**Physics 7C Section 1**
Spring 2006
**Midterm 1.** February 22, 2006
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Name:_____ SID:_____

Choose four out of the five problems proposed, the test duration is 120 minutes.

1. A laser diode emits light at $\lambda = 850$ nm in a round beam with a 2 mm diameter. The electric field is described by $E(x,t) = E_0 \cos(kx - \omega t)$ and the value of the maximum electric field is measured to be $10^2$ V/m. i) Determine the power of the laser and the maximum value of the associated magnetic field. ii) Demonstrate that the electric field propagates according to the wave equation and determine the laser wavelength, when it propagates through Si (n = 3.95).

2. A Michelson interferometer consists of two arms, each 3 km long, a laser pulse with a wavelength $\lambda = 400$ nm is sent through air at STP (n = 1.000273) in the first arm and through vacuum in the second arm. The electric field is described by $E(t) = E_0 \cos(\omega t)$.

i) compute the time delay of the pulse in the first arm, the phase shift compared to that propagating in the second and the equations of the electric fields associated to the two pulses, when the two pulses recombine.

ii) Assume that the interferometer is equipped with a photo detector able to resolve light intensity changes equal to 1/100 of that from a fringe to a minimum. Determine the smallest displacement of the reflecting mirror at the end of the first arm with is detectable by this system.

iii) How can the sensitivity be improved without changing the photo detector ?

3. A laser beam with $\lambda = 1300$ nm is focussed by means of a pair of round collimators, each consisting of an opaque plate with a 0.1 mm diameter round aperture, and located 10 cm away. The beam strikes on a Si wafer (n = 3.95) which is 2 mm thick and 1 cm away from the second collimator, with the beam axis normal to the wafer surface. Determine the beam spot in the Si, at a depth of 1.5 mm, and on a beam stop located 10 cm away from the Si wafer. ↳ size

4. Consider an equilateral prism made of a silica glass with refractive index n = 1.50. Monochromatic light of wave length $\lambda = 850$ nm is incident on one face at a $\pi/4$ angle w.r.t. the normal to the face. Using the corpuscular model of light and the Fermat principle, determine the angle at which the light beam emerges from the opposite face w.r.t. the direction at the prism entrance.

5. Consider a Young experiment setup where a beam of monochromatic light of wave length $\lambda =$ 500 nm is collimated to an area of 1 cm$^2$ on a beam stop with two slits cut out. Each slit measures 0.1 mm in width and 5 mm in height and are spaced by $d = 0.2$ mm. The power of the original beam is 10 mW. Determine the power measured on a screen which is 2 m away as a function of the distance of the points from the projection of the beam axis.