Interference

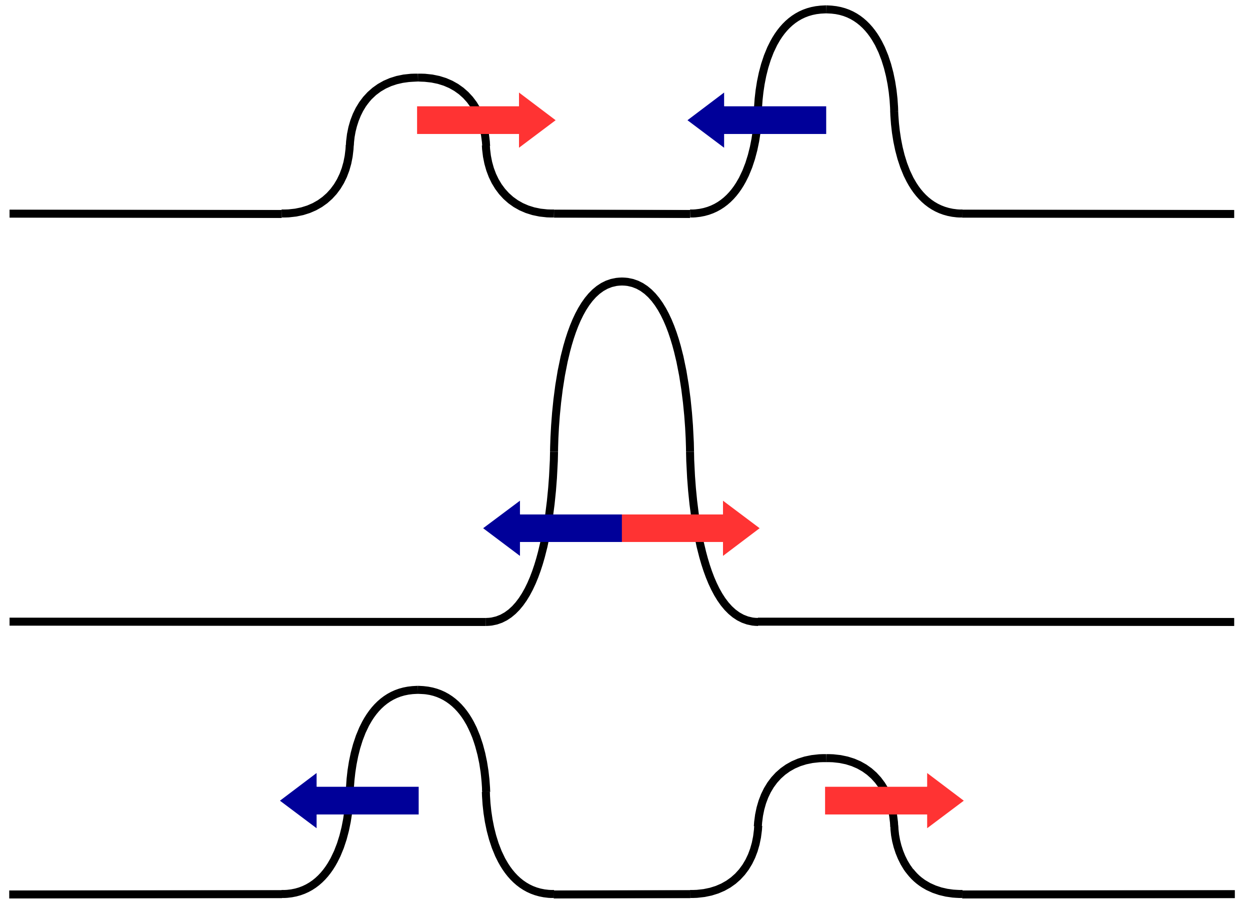
Electric fields from two different sources at a single location add together. The same is true for magnetic fields at a single location.

Thus, interacting electromagnetic waves also add together.

Interference

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

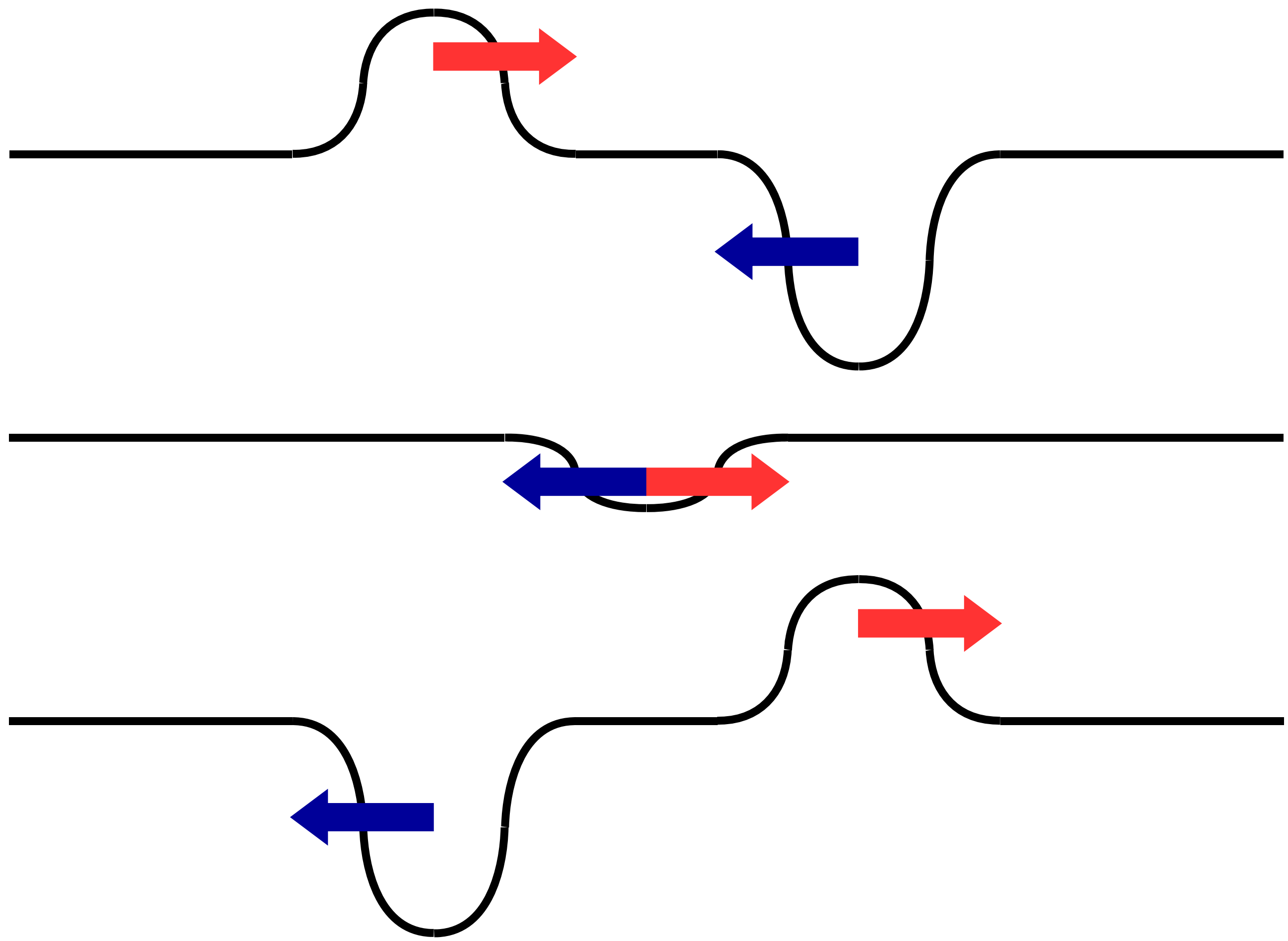
Constructive:



