Diffraction of EM Waves

Dual Nature of Light, Wave AND Particle

- Newton - particle nature of light
- Christian Huygens - wave theory of light
- Thomas Young - wave nature of light due to interference behaviors

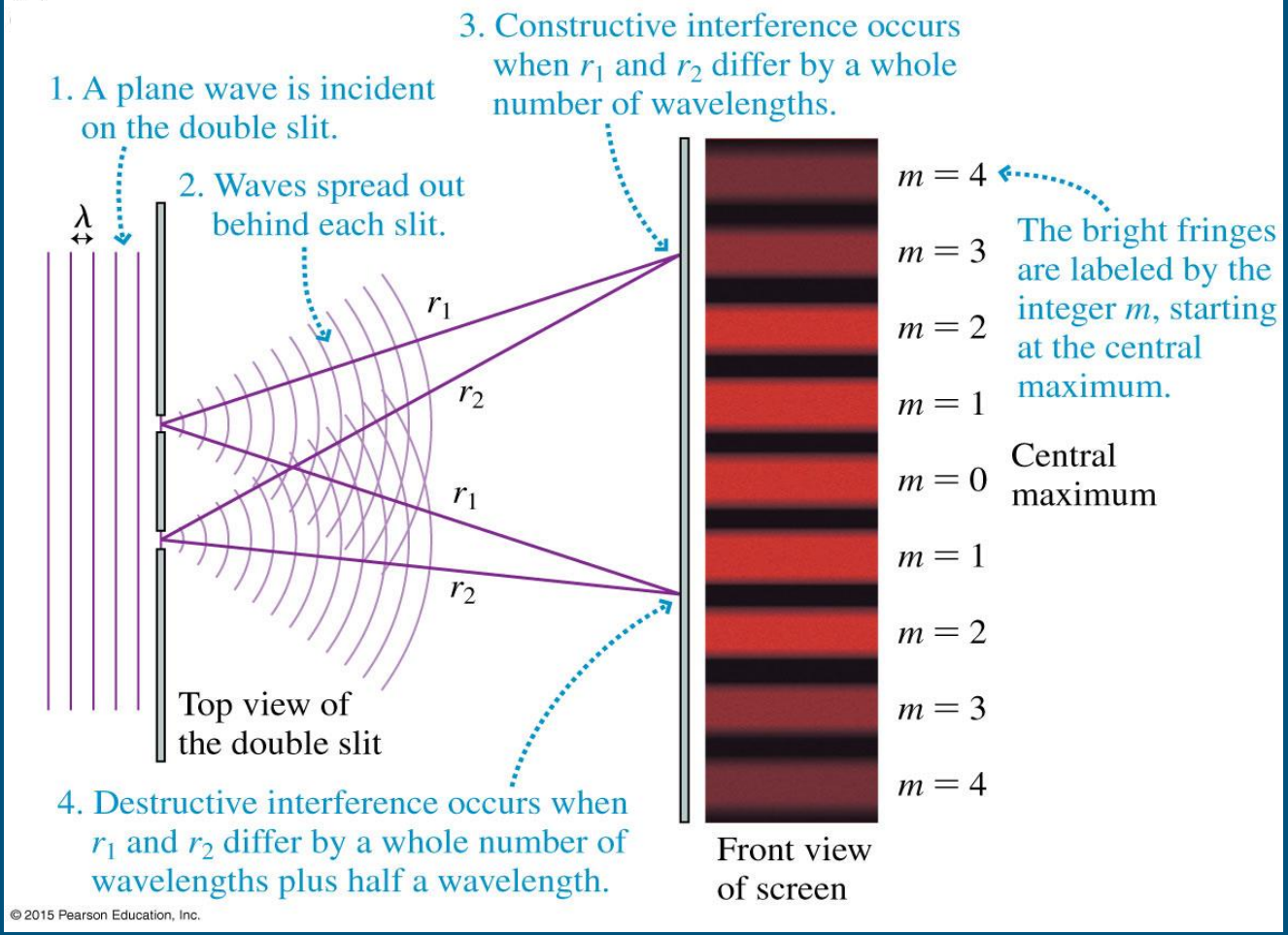
Dual Nature of Light (Continued)

- Hertz - particle nature of light through the photoelectric effect (metal surfaces emit charges when exposed to UV light)
- Einstein - explained photoelectric effect; light is composed of quanta of energy, photons; won the Nobel Prize

Image Source https://www.open.edu/openlearn/science-maths-technology/physics/light-wave-particle-duality

Young's Double-Slit Experiment

- Thomas Young first demonstrated interference of light waves from two sources in 1801.
- Two light sources with the same λ is difficult to arrange; instead, he passed one light source through a double slit.



Young's Double-Slit Experiment (Continued)

- The light from the two slits form a pattern on the screen.
- The pattern is a series of bright and dark parallel bands called **fringes.**
- *Constructive interference* - bright fringe
- *Destructive interference* - dark fringe.

