Midterm Quiz: Modern Physics 201
March 1, 2005

Textbook and 2-sided formula sheet. Total 34 points. Individual values follow each question. Usual conventions for frames S and S' apply.

1. An electron passes the origin of the lab reference frame S at $t = 0$ and travels along the x-axis at a uniform velocity. It reaches a detector at $x = 1$ m at $t = 4$ ns.

   (a) What is the speed of the electron in the lab frame? Give your answer as both m/s and as a ratio muliplied by the speed of light. (2)

   (b) How much time elapses in the rest frame of the electron? What is this time called? (2)

   (c) State the Lorentz transforms. (2)

   (d) Our usual "moving" inertial reference frame S' is moving along the x-axis with $v = 0.6\,c$. The origins coincide at $t = t' = 0$. Give the x' and t' for the electron reaching the detector in this frame. (numerical values in metres and nanoseconds, pay attention to the c factors) Based on these values what does the S' observer obtain for the velocity of the electron? (4)

   (e) Calculate V_x' using our velocity transformation formula and show that it is consistent with the previous result. (Numerical demonstration is fine). (2)

2. Give an example of a 4-vector (either covariant or contravariant) listing its components. (2)

3. What are Einstein's postulates of relativity? Are they consistent with Maxwell's equations? Newton's second law? State the new definitions of energy and momentum. State the equation relating energy, momentum, and rest mass. (6)

4. What experiment was used to directly measure the charge of an electron and show that only integer values of this charge existed? Was this the same experiment where the electron was discovered? (3)

5. Give two examples of experiments that showed the quantum nature of light. Give an example of an experiment that showed the wave nature of electrons. (3)

6. Consider a mercury gas discharge tube with a green filter that produces light with intensity 3.2 W/m^2 and wavelength 546 nm. This light is used in a photoelectric effect experiment. The metal cathode has a work function of 2.1 eV.

   (a) State Einstein's hypothesis concerning the photoelectric effect. (2)

   (b) What is the maximum kinetic energy of the photoelectrons? (2)

   (c) According to deBroglie's hypothesis what is the wavelength of these electrons? (2)

   (d) You switch to a red laser with wavelength 630 nm and intensity 1250 W/m^2. What is the maximum kinetic energy and photocurrent now? (2)