

Interference

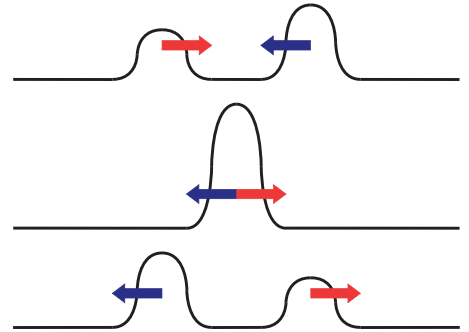
Electric fields from two different sources at a single location add together. The same is true for magnetic fields at a single location.

Thus, interacting electromagnetic waves also add together.

Interference

The addition of waves is called interference and may be constructive or destructive.

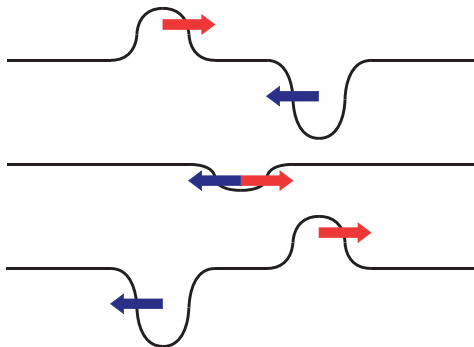
Constructive:



Interference

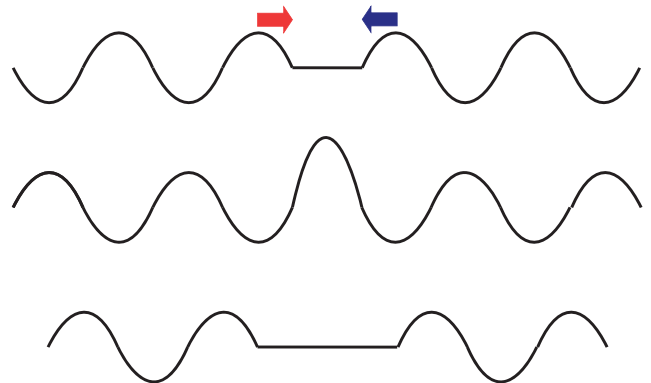
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Destructive:



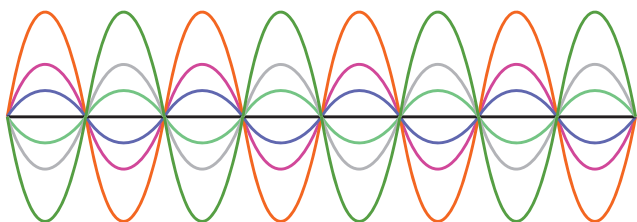
Interference

Regular patterns of interference can be produced by adding waves of the same wavelength and amplitude.



Interference

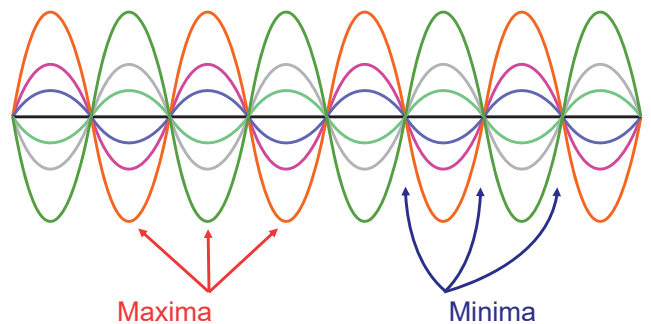
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Each color represents a snapshot at a different moment in time.