Resulting Equation

d sin Θ = m λ

d → separation distance of slits

Θ → angle between horizontal and spot on screen

m → order number, integer

λ → wavelength of light

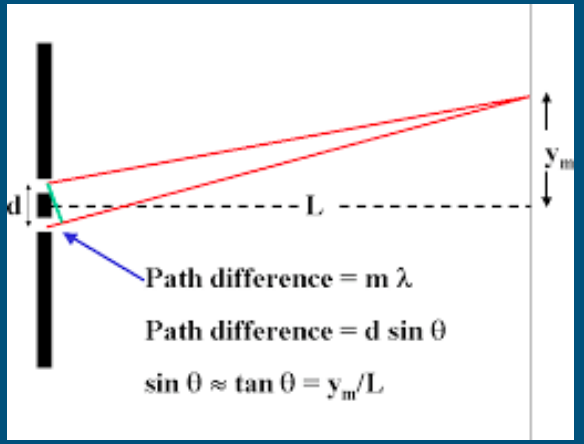


Image Source
http://www1.lasalle.edu/~blum/p106wks/pl106_Diffraction.htm

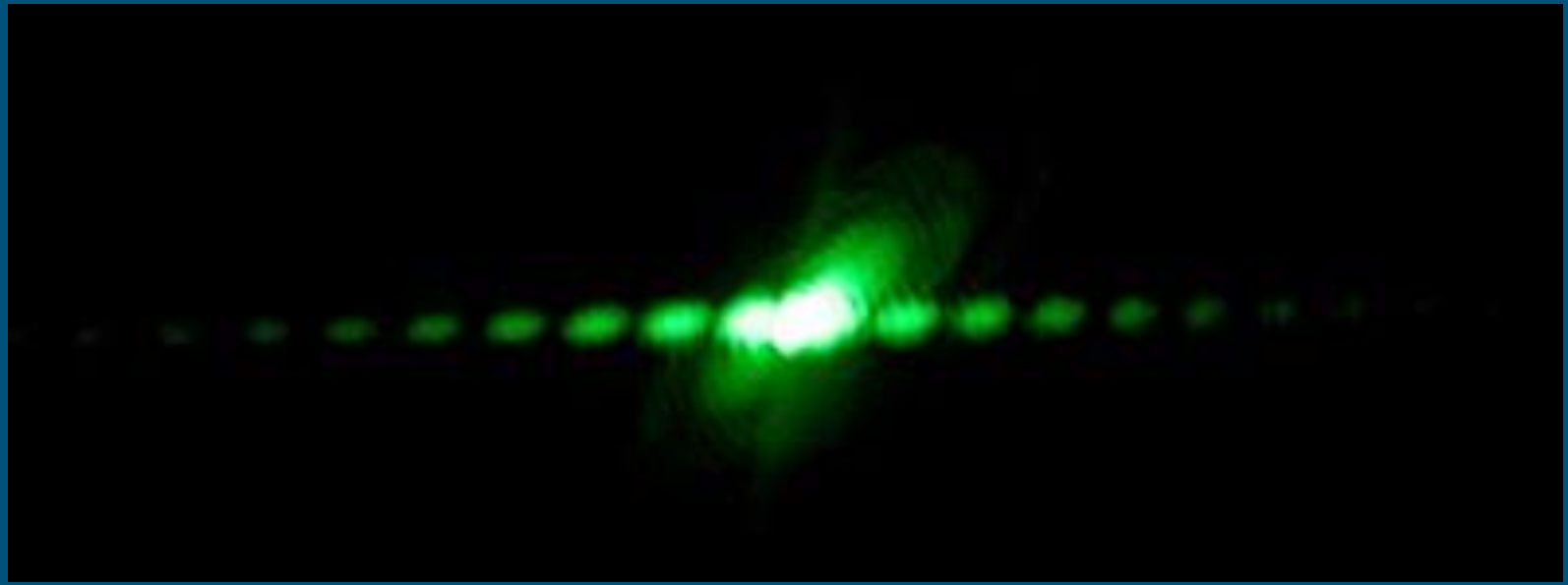
sin Θ = distance between center and spot / distance from slit to screen

Equations (from AP Exam equation sheet)

$$d \sin \theta = m\lambda$$

$$\sin \theta = \frac{y}{L}$$

Image of Interference Pattern



Diffraction Grating

A diffraction grating is a film with many closely spaced slits. Gratings are rated by the number of slits per length (500 lines/mm).

Diffraction gratings are used in spectroscopy to break apart light from a star thus allowing astronomers to identify elements in a star.

Telescope Resolution

Telescopes have a limited resolution power due to the diffraction of electromagnetic waves as it passes through the lens.

Telescopes like ALMA (Atacama Large Millimeter/submillimeter Array) increase their resolution by combining signals from many small telescopes to simulate one large telescope.

Image Source https://public.nrao.edu/telescopes/alma/

Radio Signals and Diffraction

Signals from radio and cell towers diffract when striking the edge of an obstruction. This causes the signal to spread out but the spread out signal is weaker.

5G uses more towers to reduce the possibility of a consumer receiving a weaker signal.

Image Source https://www.electronics-notes.com/articles/antennas-propagation/propagation-overview/radio-em-wave-diffraction.php