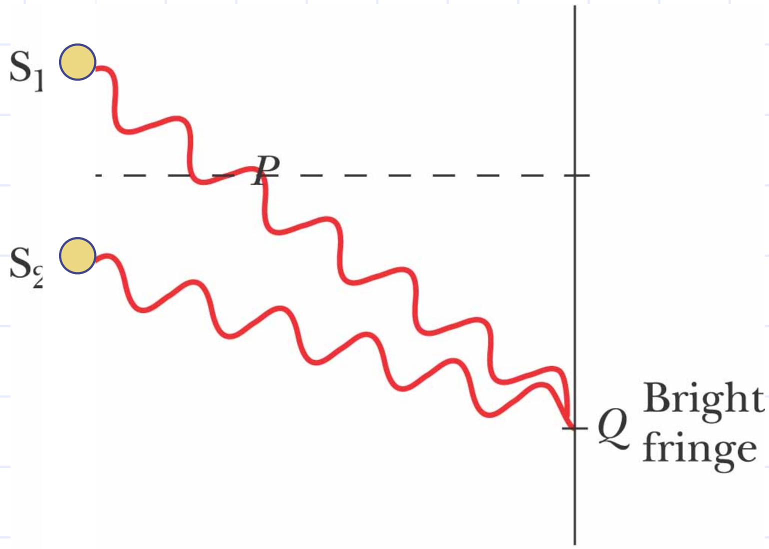
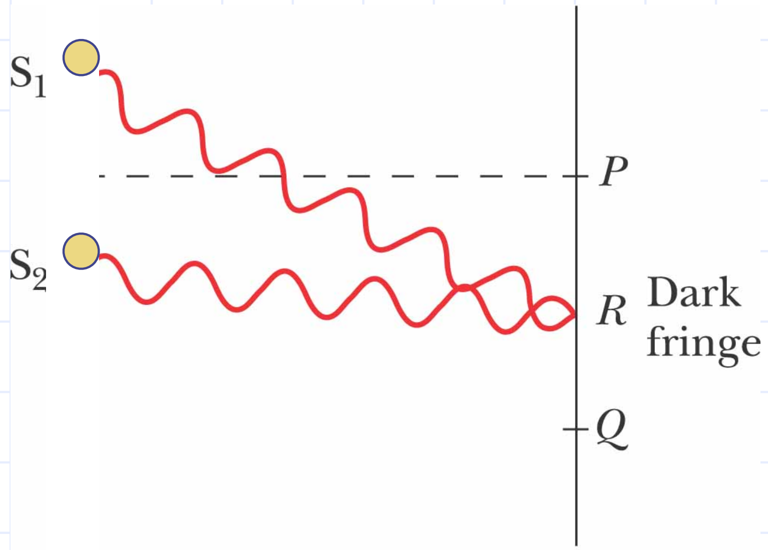
Chapter S3: Interference of Light (Electromagnetic) Waves

- Previously, we studied the superposition of waves and interference
- We applied these concepts to sound waves and standing waves
- Here we will apply, and extend, these concepts to light waves
- \- a field of study known as Physical Optics (or wave optics) where the wave properties of light become more apparent

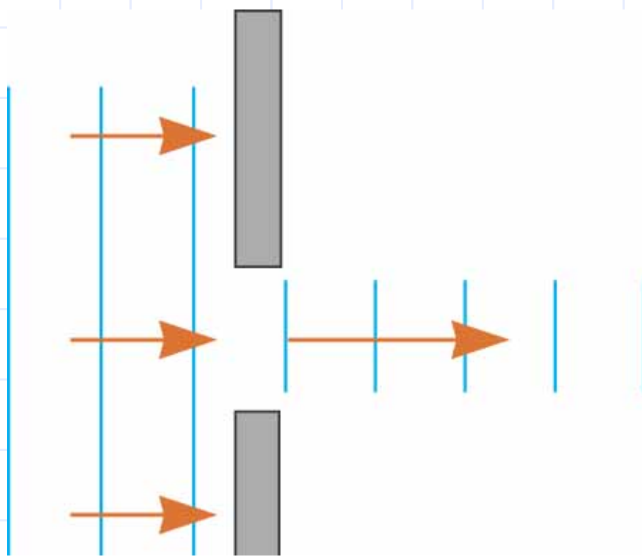
- To "add" the waves, we apply the Principle of Superposition: "When two (or more) waves overlap, the resultant wave "magnitude" at any point in space and time is found by adding the instantaneous "magnitudes" that would be produced at that point by the individual wave if each were present alone."
- Consider two light point sources S_1 and S_2 separated by some distance

