4C Problem set 10 – Diffraction of a Single Slit and Diffraction-Interference of a Double Slit1

1. Light of wavelength λ is diffracted through a single slit of width a, and the resulting pattern is viewed on a screen a long distance L away from the slit. (a) Show that the width of the central maximum on the screen is approximately $2L\lambda/a$. (b) If a slit of width $2L\lambda/a$ is cut in the screen and is illuminated, show that the width of its central diffraction maximum at the same distance L is a to the same approximation.
2. A single slit is illuminated by light whose wavelengths are λ_a and λ_b, so chosen that the first diffraction minimum of λ_a coincides with the second minimum of λ_b. (a) what relationship exists between the two wavelengths? (b) do any other minima in the two patterns coincide?
3. Light from two identical line sources passes through a single slit of width a and then to a distant screen. The sources are a distance x from the slit and produce light of wavelength λ. What is the minimum separation distance between the line sources that will permit them to be resolved into two distinct diffraction patterns on the screen?
4. Suppose that the central diffraction maximum for two slits contains 17 interference fringes for some wavelength of light. How many interference fringes would you expect in the first secondary diffraction maximum?
5. Two coherent sources are located on the y axis at $+\lambda/4$ and $-\lambda/4$. They emit waves of wavelength λ and intensity I_o. Calculate the net intensity I as a function of the angle θ measured from the *+x-axis*.
6. You are told not to shoot until you see the whites of their eyes. If their eyes are separated by 6.5 cm and the diameter of your pupil is 5mm, at what distance can you resolve the two eyes using light of wavelength 550nm?
7. An interference pattern is produced by eight parallel and equally spaced, narrow slits. There is an interference minimum when the phase difference ϕ between light from adjacent slits is π/4. The phasor diagram is a regular octagon. For which pairs of slits is there totally destructive interference?
8. An astronaut in orbit can just resolve two point sources on the earth that are 75.0 m apart. Assume that the resolution is diffraction limited, and use Rayleigh's criterion. What is the astronaut's altitude above the earth? Treat her eye as a circular aperture with a diameter of 4.00 mm (the diameter of her pupil) and take the wavelength to be 500 nm.
9. A thin slit illuminated by light of frequency f produces its first dark band at $\pm \theta_1$ in air. When the entire apparatus (slit, screen and space in between) is immersed in an unknown transparent liquid, the slit's first dark bands occur instead at $\pm \theta_2$. Find the refractive index of the liquid.
10. Monochromatic light illuminates a pair of thin parallel slits at normal incidence, producing an interference pattern on a distant screen. The width of each slit is 1/7 the center-to-center distance between the slits. (a) which interference maxima are missing in the patterns on the screen? (b) Does the answer to part (a) depend on the wavelength of the light used? (c) Does the location of the missing maxima depend on the wavelength