Interference

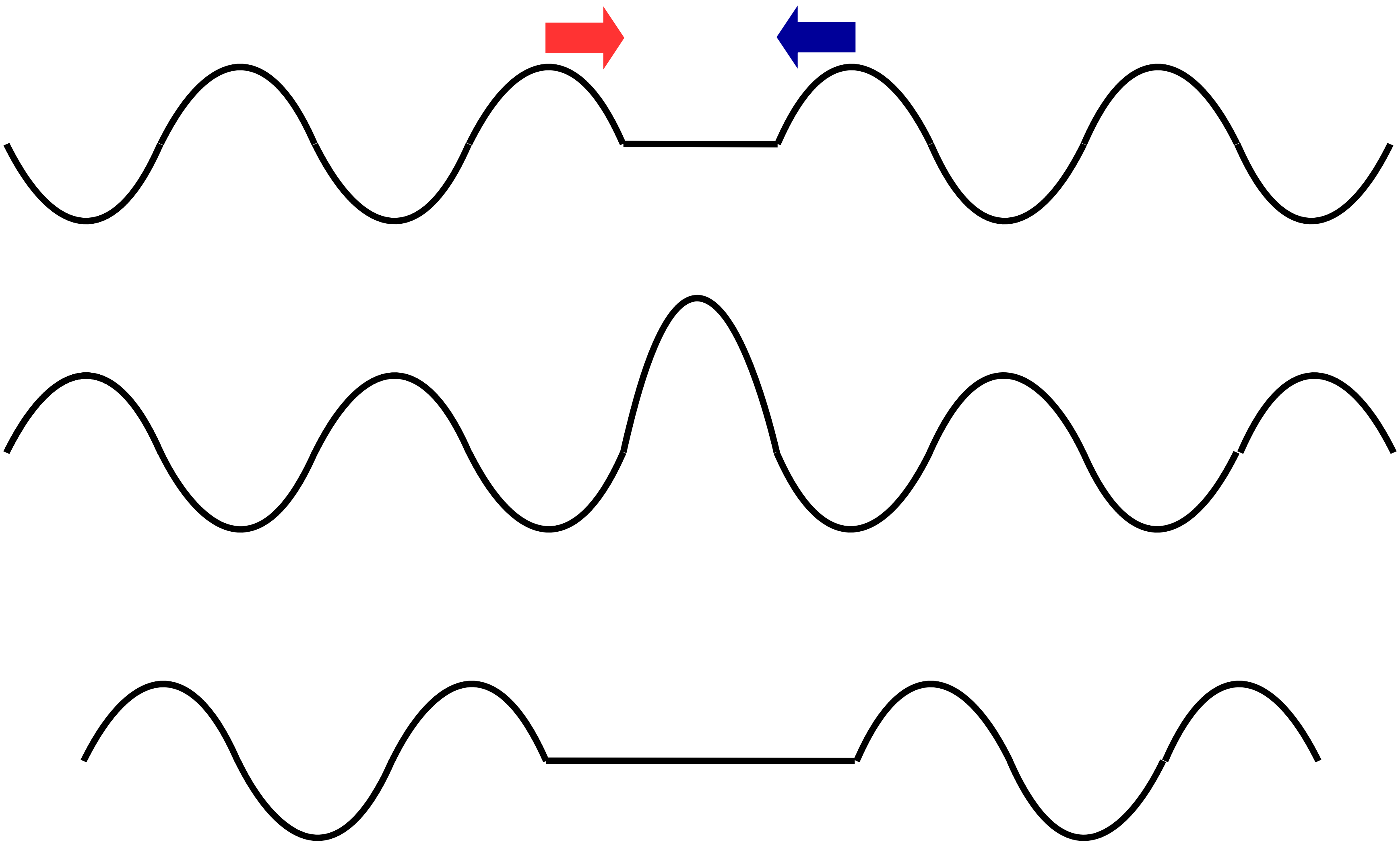
The addition of waves is called interference and may be constructive or destructive.

Destructive:



