Homework for General Physics II set 2

(Hecht's book is referring to his 4th edition, pdf or djvu provided last semester)

1. Hecht's book, problem 10.8

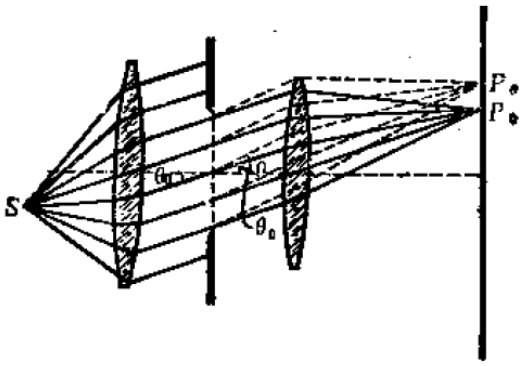
2. (Modified Hecht's 10.14) Show that If the incoming light is a plane wave normal to the diffraction screen Fraunhoffer diffraction pattern (light intensity) on the observing screen has a center of symmetry, $I(x', y') = I(-x', -y')$; x' and y' are coordinates of the observing screen; regardless of the configuration of the aperture as long as there are no phase variations in the field over the region of the hole. This restriction is equivalent to saying the aperture function is real. (In short, this problem asks you to prove for any real aperture functions, and normal illumination the F-diffraction pattern has center of symmetry)

3. For a single slit (in 1-D) with opening width of 3*a*, you should be able to write out the field distribution on observing screen for Fraunhoffer diffraction; Now consider we insert an **opaque block** with width *a* at the center of the original slit (this will block 1/3 of the original slit), please prove that the F-Diffraction pattern for the blocked slit is in form of $I(\theta) = I_0(\frac{\sin\alpha}{\alpha})^2 \cos^2 2\alpha$, $\alpha = \frac{\pi a \sin\theta}{\lambda}$.

Of course I will prove this in multi-slits diffraction, but here I'd like you to work it out with the knowledge of the single slit diffraction formula. Hint: Thinking the following questions: what is the field distribution U_1 on the observing screen that is just for the slit with 3*a* width? What is the field distribution U_2 which is for a slit with width *a*? Then what is the field of blocked slit ? Knowing the field, I am sure you can find the intensity. (Noticed here too superposition of the field not the intensity)

4. For an opening slit with width *a*, we cover the opened part with an absorbing material which will change the amplitude of the illuminating field by $t(x) = \cos(\frac{\pi}{a}x)$, x=0 is the center of the slit. The incoming light is a plane wave with wavelength λ at normal angle. What is Fraunhoffer diffraction pattern on the observing screen? Write out the field distribution first and then intensity on the observing screen. Please also make a sketch of the field distribution for this slit and compare it with the single open slit.

5. Zhao's book, problem 1, pg 224. (the single slit Fraunhoffer diffraction illuminated by a inclined plane wave, i.e the incoming light is a plane wave, but its direction has an angle θ with respect to the normal of the single slit diffraction screen, find the expression for the Fraunhoffer diffraction pattern)



1. 如图，平行光以 θ_0 角斜入射在宽度为 a 的单缝上，试证明：

(1) 夫琅和费衍射的强度公式基本不变(忽略倾斜因子)，即

$$I_\theta = I_0\left(\frac{\sin\alpha}{\alpha}\right)^2,$$

式中 I_0 为零级中心强度，只不过 α 的定义与正入射不同：

$$\alpha = \frac{\pi a}{\lambda}(\sin\theta - \sin\theta_0);$$

(2) 零级中心的位置在几何光学像点处；

(3) 零级斑半角宽度为

$$\Delta\theta = \frac{\lambda}{a\cos\theta_0}.$$

6. Hecht's book, problem 10.27 （You will need conditions in his problem 10.26, which is take the wavelength of visible light as 550nm; For human eye with 4.0 mm pupil, the angular resolution limit due to diffraction is $1.7\times10^{-4}rad$. ）

7. Hecht's book, problem 10.28