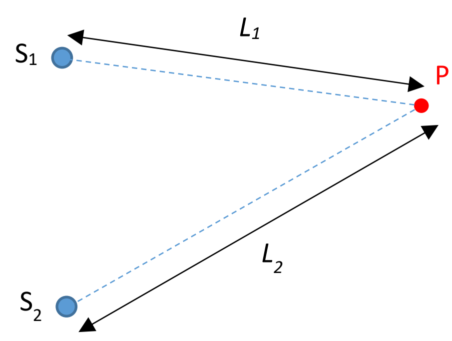
Superposition

Principle of Superposition – when two or more waves of the same nature meet at a point, the resultant displacement is the vector sum of the individual displacements due to each waves.

Interference – two or more waves of the same type superpose to produce a resultant wave.	
Constructive Interference • Two waves **meet in phase**, resultant displacement is greater than individual displacements by each wave	Destructive Interference • Two waves **meet in antiphase**, resultant displacement is minimum.

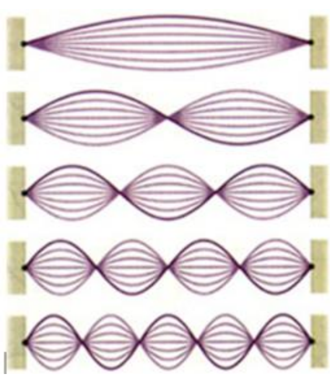
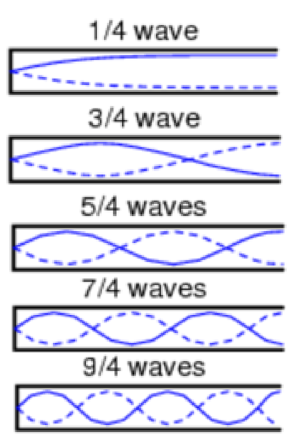
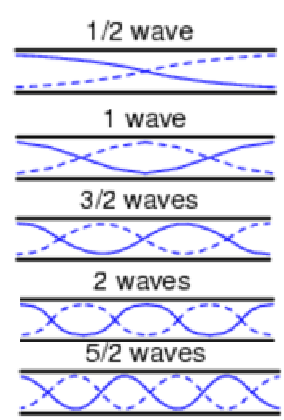
Whether Constructive or Destructive Interference at a point, P?

	1. Determine Path Difference, ΔL $\Delta L = L_2 - L_1$ 2. Determine ΔL as a full integer multiple or half-integer multiple of the wavelength $\Delta L = n\lambda$ or $\Delta L = \frac{(2n+1)}{2}\lambda$ 3. Look for whether sources are in phase or antiphase. (Note: S_1 and S_2 are coherent: constant phase difference)

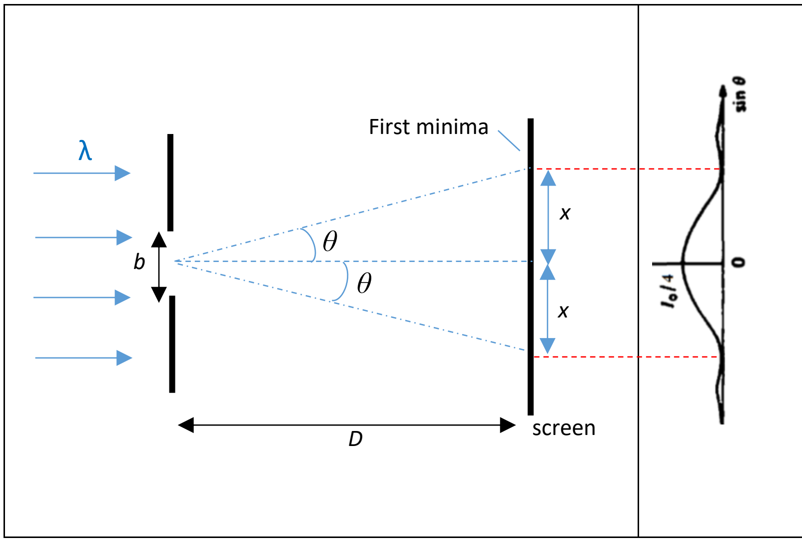
	Sources start in Phase		**Sources start in antiphase**	
Path Difference	n λ	(2n+1)/2 λ	n λ	(2n+1)/2 λ
Will Meet	In Phase	Antiphase	Antiphase	In Phase
Conclusion	Constructive	Destructive	Destructive	Constructive

Stationary Waves

Application of Stationary Waves

String	**Open-Closed Tube**	**Open-Open Tube**
• Closed at both ends, thus • Node at both ends. 	• Antinode at open end • Node at closed end 	• Antinode at both open ends 

Single Source Diffraction



Equation:

