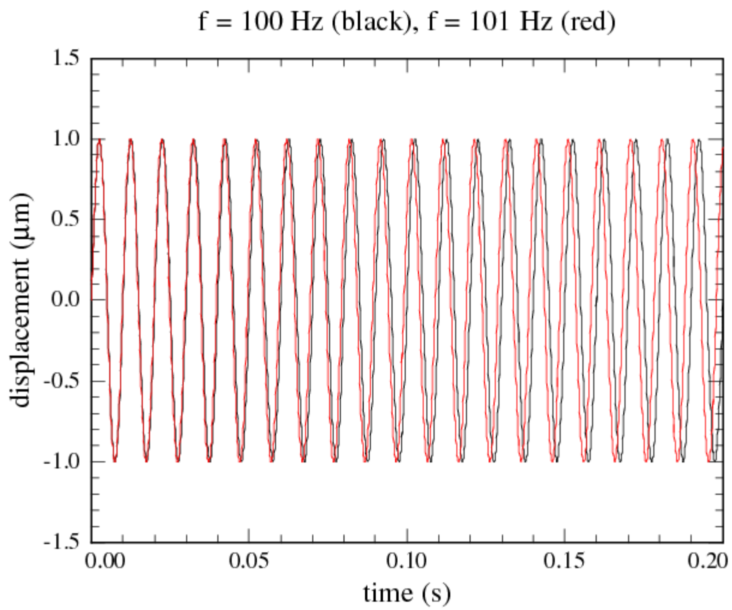
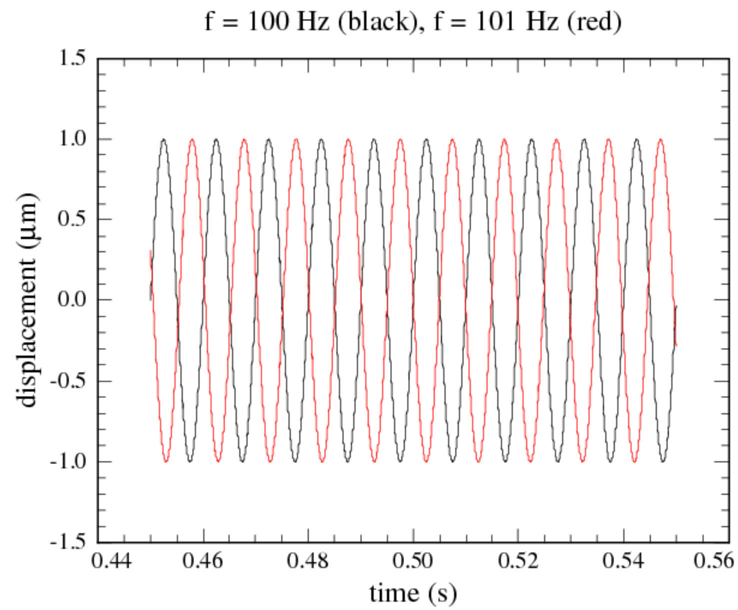
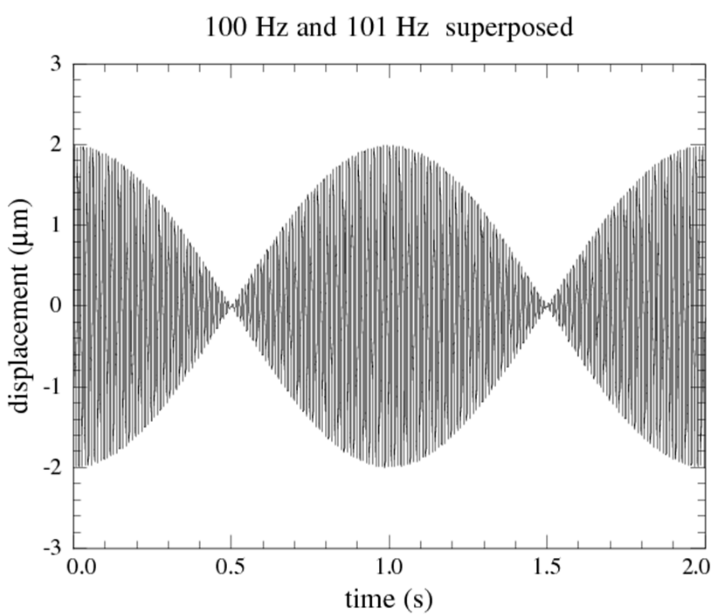
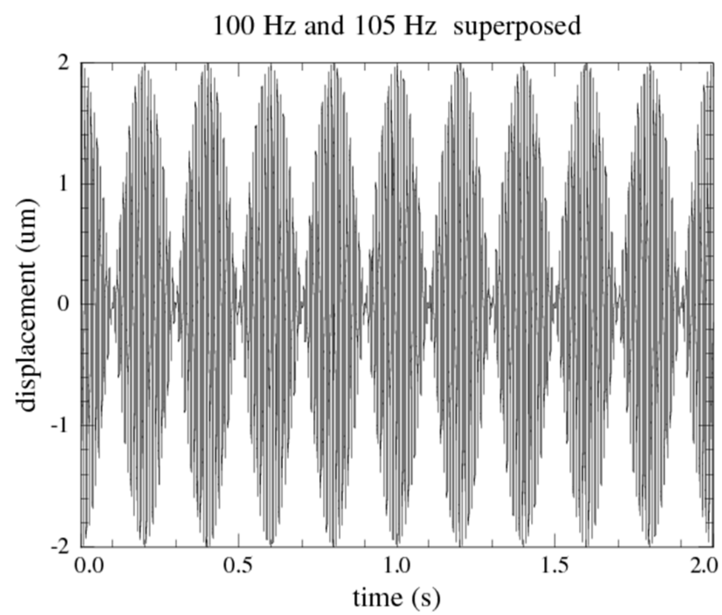
Beats


