ENEE 408E Optical System Design

Design Problems #4, October 21, 2003

Due November 6, 2003

(1) Plot the variation in reflectance for P and S waves incident on an air/glass boundary at angles from 0 to $\pi/2$. Take $n_1 = 1$, $n_2 = 1.7$. Calculate the S-wave reflectance at Brewster's angle.

(2) Calculate and plot the transmittance of a 1λ thick window designed for normal incidence as the incidence angle varies from 0 to 90°. Use n=1.55, λ_0=514.5nm.

(3) A slab of glass with $n_2 = 1.60$ is exactly 0.075mm thick and is bounded on both sides by air, $n_1 = n_3 = 1$. Coherent light of wavelength $1.06\mu m$ is incident on the slab.

Use the transformed impedance concept to plot the transmittance of the slab as a function of the angle of incidence from 0° to 90°. (Hint: use enough points).

(4) A flat, parallel-sided slab of silicon with n_2=3.5 is bounded on both sides by air n_1=1. Coherent (laser) light of wavelength 1319nm is incident normally on the slab. Calculate and plot the transmittance of the whole slab as a function of thickness as the thickness varies from 0 to 5μm. Use the transformed impedance concept. (Hint: use enough points).

(5) A slab of glass with $n = 1.55$ is exactly 3.4mm thick and is bounded on both sides by air, $n = 1$. Coherent light of wavelength $1.06\mu m$ is incident on the slab. Calculate:

(a) The fractional intensity transmission for P waves incident at an angle of 30°.

(b) The fractional intensity transmission for S waves incident at an angle of 30°.

(c) The polarization state of the the reflected wave for a wave initially composed of 50% S wave and 50% P wave (based on relative intensities).

(d) The polarization state of the reflected waves for a wave initially composed of 30% S wave and 70% P wave (based on relative intensitties).

(6) How would the answers to 5(a), and 5(b) be modified if the light were incoherent?

(7) Which of the following resonator configurations is stable? A concave mirror has positive R.
(a) $R_1 = 2\text{m},\ R_2 = 1\text{m},\ d = 4\text{m}$
(b) $R_1 = 2\text{m},\ R_2 = 1\text{m},\ d = 2\text{m}$
(c) $R_1 = 3\text{m},\ R_2 = 4\text{m},\ d = 8\text{m}$
(d) $R_1 = -3\text{m},\ R_2 = 1\text{m},\ d = 2.5\text{m}$
(e) $R_1 = 100\text{m},\ R_2 = 110\text{m},\ d = 210\text{m}$
(f) $R_1 = 5\text{m},\ R_2 = -3\text{m},\ d = 14\text{m}$

(8) Take one of the stable resonator configurations in (7) and analyze it using Code V. Show ray paths for 2 complete round trips for fields of 0°, 1°, and 2°.

(9) A quadratic index medium has an index on axis of 1.5. At a distance of 1mm off axis the index is 1.485. For a length of this medium of 1m what is the focal length and where are the principal planes?

(10) What is the minimum length of the medium in question (2) (> 0) that has no effect on the ray parameters of an input paraxial ray? What minimum length will collimate a point source placed against its entrance face?

(11) Use Code V to design a biconvex lens of focal length 100mm, f/# 5, which produces minimum aberration for rays of light entering the lens parallel to the axis. Vary the curvatures of both surfaces, thickness and glass, but keep dimensions reasonable. Use monochromatic light of wavelength 500nm.

(12) Repeat (11) for light with wavelength 450nm, 550nm, and 650 nm simultaneously. Minimize chromatic and other aberrations by making the lens a doublet.

(13) Use Code V to design a singlet lens for use at 633nm that has f=100mm, $f/\# = 4$. Optimize the lens for imaging an axial point object that is placed 200mm from the lens. Vary only curvatures, spaces and glass. Draw the lens, its spot diagram and MTF.

(14) Re-optimize the lens in (13) for an off-axis point that is 200 mm from the lens and 50mm off axis. Draw spot diagram and MTF for both the axial and off-axial points.