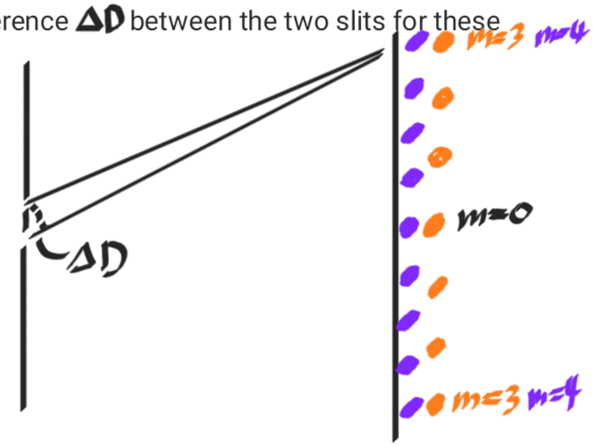
Double Slit 1 A double slit is illuminated simultaneously with light of wavelength 600 nm (orange/red) and light of an unknown wavelength. The m=4 bright fringe of the unknown wavelength overlaps the m=3 bright orange/red fringe. What is the unknown wavelength?

The location of these overlapping fringes is the same, so the path length difference ΔD between the two slits for these fringes is the same.

$$\Delta D = m\lambda$$
$$4\lambda_{unknown} = 3\lambda_{orange/red}$$
$$4\lambda_{unknown} = 3(600\,nm)$$
$$\lambda_{unknown} = 450\,nm$$

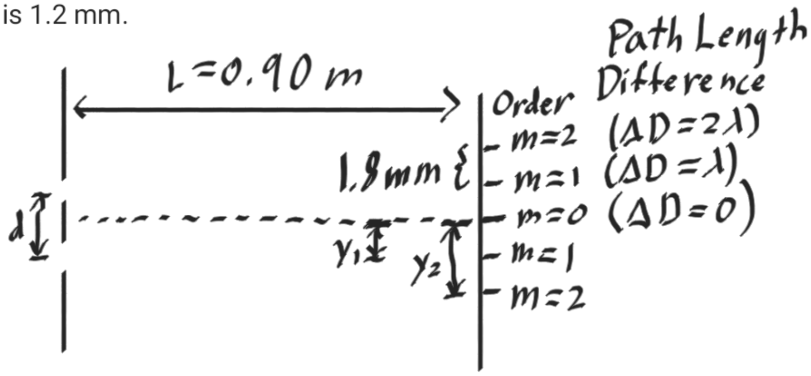


Double Slit 2 A double-slit experiment is performed with light of wavelength 600 nm. The bright interference fringes are spaced 1.8 mm apart on the screen. What will the fringe spacing be if the light is replaced with light of wavelength 400 nm?

For this situation, we can reasonably expect that the angle will be small, so we can use the small angle approximation form of the double slit equation for sites of constructive interference: $m\lambda = d\sin\theta_m \approx d\tan\theta_m = d\frac{y_m}{L}$. We are not given y_m, but instead the spacing between any two adjacent fringes. However, y_1 is equal to the distance from the central maximum to the first bright fringe, so we know that $y_1 = 1.8\,mm$, thus we have $\lambda = \frac{d}{L}y_1$, which tells us that fringe spacing is proportional to wavelength. If we multiply the wavelength by 2/3 (which is what we are doing by going from 600 nm to 400 nm), then we multiply the fringe spacing by 2/3.

$$\frac{d}{L}y_1 = \lambda \Rightarrow y_1 \propto \lambda \Rightarrow \frac{y_{1\,new}}{y_{1\,old}} = \frac{\lambda_{new}}{\lambda_{old}} \Rightarrow y_{1\,new} = \frac{\overbrace{\lambda_{new}}^{400\,nm}}{\underbrace{\lambda_{old}}_{600\,nm}} y_{1\,old} = \frac{2}{3}(1.8\,mm) = 1.2\,mm$$

The new fringe spacing is 1.2 mm.

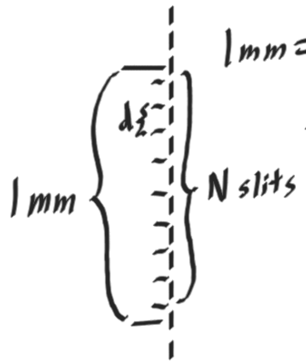


[0]Select problems may be modified from PH 212 course textbook; Knight Physics for Scientists and Engineers

"Diffraction" Grating 1 Light of wavelength 600 nm illuminates a diffraction grating. The second-order maximum is at angle 39.5°. How many lines per millimeter does this grating have?

