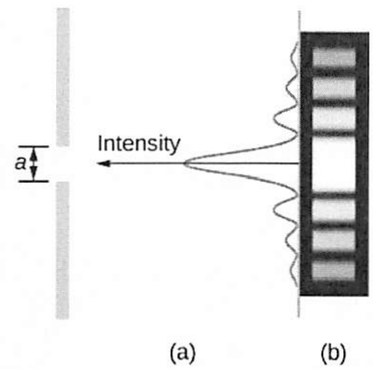
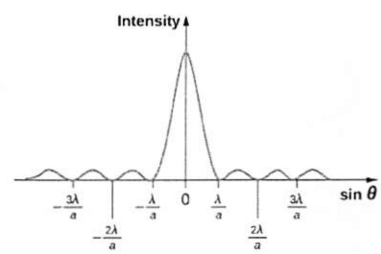
Suppose that light with wavelength λ passes through a *single slit* of width a. Much as in the case with interference, each point along the slit will become a new source of waves. This pattern is projected onto a screen. suppose we look at a position on the screen that is an angle θ away from passing straight through. Let's start by thinking about the case when $a\sin\theta = \lambda$. Light leaving the top of the slit and light leaving the middle of the slit will have a path length difference of $\frac{a}{2}\sin\theta = \frac{\lambda}{2}$ (because the distance from the top of the slit to the middle is $a/2$) and will interfere destructively. In fact, light from each point in the top half of the slit will interfere destructively with light from a point in the bottom half. This gives us the key to single slit diffraction: there will be destructive interference (an intensity minimum) whenever $a\sin\theta = m\lambda$ where $m = 1, 2, 3, \ldots$ but notably NOT 0.





Figures 4.3 and 4.5 from *OpenStax University Physics Volume 3.* Read for free at openstax.org.

A similar scenario happens with circular aperture diffraction. Light passes through a circular hole of diameter D. Diffraction will occur, with the first diffraction minimum occurring at an angle θ where $\sin\theta = 1.22\frac{\lambda}{D}$. Thus the diameter of the aperture puts a fundamental limit on our resolution: *Rayleigh's criterion* states that we lose the ability to distinguish between two objects when the diffraction minimum from one overlaps with the peak of the other, i.e. when they are this angle θ apart.

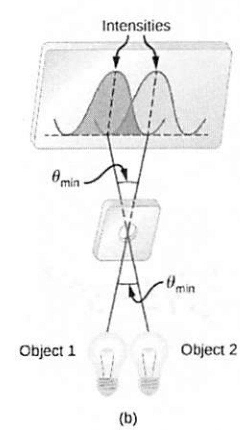
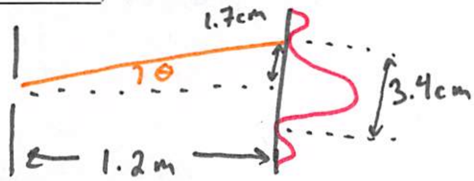


Figure 4.18 from *OpenStax University Physics Volume 3.* Read for free at openstax.org.

Light with a 400 nm wavelength passes through a single slit. On a screen that is 1.2 m away the width of the central peak is 3.4 cm (note: this is the distance between the first minimum on either side). How wide is the slit?



$$\tan\theta = \left(\frac{0.017\,m}{1.2\,m}\right) \rightarrow \theta = 0.8116^\circ$$

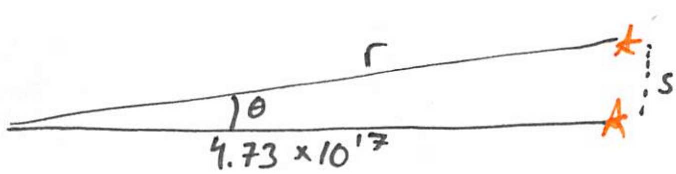
$$a \sin\theta = m\lambda$$

$$a = \frac{1 \cdot 400\times10^{-9}\,m}{\sin(.8116^\circ)} = 2.82\times10^{-5}\,m$$

$$a = 28.2\,\mu m$$

A telescope lens has a diameter of 0.56 m. Use 550 nm as the central wavelength of light. What is the minimum angle it can resolve? Suppose that a pair of binary starts is 50 light years (4.73×10^{17} m) away. What is the minimum distance between these stars that can be resolved? (Note: in the small angle approximation $\sin\theta \approx \tan\theta \approx \theta$ when measured in radians.)

$$\sin\theta \approx \theta = 1.22\,\frac{550\times10^{-9}\,m}{.56\,m} = 1.198\times10^{-6}\text{ rad}$$



$$s \approx \theta r$$

$$(4.73\times10^{17}\,m)(1.198\times10^{-6}\text{ rad}) = 5.67\times10^{11}\,m$$

minimum distance $\rightarrow$ 5.67×10^{11} m