Single-slit diffraction

1. BW.34.38. You are using light of wavelength $633\ nm$ to create a diffraction pattern with a slit of width $0.135\ mm$. How far away from the slit to you have to place the screen for the full width of the central maximum to be $5\ cm$?

Answer: $L = 5.3m$

2. HR.p.995. A slit of width a is illuminated by white light.

a) For what value of a will the 1st minimum for red light of wavelength $\lambda = 650\ nm$ appear at $15°$?

b) What is the wavelength λ' of the light whose 1st side diffraction maximum is at $15°$, thus coinciding with the 1st minimum for the red light?

Hint: assume 1st maximum approximately half-way between 1st and 2nd minimum.

Answer: *a)* $a = 2.5\ \mu m \cong 4\lambda$; *b)* $\lambda' = 433nm$

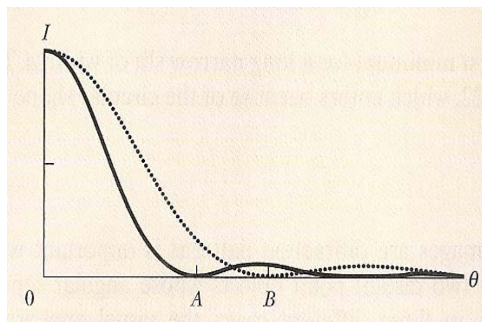
3. HR.p999. Two wavelengths, $\lambda_r = 650\ nm$ and $\lambda_v = 430\ nm$, are used separately in a single-slit diffraction experiment. The figure shows the result for the two different diffraction patterns.

If both wavelengths are then used simultaneously, what color will be seen in the combined diffraction pattern:

a. At angle A?

b. At angle B?

Answer: $a)\ red; b)\ violet$



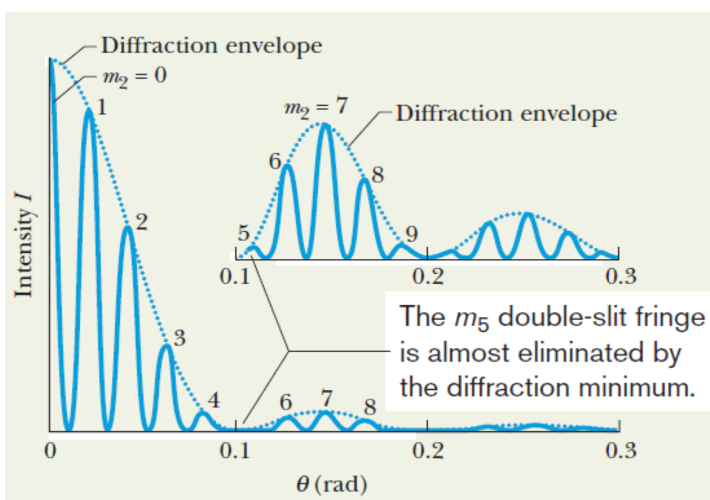
Double-slit interference and diffraction

4. HR.p1005. In a double-slit experiment, the wavelength λ of the light source is $405\ nm$, the slit separation is $19.44\ \mu m$, and the slit width is $4.05\ \mu m$. Consider the interference of the light from the two slits and also the diffraction of the light through each slit.

a) How many bright interference fringes are within the central peak of the diffraction envelope?

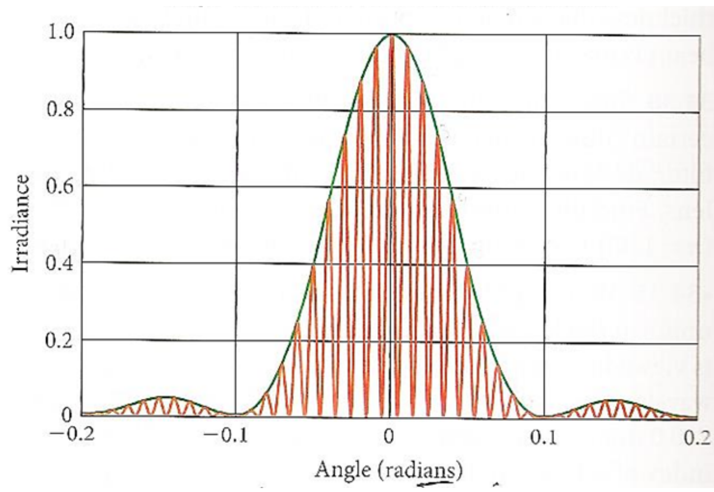
b) How many bright fringes are within either of the 1st side peaks of the diffraction envelope?