Interference

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



Interference

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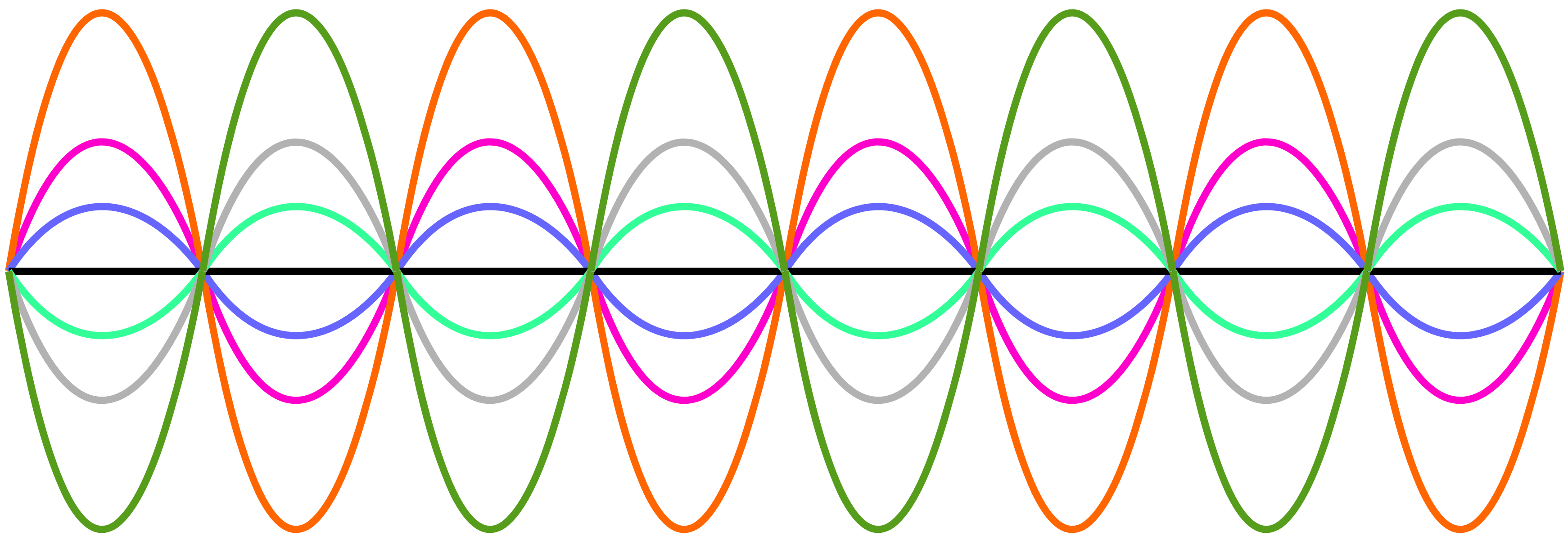
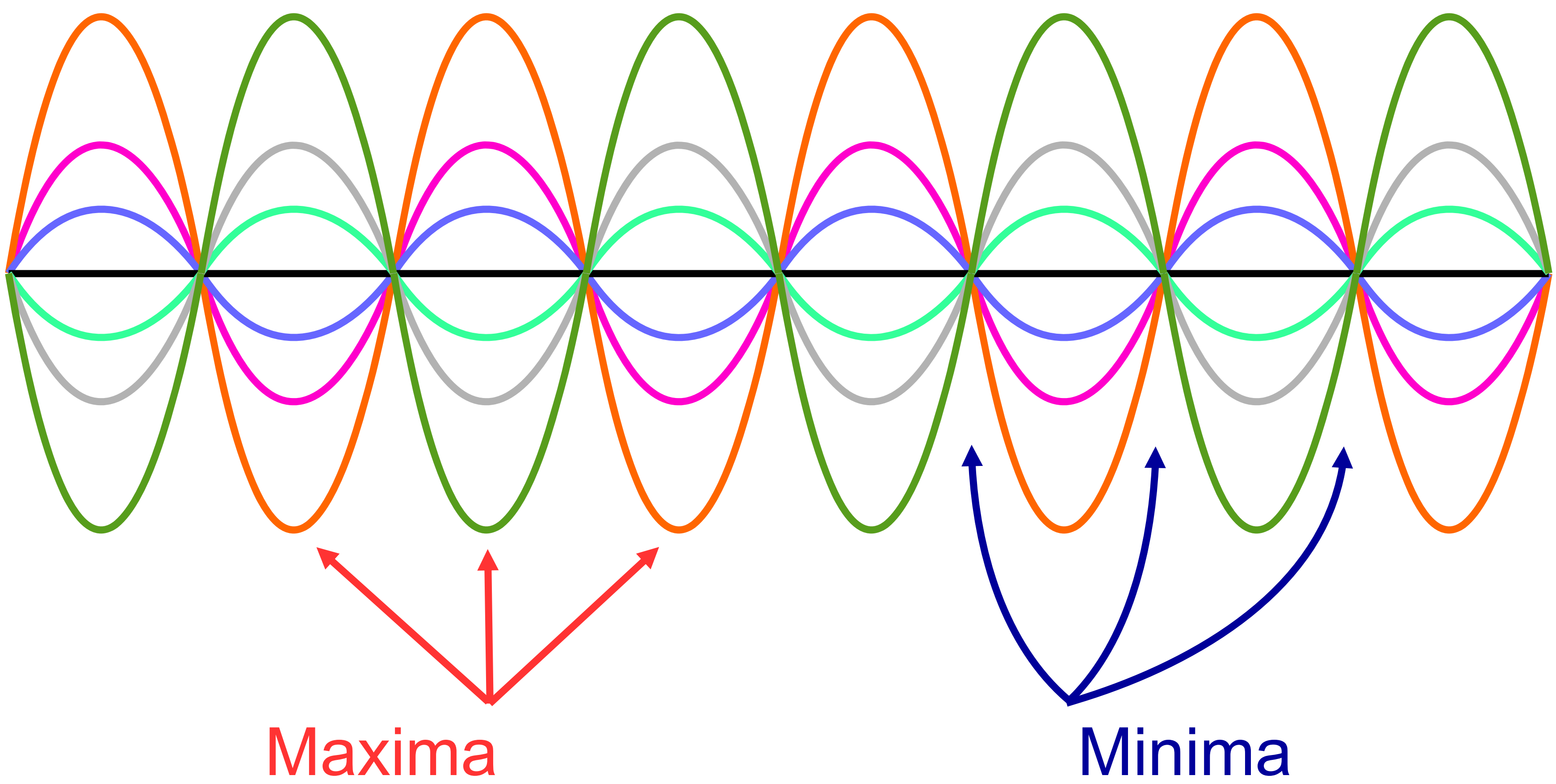


Each color represents a snapshot at a different moment in time.

Interference

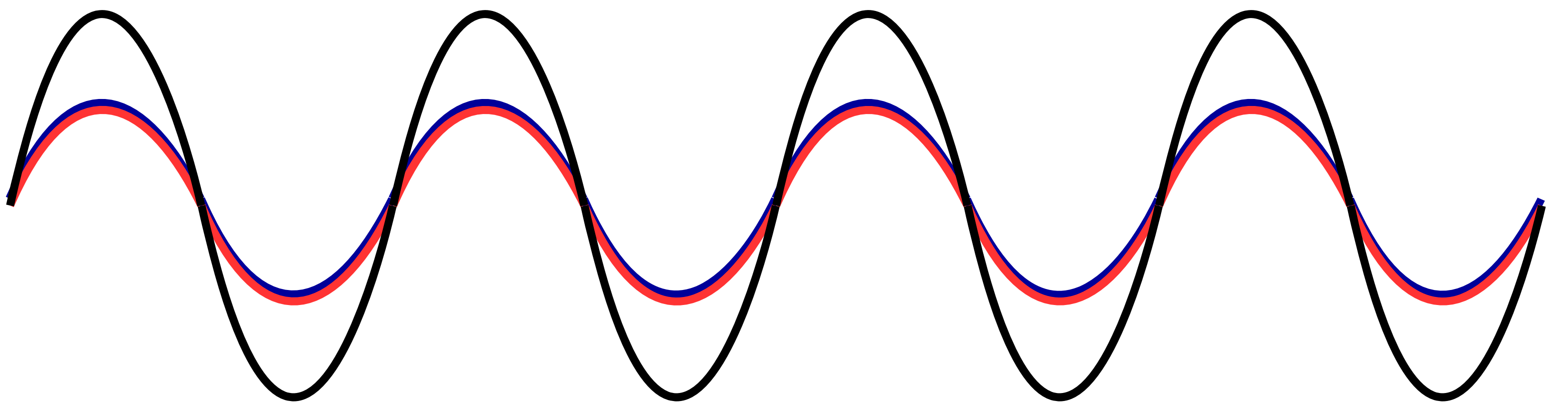
Regular patterns of interference can be produced by adding waves of the same wavelength and amplitude.



