Problem Set One – Special Relativity – Tuesday, 27th January 2015

Question 1

1. Consider two events A and B. Explain under which circumstances it is possible that for one observer they occur in the order AB, but for some other observer in the order BA or simultaneously. Support your conclusion by drawing a spacetime diagram.

2. Three events A, B, and C are seen by observer $\mathcal{O}$ to occur in the order ABC. Another observer, $\bar{\mathcal{O}}$ sees the events to occur in the order CBA. Is it possible that a third observer sees the events in the order ACB? Support your conclusion by drawing a spacetime diagram.

Question 2

Two people start their journeys from Amsterdam to Tokyo ($\Delta x = 9000$ km), carrying clocks initially synchronized in Amsterdam. One of them (A) takes an airplane ($v_A = 1000$ km h^{-1}) and the other (B) walks ($v_B = 4$ km h^{-1}). A waits for B in Tokyo, then they meet and compare their clocks. What's the time difference? Neglect all effects other than special relativity.

Question 3

Particle physicists are so used to setting $c = 1$ that they measure mass in units of energy. In particular, they tend to use electron volts (1 eV $= 1.6 \times 10^{-12}$ erg $= 1.8 \times 10^{-33}$ g), or more commonly, keV, MeV, and GeV (10^3 eV, 10^6 eV, and 10^9 eV, respectively).

The muon has been measured to have a mass of 0.106 GeV and a rest frame lifetime of 2.19×10^{-6} seconds. Imagine that such a muon is moving in the circular storage ring of a particle accelerator, 1 km in diameter, such that the muon's total energy is 1000 GeV. How long would it appear to live from the experimenter's point of view? How many radians would it travel around the ring?