**Phys 375 - Homework #5**

1) (3 pts) When one mirror of a Michelson interferometer is translated by 0.0114 cm, 523 fringes are observed to pass on the screen. What is the wavelength of the light?

2) (3 pts) A thin sheet of material with index of refraction of 1.434 is inserted at normal incidence into one beam of a Michelson interferometer. Using light of wavelength 589 nm, the fringe pattern is observed to shift by 35 fringes. What is the thickness of the sheet?

3) (6 pts) A Michelson interferometer is used to measure the refractive index of a gas. The gas is allowed to flow into an evacuated glass cell of length (L) placed in one arm of the interferometer. The wavelength of the light is (l).

a) If (N) fringes are counted as the pressure in the cell changes from vacuum to atmospheric pressure, what is the index of refraction (n) (at one atmosphere) in terms of (N), (l), and (L)?

b) How many fringes would be counted if the gas were carbon dioxide (n = 1.00045) for a 10 cm cell length, using sodium light at 589 nm?

4) (6 pts) Imagine that a Michelson interferometer is oriented so that one arm points in the direction of earth's motion around the sun, and that the other arm is transverse to the earth's motion. The interferometer is illuminated with a He-Ne laser, with wavelength 633 nm, and the length of each arm is one meter. Six hours later, both arms are perpendicular to the earth's motion, because the earth has rotated.

If we assume, incorrectly(!), that the speed of light for motion parallel to the earth's velocity is $c + v_e$, and the speed of light perpendicular to the earth's motion is simply c, how many fringes should be observed to pass by a detector during the six hours that it takes the earth to rotate from the first configuration to the second? (c) is the speed of light in vacuum = $3.0 \times 10^8$ m/s, and ($v_e$) is the Earth's orbital velocity around the sun = $3.0 \times 10^4$ m/s.

(As you know, no fringe shift has ever been observed in this type of experiment. This is in accordance with the postulates of special relativity, which posits that the vacuum speed of light is exactly (c) in all frames of reference.)

**Phys 375 – Homework #6**

1) (6 points) A collimated beam of mercury lamp light at 546.1 nm is normally incident on a slit 0.015 cm wide. A lens of focal length 60 cm is placed behind the slit. A diffraction pattern is formed on a screen placed in the focal plane of the lens behind the screen. Determine the distance between

a) the central maximum and the first minimum observed on the screen

b) the first and second minima observed on the screen.

2) (6 points) The width of a rectangular slit is measured in the laboratory by means of its diffraction pattern at a distance of 2 meters from the slit. When illuminated normally with a parallel beam of laser light (632.8 nm), the distance between the third minima on either side of the principal maximum is measured. An average of several tries gives 5.625 cm.

a) Assuming that this situation is far-field diffraction, what is the slit width?

b) Is the assumption of far-field diffraction justified in this case? Explain your answer.

3) (6 points) In class we saw that the electric field amplitude for a double slit diffraction pattern is given by

$$E_P = \frac{E_L}{r_0} e^{i(kr_0 - \omega t)} \left[ \int_{-(a+b)/2}^{-(a-b)/2} e^{iks\sin\theta} ds + \int_{(a-b)/2}^{(a+b)/2} e^{iks\sin\theta} ds \right]$$

where a is the slit spacing and b is the slit width. Evaluate the integrals and show that

$$E_P = \frac{2E_L b}{r_0} e^{i(kr_0 - \omega t)} \frac{\sin\beta}{\beta} \cos\alpha$$

where $\alpha = \frac{1}{2} ka \sin\theta, \beta = \frac{1}{2} kb \sin\theta$.

5) (9 points) Sketch the diffraction patterns that you would observe on a screen 100 cm from an aperture illuminated by a He-Ne laser, for the following cases:

a) single slit, slit width = 20 microns.
b) double slit, slit width = 20 microns, slit spacing = 80 microns.
c) four slits, slit width = 20 microns, slit spacing = 80 microns.

Draw these diffraction patterns on a one-to-one scale as you would see them on the screen, and label the position of the first zero due to the "slit width" term.