6.9 PROBLEMS

Problem 6.9.1. Two light waves of wavelengths 589 nm and 632.8 nm are incident on a single slit of width 1.2 μm. There is a screen 2 meters away. How far apart are the $m = 1$ bright spots for the two colors on the screen? Ans: approx. 15 cm.

Problem 6.9.2. A single slit is illuminated by two light waves of wavelengths 440 nm and an unknown λ such that the second diffraction minimum of 440-nm coincides with the third diffraction minimum for λ. Find the value of λ. Ans: $\lambda = 293.3\,\text{nm}$.

Problem 6.9.3. Two slits each of width 1200 nm and separated by the center-to-center distance of 1800 nm are illuminated by plane waves of a krypton ion laser emitting at wavelength 461.9 nm. Find the number of interference peaks in the central diffraction peak. Ans: 3.

Problem 6.9.4. Two slits each of width 1800 nm and separated by the center-to-center distance of 1200 nm are illuminated by plane waves from a krypton ion laser emitting at wavelength 461.9 nm. Find the number of interference peaks in the central diffraction peak. Ans: 1.

Problem 6.9.5. Prove that in a double-slit experiment if the width b and the center-to-center distance a are related by $a = pb$, then the number of peaks inside the central maximum of the diffraction peak is $2p + 1$.

Problem 6.9.6. A microwave of an unknown wavelength is incident on a single slit of width 6 cm. The angular width of the central peak is found to be 25°. Find the wavelength. Ans: $\lambda = 1.3\,\text{cm}$.

Problem 6.9.7. An infrared light beam of wavelength 1,152.2 nm from a helium-neon laser illuminates 2 cm of a diffraction grating with the unknown number of horizontal lines per unit length. It is found that the central peak has a half-width angle of 1.5×10^{-4} radians. Determine the total number of lines in 2 cm of the diffraction grating illuminated by the light beam. Ans: $6,667$. [Suggestion: Change to more realistic numbers: instead of 2 cm use 2 mm.]

Problem 6.9.8. Red light (wavelength 632.8 nm in air) from a helium-neon laser is incident on a single slit of width 0.05 mm. The entire apparatus is immersed in water of refractive index $\frac{4}{3}$. Determine the angular width of the central peak. Ans: 0.19 rad.

Problem 6.9.9. A light ray of wavelength 461.9 nm emerges from a 2 mm circular aperture of a krypton ion laser. Due to diffraction the beam expands as it moves out. How large is the central bright spot

at (a) 1 m, (b) 1 km, (c) 1000 km, and (d) at the surface of the Moon at a distance of 400,000 km from the Earth. Ans: (a) 0.28 mm, (b) 280 mm, (c) 280 m, (d) 112 km.

Problem 6.9.10. Determine the minimum number of lines per mm in the diffraction grating if the yellow doublet of sodium of wavelengths 589.0 and 589.6 nm can be resolved in the fourth order if the beam width is 2 mm? Ans: 123 per mm.

Problem 6.9.11. Determine the minimum number of lines per mm in the diffraction grating so that the mercury doublet of wavelengths 579 and 577 nm will be just resolved in the third order if the beam width is 5 mm?

Problem 6.9.12. How far apart must two objects be on the Moon to be distinguishable by eye if only the diffraction effects of the eye pupil limit the resolution? Assume 550 nm for the wavelength of light, the pupil diameter 5 mm, and 400,000 km for the distance to the Moon.

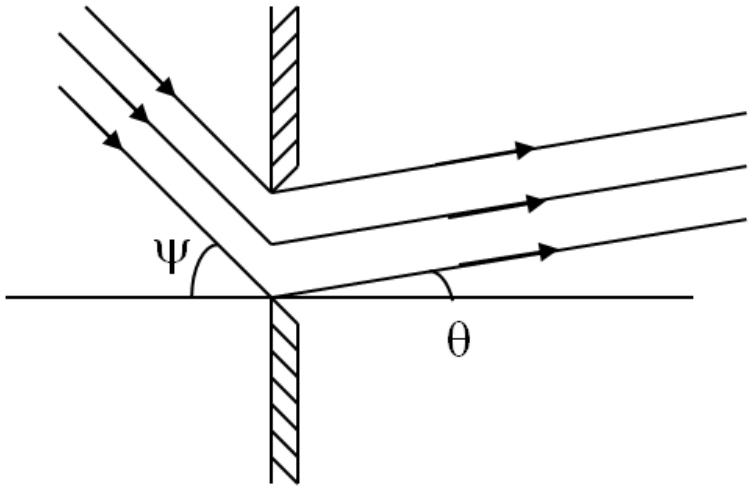
Problem 6.9.13. How far apart must two objects be on the Moon to be resolvable by the 200-inch diameter telescope at Mount Palomar observatory if only the diffraction effects of the telescope aperture limit the resolution? Assume 550 nm for the wavelength of light and 400,000 km for the distance to the Moon.

Problem 6.9.14. The Hubble telescope has an aperture diameter of 2.4 m and is approximately 600 km from the surface of the Earth. If the resolution is only limited by diffraction of the telescope aperture, what is the smallest separation between two points on the Earth that the Hubble telescope can resolve? Use 550 nm for light.

Problem 6.9.15. A spy satellite is reputed to be able to resolve objects 10 cm apart while operating 200 km above the surface of the Earth. What is the diameter of the aperture of the telescope if the resolution is only limited by the diffraction effects? Use 550 nm for light. Ans: 1.32 m.

Problem 6.9.16. If a diffraction grating can barely resolve the light waves of frequencies 5.085×10^{14} Hz and 5.093×10^{14} Hz in the first order. What is the resolving power of the grating in the first order?

Problem 6.9.17. Use the simpler method of finding diffraction minima in a single-slit diffraction to discover the condition for the minima when light is incident at an angle ψ rather than normally incident on the slit.



Problem 6.9.18. The sunlight containing light of wavelength from 390 nm to 780 nm is incident on a transmission grating containing 750 lines per mm. (a) What is the angular width of the $m = 1$ spectrum? (b) By explicitly working out the angular positions of the spectra determine whether the $m = 1$ and $m = 2$ spectra overlap. (c) By explicitly working out the angular positions of the spectra determine whether the $m = 2$ and $m = 3$ spectra overlap. Ans: (a) 17° to 35.8°. (b) and (c) Hint: $m = 2$ may not exist for some wavelengths.