Interference

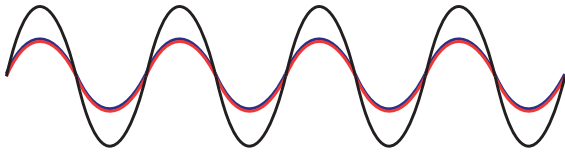
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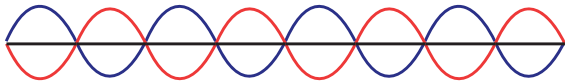
Interference

Consider two waves traveling in the same direction:

Waves in phase (Wave 1, Wave 2, Sum)

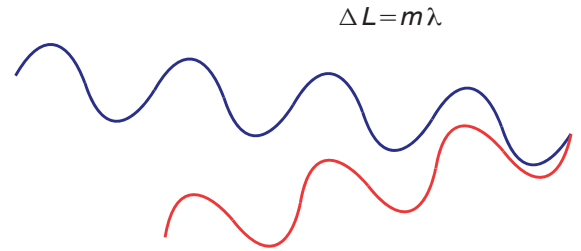


Waves out of phase by π (Wave 1, Wave 2, Sum)



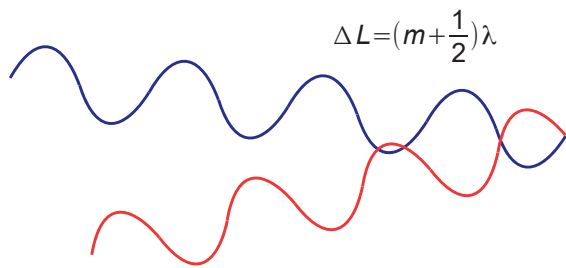
Interference

For simultaneous waves, path difference must be an integer number of wavelengths for constructive interference.



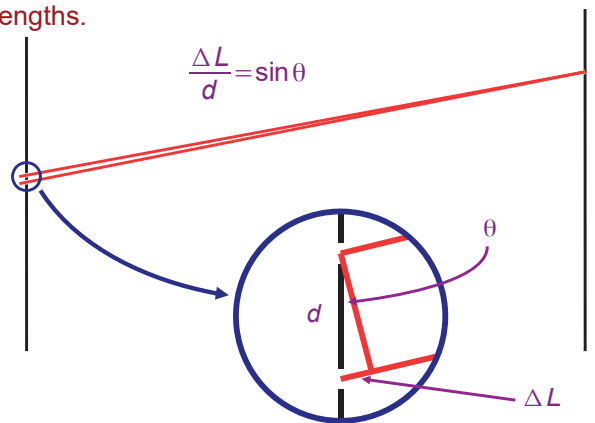
Interference

For simultaneous waves, path difference must be an half-integer number of wavelengths for destructive interference.



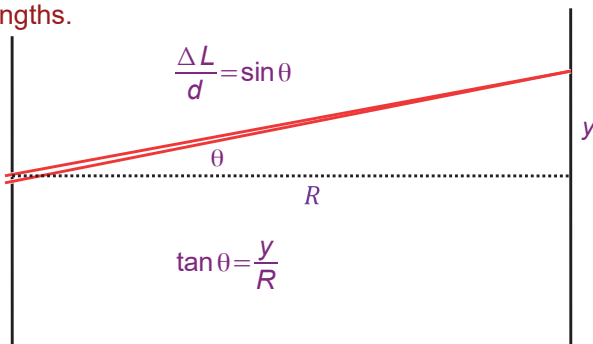
Young's Double Slit Experiment

For intensity maximum, paths differ by integer number of wavelengths.