$600\,nm = 0.6\,\mu m = 600\times10^{-6}\,mm$

The number of lines per millimeter is equal to the inverse of the slit spacing (see the accompanying diagram), so we can solve for slit spacing to find the number of lines per millimeter.



$1\,mm = dN$

$$\frac{N}{1\,mm} = \frac{1}{d}$$

$$d\sin\theta_2 = 2\lambda$$

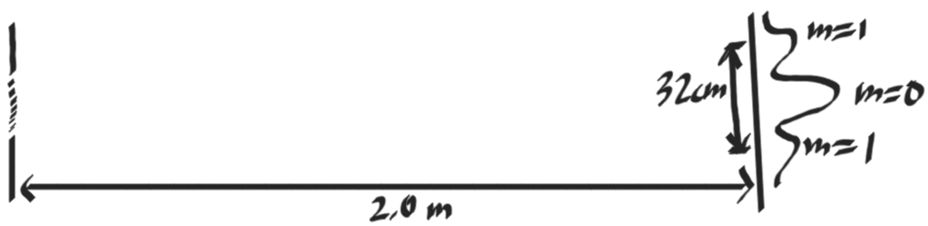
$$d = \frac{2(600\,nm)}{\sin(39.5^\circ)} \approx 1.9\,\mu m$$

$$\frac{1}{d} = \frac{\sin(39.5^\circ)}{1200\times10^{-6}\,mm} \approx \boxed{530\ \text{lines/mm}}$$

"Diffraction" Grating 2 A helium neon laser ($\lambda = 633nm$) illuminates a diffraction grating. The distance between the two m=1 bright fringes is 32 cm on a screen 2.0 meters behind the grating. What is the spacing between slits of the grating?

We are given the distance between non-adjacent bright fringes, so each of the $m=1$ fringes is 16 cm from the central fringe. We are in the realm of small angles, so

$$d\frac{y_1}{L} = \lambda \Rightarrow d = \frac{\lambda L}{y_1} = \frac{(633\,nm)(200\,cm)}{16\,cm} = 7912.5\,nm \approx 7.9\,\mu m$$



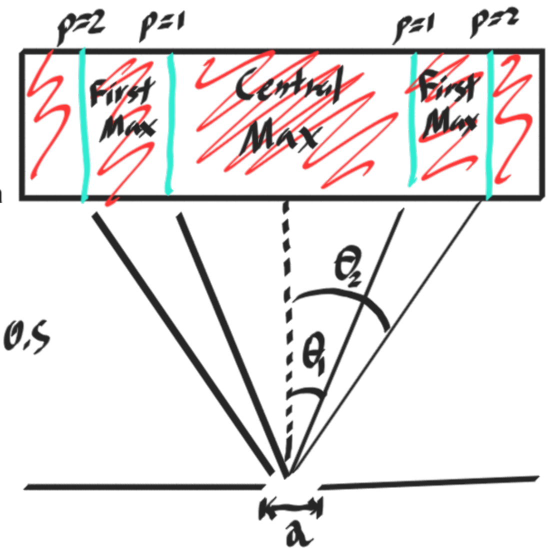
Diffraction 1 Calculate the wavelength of light that produces its first minimum at an angle of 36.9° when falling on a single slit of width 1 μm

The first minimum of a single slit diffraction pattern occurs at $p=1$ (there is a central maximum, so there is no zeroth-order dark fringe). We can calculate the dark fringes with the equation $a \sin\theta_p = p\lambda$, and we find for the first minimum that

$$\lambda = (1000\,\text{nm}) \sin(36.9^\circ) \approx 600\,\text{nm}$$

Diffraction 2 If a single slit produces a first minimum at 14.5°,
(a) What is the angular width of the central maximum?
(b) What is the angle of the second order minimum?
(c) What is the angular width of the first maximum?

Start by drawing a picture of the screen



The central maximum is the entire space between the first minima, so the angular width of the central maximum is twice the angle of the first minima from the center, or 29 degrees.

From $a \sin\theta_p = p\lambda$, we can see that

$$\frac{\sin\theta_1}{1} = \frac{\lambda}{a} = \frac{\sin\theta_2}{2} \Rightarrow \sin\theta_2 = 2\sin\theta_1 = 2\sin 14.5^\circ \approx 0.5$$

$$\Rightarrow \theta_2 = \underbrace{\arcsin}_{\substack{\text{also known} \\ \text{as} \\ \sin^{-1}}}(2\sin\theta_1) \approx 30^\circ$$

The angular width of the first maximum is the angle between the first and second minima, which is about 15.5 degrees.