Homework Set 4

Exercises; due Friday 9/25

E7. Describe a microwave detector (1 page essay).

E8. Single slit diffraction. Suppose the wavelength of light is λ and the width of the slit is w = 2 a. For what range of distance D from the slit will the Fraunhofer approximation be a good approximation?

Problems; due Monday 9/28

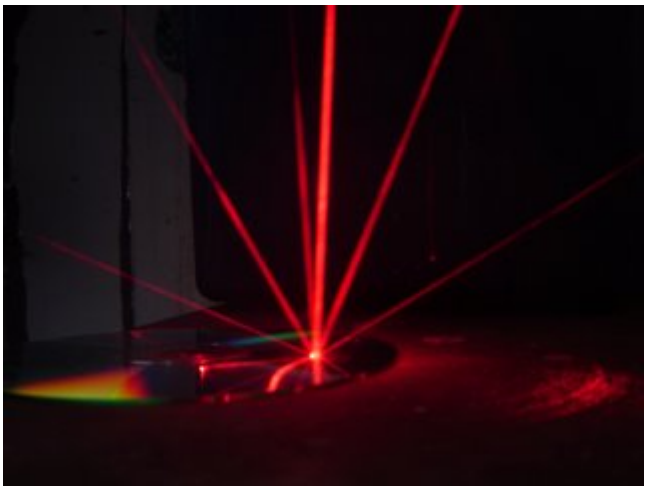
P17. A monochromatic beam of microwaves is incident on a metal foil. The foil is cut by a long narrow slit with width = 20 cm. A microwave detector far in back of the foil shows that there is minimum intensity at an angle θ = 36 degrees from a line through the center of the slit. Determine the wavelength of the microwaves.

P18. Diffraction from a knife edge. Consider coherent light incident normally on a knife edge. There is a diffraction pattern in the Fresnel Region. Use Mathematica to make a plot of the interference pattern of the diffracted light, for these parameters: wavelength = 550 nm; distance from the knife edge to the observation screen = 1 meter.

P19. The MSU Observatory has a 24–inch diameter telescope. Determine the minimum angle between two distant point sources of light (λ = 550 nm) that can be resolved by the telescope. (limited only by diffraction) Determine the minimum distance between two points on the moon that can be resolved by the telescope.

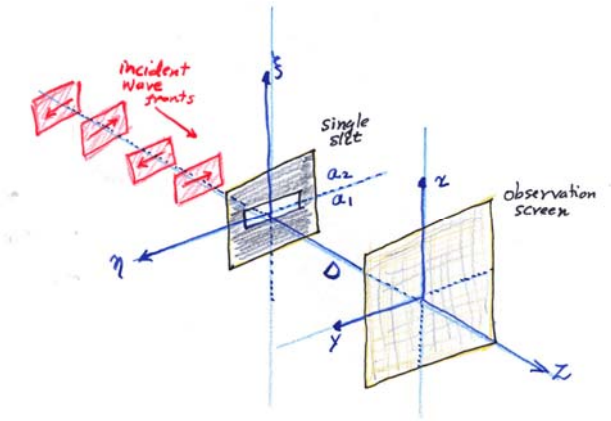
P20. Determine the minimum angle between two distant point sources of light (λ = 550 nm) that can be resolved by the naked eye (limited by diffraction only). Assume that the pupil diameter is 3 mm. Determine the minimum distance between two points on the moon that can be resolved by the naked eye.

P21. Young's type interference can be seen with a CD, in which the pits act like the lines of the diffraction grating. The photograph shows incident laser light (strong vertical beam) striking a CD and producing antinodal lines. The zero, first and second-order lines can be seen very clearly. If light of λ=632 nm is incident on a CD, and the distance between the two first-order fringes (i.e., n=1 and n = -1) is 98.4 cm on a screen 1.20m from the CD, calculate the distance between pits.



Examples of Fresnel Diffraction

Single slit diffraction



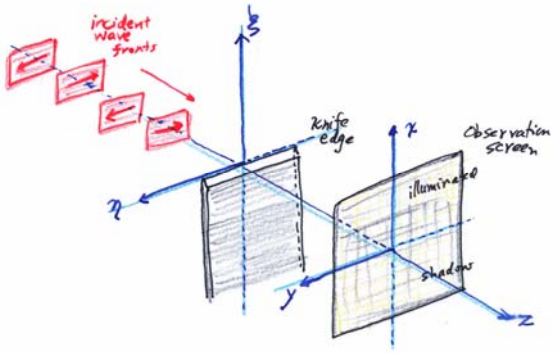
$$\text{Intensity} = I_0 \frac{R^2(x)}{R^2(0)}$$

$$R^2(x) = \left(C[q(x-a_2)] - C[q(x-a_1)]\right)^2 + \left(S[q(x-a_2)] - S[q(x-a_1)]\right)^2$$

where $q = \sqrt{2/(\lambda D)}$

Diffraction from a knife edge

Same formulas with $a_1 = 0$ and $a_2 = \infty$.



Note that $C(-\infty) = S(-\infty) = -0.5$
and $C(+\infty) = S(+\infty) = +0.5$.
Thus,

$$Intensity = I_\infty \frac{R^2(x)}{R^2(\infty)} = \frac{1}{2} I_\infty R^2(x)$$

$$R^2(x) = \left(0.5 + C(qx)\right)^2 + \left(0.5 + S(qx)\right)^2$$