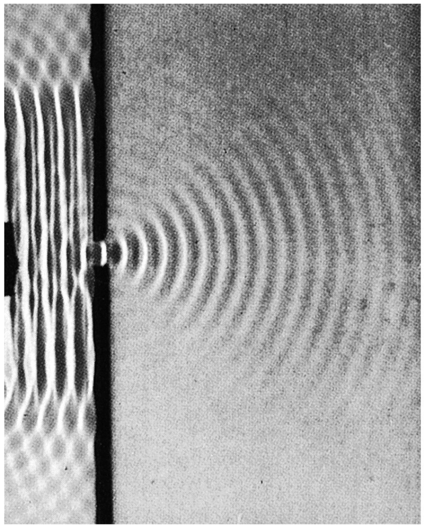




Young's Double Slit Experiment

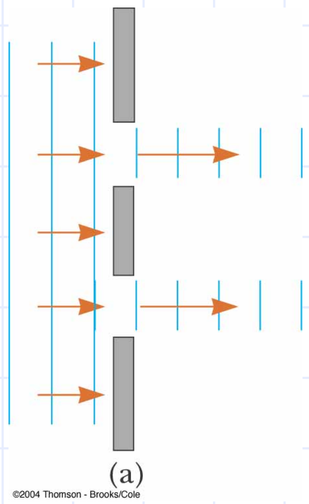
- Consider a plane wave of wavelength λ incident on an opaque barrier with an opening of size D
- If D >> λ, the rays continue in a straight line (ray approx. is valid)
- If D < λ, the plane wave diffracts through the opening creating spherical waves in all directions.



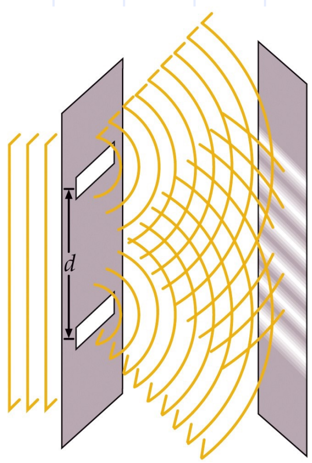


- The divergence of the light ray from its original path is called diffraction
- Now consider a barrier, but with two small slits ($D < \lambda$) and a slit separation given by d (Young's double slit experiment - 1801)
- The slits produce two point light sources, S_1 and S_2 – spherical waves, same λ, and in phase $\rightarrow$ two coherent light sources
- The two waves propagate over all space (right of barrier) and interfere over all space
- For convenience, we place a screen at L

