NATIONAL TECHNICAL UNIVERSITY OF ATHENS

SCHOOL OF ELECTRICAL & COMPUTER ENGINEERING

DIVISION OF ELECTROMAGNETIC APPLICATIONS, ELECTRO-OPTICS & ELECTRONIC MATERIALS

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OPTICAL ENGINEERING

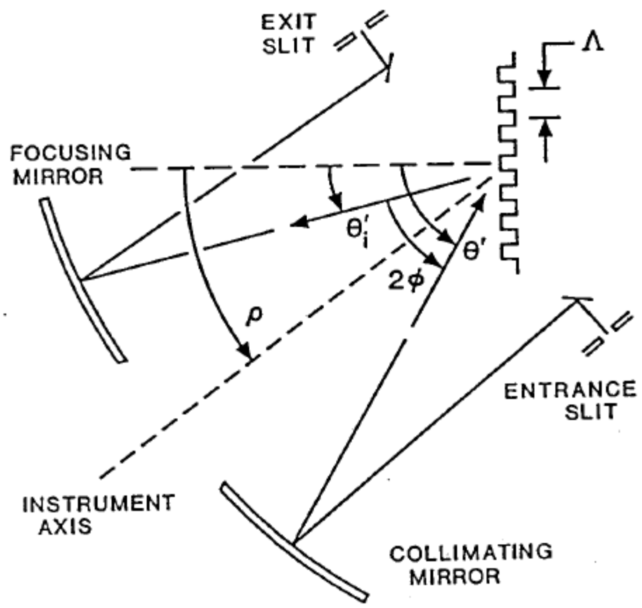
Problem Set No. 5

Due Date: For practive only

Problem 1 (Czerny-Turner Monochromator): [0%]

A monochromator selects out a single wavelength from a light beam. To accomplish this, the light must be dispersed into its component colors. The dispersive element could be a prism or a grating. In a Czerny-Turner monochromator, a planar metallic reflection grating serves this role. A Czerny-Turner monochromator is shown in the figure below. To select a particular wavelength to be diffracted to the exit slit, the grating is rotated about a vertical axis. The rotation angle of the grating *(p)* is the angle between the normal to the grating (long dashed line) and the axis of the instrument (short dashed line) as given by the bisector of the mirror-grating-mirror angle, (2φ), also known as the Ebert angle.

In a particular commercial Czerny-Turner monochromator, the grating is specified as having 1200 grooves/mm. This corresponds to 1200 periods/mm and is equivalent to $1/\Lambda$. This monochromator has an Ebert angle of $2\varphi = 9.2°$ and is filled with air. It operates in the first diffracted order. For a grating rotation of $\rho = 17.5158°$, calculate, showing all work, the wavelength (in nanometers) of the light passing through the exit slit of the monochromator. For this grating rotation angle, calculate, showing all work, the angular dispersion (in nanometers per degree, $d\lambda_0/d\rho$) of the light passing through the exit slit of the monochromator. (This problem was originally created by Prof. T. K. Gaylord, of Georgia Tech, USA)



Problem 2 (Grating Diffraction): [0%]

An unslanted grating has a period $\Lambda = 5\mu m$, and an average refractive index of $n_0 = 2.0$. Its thickness is 250μm. The grating is illuminated in air by a 2mW He-Ne laser beam (of freespace wavelength $\lambda_0 = 0.6328\mu m$) at an angle of incidence of 20 deg. (a) Determine the Bragg angle in air an inside the grating region. (b) Determine the diffraction angles of -2, -1, 0, +1, +2 forward diffracted orders. (c) Determine the largest posiive forward diffracted order that could carry power into the forward direction.

Problem 3 (Fourier Transform of a Rectangular Aperture): [0%]

A rectangular opening of dimensions a × b ($-a/2 < x < a/2$, $-b/2 < y < b/2$) is placed at the first focal plane of a spherical thin lens. Calculate and plot the light intensity ($I = |E|^2$) that exists at the second focal plane of the thin lens when the aperture is illuminated by a plane wave traveling parallel to the lens axis.

Problem 4 (Edge Fresnel Diffraction): [0%]

(a) A plane wave of freespace wavelength $\lambda_0 =$ 589nm is incident on a opaque edge from left to right as it is shown in the figure below. The wave diffracts (in the Fresnel diffraction region) and the diffraction fringes are evident on the screen that exists at a distance q = 120cm. Determine the light intensity ($I = |E|^2$) (normalized to I_u, which is the intensity without the edge) at points z_1 = 1mm and z_2 = -2mm. (b) Instead of a plane wave the light from a slit is used at position A that is illuminated by monochromatic light of freespace wavelength λ_0 = 589nm (the slit becomes a source of spherical waves emanating from point A) while the edge is at a distance p = 60cm. Again the spherical wave diffracts (in the Fresnel diffraction region) and the diffraction fringes are evident on the screen that exists at a distance q = 120cm. Determine again the light intensity ($I = |E|^2$) (normalized to I_u, which is the intensity without the edge) at points z_1 = 1mm and z_2 = -2mm.