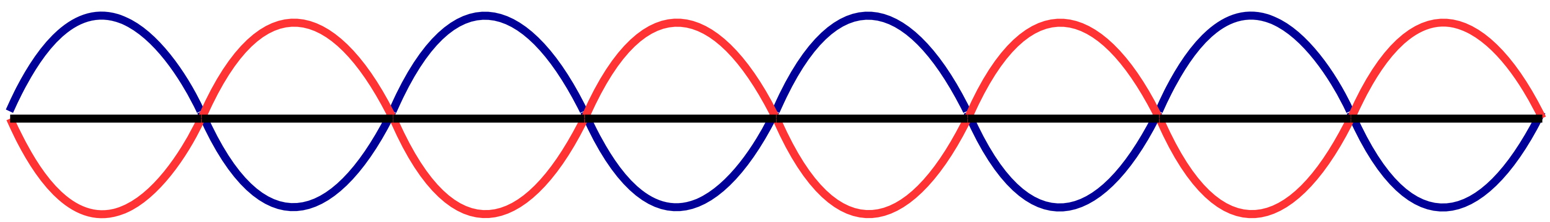
Interference

Consider two waves traveling in the same direction:

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



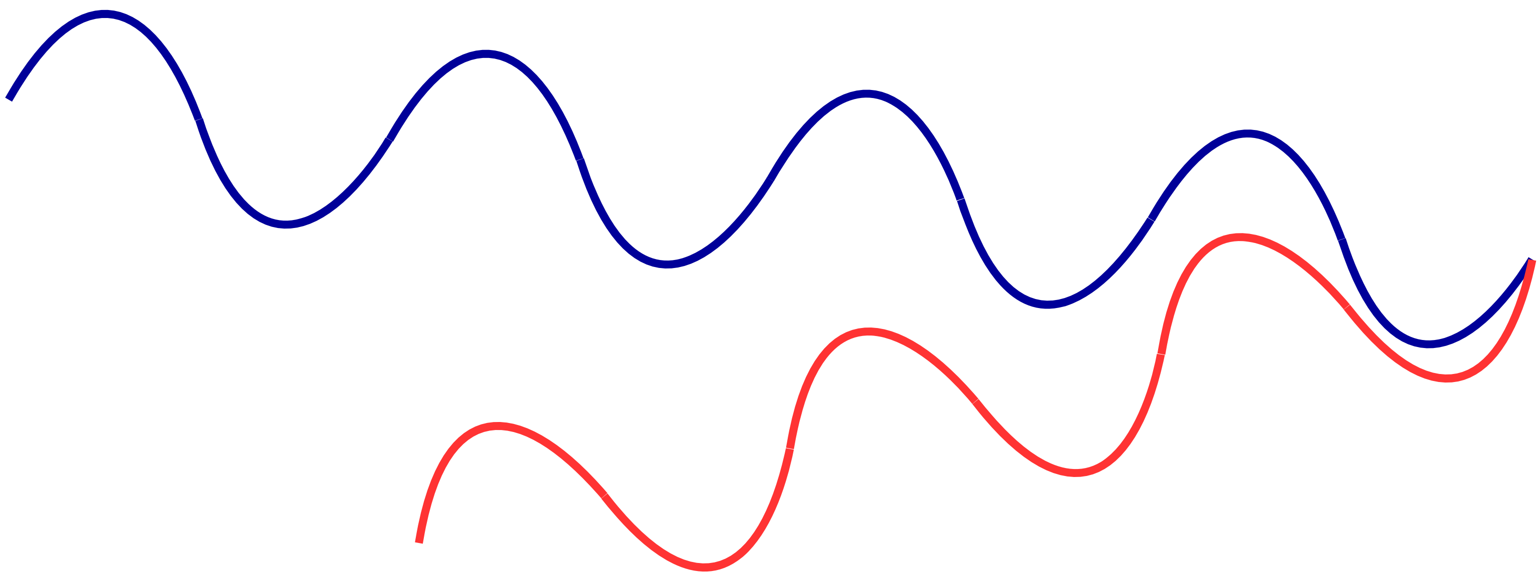
Waves out of phase by π (Wave 1, Wave 2, Sum)