f = 100 Hz (black), f = 101 Hz (red)
displacement (µm)
time (s)

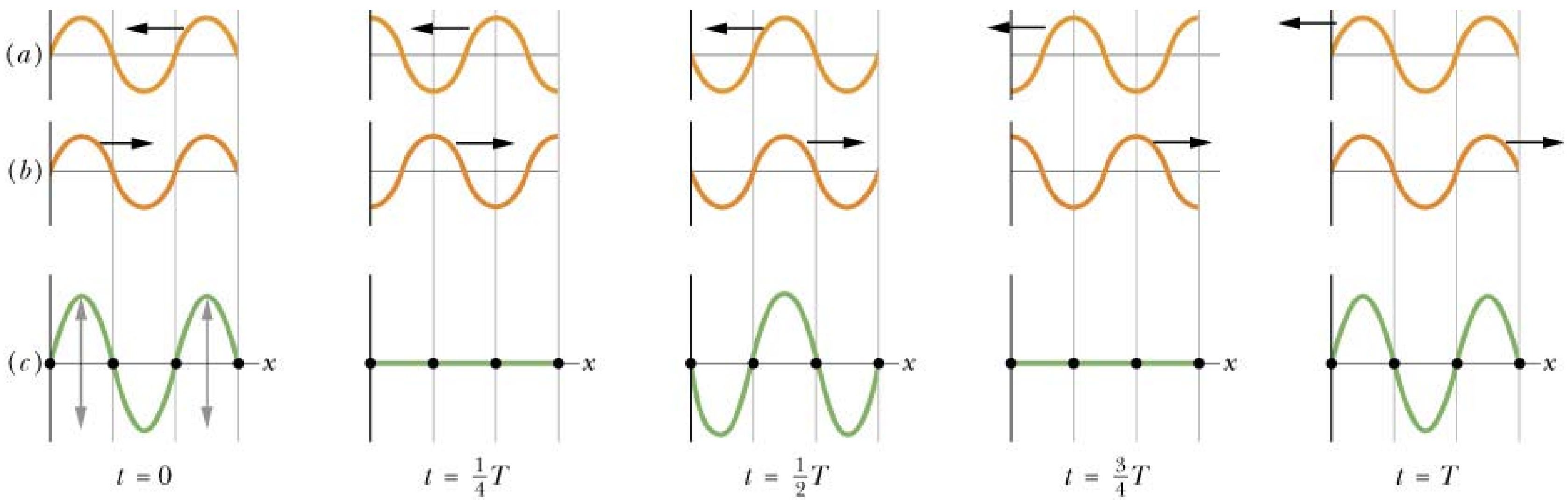

f = 100 Hz (black), f = 101 Hz (red)
displacement (µm)
time (s)


