PHY 1120 - Dr. Rowley

Chapter 27 - Wave Nature of Light

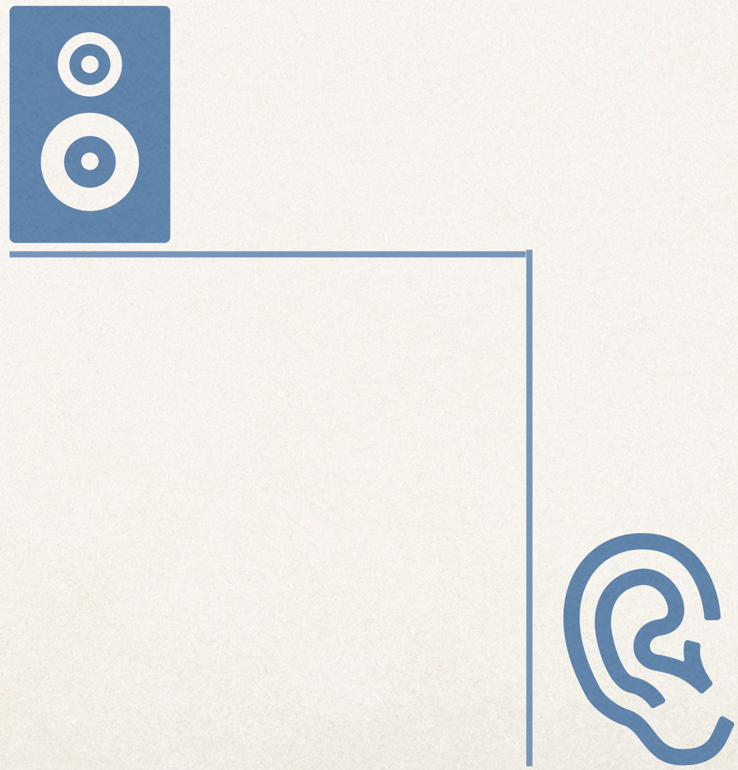
Summer 2020

Huygens' Principle

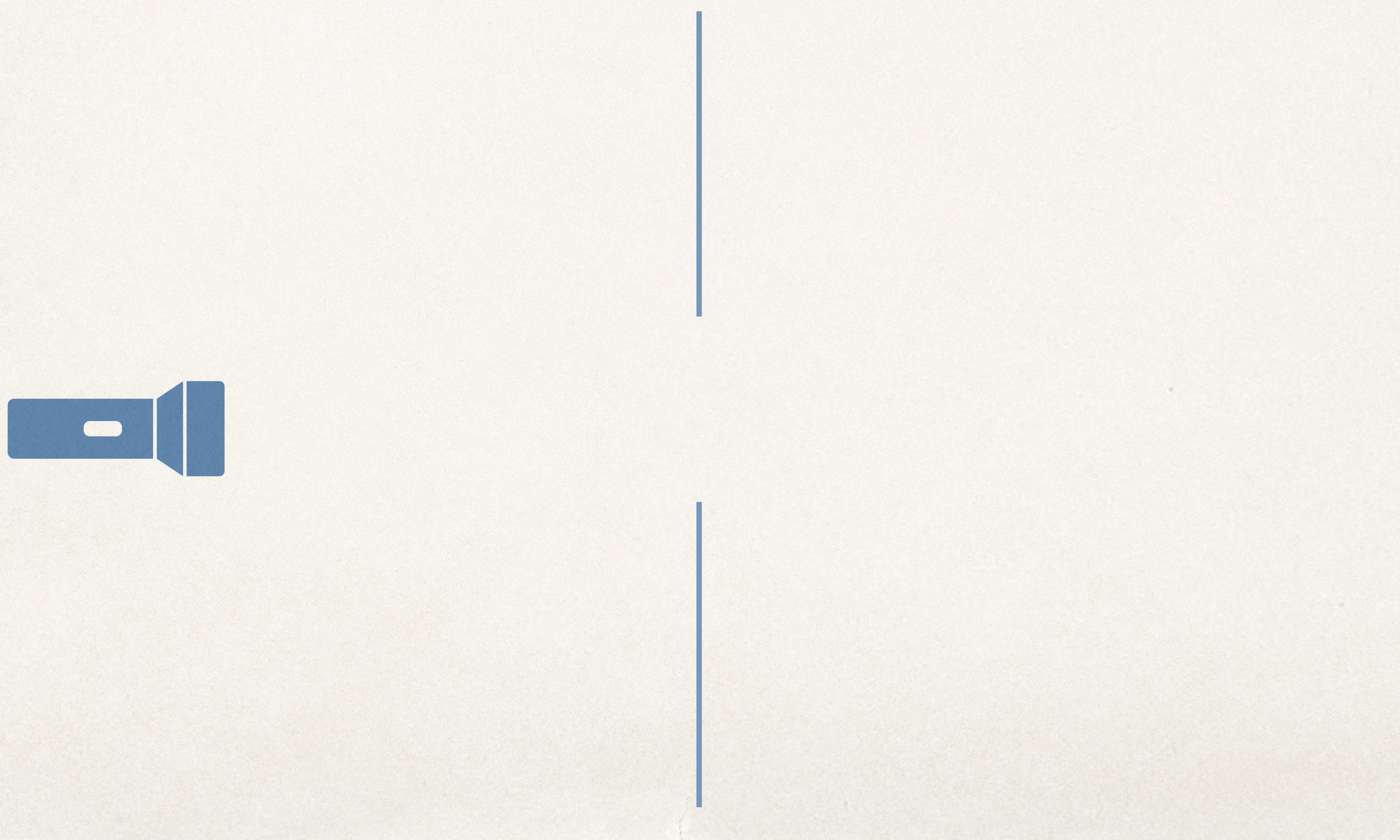
- *Every point on a wave front can be considered as a source of tiny wavelets that spread out in the forward direction at the speed of the wave itself. The new wave front is the envelope of all the wavelets (tangent to them all).*

