Set 7 – due 8 March

The midterm exam will be in Duane G2B41 on Thursday, March 14, 7:00 – 8:30 PM

"The nonmathematician is seized by a mysterious shuddering when he hears of 'four-dimensional' things, by a feeling not unlike that awakened by thoughts of the occult. And yet there is no more commonplace statement, that the world in which we live is a four-dimensional space-time continuum."–A. Einstein

1) [10 points] Compton scattering. You might recall that when a photon scatters off a free electron, its wavelength is shifted. Derive the Compton formula. The invariants s, t and u from last week are quite useful. You are working in a frame where the photon comes in along the z direction, so $p_1 = (E, 0, 0, E/c)$, the electron has $p_2 = (mc^2, 0, 0, 0)$ and the outgoing photon is $p_3 = (E', 0, (E'/c)\sin\theta, (E'/c)\cos\theta)$. Recall the relation between photon energy and wavelength, $E = hc/\lambda$. I think I have the c's right in the momenta, but I put them in by hand at the end.

2) [15 points] A particle originally at rest and with initial rest energy $m_1 = m + \Delta E$ emits a photon and decays to a particle of rest energy m. What is the energy of the photon? Check explicitly the limiting cases $m >> \Delta E$, and $m = 0$. ($c = 1$ here). Analogs of these cases are the decay of the 2P state of hydrogen to the 1S state, and the decay Higgs $\rightarrow \gamma\gamma$.

3) [20 points] A beam of light of frequency ω travelling in the $x - y$ plane (at an angle θ_0 with respect to the x axis) is reflected from a mirror moving with velocity v in the x direction. Calculate (a) [10 points] the frequency of the reflected beam and b) [10 points] the angle of reflection (in the frame where the incident angle is θ_0).