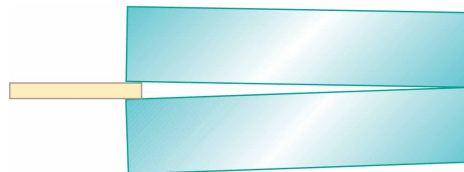


Physical optics

1. **Thin-film interference.** Suppose a wedge-shaped air film is made between two sheets of glass, with a piece of paper 7.618×10^{-5} m thick used as the spacer at their very ends. If light of wavelength 500 nm comes down from directly above, determine the number of bright fringes that will be seen across the wedge.

2. **Interference of light.** Light from a sodium lamp ($\lambda = 589$ nm) illuminates two narrow slits. The fringe spacing on a screen 150 cm behind the slits is 4.0 mm. What is the spacing (in mm) between the two slits?



3. **Single-slit diffraction.** A helium-neon laser ($\lambda = 633$ nm) illuminates a single slit and is observed on a screen 1.5 m behind the slit. The distance between the first and second minima in the diffraction pattern is 4.75 mm. What is the width (in mm) of the slit?

4. The diffraction pattern shown along the right side of the page is observed when a 633 ± 1 nm red laser pointer is passed through 2 parallel slits. The screen is placed 3.000 ± 0.002 m away from the slits. In the following figure, the central dots appear darker than the rest of the pattern since they are lot more luminous.

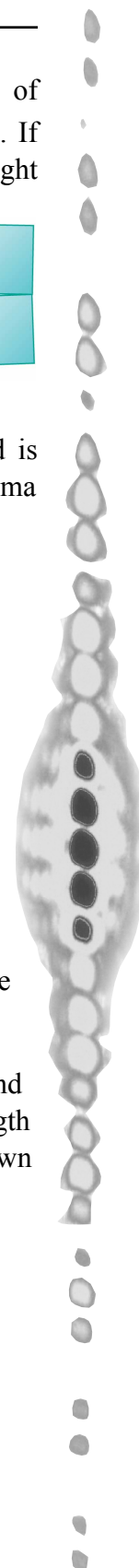
- a) (10 points) Using this pattern, calculate the distance between the two slits.
b) (5 points) Evaluate the uncertainty on your previous result.

5. **The Diffraction Grating.** The two most prominent wavelengths in the light emitted by a hydrogen discharge lamp are 656 nm (red) and 486 nm (blue). Light from a hydrogen lamp illuminate a diffraction grating with 500 lines/mm, and the light is observed on a screen 1.5 m behind the grating. What is the distance between the first order red and blue fringes?

6. A diffraction grating is illuminated simultaneously with red light of wavelength 660 nm and light of an unknown wavelength. The fifth-order maximum of the unknown wavelength exactly overlaps the third-order maximum of the red light. What is the unknown wavelength?

7. Light emitted by element X passes through a diffraction grating having 1200 lines/mm. The diffraction pattern is observed on a screen 75.0 cm behind the grating. Bright fringes are seen on the screen at distances of 56.2 cm, 65.9 cm, and 93.5 cm from the central maximum. No other fringes are seen.

- a) (10 points) Explain why only the value $m = 1$ is possible for each of these of these diffracted wavelengths?
b) (5 points) What are the wavelengths of light emitted by element X?



Answers

1. 305 bright fringes. (m starts at $m = 0$)
2. $d = 0.221$ mm
3. $a = 0.200$ mm
4. Using 5 dark fringes on each side to measure the dark fringes spacing with a ruler and taking an average gives 6.2 ± 0.2 mm. From this one can calculate a slit spacing of 0.31 ± 0.01 mm.
5. The blue fringe is 37.6 cm from the center, while the red is 52.1 cm, making the spacing between them 14.5 cm.
6. 396 nm
7. (a) the bright fringe at 56.2 cm must be a first order. Then, since $d \sin \theta = m \lambda$, if the second fringe was the second order of the first wavelength $\sin \theta_1 / \sin \theta_2 = 1/2$. However $\sin \theta_1 / \sin \theta_2 = 0.908$ and $\sin \theta_2 / \sin \theta_3 = 0.846$. They must all then be first order maxima.
(b) $\lambda_1 = 500$ nm, $\lambda_2 = 550$ nm, and $\lambda_3 = 650$ nm.