HW4

Reading assignment: Feynman chapter 4.1 and 4.2. Einstein chapters 10 - 14 and, optionally, 15-17. Mr. Tompkins chapter 2 (optional, overlap with other readings).

0. By Monday please make sure you have finished all of homework 3.

1. A muon has a half-life of about $10^{-6}s$. Suppose you start with 100 muons. (a) Draw a graph showing number of muons vs time. (b) Now draw a similar figure for 100 muons moving at $v = .999c$. (c) Describe a cloud chamber based experiment testing the prediction of time dilation. Nothing fancy, just explain what you would need to measure both at sea level and at some much higher altitude. What do you expect?

2. Optional Relativistic Doppler shift. A candle is emitting photons in all 3 spatial directions with a frequency f and wavelength λ in the candle's rest frame. Suppose the candle is now moving with a speed V along the x-axis. What frequency will be observed by someone located on the x axis?

3. Optional Theoretical: In $d \geq 3$ spatial dimensions Newton's gravitational law becomes $F = G^{(d)} \frac{mM}{r^{d-1}}$ where $G^{(d)}$ is a constant. In this problem you will consider the possibility that gravity's weakness (compared to the other forces such as electromagnetism) might be due to the fact that we live in a higher dimensional Universe. (i) Using dimensional analysis find a formula for the d dimensional planck length. (ii) suppose $d-3$ of these dimensions are compactified; that is they are wrapped up into "circles" of length L. Using dimensional analysis show how L can be related to some combination of G^3 and G^d. (iii) $L^{(d-3)}$ is the volume of the compactified dimensions. Using previously derived formulas, relate $L^{(d-3)}$ to some combination of the d-dimensional planck length and the 3-dimensional planck length.

Experimental: The relations you just derived enables you to explore the possibility that the world is actually d-dimensional with a fundamental Planck length that is much larger than 10^{-35} meters. Of course, the 3-dimensional Planck length is about 10^{-35} meters. Particle accelerators have already excluded d-dimensional Planck lengths as small as 10^{-20} meters (smaller values are not excluded by experiment). (iv) Using this information, namely that the d-dimensional Planck length can be as large as 10^{-20} meters, give an order of magnitude estimate for what could be the length of these compactified dimensions for $d = 4$, 5, and 6. Can any cases be excluded from everyday experiences?