University of California, Berkeley Physics
110B Fall 2012
MidTerm Exam I on Optics
Maximum score: 100 points

1. (25 points) Light propagation inside a medium.

An optical material has a complex susceptibility that can be approximated as 3-0.01*λ+0.0001i in the visible spectral range, where λ is in the unit of μm.

(a) If we shine a laser light with wavelength at 500nm into this material. How deep the laser can penetrate the material (defined by when the intensity of the laser light will become 1/e compared to its value at the surface).

(b) What is the phase velocity and group velocity of a light beam with center wavelength at 500 nm?

2. (35 points) Scattering from a particle.

A laser light at 800nm from –z direction hits a particle at the origin (Fig. 1). The incident light is polarized in y direction. If we put a optical detector at position (1,0,0) and facing the particle, we measure a scattered light power to be P_0. The position co-ordinate is defined as (x,y,z).

(a) If we put the same detector at (0,1,0) facing the particle, what will be the power measured?

(b) If we put the same detector at (1,1,0) facing the particle, what will be the power measured?

(c) If we put the same detector at (1,0,1) facing the particle, what will be the power measured?

(d) If we put the same detector at (1,1,1) facing the particle, what will be the power measured?

(e) If we change the incident light to be at 400 nm, but with the same incident light intensity, polarization, and beam diameter, what will be the detected power at (1,0,0)? Assume that the particle susceptibility is the same for 400nm and for 800nm.

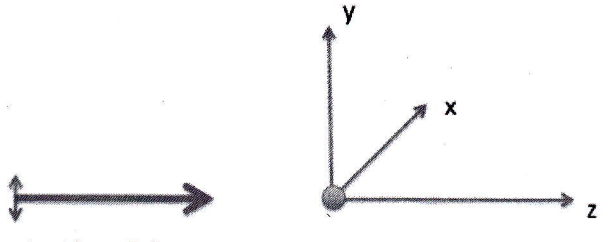

Fig. 1.

3 (40 points). Thin film interference and optical pressure.

We have a silicon wafer that is composed of a 0.5 mm thick of silicon and a thin silicon oxide film of thickness d on top of it. The refractive index of silicon oxide is 1.5, and the refractive index of silicon at 800 nm is 3+0.01i. Now we shine a 1 Watt laser of 800nm wavelength at the silicon wafer in normal direction. In the following calculations, neglect multiple reflections, and use any reasonable approximations.

(1) Plot the reflected light intensity as a function of silicon thickness, with the thickness varying from 0 to 300 nm. Note the thickness that you get maximum and minimum reflection intensities.

(2) The light shining on the wafer will exert a force due to the finite momentum present in electrical magnetic waves. Calculate this force. (Hint: consider the initial and final momentum in the optical light.)

(3) If we allow the laser to incident from any angle and assume it is s-polarized, is it possible to have an angle where the total reflection is zero for certain SiO2 thickness? If yes, what is the incident angle, and what is the thickness of the SiO2 film? (You can express everything in equations, and do not need to calculate values).