Interference

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

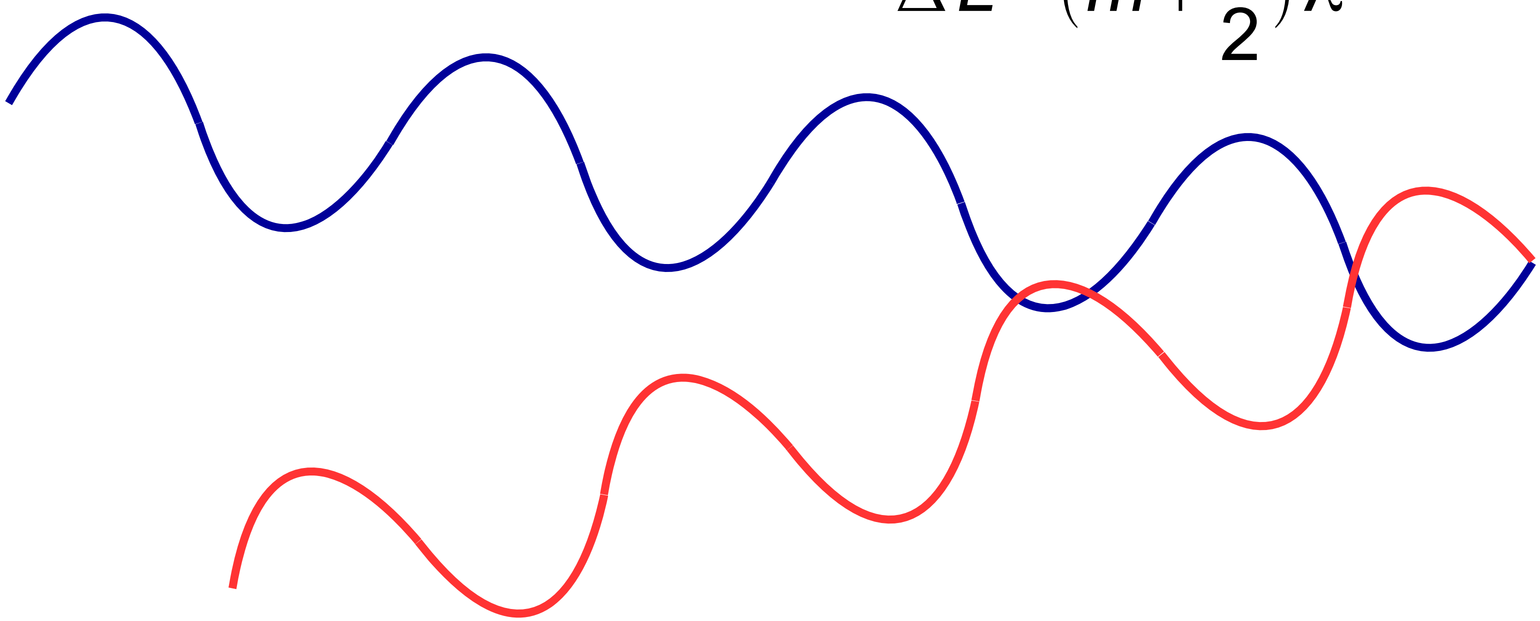
$$\Delta L = m\lambda$$



Interference

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

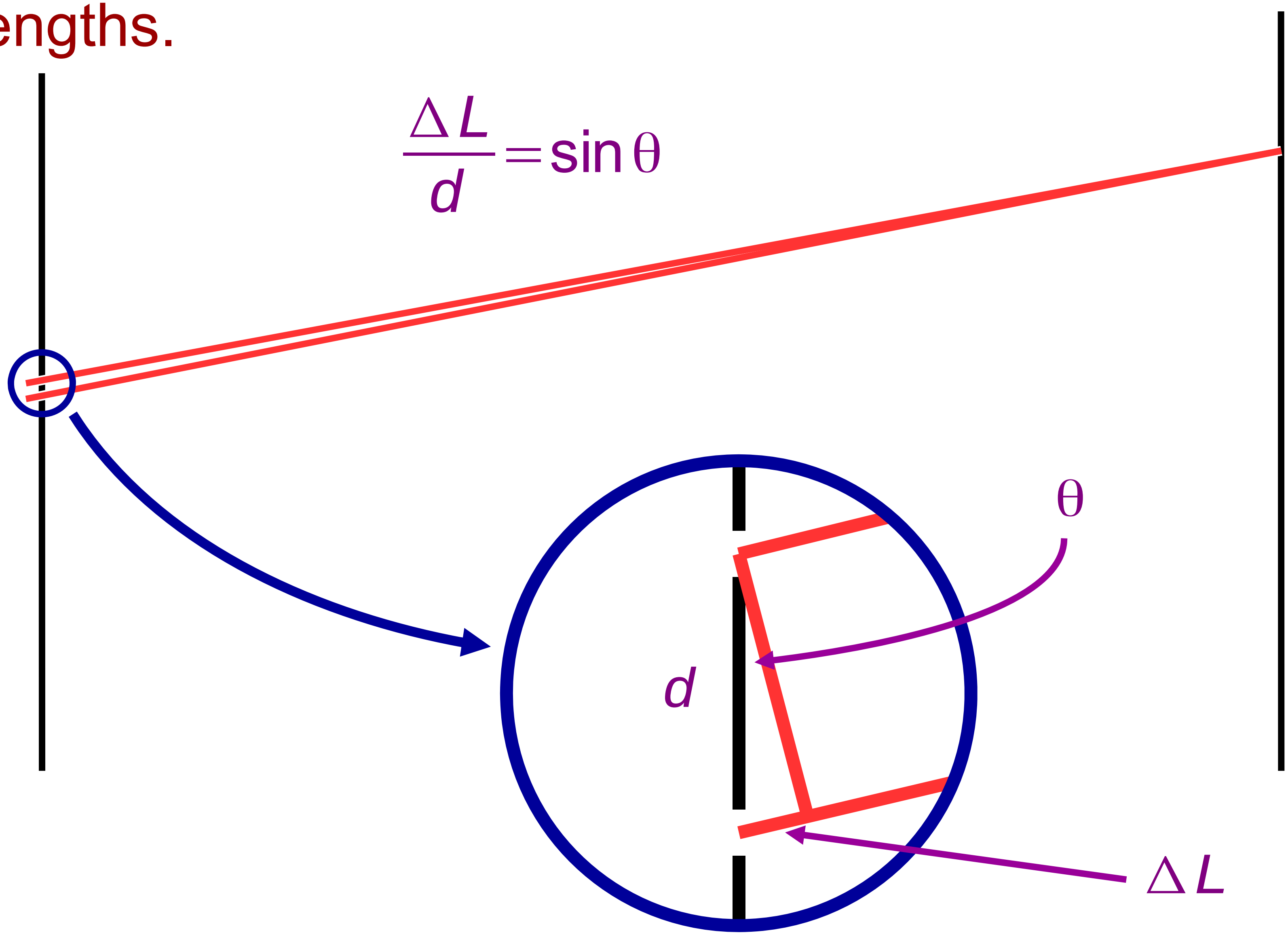
$$\Delta L = \left(m + \frac{1}{2}\right)\lambda$$



