Problem Set 4.
1. Show that $E^2 = m_0^2 c^4 + p^2 c^2$ starting from the expression for energy mass equivalence and the special relativity expression for momentum.

2. Starting with the special relativity expression for kinetic energy, show that in the case $v \ll c$, the classical expression $KE = (mv^2)/2$ is obtained.

3. A muon is a particle that decays to three particles: electron, neutrino, anti-neutrino. (assume the mass of the neutrino and anti-neutrino are 0)
   a) what is the are masses of the muon and electron in units of eV/c² (look this up)?
   b) what is the lifetime of the muon in microseconds (look this up)?
   c) Consider the decay of a muon at rest. Assuming that the neutrino and anti-neutrino travel in the same direction with equal momentum, apply conservation of momentum and energy (in SR) and calculate the kinetic energy (in eV) and speed (in v/c) of the electron produced.
   d) calculate the kinetic energy (in eV) of the neutrino produced.
   d) calculate the momentum (in eV/c) of the anti-neutrino produced.

4. A pion has a rest energy of 135 MeV. It decays into two gamma ray photons. A pion moving through the laboratory at $v = 0.98c$ decays into two gamma ray photons of equal energies, making equal angles ($\theta$) with the original direction of motion. Find the angle $\theta$ and the energies of the two gamma ray photons.

5. (a) At what wavelength will the human body radiate the maximum radiation?
   (b) Estimate the total power radiated by a person of medium build (approximating a person as a cylinder 165 cm in height and 13 cm radius).

6. Calculate the energy range of photons of visible light with wavelengths from 700 nm to 400 nm. Express your answers in units of electron volts.

7. When sodium metal is illuminated with light of wavelength 420 nm, the stopping potential is found to be 0.65 V; when the wavelength is changed to 310 nm the stopping potential is 1.69 V. Using only these data and the values of the speed of light and the electronic charge, find the work function of sodium and a value of Planck's constant.

8. Extra Credit: Consider a neutron created at the center of our galaxy and traveling toward earth. To have a probability of $e^{-1}$ to reach earth before it decays (isolated neutrons are not stable), calculate the energy required. Express your answer in EeV.