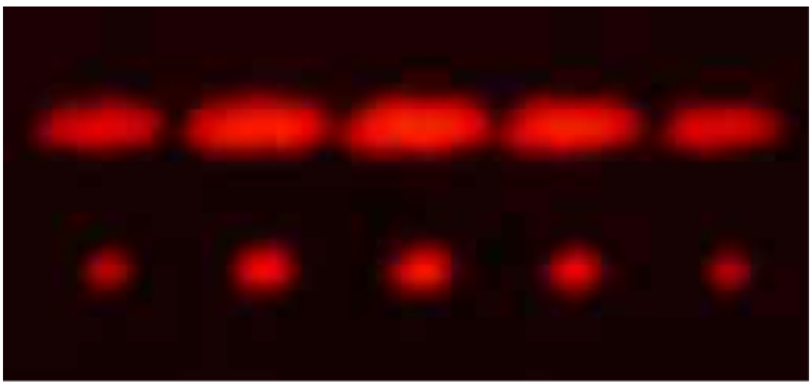
Diffraction of Light

As mentioned before, diffraction can be demonstrated by the bending of a wave around a sharp edge. More specifically: *If a single source causes an* ***interference*** *pattern such that the combining waves originate from a* ***single*** *wavefront.*

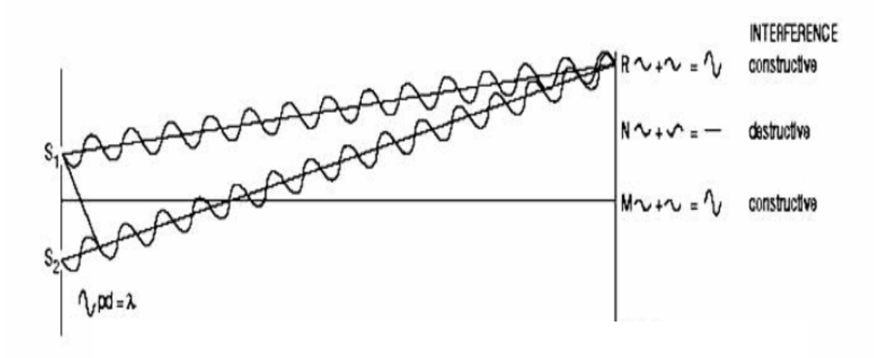
Simulated Water Waves

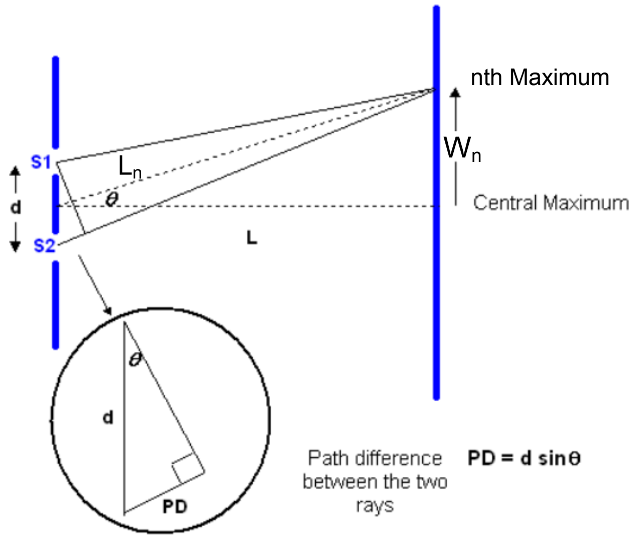
When light enters a single or multiple slit an interference pattern is observed on a screen.



Single Slit

5 Slits





When the path difference, $dsin\theta$, equals an integral wavelength (1λ, 2λ, 3λ,..., $n\lambda$) we observe a bright spot to the right and left of the central spot a distance W_n away.

$$n\lambda = dsin\theta$$

Looking at the diagram: $$sin\theta = \frac{W_n}{L_n}$$

We put this all together to get a relationship between the wavelength λ, slit (grating) separation d, distance from grating L_n, and the distance to the maximum W_n.

$$n\lambda = \frac{dW_n}{L_n}$$

- n is the order number
- W_n is the distance to nth maximum (always from centre bright spot)
- L_n is the distance between the diffraction grating and the nth maximum

For small angles, $\theta \leq 15^o$, $\sin\theta \approx \tan\theta$; and the above equation can be written as:

$$n\lambda = dtan\theta \longrightarrow tan\theta = \frac{W_n}{L}$$

$$n\lambda = \frac{dW_n}{L}$$

Where L is the perpendicular distance between the grating and the screen.

Practice Questions

1. A diffraction pattern is observed as a laser is fired through a grating with a separation of slits equal to 560 μm. The first maximum is 8.5 cm from the centre and the screen is 1.25 m from the grating. What is the wavelength of the laser?

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2. Find the separation between slits if a 625 nm laser creates a 4th maximum 3.5 cm from the centre line. The screen is 1.6 m from the slits.

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3. An unknown diffraction grating is used to observe a diffraction pattern of a 570 nm green laser. The 3rd order maximum occurs at an angle of 35^o. How many slits are there per meter in the grating?

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4. What is the wavelength of light that creates an 8th maximum 45 cm from the central line on a screen that is 87 cm from the diffraction grating if the separation between slits is 12 μm?

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