Physics 7C, Spring 2007, Instructor: Prof. Adrian Lee
Second Midterm Examination, Thursday, April 4, 2007

Please do work in your bluebooks. You may use one double-sided 3.5" x 5" index card of notes. Test duration is 110 minutes (6:10-8:00 pm)

Diffraction

1) For single slit diffraction, given a slit of width a and wavelength λ, find the positions of the first 2 maxima and first 2 minima of the interference pattern. It is easiest to make a qualitative argument based on path length differences, but it can be solved with phasor diagrams also. Please do not restate the diffraction intensity formula and find the maxima and minima. (15 points)

2) An observer in a rocket moves toward a mirror at speed v relative to the reference frame S. The mirror is stationary with respect to S. A light pulse emitted by the rocket travels toward the mirror and is reflected back to the rocket. The front of the rocket is a distance d from the mirror (as measured by an observer in S) at the moment the pulse leaves the rocket. (10 pts each part)

Rel.

a) What is the total time travel time of the pulse as measured by observers in the S frame?

b) What is the total time travel time of the pulse as measured by observers in the S' frame?

Doppler?

c) If the frequency of the emitted photons is f' what is the frequency f_{ref}' of the reflected photons as seen by the rocket in S'?

Energy

3) An electron having kinetic energy K = 1 MeV makes a head-on collision with a positron at rest. In the collision the two particles annihilate each other and are replaced by two gamma rays (photons) of equal energy, each traveling at equal angles θ with the electron's directions motion.

a) Find the energy of the photons (10 pts)
b) Find the momentum p of the photons (10 pts)
c) Find the angle of emission of the photons (10 pts)

Photo E-

4) When light of wavelength 450 nm is shone on potassium, photoelectrons with stopping potential of 0.52 V are emitted. If the wavelength of the incident light is changed to 300 nm, the stopping potential is 1.90 V. Using only these numbers, together with the values of the speed of light and the electron charge, (a) find the work function of potassium and (10 pts) (b) compute a value for Planck's constant (5 pts).

Planck constant $h = 6.6260755 \cdot 10^{-34}$ J·s, $h / (2\pi) = 1.05457266 \cdot 10^{-34}$ J·s, Boltzmann constant $kB = 1.380658 \cdot 10^{-23}$ J/K ($= 8.617385 \cdot 10^{-5}$ eV/K), Elementary charge $e = 1.60217733 \cdot 10^{-19}$ C, Speed of light $c = 2.99792458 \cdot 10^{8}$ m/s, Electron rest mass $m_e = 9.1093897 \cdot 10^{-31}$ kg=511 keV/c^2, Proton rest mass $m_p = 1.6726231 \cdot 10^{-27}$ kg=928MeV/c^2, Neutron rest mass $m_n = 1.6749286 \cdot 10^{-27}$ kg=940 Mev/c^2
Charge-to-mass ratio for the electron $e / me = 1.75880 \cdot 10^{11}$ C/kg, Atomic mass unit amu=$1.66057 \cdot 10^{-27}$ kg, Compton wavelength of the electron $= h / (me\ c) = 2.42631 \cdot 10^{-12}$ m