Young's Double Slit Experiment

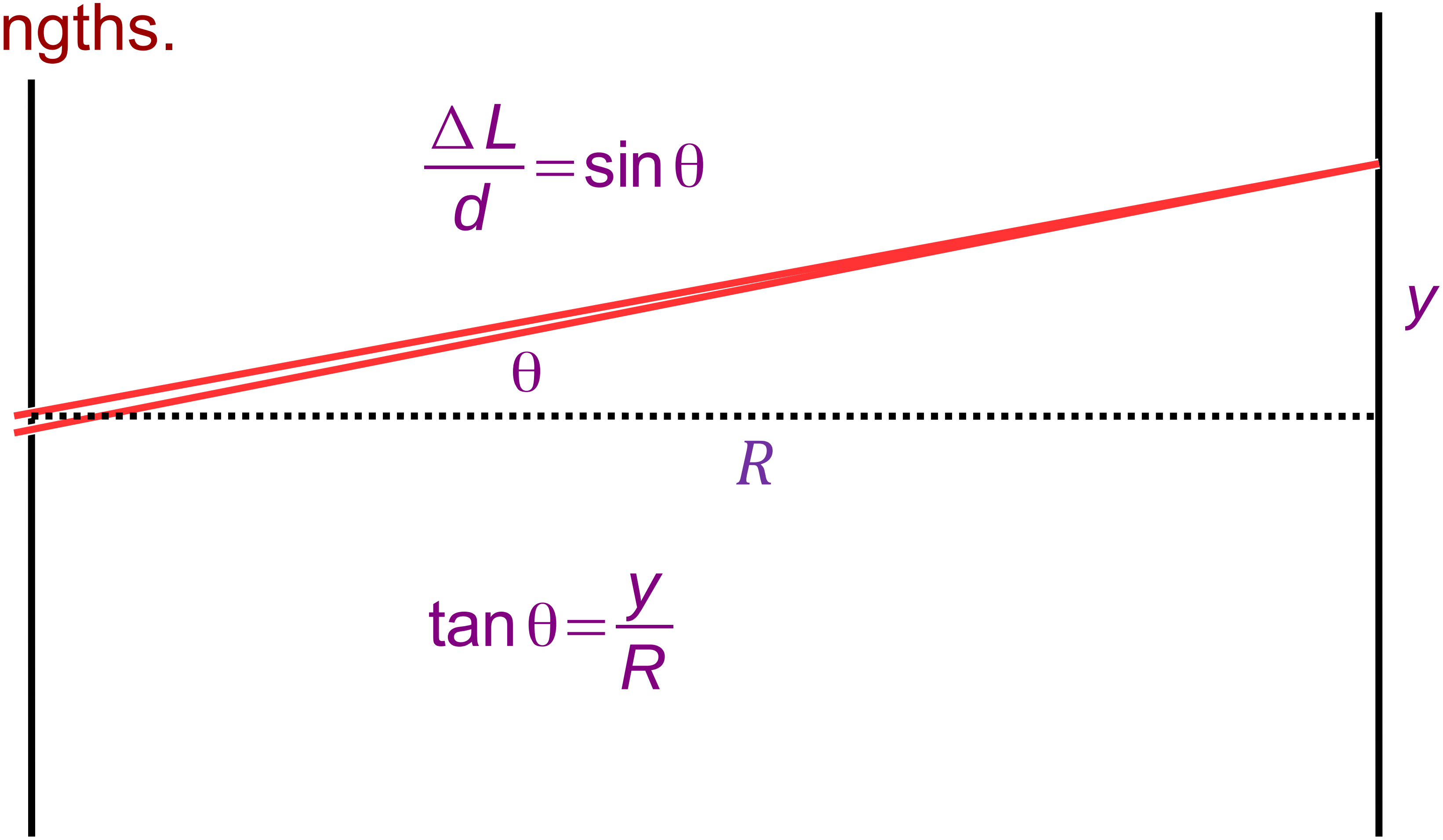
For intensity maximum, paths differ by integer number of wavelengths.

$$\frac{\Delta L}{d} = \sin\theta$$



Young's Double Slit Experiment

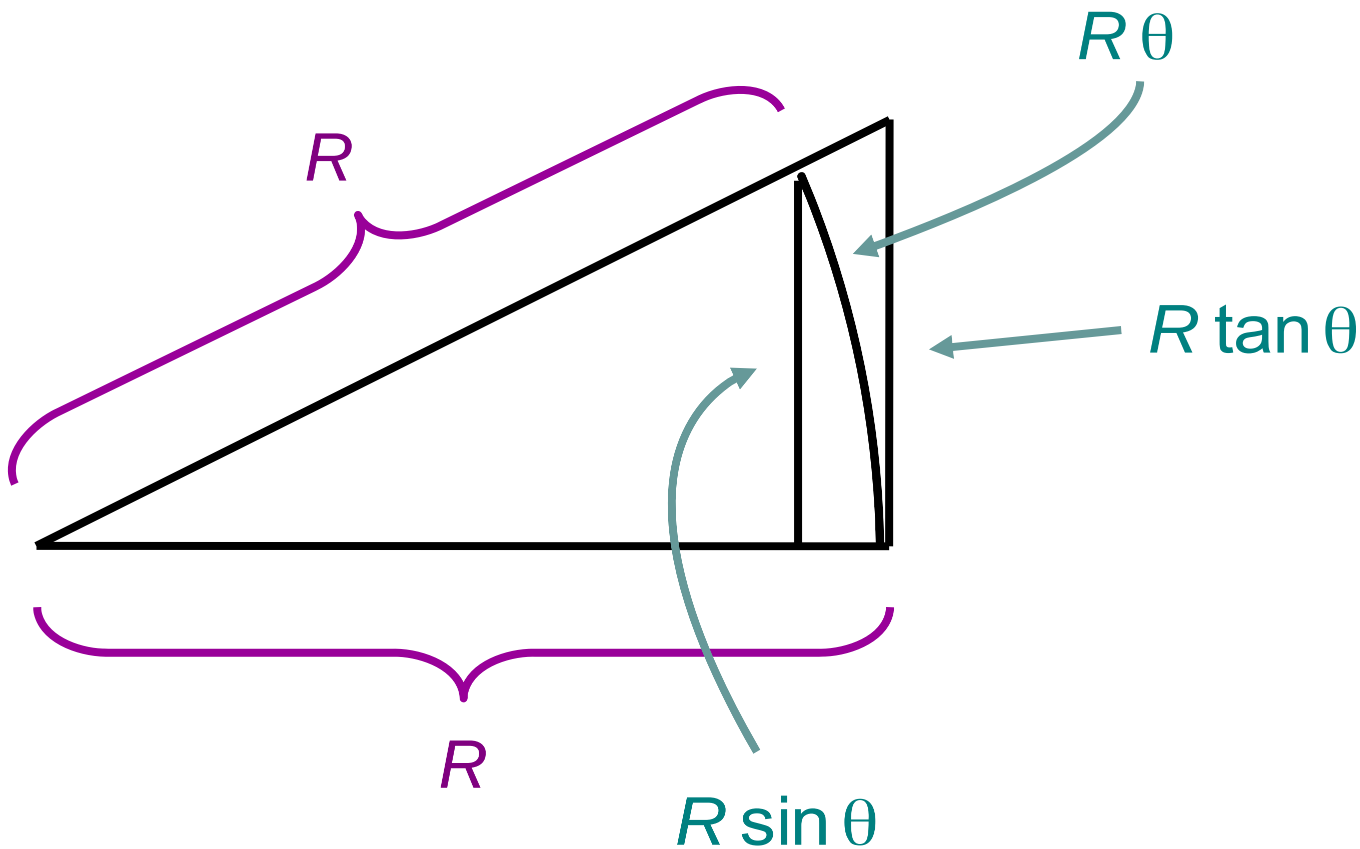
For intensity maximum, paths differ by integer number of wavelengths.