Answer: $a)\ N_1 = 9; b)\ N_2 = 5$

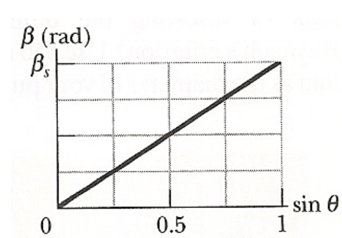


5. BW.34.48. A two-slit apparatus is covered with a red $(670\ nm)$ filter. When white light is shone on the filter, on the screen beyond the two slit apparatus, there are nine interference maxima within the $4.5\ cm$ wide central diffraction maximum.
When a blue $(450\ nm)$ filter replaces the red one, how many interference maxima will there be in the central diffraction maximum, and how wide will that diffraction maximum be?
Answer: $N = 4;\ w = 3.02\ cm$

6. BW.34.49. For the two-slit pattern in the figure:
a. Determine the slit width a in terms of the wavelength λ of the light used in the experiment.
b. Determine the center-to-center slit separation d in terms of wavelength λ.
c. Using the information in the graph, determine the ratio of slit width a to center-to-center separation between slits d.
d. Can you calculate the wavelength of light, actual slit separation, and slit width?
Answer: $a)\ a = 10\lambda; b)\ d = 100\lambda; c)\frac{a}{d} = 0.1$



7.HR.36.40. The figure gives the parameter β versus $sin\theta$ in a two-slit interference experiment using light of wavelength $435\ nm$. The vertical axis scale is set by $\beta_s = 80\ rad$. What are: a) the slit separation; b) the total number of interference maxima on both sides of the center; c) the smallest angle for a maxima, and d) the largest angle for a minimum? Assume that none of the interference maxima are completely eliminated by a diffraction minimum.
Answer: $a)\ d = 11.1\ \mu m; b)\ N = 51; c)\ \theta = 0°; d)\ \theta = 79°$



Diffraction grating

7. HR.p1011. A diffraction grating has $1.26\ 10^4$ rulings uniformly spaced over a width $w = 25.4\ mm$. It is illuminated at normal incidence by yellow light from a sodium vapor lamp. This light contains two closely spaced emission lines (known as the sodium doublet) of wavelength $589.00\ nm$ and $589.59\ nm$.
a. At what angle does the 1st order maximum occur (on either side of the center of the diffraction pattern) for the $589\ nm$ wavelength?
b. Calculate the angular separation between the two lines in the 1st order. Use SAA.
c. What is the least number of rulings a grating can have and still be able to resolve the sodium doublet in the 1st order?
Answer: $a)\ \theta = 0.29\ rad \cong 17°\ ;\ \ b)\ \Delta\theta = 3\ 10^{-4}\ rad = 0.017°;\ \ c)\ N = 999$

8. HR.36.51. A diffraction grating having *180 lines/mm* is illuminated with a signal containing only two wavelengths, $\lambda_1 = 400\ nm$ and $\lambda_2 = 500\ nm$. The signal is incident perpendicular to the grating.
a. Find the angular separation between the second order maxima of these two wavelengths. Use SAA.
b. What is the smallest angle at which two of the resulting maxima are superimposed?
c. What is the highest order for which maxima for both wavelengths are present in the diffraction pattern? Use $\theta = 90°$.
Answer: $a)\ \Delta\theta = 2.1°; b)\ \theta_{min} = 21°; c)\ m_{max} = 11$

9. HR.36.53. A diffraction grating has $350\ rulings/mm$ and is illuminated at normal incidence by white light. A spectrum is formed on a screen $30\ cm$ from the grating. If a whole of $10\ cm$ square is cut in the screen, its inner edge being $50\ mm$ from the central maximum and parallel to it, what the (a) shortest and (b) longest wavelength of the light that passes through the hole?
Answer: $a)\ \lambda = 470\ nm; b)\ \lambda = 560\ nm$