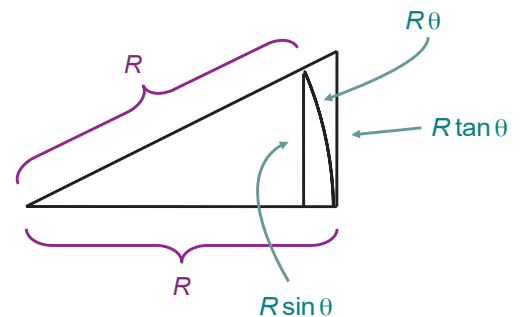


Young's Double Slit Experiment

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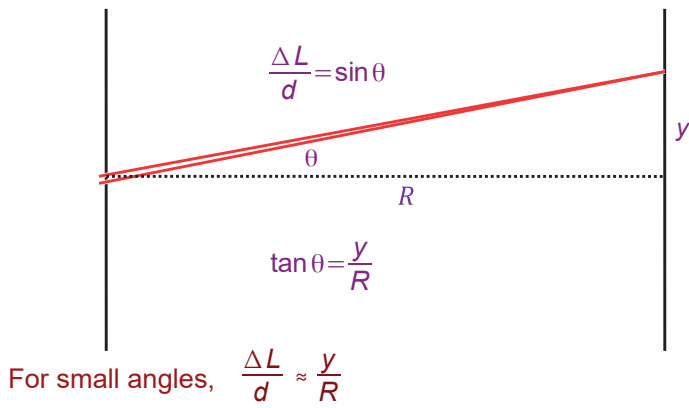


Small Angle Approximations



For small angles, $\sin \theta \approx \theta \approx \tan \theta$

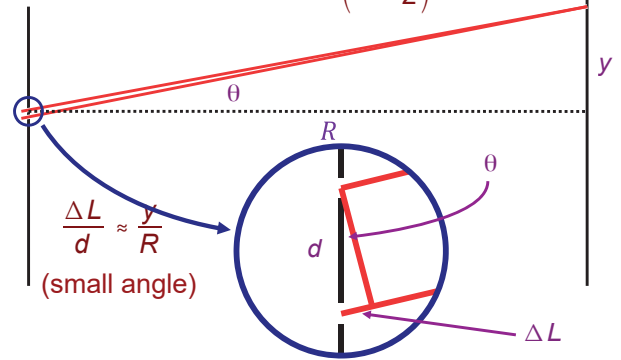
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Young's Double Slit Experiment

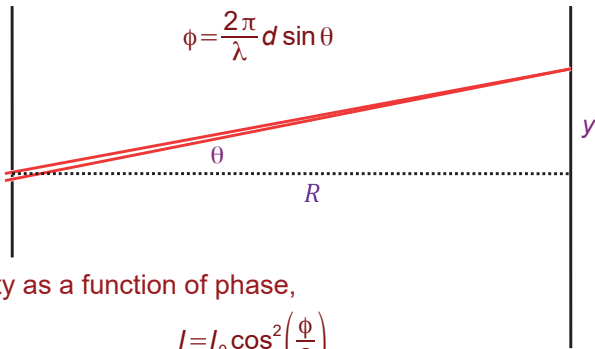
For constructive interference, $\Delta L = m\lambda$

For destructive interference, $\Delta L = \left(m + \frac{1}{2}\right)\lambda$



Young's Double Slit Experiment

Phase difference as a function of angle,



Intensity as a function of phase,

$$I = I_0 \cos^2 \left(\frac{\phi}{2} \right)$$

Example: a viewing screen is separated from the double-slit source by 1.2 m. The distance between the two slits is 0.030 mm. The second-order bright fringe ($m = 2$) is 4.5 cm from the center line. Determine the wavelength of the light.

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Example: a viewing screen is separated from the double-slit source by 1.2 m. The distance between the two slits is 0.030 mm. The second-order bright fringe ($m = 2$) is 4.5 cm from the center line. Determine the width of the bright fringes.

Intensity

Maximum intensity corresponds to constructive interference (bright fringes).

Double slit

Phase difference:

$$\phi = 2\pi \left(\frac{\Delta L}{\lambda} \right)$$

Intensity:

$$I = I_0 \cos^2 \left(\frac{\phi}{2} \right)$$

Single slit

Phase difference:

$$\beta = \frac{2\pi}{\lambda} a \sin \theta$$

Intensity:

$$I = I_0 \left[\frac{\sin(\beta/2)}{\beta/2} \right]^2$$