Start each problem on a new sheel of paper.

(1) Consider a single-layer reflectance-reducing coating made of MgF_2 on glass. The glass has a refractive index of 1.61. The index of MgF_2 is 1.38. The coating is designed to operate at normal incidence at $\lambda = 500$nm.

(a) How thick should the coating be for minimum reflection at 500nm.
(b) Calculate the net reflectance at this wavelength considering only the first two reflected beams.
(c) Include the effect of multiple reflection in the calculation of part (b).
(d) Calculate the net reflectance of the film at $\lambda = 400$ and 650nm.

(2) In a laser etching application, it is neccessary to focus light from argon ion laser to an elliptical spot of size 20μm by 50μm. The argon ion laser emittes coherent light at $\lambda = 488$nm and operates in a Gaussian TEM_{00} mode with a $1/e^2$ beam waist of size of $w_1 = 1.2$mm at the output mirror. Physical constraints place the target a distance 75cm from the laser.

(a) Using paraxial optics and preferably the y-ybar diagram, specify a simple optical system (which must contain at least two cylindrical lenses), which meet the dedign objectives. Specify the lenses focal lengths and distance relative to the laser.

(b) The contractor that built the system misundertood the design. He build the system you specified in part (b) (with the lenses placed properly relative to the laser) but placed the target a distance 7.5m away! Specify the size and shape of the resulting spot on the displaced target.

Physics Comprehensive Exam

Spring 1995
Special Topic: Optics

(3) Consider a prism with apex angle α. Its refractive index is $n = 2.0$ at the wavelength of interest. When a beam is incident in the plane containing the two surface normals the exiting beam lies in this plane but is deviated through an angle δ which is a complex function of the angle of incidence I. Minimum deviation is the condition where for a particular angle of incidence I_m that δ is minimized.

a. Calculate I_m. Symmetry arguments provide the shortest derivation.

b. Next, design a prism which operates both at minimum deviation and at Brewster's angle at both interfaces. Specify I and α.

c. Consider an incident beam of light polarized in the plane of incidence. What is the intensity transmittance of the prism? What is the exiting polarization state?

Reference:

Fresnel equations

$$t_s(i) = \frac{2n\cos i}{n\cos i + n'\cos i'}$$

$$t_p(i) = \frac{2n\cos i}{n'\cos i + n\cos i'}$$

$$r_s(i) = \frac{n\cos i - n'\cos i'}{n\cos i + n'\cos i'}$$

$$r_p(i) = \frac{n'\cos i - n\cos i'}{n'\cos i + n\cos i'}$$

Physics Comprehensive Exam

Spring 1995
Special Topic: Optics

(4) Consider three narrow slits in the plane $z = 0$ illuminated by a beam wavelength λ propagating along the z-axis. The separation between the slits is 100 λ. The far field intensity $I(\theta)$ consists of a set of bright fringes with one or more secondary fringes and nodes between each pair.

a. Calculate and sketch $I(\theta)$ for $\theta \ll 1$ radian.

b. Estimate the locations and relative intensities of the maxima of the secondary fringes.

c. Is the period of the interference pattern the same as the period of two adjacent slits or the period of the two outside slits?

Now let the slits have a finite width $\delta x = 20\lambda$.

d. Calculate and sketch $I_1(\theta)$.

e. Place a plane parallel glass plate over the central slit with an optical path length $OPL_1 = \lambda/10$. Place a plate over one of the slits on the end with $OPL_2 = \lambda/5$. Calculate $I_2(\theta)$ and explain the results in plain English.