Assignment 8
Due November 29, 2011

Text readings

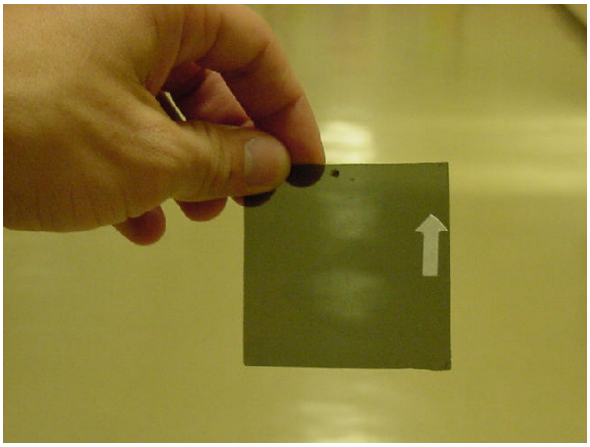
Fresnel equations, chapter 4.6
Polarization, chapter 8, sections 1, 2, 3, 5, 6, 7, and 8.

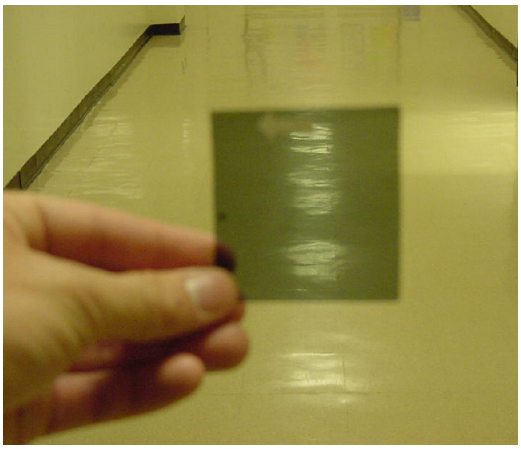
Problems

Problem 1

Polarization by Reflection: Given a polarizer with known transmission axis (TA), determine the direction of polarization of the reflected light from the floor.

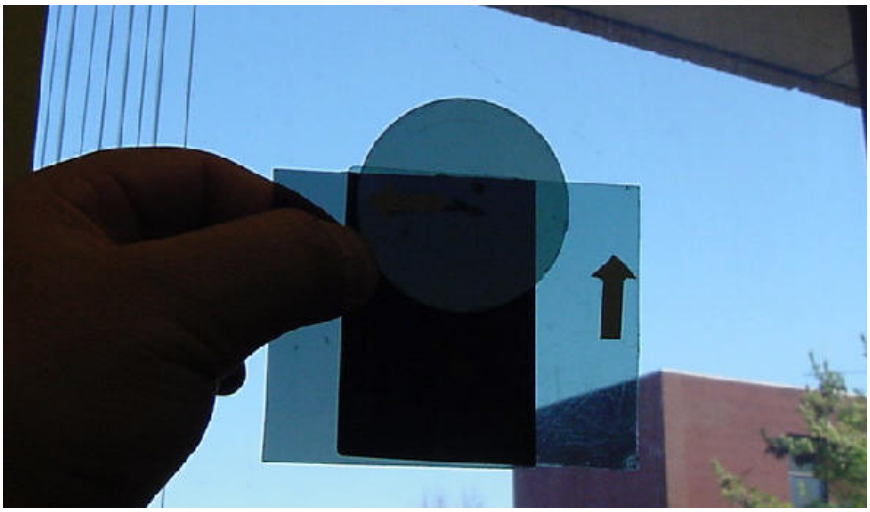
(a) What is the direction of the electric field that reflects from the floor at the Brewster angle?
(b) What direction will a free electron oscillate in response to light reflecting at the Brewster angle?
(c) Why wear polarized sunglasses when driving a car?
(d) What is the orientation of the polarizers in the glasses?
(e) You will be given polarizers with unknown TA. Look at the reflected light from the floor and rotate the polarizer until the transmitted light is a minimum. Now you should be able to identify the TA. Make sure to label or mark the TA. Repeat the same measurements by using the reflection of a laser beam reflected off a mirror. Compare the results in both cases. Which method is more accurate?



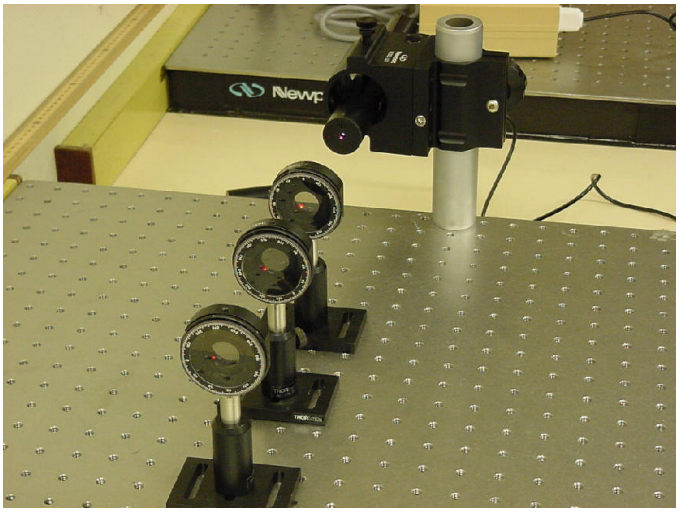


Problem 2

Malus's Law and Linear Polarizers: The picture below shows three linear dichroic polarizers in a row, the Rectangular ones are crossed. Note there are different regions that you can see through and other regions that you cannot.