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

Also,

$$\tan\theta = \frac{x}{D}$$

Small Angle Approximation,

$\sin\theta \approx \theta$

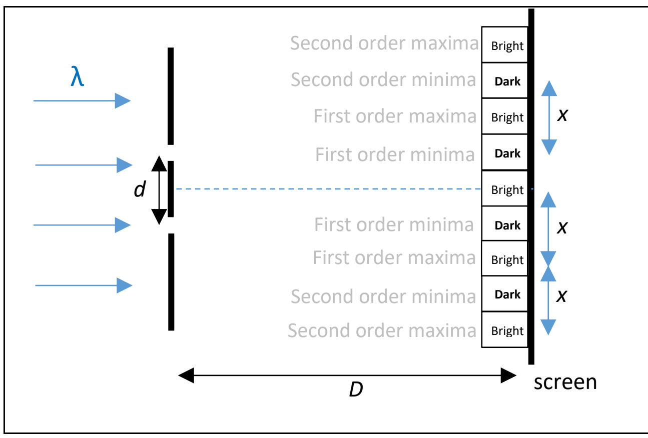
$\tan\theta \approx \theta$, therefore,

$\sin\theta \approx \tan\theta$

$$\frac{\lambda}{b} = \frac{x}{D}$$

(Note: in some reference, *2x* ≈ *x* since *x* is very small)

Young's Double Slit Experiment



Assumption:

- $d << D$ ($\sim 10^3$)
- Infinite numbers of bright and dark fringes which are equally spaced

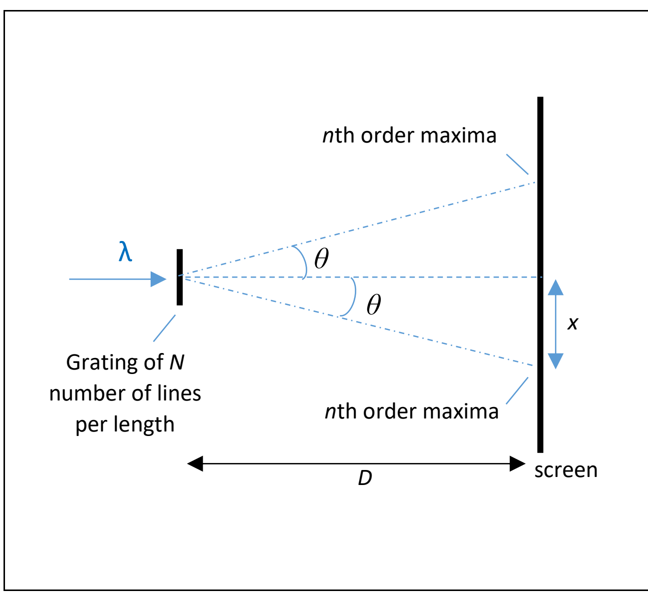
Equation:

$$x = \frac{\lambda D}{d}$$

Small Angle Approximation,
Consider 0^{th} order to 1^{st} order maxima,

$$\tan\theta = \frac{x}{D}$$

Diffraction Grating



Equation:

$$d\sin\theta = n\lambda$$

$$d = \frac{1}{N}$$

Small Angle Approximation,
Consider n^{th} order maxima,

$\sin\theta \approx \tan\theta$

$$\frac{x}{D} = \frac{n\lambda}{d}$$

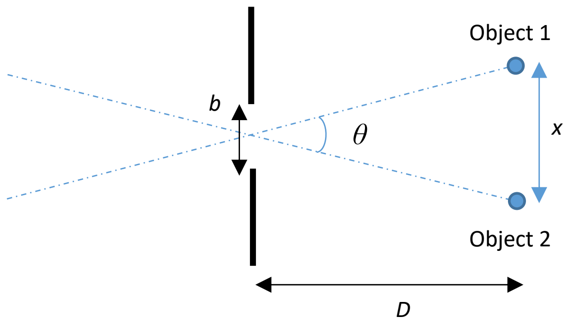
There exist a maximum order of maxima,

$\sin\theta \le 1$

$\frac{n\lambda}{d} \le 1$,

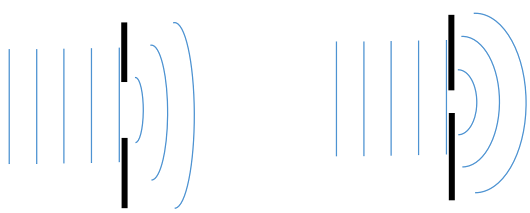
$n \le \frac{d}{\lambda}$, round down to nearest integer.

Rayleigh Criterion

	Equation: $sin\,\theta_{min} = \frac{\lambda}{b}$ Two objects are resolved when $\theta \geq \theta_{min}$. Achievable by • Increasing x • Decreasing D At angle of resolution θ_{min}, 1. As θ_{min} is very small, $sin\,\theta_{min} \approx tan\,\theta_{min}$ $\frac{\lambda}{b} \approx \frac{x}{D}$ 2. As light from each source diffract through aperture, the central maxima of one object falls exactly at the first minima of the other object.

Further Note:

- Each equation above applies to only one wavelength. If there are multiple wavelengths (e.g. magenta) entering each slit / grating / aperture at the same time, treat each wavelength of light separately.
    - In diffraction grating, there might be maximas from different wavelengths of light overlapping
- Example of single slit diffraction
    - Water waves



- Example of Young's Double Slit Experiment
    - Sound Waves: Speakers and microphone that detects loud sounds at pressure antinodes
    - Microwaves (same as light source)