$$\frac{\Delta L}{d} = \sin\theta$$

$$\tan\theta = \frac{y}{R}$$

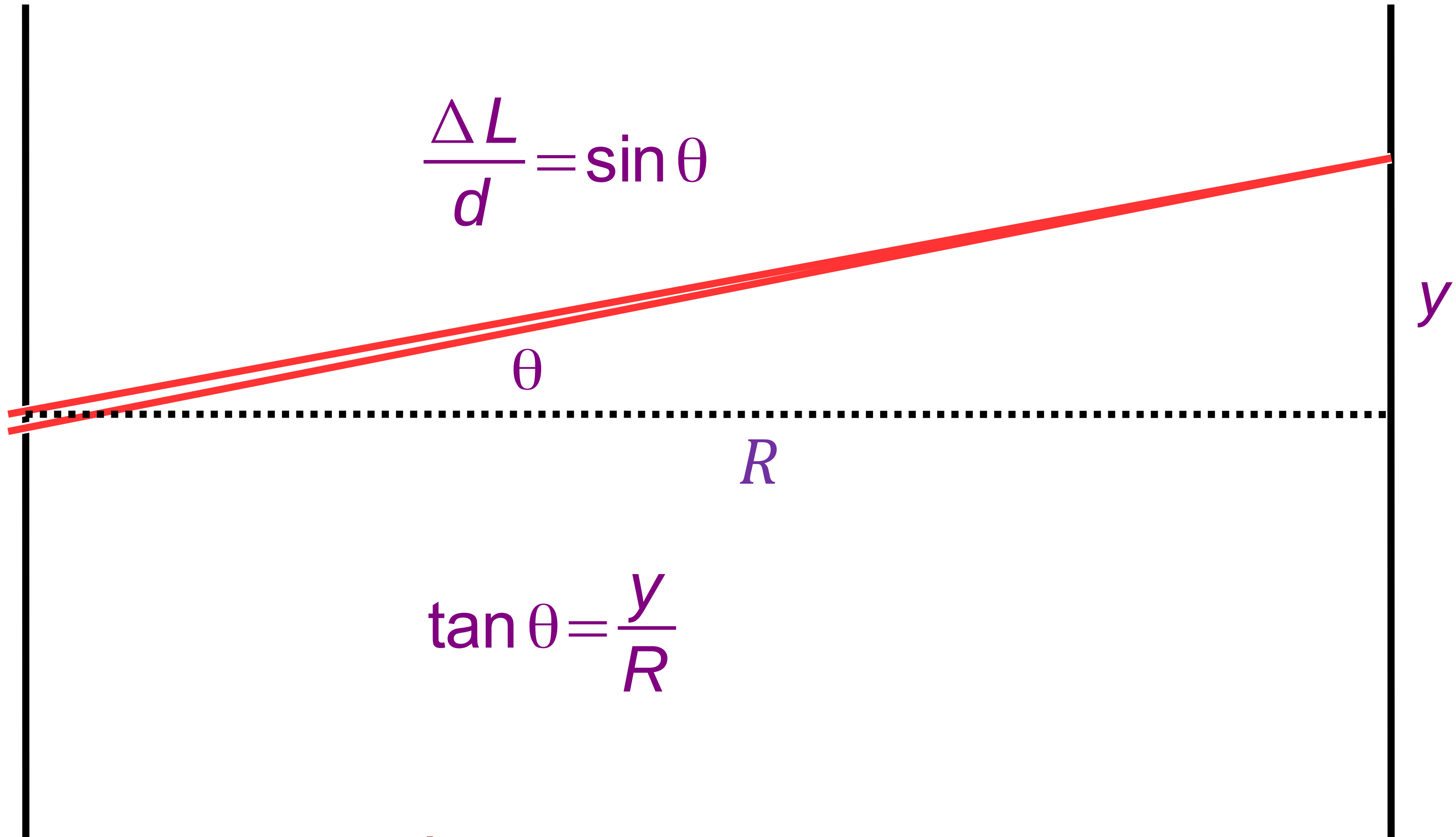
Small Angle Approximations



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

Young's Double Slit Experiment

$$\frac{\Delta L}{d} = \sin\theta$$



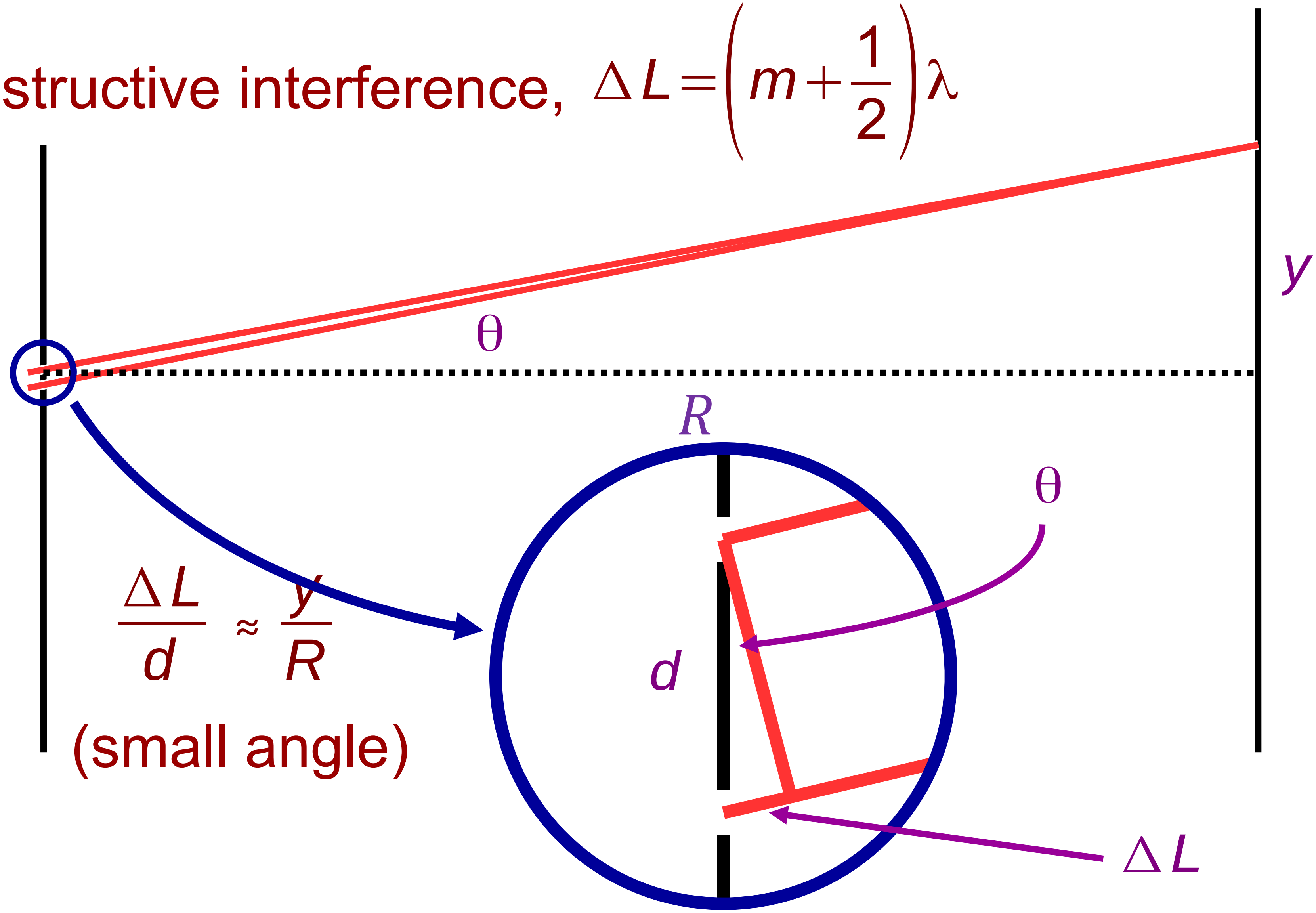
$$\tan\theta = \frac{y}{R}$$

For small angles, $\frac{\Delta L}{d} \approx \frac{y}{R}$

Young's Double Slit Experiment

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

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