Group Work: Huygens' Principle

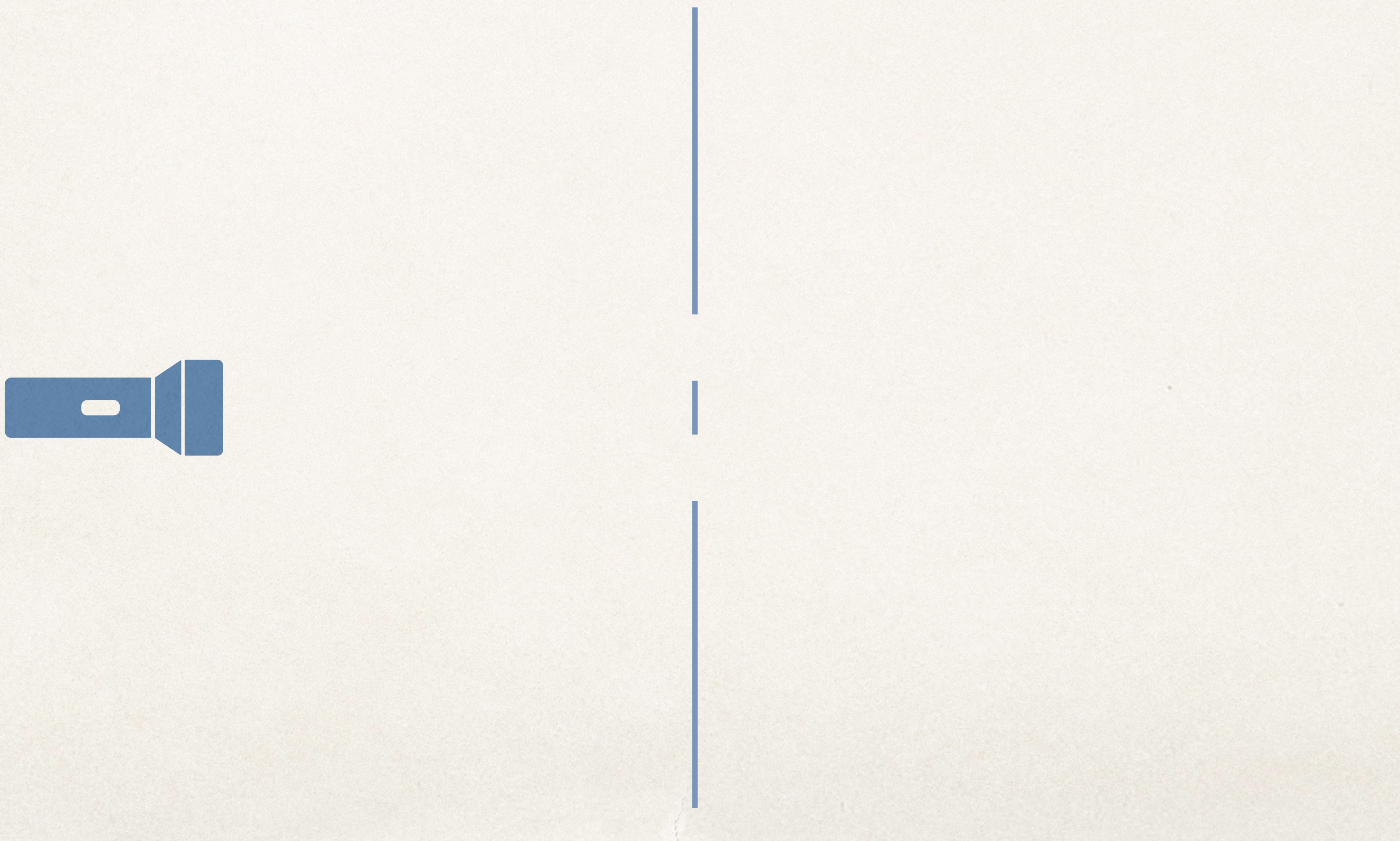
- Use Huygens' Principle to explain why you can hear music around a corner even if you can't see the speaker.



