurs at angle θ from the central maximum where

$$\sin\theta = \frac{\lambda}{b}$$

Rayleigh Criteria: for the resolving power of a single aperture of width b is given by:

$$\theta_{min} \approx \frac{\lambda}{b}$$