

HW12 Ch 9:27 (repeat for light incident at 30°),34,36 (note: each of these three is simple enough that you should be able to solve with lecture notes...use the text's equations to check your thinking.)

P12A.

1. Use eq 9.97 and 9.104 to show that for a double $\lambda/4$ layer on a substrate and normal incidence

$$R = \left(\frac{n_2^2 n_0 - n_s n_1^2}{n_2^2 n_0 + n_s n_1^2} \right)^2 \quad (\text{eq 9.105}).$$

2. If $n_s=1.5$ (common glass), and you have a choice of the common coating materials: ZnS ($n=2.32$), CeF ($n=1.63$) and MgF ($n=1.38$), find the *lowest* R possible.

3. If you design your coating for $\lambda=550$ nm, in the middle of the visible range, R above will be true only for that wavelength for two reasons: the index changes slightly with λ , but more importantly, the thicknesses will not be $\lambda/4$ for other wavelengths. Ignore the index change with λ and plot on the computer (Maple, Matlab, Mathematica) $R(\lambda)$ for 400 to 700 nm (visible range) for your choice of materials for the double coating in 2), but do it for 2, 4, and 8 total layers. (Note: once you've chosen the thicknesses of your H and L layers in part 2), only k_0 (vacuum value of k) will vary with λ in eq 9.91.)

HW13: 10.2

and

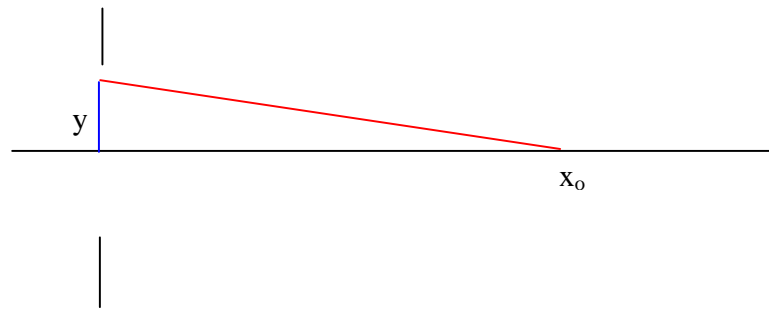
Problem 13A: Fraunhofer vs Fresnel diffraction.



- a) For an aperture of radius a , find the path length difference ΔL between the light reaching P from the point at the edge (at a) vs from the center (at 0), using the binomial approximation and $L \gg a$.
- b) Show that the boundary $L > \frac{a^2}{\lambda}$ (which puts us in the Fraunhofer regime) is the same as saying ΔL is small enough (because L is long enough) that *less than one Fresnel zone fills the aperture*, i.e. that a does not reach the edge of the first zone.

Problem 13B: Fresnel zones for a long slit

Fresnel diffraction for a very long slit can also be described in zones. Imagine a screen at x_0 from the slit, which runs out of the page in the z direction. We illuminate the aperture of width $2a$ with plane waves, so there is not phase variation in the Huygens “emitters” in the aperture.



- a) Assuming $x_0 \gg y, a$, write equations for the positions y_m of the outside edge of m th zone in terms of x_0, λ
- b) Unlike in circular apertures, where the *areas* of the circular zones helps determine the contribution from each zone, in this essentially one-dimensional problem, we find the *width* w of each zone.

For the first 10 zones, make the following table, assuming $x_0 = 100\lambda$:

m	y_m	θ_m	K_m	r_m	w_m	Contribution

θ_m is the angle of the boundary y_m , seen from x_0

K_m is the average obliquity factor for the m 'th zone (use the average angle for the zone)

r_m is the average distance from the m th zone to x_0 , which decreases strength for a spherical wave

$w_m = 2(y_m - y_{m-1})$, is the width of the m th zone.

$$\text{Contribution} = \frac{w_m K_m}{r_m}$$

Now sketch a vibration curve for the Fresnel diffraction at x_0 , similar to fig. 10.40 for an aperture opening up to expose these 10 zones. The “contribution” from each zone is proportional to the *vertical change* during each half turn, as shown by the Z points in the figure, and will determine how fast this spirals in.

- c) Which of the contribution factors determines most how fast it spirals? (This is not the same for circular case).
- d) Find the intensity of light when m zones fill the aperture, in terms of the incident intensity I_0 , for $m = 1..10$.

Lab 13. Create a source of unknown elliptical polarization by reflecting a linearly polarized laser beam (with equal s and p-components by polarizing it at 45 degrees) from a metal mirror with a large incident angle (i.e. $\theta_i > 80^\circ$). Use a quarter-wave plate and a polarizer to determine the Jones vector of the reflected beam. Find the helicity (right or left handed), and the orientation of the major axis.

Solution notes: There are two unknowns if you normalize the Jones vector: A/B and phase ϵ . You should be able to get two equations from the condition that the final Jones vector is $(0 \ 0)$.

See video at optics.byu.edu/video/ellipola.mov

H14 Ch 7: 38, 44 Ch 11: 8,11,14 (read Ch11.2.1 as I mistakenly left it off the reading for last lecture)
Notes:

- 1) on 7.38, use the complex formalism of Ch 11. Write $\cos \omega_p t$ in terms of complex exponentials, and simplify your result until you see the sinc function. Explain how this satisfies the carrier frequency – envelope principle we discussed in class.
- 2) on 11, you can ignore the fancy definition of the “shutter” or “top hat” function, called a rect function here. It’s simply given by the drawing. Your result should agree with the principle in #14...should be able to write in terms of a sinc function times a linear phase term like $C\kappa$, where C is a constant

H15 Ch11:15, 22,26 (also find the FT of this convolution if the square pulse has height A), 30.

P15. Fraunhofer diffraction and Fourier transforms.

$$E_{screen}(\theta_y, \theta_z) \approx C \iint_{aperture} E(y, z) e^{-ik(y\theta_y + z\theta_z)} dydz. \quad C \text{ is a constant.}$$

- a. Slit diffraction. Find $E(\theta_x)$ for an infinitely tall vertical slit of width a centered at the origin, illuminated uniformly, $E(x') = 1$ over the slit and zero outside the slit (set $C = 1$). Plot $E(\theta_x)$ vs θ_x from -0.1 to 0.1 radians, for the case $a = 50\lambda$. Note that because the slit is infinitely tall and illuminated the same at all y 's, the answer cannot depend on y . You will see this in the math by showing that the integral in y gives you a delta function with only one vertical angle allowed: zero. The slit can't change the vertical angle of any photon encountering it. For the purposes of plotting, ignore the delta function, and just plot the one dimension.
- b. Rectangular aperture. Find $E(\theta_x, \theta_y)$ for an aperture of vertical height b and horizontal width a (set $C = 1$). Plot $E(\theta_x, \theta_y)$, θ_x in radians, for the case $a = 50\lambda$, $b=3a$. You can use Maple plot3d function:

```
plot3d(E(tx,ty),tx=-0.1..0.1,ty=-0.1..0.1,grid=[50,50]);
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