

PHY 3106, Fall 2017, Homework #4
due Tuesday, Oct. 3, at 9:30 am (beginning of class)

- 1.) A K^+ kaon is a positively-charged member of the particle zoo composed of an up quark (charge $+2/3$) and an anti-matter strange quark (charge $+1/3$). It has a mass of $m = 493.677 \frac{MeV}{c^2}$. In the rest frame of the kaon, the mean lifetime is $\tau = 1.238 \times 10^{-8}$ seconds. I am the co-spokesperson on a set of experiments probing these particles at Jefferson Lab. Let's look at how the experiments work. A) One of our upcoming experiments will measure kaons with momenta of $1.8 \text{ GeV}/c$. What is the total energy of the kaons? B) What is the relativistic γ -factor? C) What is the kinetic energy? D) Find the velocity of the kaons divided by the speed of light, u/c .
- 2.) A beryllium nucleus fissions into two α -particles or helium nuclei. [The mass of beryllium is 8.003111 u , where $u = 1.66 \times 10^{-27} \text{ kg}$. The α -particle mass is 4.001506 u .] A) In the rest frame of the beryllium nucleus, what speed will the fission fragments have? [Hint: keep 7 or 8 significant figures for this problem. You can find u as a fraction of c for the speed.] B) How much kinetic energy is released in the fission? [I.e., what is the "Q" value?]
- 3.) A rho meson, ρ^+ , has a rest mass of $m_\rho c^2 = 775.5 \text{ MeV}$. It decays to a pion, π^+ ($m_\pi = 139.6 \text{ MeV}/c^2$), and a massless photon, γ : $\rho^+ \rightarrow \pi^+ + \gamma$. A) Find the total energy of each decay particle, and B) find the velocity of each decay particle.
- 4.) A metal electrode is illuminated with laser light of wavelength 380 nm . Electrons are ejected from the metal, and slowed down by an adjustable opposing electric potential. A) If the potential difference is adjusted to 1.10 V , the current of photoelectrons is stopped completely. What is the work function of the metal? B) The adjustable potential is now switched off. What is the maximum wavelength light that is able to eject electrons from the metal?
- 5.) An X-ray photon with a wavelength of 0.0500 nm Compton scatters from a free electron which is initially at rest. The scattered photon is detected at an angle of 90 degrees. Find a) the initial momentum of the photon, b) the momentum of the scattered photon, and c) the momentum of the scattered electron.
- 6.) KISS Country (WKIS) is a radio station at 99.9 on the FM dial. It broadcasts at a frequency of 99.9 MHz , and has a broadcast power of $98,400 \text{ Watts}$. A) What is the wavelength of these electromagnetic radio waves? B) These waves are also considered particles, i.e., photons. How many photons per second emanate from the broadcast antenna?