100 Hz and 101 Hz superposed
displacement (µm)
time (s)


100 Hz and 105 Hz superposed
displacement (um)
time (s)

Standing Waves

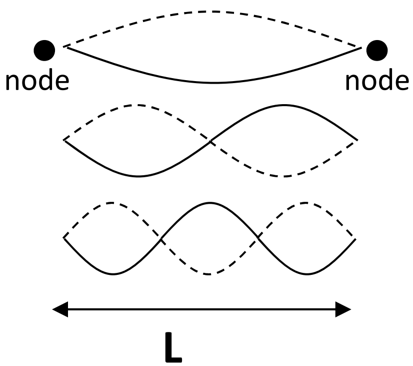
$$y'(x,t) = [2y_m \sin kx] \cos \omega t$$



HRW, 8th ed, Fig. 16-19

Standing Waves – resonance

Simple Case (1): There must be a node (or antinode) at both ends.

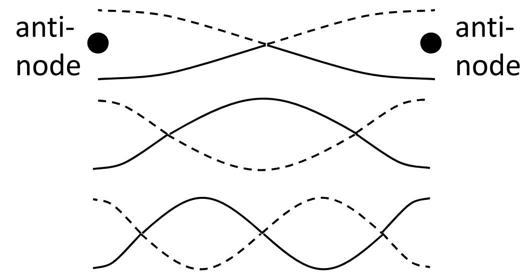


$\lambda = 2L$ $f = v/2L$

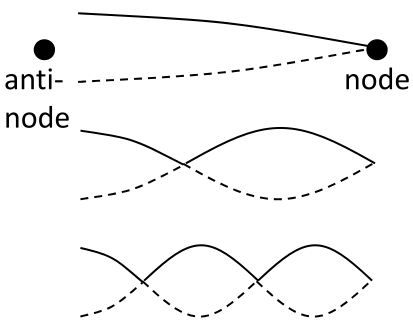
$\lambda = L$ $f = 2\,v/2L$

$\boxed{\lambda = 2L/n \quad f = n\,v/2L}$

n = 1,2,3,…



Simple Case (2): A node at one end and an antinode at the other.



