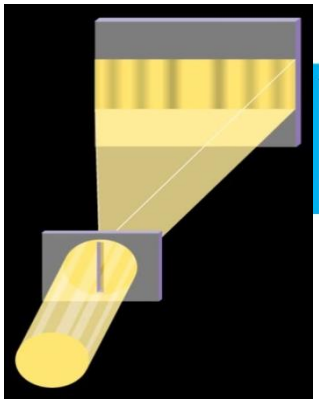
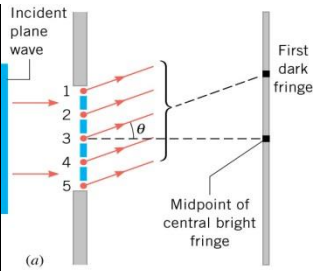
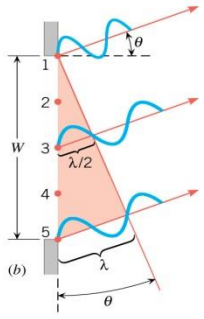
Physics 11-10 Single Slit Diffraction, Limits of Resolution, Thin Film Interference Name: _____

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?

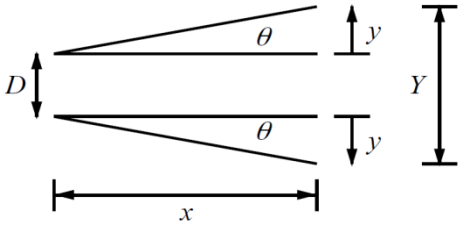
Limits of Resolution

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

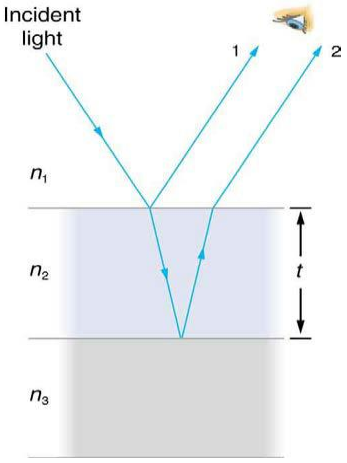
$$\theta = 1.22\frac{\lambda}{D}$$

- 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?



Thin Film Interference



- Light interference depends on the _____ of its _____ and the _____ size
- If the object is _____ the size of the wavelength, there will be _____
- Since each _____ of light is a different _____, light can be split using thin _____
- When light _____ from a medium having an _____ of refraction _____ than that of the medium in which it is _____, a _____ phase change (or a λ/2 shift) occurs
- The light hits the _____ surface.
  - Is it _____ shifted? Only if $n_2 > n_1$
- The transmitted light _____ off the _____ surface.
  - Is it _____ shifted? Only if $n_3 > n_2$
- _____ interference when
  - $\boldsymbol{2t = \frac{\lambda_n}{2}}$ if both rays 1 and 2 phase shift or $\boldsymbol{2t = \lambda_n}$ if only one ray phase shifts

- Where $\lambda_n = \frac{\lambda}{n_2}$
- _____ interference when
  - $\boldsymbol{2t = \lambda_n}$ if both rays 1 and 2 phase shift or $\boldsymbol{2t = \frac{\lambda_n}{2}}$ if only one ray phase shifts

An oil slick on water is 120 nm thick and illuminated by white light incident perpendicular to its surface. What color does the oil appear (what is the most constructively reflected wavelength), given its index of refraction is 1.40?

Homework

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. Is there a phase change in the light reflected from either surface of a contact lens floating on a person's tear layer? The index of refraction of the lens is about 1.5, and its top surface is dry.
4. In placing a sample on a microscope slide, a glass cover is placed over a water drop on the glass slide. Light incident from above can reflect from the top and bottom of the glass cover and from the glass slide below the water drop. At which surfaces will there be a phase change in the reflected light?
5. (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**
6. (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) **$11.8°$, $20.5°$**
7. (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, $69.9°$**
8. (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**
9. 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**
10. 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**
11. 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**
12. 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**
13. 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, 235 m**
14. A soap bubble is 100 nm thick and illuminated by white light incident perpendicular to its surface. What wavelength and color of visible light is most constructively reflected, assuming the same index of refraction as water? (OpenStax 27.70) **532 nm, Green**
15. Calculate the minimum thickness of an oil slick on water that appears blue when illuminated by white light perpendicular to its surface. Take the blue wavelength to be 470 nm and the index of refraction of oil to be 1.40. (OpenStax 27.72) **83.9 nm**
16. A film of soapy water (n = 1.33) on top of a plastic cutting board has a thickness of 233 nm. What color is most strongly reflected if it is illuminated perpendicular to its surface? (OpenStax 27.74) **620 nm, Orange**