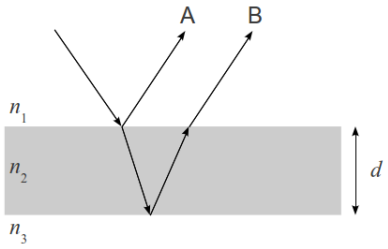
Problem Set 11

Due: 7 December 2019, 12.30 p.m.

Problem 1. Light traveling downward is incident on a horizontal film of thickness d as shown in the figure below. The incident ray splits into two rays, A and B. Ray A reflects from the top of the film. Ray B reflects form the bottom of the film and then refracts back into the material that is above the film. If the film has parallel faces, show that rays A and B end up parallel to each other.



(*3 points*)

Problem 2. We want to rotate the direction of polarization of a beam of linearly polarized light by 90^o using one ore more polarizing sheets.

(a) What is the minimum number of sheets required?

(b) What is the minimum number of sheets required if the transmitted intensity is to be more than 60% of the original density.

(*1 + 3 points*)

Problem 3. Consider a two-slit interference experiment, with waves polarized linearly in the same direction, in which the two slits are of different widths. As measured on a distant screen, the amplitude of the wave from the first slit is E, while the amplitude of the wave from the second slit is $2E$.

(a) Show that the intensity at any point in the interference pattern is

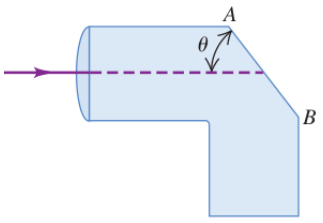
$$I = I_{\max}\left(\frac{5}{9} + \frac{4}{9}\cos\phi\right),$$

where ϕ is the phase difference between the two waves as measured at a particular point of the screen and $I_{\max}$ is the maximum intensity in the pattern.

(b) Graph I versus ϕ. What is the minimum value of intensity, and for which values of ϕ does it occur?

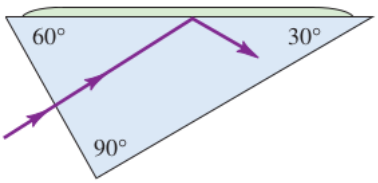
(*3 + 1 points*)

Problem 4. Light enters a solid pipe made of plastic having an index of refraction of 1.60. The light travels parallel to the upper part of the pipe (see the figure). You want to cut the face AB so that all the light will reflect back into the pipe after it first strikes that face. (a) What is the largest that θ can be if the pipe is in air? (b) If the pipe is immersed in water of refractive index 1.33, what is the largest that θ can be?



(*3/2 + 3/2 points*)

Problem 5. Light is incident normally on the short face of a 30^o-60^o-90^o prism (see the figure). A drop of liquid is placed on the hypotenuse of the prism. If the index of refraction of the prism is 1.62, find the maximum index that the liquid may have if the light is to be totally reflected.



(*2 points*)

Problem 6. When viewing a piece of art that is behind glass, one often is affected by the light that is reflected off the front of the glass (called *glare*), which can make it difficult to see the art clearly. One solution is to coat the outer surface of the glass with a film to cancel part of the glare. (a) If the glass has a refractive index of 1.62 and you use TiO_2, which has an index of refraction of 2.62, as the coating, what is the minimum film thickness that will cancel light of wavelength 505 nm? (b) If this coating is too thin to stand up to wear, what other thickness would also work? Find only the three thinnest ones.

(*3/2 + 1/2 points*)

Problem 7. A compact disk (CD) is read from the bottom by a semiconductor laser with wavelength 790 nm passing through a plastic substrate of refractive index 1.8. When the beam encounters a pit, part of the beam is reflected from the pit and part from the flat region between the pits (see the figure), so these two beams interfere with each other. What must the minimum pit depth be so that the part of the beam reflected from a pit cancels the part of the beam reflected from the flat region? (It is this cancellation that allows the player to recognize the beginning and the end of a pit.)

(*4 points*)