$\lambda = 4L$ $f = v/4L$

$\lambda = 4L/3$ $f = 4\,v/4L$

$\boxed{\lambda = 4L/n \quad f = n\,v/4L}$

n = 1,3,5,…

Time-independent interference

$$y_1(x,t) = y_m \sin(kx-\omega t)$$

$$y_2(x,t) = y_m \sin(kx-\omega t+\phi_o)$$

$$y'(x,t) = y_1 + y_2$$ **Principle of Superposition**

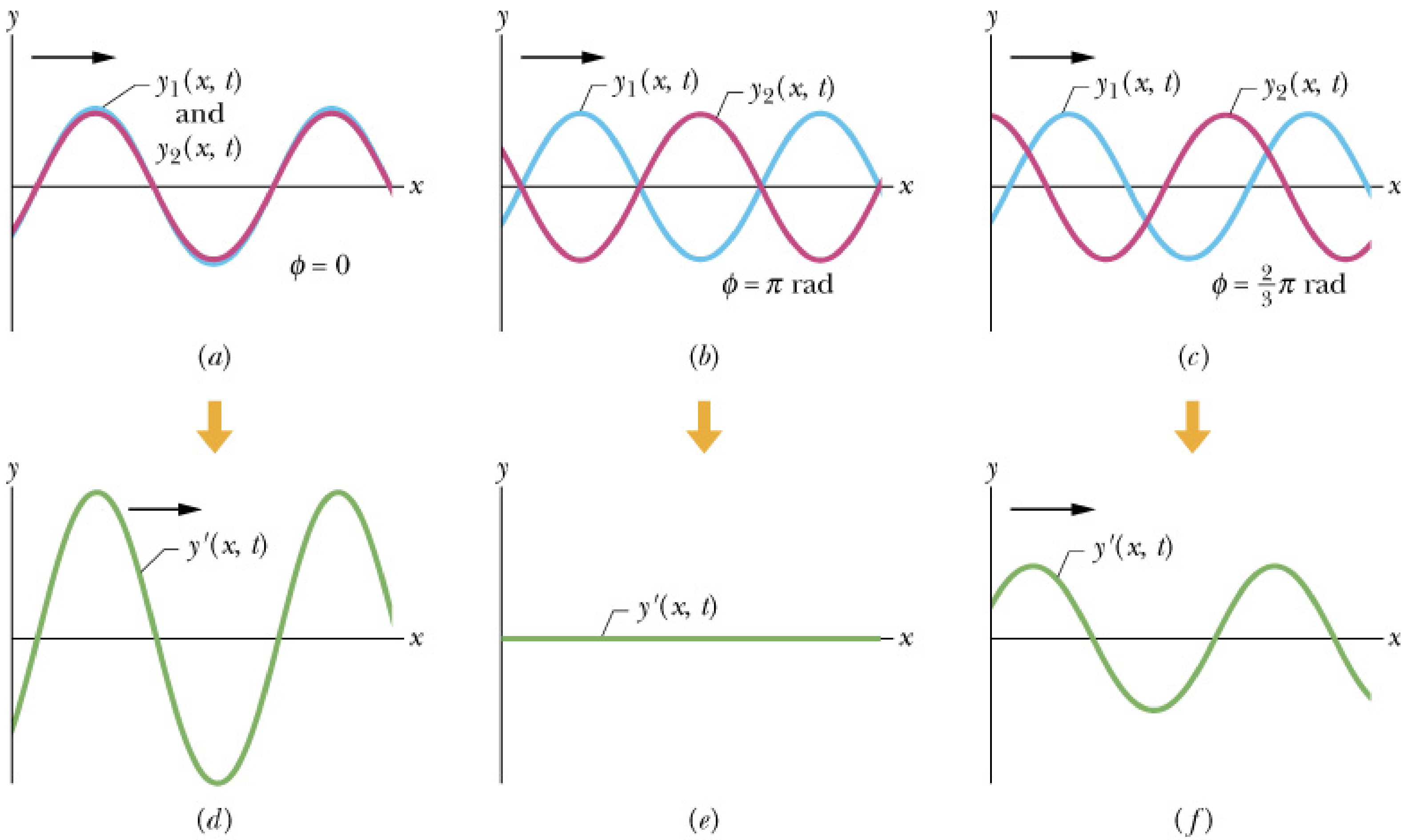
Using: $$\sin\theta_1 + \sin\theta_2 = 2\cos\left(\frac{\theta_1-\theta_2}{2}\right)\sin\left(\frac{\theta_1+\theta_2}{2}\right)$$