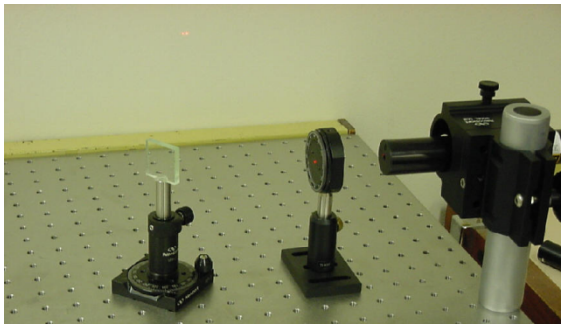


(a) Given a polarizer, what trick can you use to determine the direction of TA?
(b) Orient one polarizer to let vertically polarized light through. Rotate a second linear polarizer with respect to the first and determine the angles for which the irradiance throughput is maximum. For what angles is it minimum?
(c) Plot the prediction of the Malus law as a function of the angle of the second polarizer (remember that only half of the light energy for randomly polarized light comes through the first polarizer).
(d) Orient one polarizer to let vertically polarized light through. Place a second polarizer about 30 cm from the first and orient it for minimum transmission. Now place a third linear polarizer between the two and find the angles that give maximum transmission. What angles give minimum transmission?
(e) Derive an expression for the expected transmission in part (d) based on application of the Malus law and plot it as a function of the angle of the middle polarizer.



Problem 3

Brewster angle and the index of refraction:

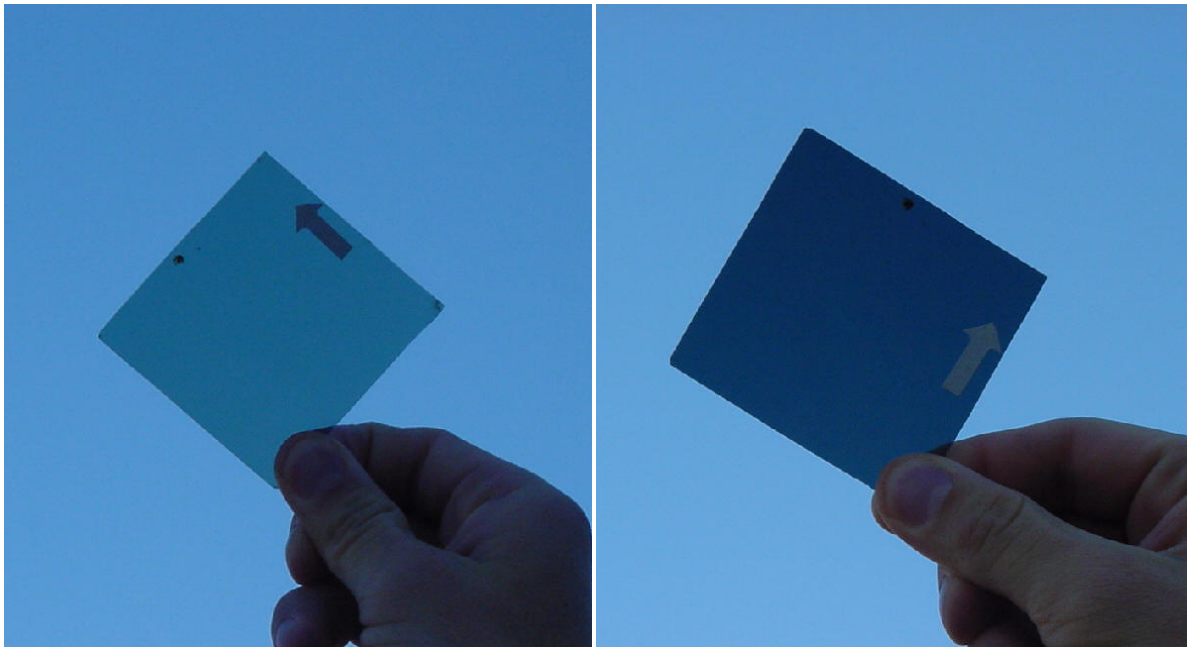


(a) Determine the index of refraction of the glass sample using the Brewster angle technique.
(b) Make a clear diagram showing your measurements (angles of incidence and reflection, etc.)
(c) What is your estimated error in the index of refraction? Show all the math.

