The midterm exam will be in Benson Earth Sciences 185, Wednesday 11 March, 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, $E = h \nu$. 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 $m \gg \Delta E$, 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 $\omega$ travelling in the $x-y$ plane (at an angle $\theta_0$ 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 $\theta_0$).