$$y'(x,t) = 2y_m \cos(\phi_o/2)\,\sin(kx - \omega t + \phi_o/2)$$

This is the amplitude of the resultant wave, not y_m. Depends on ϕ_o

resultant wave phase constant

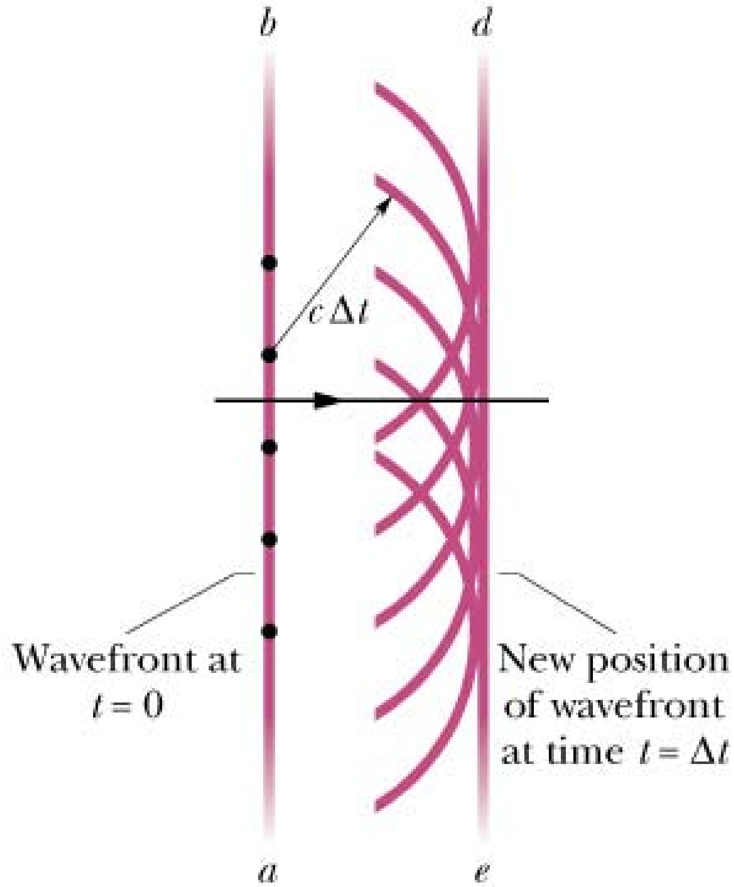
Time-independent interference



HRW, 8th ed, Fig. 16-16

Huygen's Principle

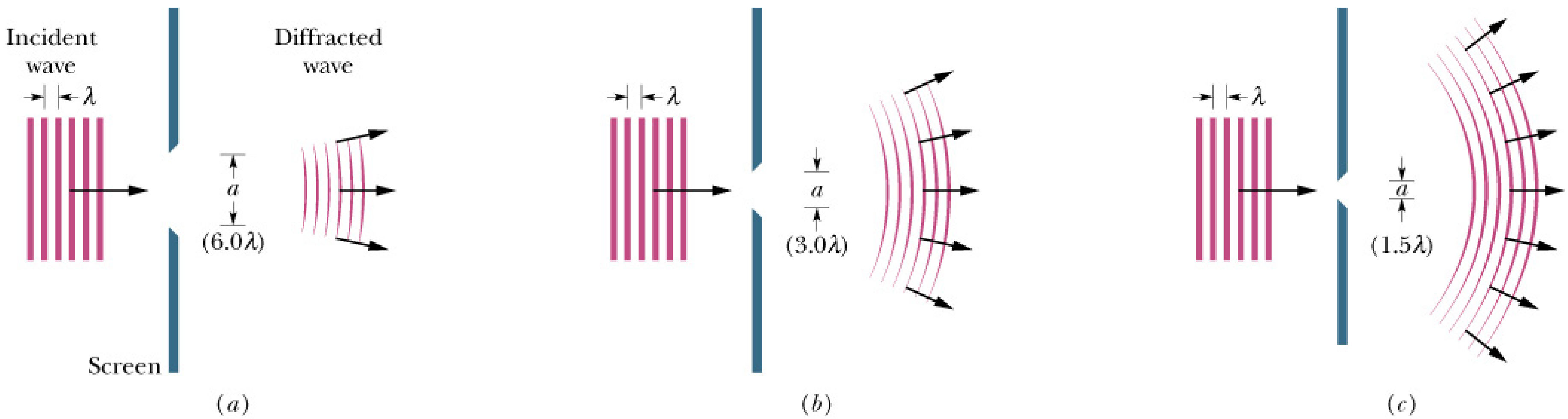
Huygen's Principle: All points on a wavefront serve as point sources of spherical secondary wavelets. After time t, the new position of the wavefront will be that of a surface tangent to these secondary wavelets.