Light Behavior - Single Slit



Light Behavior - Double Slit



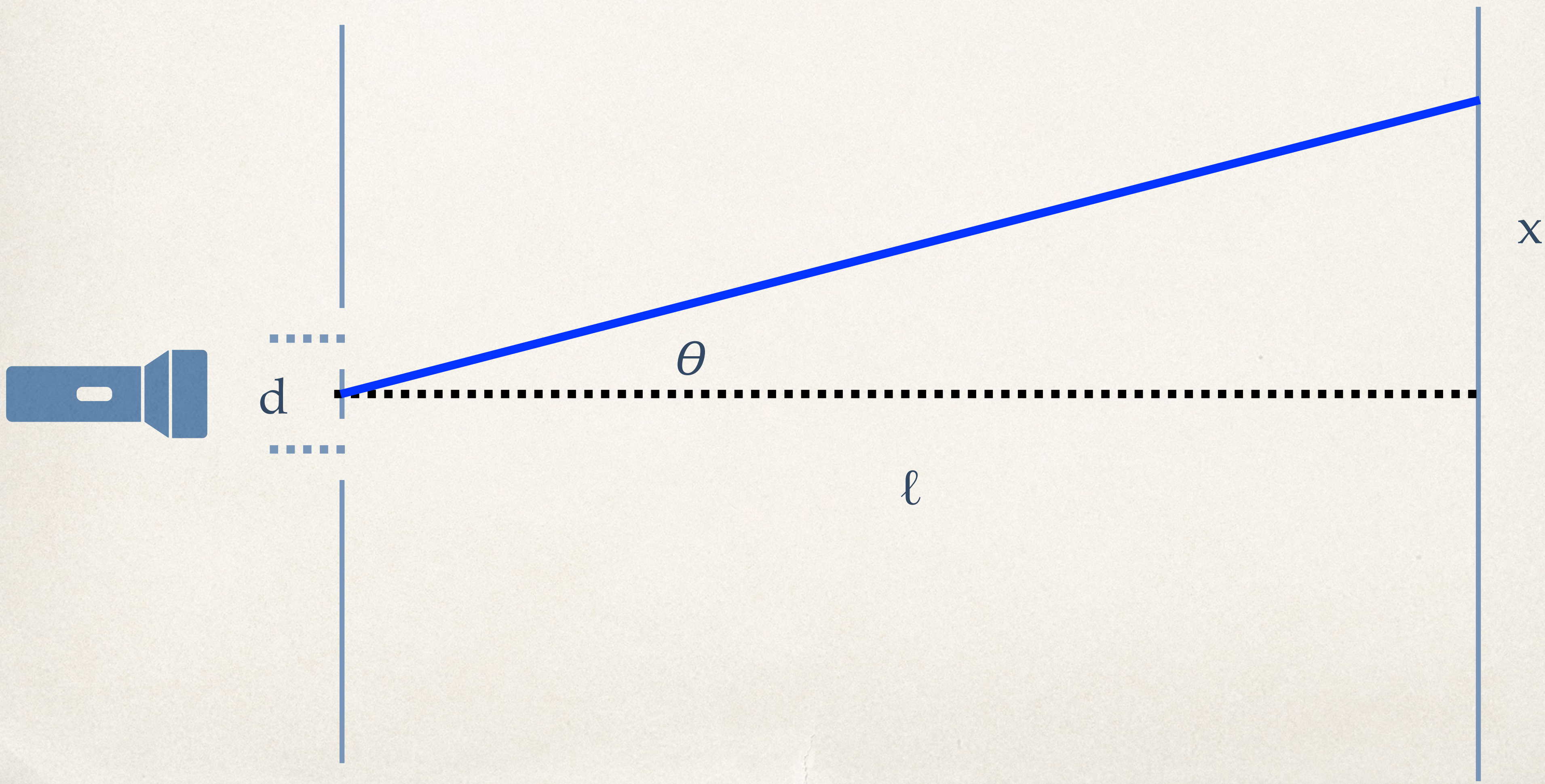
Key Assumptions

- Mono-Chromatic Light
- Waves hit the slit(s) at the same time
- θ is small. So, $\sin(\theta) \sim \theta$!

Types of Diffraction

- Young's Double-Slit
- Single-Slit
- Diffraction Grating
- Thin-Flim

Light Behavior - Double Slit



Young's Double Slit

- d = space between small slits
- θ = angle from mid-line to a point on the diffraction pattern
- λ = wavelength
- x = position of fringe above or below the mid-line
- ℓ = distance from double-slit to screen

$$\boxed{\begin{aligned} d\sin\theta &= m\lambda \\ d\sin\theta &= \left(m+\tfrac{1}{2}\right)\lambda \end{aligned}}$$

$$\boxed{\begin{aligned} x &= m\frac{\lambda\ell}{d} \\ x &= \left(m+\tfrac{1}{2}\right)\frac{\lambda\ell}{d} \end{aligned}}$$

Young's Double Slit

Constructive

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

Destructive

$$d\sin\theta = \left(m + \tfrac{1}{2}\right)\lambda$$

but, …

$$\sin\theta \approx \theta$$

$$d\theta = m\lambda$$

$$d\theta = \left(m + \tfrac{1}{2}\right)\lambda$$

but, …

$$\theta \approx \frac{x}{\ell}$$

$$d\left(\frac{x}{\ell}\right) = m\lambda$$

$$d\left(\frac{x}{\ell}\right) = \left(m + \tfrac{1}{2}\right)\lambda$$

Young's Double Slit

