University of Calgary
Winter semester 2007

PHYS 471: Optics

Homework assignment 5

Due March 28, 2007

Problem 5.1. A thin symmetric biconvex lens touches a thin symmetric biconcave lens in the center. Newton rings are observed in reflection. Find the focal length F of this system of lenses if the radius of the 5th bright ring equals $r = 2$ mm. The wavelength is $\lambda = 600$ μm, index of refraction $n = 1.6$. Estimate the maximum allowed linewidth $\Delta\lambda$ of the light source with which such an observation is possible.

Problem 5.2. A plane wave of wavelength λ is incident on a slit of width a. The slit is covered by two glass plates of width $a/2$ and thickness h with indices of refraction n_1 and n_2 and intensity transmission coefficients τ_1 and τ_2. Find the intensity distribution in the Fraunhofer diffraction pattern observed in the focal plane of a lens of focal length f. Under which condition will there be a dark fringe in the center of the pattern?

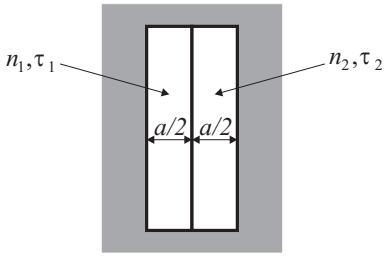

Figure 1: diagram for Problem 5.2

Problem 5.3. A plane wave is incident on a blazed reflection grating with a profile shown in Fig. 1. Find the intensity distribution in the Fraunhofer diffraction pattern (in terms of the diffraction angle θ), plot it and find the condition under which the first diffraction order is enhanced due to blazing. **Hint:** use the Fourier transform of a convolution.

Problem 5.4. A phase grating is made of a glass plate whose thickness is modulated as $d = d_0 + h\cos(2\pi x/b)$, where b is the grating period and $h \ll \lambda$ is the modulation depth. Find the intensity distribution in the Fraunhofer diffraction

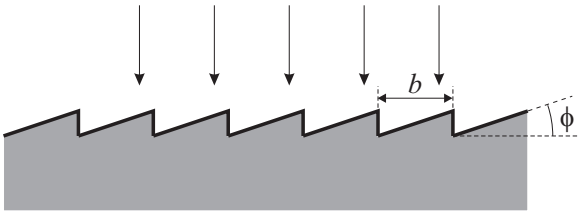

Figure 2: diagram for Problem 5.3

pattern in terms of the diffraction angle θ. How many diffraction orders are there?

Problem 5.5. A flat parallel glass plate with the index of refraction n contains a round hole whose diameter equals that of the first Fresnel zone for some point P lying on the system's axis. Find the thickness h of the plate at which the intensity I at P is maximized. Find $I_{\max}$ if the intensity of unobstructed light is I_0. The wavelength is λ.

Assume normal incidence in all problems.