HRW, Fig. 35-2

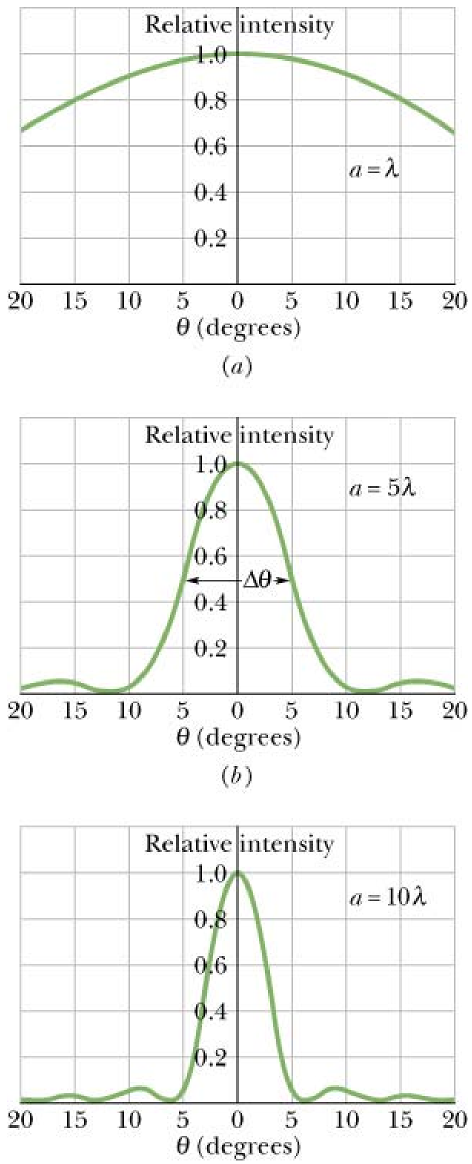
Diffraction

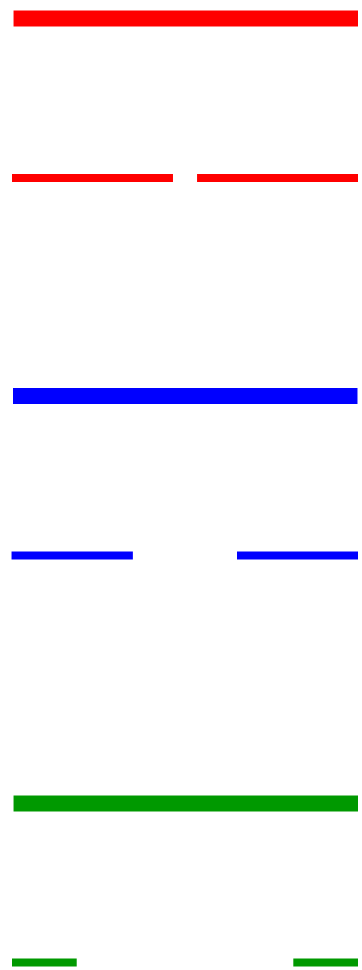
For plane waves entering a single slit, the waves emerging from the slit start spreading out, diffracting.