Constructive

$$d\left(\frac{x}{\ell}\right) = m\lambda$$

$$\boxed{x = (m)\frac{\lambda\ell}{d}}$$

Destructive

$$d\left(\frac{x}{\ell}\right) = \left(m + \tfrac{1}{2}\right)\lambda$$

$$\boxed{x = \left(m + \tfrac{1}{2}\right)\frac{\lambda\ell}{d}}$$

Young's Double Slit

$$\boxed{x = (m)\frac{\lambda \ell}{d}} \quad \boxed{x = \left(m + \tfrac{1}{2}\right)\frac{\lambda \ell}{d}}$$

- If I double the spacing between the slits what happens to the spacing between the 2nd and 3rd maxima?

decreases, d & x are inversely proportional

- If I double the wavelength in a double-slit experiment, what to the spacing between the 1st and 2nd minima?

increases, λ & x are directly proportional

Young's Double Slit

$$\boxed{x=(m)\frac{\lambda\ell}{d}}\quad\boxed{x=\left(m+\tfrac{1}{2}\right)\frac{\lambda\ell}{d}}$$

- Calculate the location of the first minima and maxima, on a screen 1.25 m away, for 5500Å light incident upon two, thin slits spaced 0.15 mm apart.

$$x=(m)\frac{\lambda\ell}{d}\qquad m=0\qquad x=(0)\frac{\left(5.5x10^{-7}m\right)\left(1.25m\right)}{\left(0.00015m\right)}\qquad x=0!$$

$$x=\left(m+\tfrac{1}{2}\right)\frac{\lambda\ell}{d}\qquad m=0\qquad x=\left(\tfrac{1}{2}\right)\frac{\left(5.5x10^{-7}m\right)\left(1.25m\right)}{\left(0.00015m\right)}$$

$$x=0.0023m$$