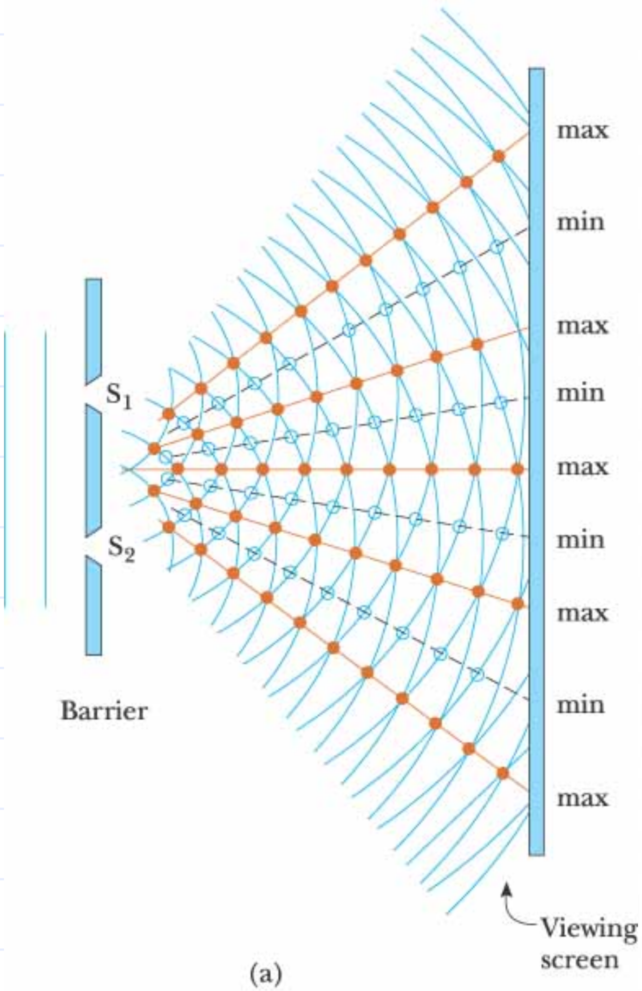
$D >> \lambda$

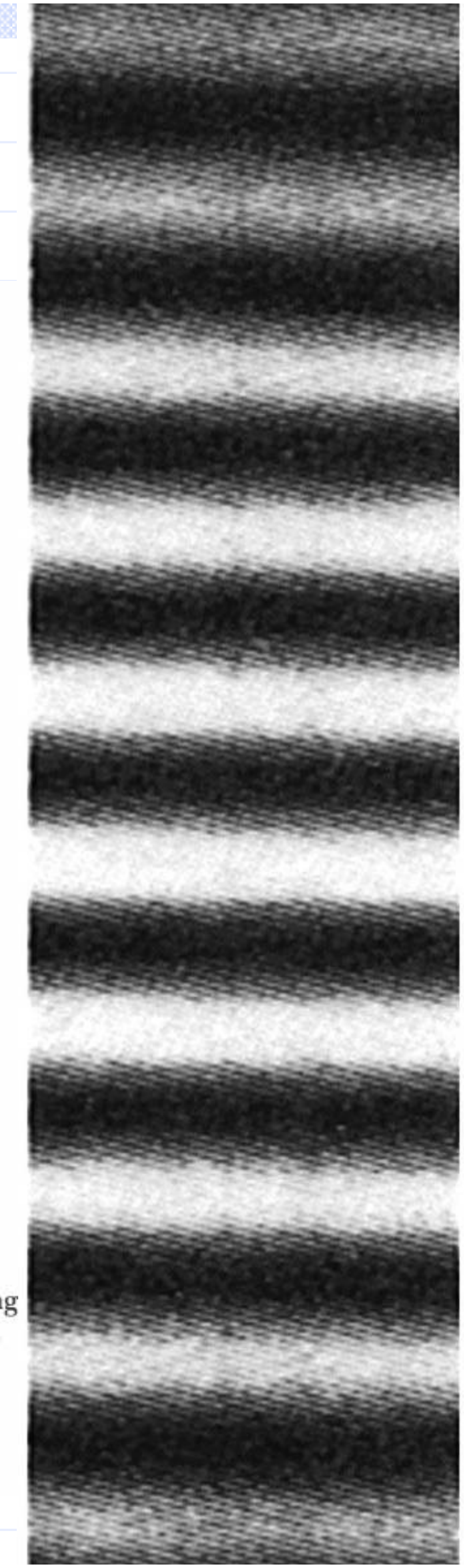


$D << \lambda$



- A "classic" interference pattern is created on the screen
- The waves from the two sources interfere in exactly the same wave as for two point sources





Example Problem 1

- Coherent light from a sodium-vapor lamp is passed through a filter which blocks everything except for light of a single wavelength. It then falls on two slits separated by 0.460 mm. In the resulting interference pattern on a screen 2.20 m away, adjacent bright fringes are separated by 2.82 mm. What is the wavelength?

Example Problem 2

- Two very narrow slits are spaced 1.80 μm apart and are placed 35.0 cm from a screen. What is the distance between the 1st and 2nd dark fringes of the interference pattern when the slits are illuminated with coherent light of λ=550 nm?