MASSACHUSETTS INSTITUTE of TECHNOLOGY

Department of Electrical Engineering and Computer Science

6.161 Modern Optics Project Laboratory

| Problem Set No. 3	**Coherence and Interference**	Issued Tues. 9/27/2005
Fall Term, 2005	-	Due Tues. 10/1/2005

Reading recommendation: Class Notes, Chapter 3. Be neat in your work!

Problem 3.1

Two mutually coherent intersecting plane waves of equal amplitude A, wavelength λ_1 and separation angle θ, are incident symmetrically on a planar slab of recording material of refractive index n as shown.
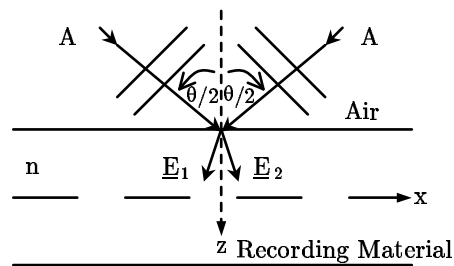
(a) Write equations for the two waves inside the slab.

(b) Assuming the phase difference between the waves is zero at $(x = 0, z = 0)$, use your equations to derive expressions for the separation Λ of the interference fringes in the material.

(c) Show via geometric construction of the fringes that your results are correct.

Problem 3.2

An infinitely wide plane wave beam of TM-polarized light ($\lambda = 500$nm) is incident upon a thin soap film of refractive index $n = 1.3$ and thickness d μm at the Brewster angle. The wavelength of the light is 0.5 μm

(a) What is this angle of incidence?

(b) Are there fringes in Region I arising from the reflected beam? Show your reasoning. If so, what is the interference condition for a bright maximum?

(c) Are there fringes in Region III arising from the transmitted beam? Show your reasoning. If so, what is the interference condition for a bright maximum?

Suppose the polarization of the beam, still incident at the Brewster angle, was changed to TE polarization:

(d) Give an expression for the reflectivity R_{TE} of the air glass interface.
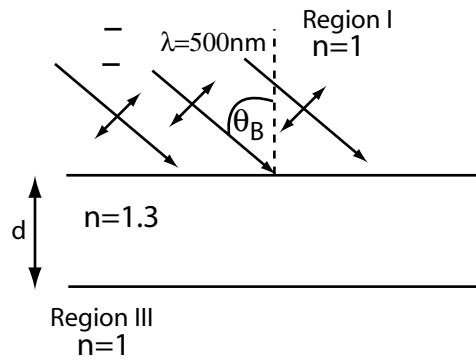
(e) Ignoring diffraction, what is the minimum thickness d of the soap film (in microns) that puts maximum power into reflected beam at this angle of incidence? (Show your reasoning)

Problem 3.3

Two lenses were found in the laboratory. One is plano-convex with a 50cm radius of curvature, and the other is plano-concave with an unknown radius of curvature. The refractive index of the lens material is $n = 1.52$ for both lenses. So you decided to set up the Newton's rings interference experiment shown below in order to find the radius of curvature of the plano-concave lens. In the setup, the curved surfaces of both lenses are placed in contact and the system illuminated with collimated monochromatic light of wavelength 550nm. With the aid of a beamsplitter, you observe a set of circular fringes called "Newton's rings". in particular you witness that the 20th bright ring has a diameter of 12mm.
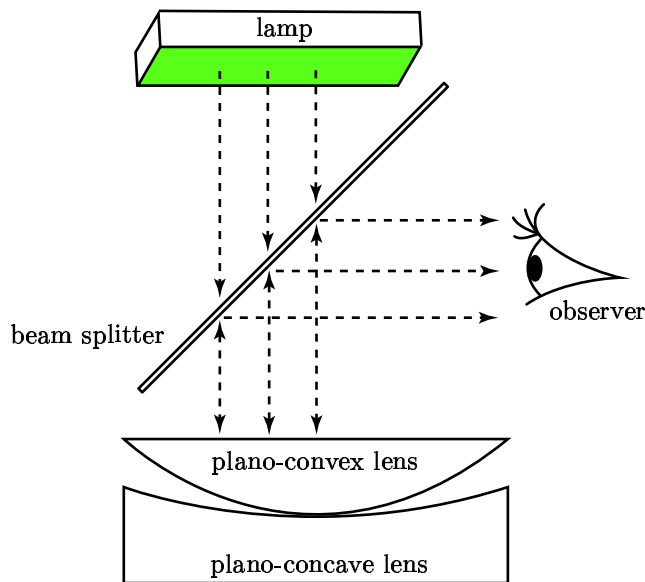
(a) What is the radius of curvature, R_{concave}, of the concave lens surface?

(b) What are the focal lengths, F_{concave} and F_{convex}, of both lenses?