

Problems 1

1. (a) Consider two events A and B . Explain 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. (b) 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 ?
2. Two people start their journeys from Amsterdam to Tokyo, by carrying clocks initially synchronized in Amsterdam. One of them (A) takes an airplane ($v_A = 1000 \text{ km h}^{-1}$) and the other (B) walks ($v_B = 4 \text{ km h}^{-1}$). A waits for B until he comes, then they meet in Tokyo and compare their clocks. What's the time difference? Neglect all the effects other than special relativity, which might otherwise affect.
3. Projection effects can trick you into thinking that an astrophysical object is moving "superluminally." Consider a quasar that ejects gas with speed v at an angle θ with respect to the line-of-sight of the observer. Projected onto the sky, the gas appears to travel perpendicular to the line of sight with angular speed v_{app}/D , where D is the distance to the quasar and v_{app} is the apparent speed. Derive an expression for v_{app} in terms of v and θ . Show that, for appropriate values of v and θ , v_{app} can be greater than 1.
4. 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 ($1 \text{ eV} = 1.6 \times 10^{-12} \text{ erg} = 1.8 \times 10^{-33} \text{ g}$), 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?