HRW, Fig. 35-7

Single Slit Intensity



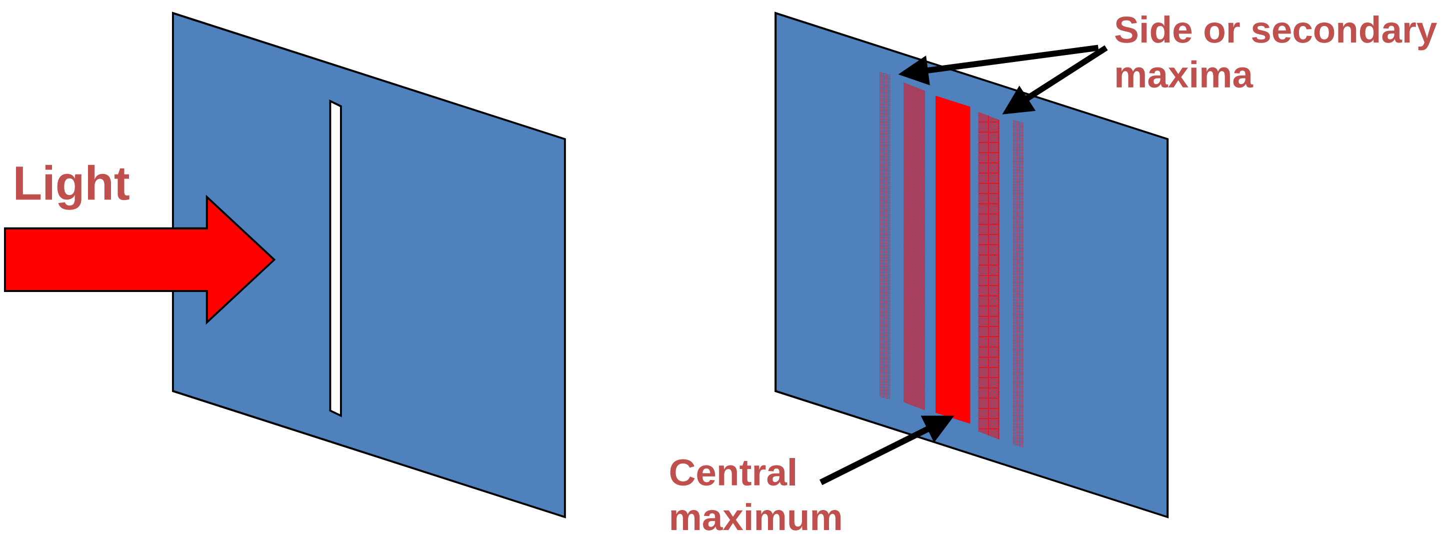


$$I = I_m \left(\frac{\sin \alpha}{\alpha} \right)^2$$

$$\alpha = \frac{\pi\ a}{\lambda} \sin\theta$$

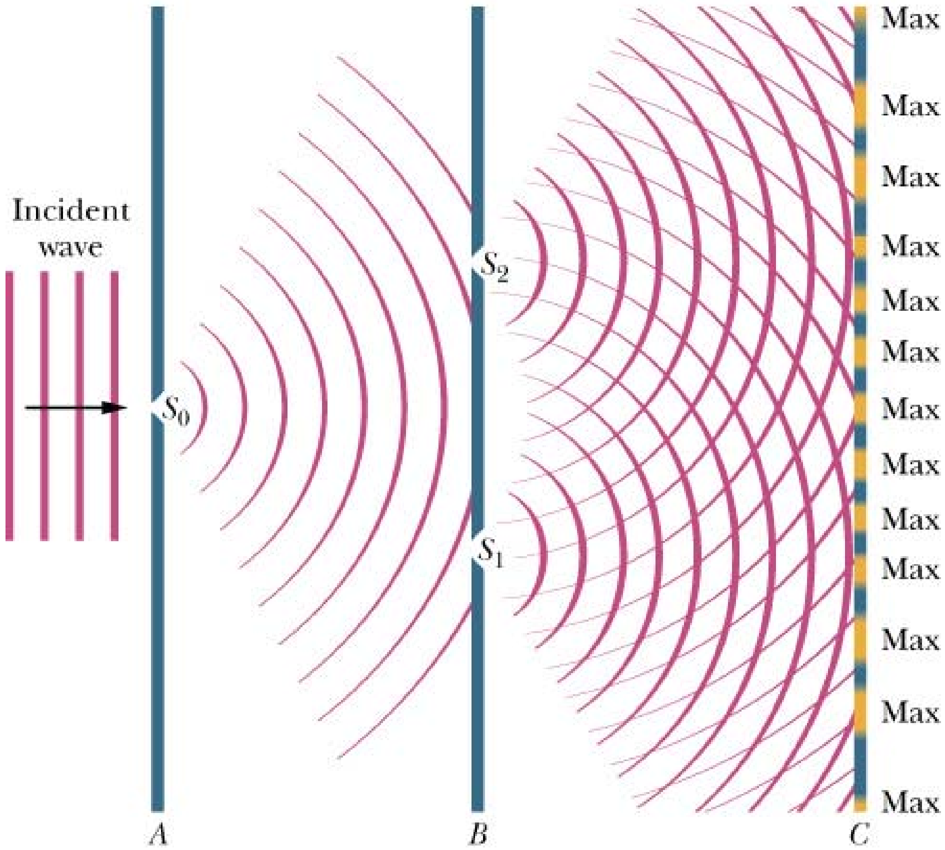
HRW, Fig. 36-8

Fringes



Young's Experiment

We can use a single slit to provide the input light to the double-slit.



HRW, Fig. 35-8

Young's Exp

$d \sin\theta = m\lambda$ Max. constructive interference, "bright spots or fringes"

$d \sin\theta = (m+½)\lambda$ Max. destructive interference, "dark spots or fringes"

(m = 0, 1, 2, … for both equations)

$I = I_m \cos^2\beta$ $\beta = (\pi d/\lambda) \sin\theta$. (Same result but different form than text.)

Small angle approximation: $\theta \approx \sin\theta \approx \tan\theta$.
So, for example: $d \sin\theta = m\lambda$ becomes $d\theta \approx m\lambda$.

Young's Experiment: The light is 632.8 nm and the screen is 40.0 m away. The distance between the bright fringes is 10.0 cm. Find: d.

So: λ = 632.8 nm, D = 40.0 m, Δy = 10.0 cm. Find d.

We need to get $\Delta y = y_{m+1} - y_m$:

$y_m = D \tan\theta_m \rightarrow y_m \approx D\theta_m$

$d \sin\theta = m\lambda \rightarrow d\,\theta_m \approx m\lambda$

$$
\begin{aligned}
\Delta y &= y_{m+1} - y_m \\
&= D(\theta_{m+1} - \theta_m) \\
&= D[(m+1)\lambda/d - m\lambda/d] \\
&= D\lambda/d
\end{aligned}
$$

Thus, $d = D\lambda/\Delta y$ ✓