

## Assignment #1

### Readings:

- Moore - Chapter 1
- Moore - Chapter 2
- Boccio - Relativity 1

**Summary:** This week we will be studying the principle of relativity, inertial reference frames, clock synchronization, Newtonian-Galilean relativity, speed of light, events, worldlines, spacetime diagrams, and units. We will start to think about spacetime and observers in relative motion.

This will start us on the semester's journey into modern theoretical physics.

### Everyone Problems:

- M:2-8 Spacetime diagrams
- M:2-9 Radar method
- EP-3 Who fired first?
- EP-4 Volcanoes on Io

### Individual Problems:

- M:1-10 Coordinates in Newtonian relativity
- M:1-13 Relative velocity
- M:2-2 Synchronization
- M:2-4 Interpreting worldlines
- M:2-5 Drawing worldlines
- M:2-6 Reading a spacetime diagram
- M:2-7 Spacetime diagrams
- M:2-10 Radar method
- EP-1 Happy birthday
- EP-2 What is happening?
- EP-5 The earliest time?

### Presentations:

- Inertial Frames
- Galilean Relativity
- Spacetime Diagrams

**Seminar Break:** Boccio

### Extra Problems:

**EP-1 (from Amy Bug) Happy Birthday to who?** ... Alice and Blair are twins, who like to blow out their birthday candles at the same moment each year. Usually, they are together on their birthday. But this year, while Alice is here on earth, Blair is on vacation on a planet many light-years distant.

(a) Assume that Alice and Blair share a single inertial frame, and that their watches have been carefully synchronized. Assume that they agree to blow out candles at noon on September 4, 2001, Eastern

Standard (earth) time. They do.

**Draw a spacetime diagram from the point of view of an observer halfway between them, and sharing their frame of reference.**

**Show the following 2 events:** Alice blowing out the candles and Blair blowing out the candles.

**Show the following 4 worldlines:** Alice, Blair, a beam of light from the observer striking Alice just as she blows out the candles, a beam of light striking Blair as he blows out the candles.

(b) Unbeknownst to the twins, a fast rocket is cruising through the galaxy. It is traveling at a constant velocity with respect to the frame of Alice and Blair. It zooms right over Alice's head at the moment she blows out the candles. It is heading directly toward Blair's planet. A clock on board the rocket tells the pilot that on noon of September 24, 2001, Alice blew out her candles.

**Does the pilot think they blew out their candles simultaneously? If not, which twin does the pilot think blew out the candles first? Draw another spacetime diagram in order to justify your answer.**

**EP-2** Two radar pulses sent out from the earth at 6:00 AM and 8:00 AM one day bounce off an alien spaceship and are detected on earth at 3:00 PM and 4:00 PM. You are not sure, however, which reflected pulse corresponds to which emitted pulse, Is the spaceship moving toward earth or away? If its speed is constant (but less than  $c$ ), when will it (or did it) pass by the earth? Drawing a spacetime diagram will make this problem easy.

**EP-3** According to a nuclear treaty between two superpowers, if either strikes first, then the second is entitled to destroy the first completely. The superpowers deploy two ships A and B which move at a very high speed towards each other. Ship A sends off radar signals at one-second intervals which are reflected back by B. At  $t=0$  in its coordinates, A fires a weapon at B. At  $t=4$ , A receives back the signal A sent out at  $t=-6$ , which detects B firing at A.

What can A conclude about who fired first?

**EP-4** Two volcanoes 100 km apart on Io (a satellite of Jupiter) are seen by and observer A at rest on Io to erupt simultaneously. Observer B is the pilot of a rocket, which according to A is 10 km directly above the first volcano when it explodes, flying towards the second volcano at the speed  $1/2$  .

What will B see as happening at the second volcano at the moment when she sees the first explode?

**EP-5** A rocket R moves in the  $+x$  direction relative to an observer A on Mars, at a speed  $1/2$ . Their positions coincide at  $t=0$ . Plot the worldlines of A and R in a  $(t,x)$  spacetime diagram.

The rocket emits light signals in both the forward and backward directions at  $t=2$  sec. Draw the corresponding light rays on your spacetime diagram. The observer A signals to the rocket at time  $t=1$  sec. What is the earliest time she can expect to get a reply?