Problem 4

Polarization by Scattering: The pictures displayed below show clearly that the skylight is partially polarized. Take some polarizers, go outside and see for yourself.

(a) Let the sun and your head determine an axis. What angle must you look with respect to this axis to see the maximum change in polarization as you rotate the polarizer?
(b) What is the direction of the dominant electric field (perpendicular or parallel to the axis or something else)?
(c) You are inside a building and you have a polarizer. Explain how you can determine the direction of the sun by looking through a window not facing the sun.

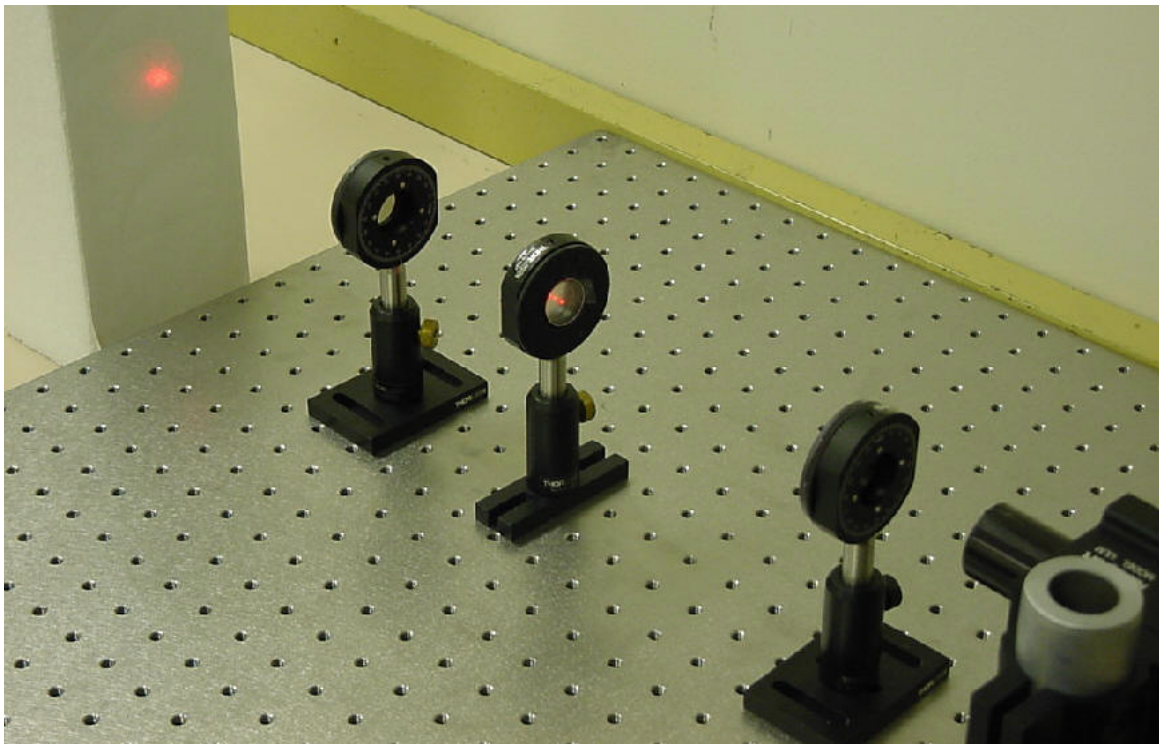


Problem 5

Retarders: Half-Wave and Quarter-Wave Plates

(a) Take two polarizers. Rotate one of them to allow the vertically polarized laser to go through. Rotate the second to allow the horizontally polarized laser to go through. Now set the first near the laser and locate the second one at 20 cm from the first. You should see no laser going through the second polarizer. If you insert a quarter-wave plate between the two crossed polarizers, what do you expect to see? Rotate the quarter-wave plate to maximize the output of the second polarizer. What do you expect to see if you rotate the second polarizer? Record you observation and explain. What is the function of the quarter-wave plate?

(b) Remove the quarter-wave plate and rotate the second polarizer to minimize the output through it. Place the second quarter-wave plate between the crossed polarizers and rotate it to keep the output through the second polarizer minimum. Now, insert the first quarter-wave plate to the system. Record your observations. Explain. What is the function of this configuration of the two quarter-wave plates? Rotate the first polarizer to get minimum output through the second polarizer. Record the angle of rotation. What is the direction of polarization of both polarizers?



Problem 6

Fresnel Reflection Equations: Use a He-Ne laser operating at 632.8 nm, a polarizer, and a power meter to verify Fresnel equations for reflection.

(a) Use vertically polarized laser measure the power of the reflected beam off a glass surface for different angles of incidence. Plot the reflectance R as a function of the angle of incidence θ_i. Fit the data using Fresnel equation for perpendicular field. Note that the index of refraction is the only fitting parameter. This is another way to determine the index of refraction.
(b) Repeat the same procedure you used in part (a) for horizontally polarized laser.
(c) Discuss any differences.