Physics 200 Problem Set 6

Problem 1

An X-ray of wavelength 0.1nm scatters directly backwards from an initially stationary electron. What is the wavelength of the scattered photon? Compared to this, how much different is the wavelength of this scattered photon as observed in the final frame of reference of the electron (i.e. the frame in which the electron is stationary after the collision)?

Problem 2

Two polarizers are oriented at 90 degrees to each other, such that no light passes through. A third polarizer is now inserted between these, at an angle θ to the first polarizer. What is the intensity of the light passing through all three polarizers compared with the intensity of the original light? Assume that the original light is unpolarized, so that the intensity is reduced by half when the light passes through the first polarizer.

Problem 3

The photoelectric effect simulation that I did in class may be found on the "Resources" page of the course website. For the sample labelled ?????, use the simulation to determine the work function of this metal. The sample may be changed using the menu in the box labelled "target" (the default is sodium).

Problem 4

a) A perfectly absorbing 1 gram black jelly bean sits on a frictionless table. A red laser with wavelength 632nm is turned on such that the beam shines horizontally directly on the jelly bean. The jelly bean starts moving, and when its velocity reaches 1mm/second, the laser is turned off. How many photons did the jelly bean absorb in this time?

b) Suppose the red laser in part a) was on for a time T. If, instead of the red laser, a laser with the same power output but with wavelength 316nm was used, how long would it have to be on before the jelly bean was moving at 1mm/second?

Problem 5

This question explores the photon picture of the experiment in question 2. As we will discuss in Wednesday's class, we can represent the polarization state of a photon by a unit vector pointing in the direction of the polarization (we can think of it as the electric field vector, but since all photons carry the same amount of energy, there is no meaning to the amplitude, and we just set it to 1). To determine the probability that a photon will pass through a polarizer, we break the unit vector up into components parallel to the polarizer and perpendicular to the polarizer. The squared length of the component parallel to the polarizer gives the probability that the photon will pass through. Note that after the photon passes through, it is polarized in the direction of the polarizer, so it should be represented by a unit vector in this direction.

For the setup in question 2, assume that the first polarizer is oriented along the $\hat{y}$ direction and the third polarizer is oriented along the $\hat{x}$ direction. Assuming that a given photon has a 50 percent probability of passing through the first polarizer, use the model we have just described to calculate the probability that a given photon will make it through the first two polarizers, and the probability that a given photon will make it through all three polarizers.