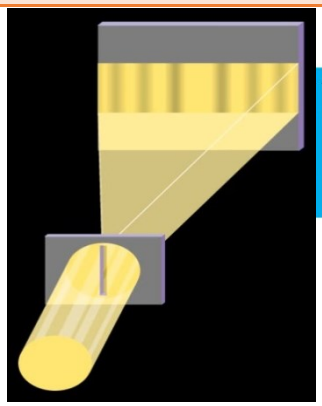
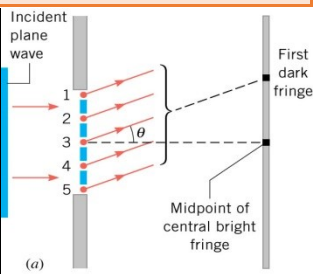
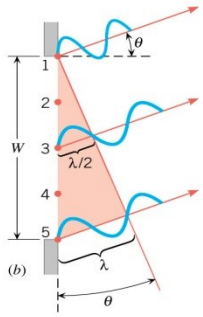
Physics 12-03 Single Slit Diffraction *Name:* _____

Single Slit Diffraction







- Large opening → _____ bend
- Small opening → _____ bend
- _____ slit produces a _____ pattern
- The _____ wavelets _____ with each _____
- The center _____ band is _____ width of the other _____.
- First order _____ band occurs when _____ edge and _____ edge _____ lengths differ by 1 wavelength.
- The _____ wave path length _____ by _____ wavelength leading to the _____ interference.
- The wavelet slightly _____#1 will cancel with wavelet slightly below _____ and so on.

For multiple dark fringes

$$\sin\theta = m\frac{\lambda}{W}$$

- Where θ = angle between wave and normal to slit, m = dark band order, λ = wavelength, W = width of slit

A laser shines through a single slit of width 3.25×10^{-6} m. The first order dark fringe is 10.2 cm from the center and the slit is 50 cm from the screen. What is the wavelength of the laser?

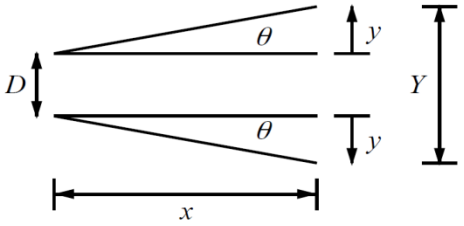
Limits of Resolution

- Light going through a _____ aperture has _____
  - Also true for light from _____ and _____
- 1st minimum at

$$\theta = 1.22\frac{\lambda}{D}$$

- Where θ is in _____, λ = wavelength, D = diameter of aperture, lens, mirror, etc.
- Two light sources are "_____" when one's _____ is at the 1st _____ of the other

(a) What is the minimum angular spread of a 633-nm wavelength He-Ne laser beam that is originally 1.00 mm in diameter? (b) If this laser is aimed at a mountain cliff 15.0 km away, how big will the illuminated spot be?



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Practice Work

1. As the width of the slit producing a single-slit diffraction pattern is reduced, how will the diffraction pattern produced change?
2. A beam of light always spreads out. Why can a beam not be created with parallel rays to prevent spreading? Why can lenses, mirrors, or apertures not be used to correct the spreading?
3. (a) At what angle is the first minimum for 550-nm light falling on a single slit of width 1.00 μm? (b) Will there be a second minimum? (OpenStax 27.43) **$33.4°$, No**
4. (a) Calculate the angle at which a 2.00-μm-wide slit produces its first minimum for 410-nm violet light. (b) Where is the first minimum for 700-nm red light? (OpenStax 27.44) **$11.8°$, $20.5°$**
5. (a) How wide is a single slit that produces its first minimum for 633-nm light at an angle of 28.0°? (b) At what angle will the second minimum be? (OpenStax 27.45) **1.35×10^{-6} m, $69.9°$**
6. (a) What is the width of a single slit that produces its first minimum at 60.0° for 600-nm light? (b) Find the wavelength of light that has its first minimum at 62.0°. (OpenStax 27.46) **693 nm, 612 nm**
7. Find the wavelength of light that has its third minimum at an angle of 48.6° when it falls on a single slit of width 3.00 μm. (OpenStax 27.47) **750 nm**
8. Calculate the wavelength of light that produces its first minimum at an angle of 36.9° when falling on a single slit of width 1.00 μm. (OpenStax 27.48) **600 nm**
9. The 300-m-diameter Arecibo radio telescope detects radio waves with a 4.00 cm average wavelength. (a) What is the angle between two just-resolvable point sources for this telescope? (b) How close together could these point sources be at the 2 million light year distance of the Andromeda galaxy? (OpenStax 27.57) **1.63×10^{-4} rad, 325 ly**
10. Diffraction spreading for a flashlight is insignificant compared with other limitations in its optics, such as spherical aberrations in its mirror. To show this, calculate the minimum angular spreading of a flashlight beam that is originally 5.00 cm in diameter with an average wavelength of 600 nm. (OpenStax 27.59) **1.46×10^{-5} rad**
11. A telescope can be used to enlarge the diameter of a laser beam and limit diffraction spreading. The laser beam is sent through the telescope in opposite the normal direction and can then be projected onto a satellite or the Moon. (a) If this is done with the Mount Wilson telescope, producing a 2.54-m-diameter beam of 633-nm light, what is the minimum angular spread of the beam? (b) Neglecting atmospheric effects, what is the size of the spot this beam would make on the Moon, assuming a lunar distance of 3.84×10^8 m? (OpenStax 27.61) **3.04×10^{-7} rad, 236 m**