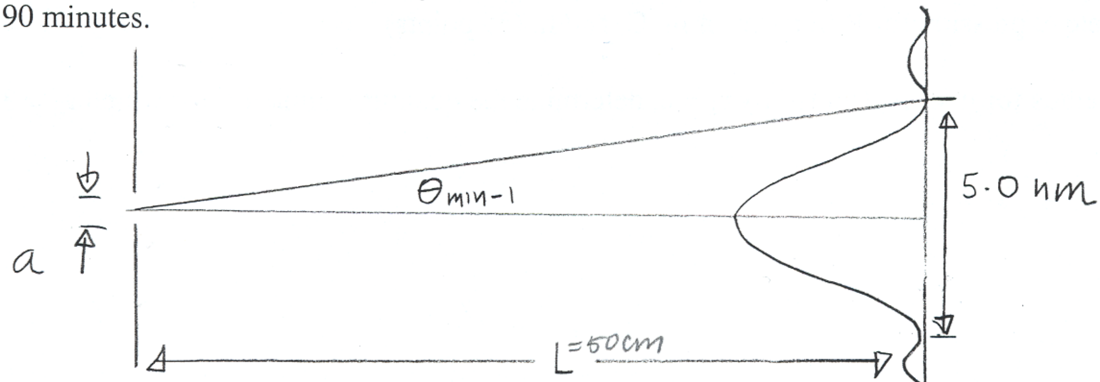
Physics 7C, Fall 2003, Section 1
Instructor: Prof. Adrian Lee

Second Midterm Examination, Monday November 3

Please do work in your bluebooks. You may use two double-sided 3.5" x 5" index card of notes. Test duration is 90 minutes.



1) Parallel sodium yellow light (λ = 589.3 nm) is diffracted by a long narrow slit a distance L = 50 cm from the screen. The first minima are 5.0 nm apart.

a) Derive from first principles the location of the first minimum, θ_{min-1} of a difraction pattern from a long narrow slit of width a (a << L). Be explicit, define your variables, and explain your steps. Do not merely restate the diffraction formula. There are several ways to do this problem, but the point is to show your knowledge of the basic mechanism of diffraction. (30 points)

b) Calculate the slit width a (use the small angle approximation) (10 points)

2) Frames S and S' are moving relative to one another along the x-axis. Observers in the two frames set their clocks to t = 0 when the origins coincide. In frame S, event 1 occurs at x_1 = 1.0 c*yr (this is a lightyear, the speed of light times a year) and t_1 = 1 yr and event 2 occurs at x_2 = 2.0 c*yr at t_2 = 0.5 yr. These events occur simultaneously in frame S'.

(a) Find the magnitude and direction of the velocity of S' relative to S. The direction part asks if they are moving toward each other or apart. (25 points)

(b) At what time do both of these events occur as measured in S'? (15 points)

3) Photoelectric Effect:

(a) If the work function for a metal is 1.85 eV, what would be the stopping potential for light having a wavelength of 410 nm? (25 points)

(b) What would be the maximum speed of the emitted photoelectrons at the metal's surface? (15 points)

4) Imagine a universe where the potential between a proton and an electron was $V(r) = Cr^4$ rather than that given by Coulomb's law. Use the assumption that the angular momentum of the electron around the nucleus is quantized (= n h_bar) to construct a Bohr-like theory for Hydrogen. (C is positive, therefore the force is attractive)

(a) Prove that the allowed energies of the stationary states are $E_n = R^*n^{4/3}$ for n = 0,1,2... Determine the complete expression for R in terms of m, C, and h. (25 points)

(b) If the radius for n =1 is denoted by $r_1 = a$, determine the quantum number n for which $r_n = 3a$. (15 points)