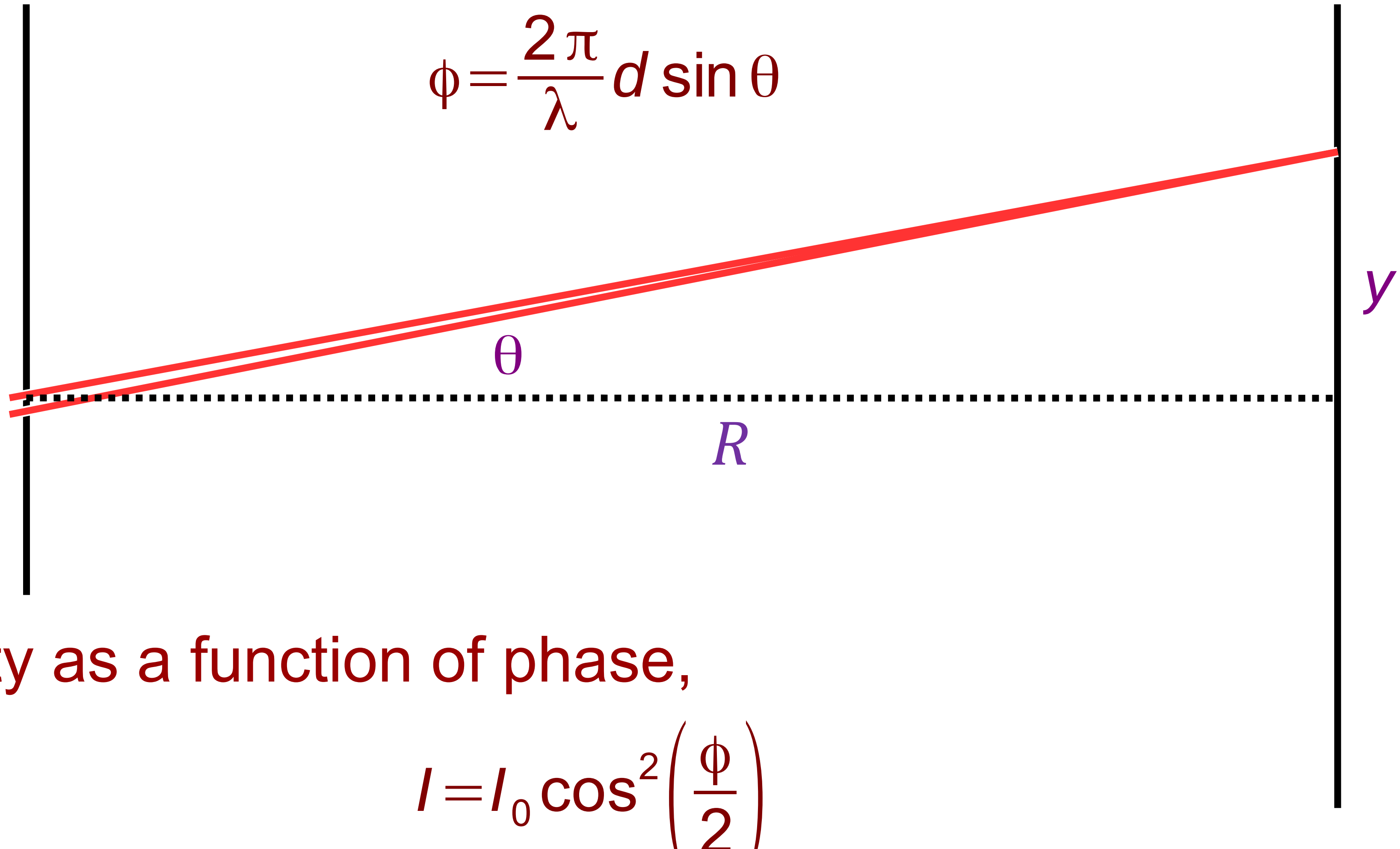
$$\frac{\Delta L}{d} \approx \frac{y}{R}$$

(small angle)

Young's Double Slit Experiment

Phase difference as a function of angle,

$$\phi = \frac{2\pi}{\lambda} d \sin\theta$$



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.

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 distance between adjacent bright fringes.

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:

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