Lab Report for Lab R1: Relativity of Simultaneity - The Train “Paradox”

**Modern Physics 3/12/12**

**C. How to Read the Screen:**

1. According to the lanes in which they move in the Ground Reference Frame, what are the velocities of the following objects that are visible on the screen:

a) \* near top of screen: v\*top = \_\_\_\_\_\_\_\_ c

b) train (Mary): vtrain = \_\_\_\_\_\_\_\_ c

c) you (John): vyou = \_\_\_\_\_\_\_\_ c

d) \* near bottom of screen: v\*bottom = \_\_\_\_\_\_\_\_ c

2. According to the Ground Reference Frame, are your three clocks synchronized ? Should they be ? Why or why not ? If not, explain using words and diagrams which of your three clocks should read the *earliest* time.

3. According to the Ground Reference Frame, are the train’s three clocks synchronized ? Should they be ? Why or why not ? If not, explain using words and diagrams which of the train’s three clocks should read the *earliest* time.

# D. Animation vs. What You Would Actually See

1. Explain why, in real life, you see different parts of an object as they appear at different times. Explain why that fact does not usually make any difference to us. A diagram is necessary here.

2. For what kinds of objects is the image we would actually see substantially different from what the animation shows ? Does the animation’s depiction of the train look much different from how the train would actually look (if you could watch such a train in real life) ?

**E. Recording Events as Viewed by Ground Observer:**

1. Determine the position and time coordinates of the following two events as observed in the ***Ground Reference Frame***: E1) lightning bolt strikes front of train, E2) lightning bolt strikes rear of train. Record your data in your Event Table below. The software does not give any units for position or time coordinates. For our purposes, assume that each time step corresponds to one microsecond (s), and each division on the position scale corresponds to one light-microsecond (c-s), which is the distance that light travels in one microsecond.

2. According to the Ground Reference Frame, do the two lightning bolts strike the train simultaneously ? Explain how you know.

3. Continue moving the simulation forward in time, noticing when each of the light flashes reaches your position on the screen, and when each flash reaches the train passenger. In your Event Table, record the information you observe about the following four events, again as they are viewed from the ***Ground Reference Frame***: E3) light flash from front reaches train passenger, E4) light flash from rear reaches train passenger, E5) light flash from front of train reaches ground observer, E6) light flash from rear of train reaches ground observer.

4. Another way to find the position and time coordinates for an event is to consult the software’s Event Table. After you’ve found the coordinates of all the events, check your work by referring to the Event Table tab in the software.

**F. Recording Events as Viewed by Train Passenger:**

1. According to the lanes in which they move in the Train Reference Frame, what are the velocities of the following objects that are visible on the screen:

a) \* near top of screen: v\*top = \_\_\_\_\_\_\_\_ c

b) train: vtrain = \_\_\_\_\_\_\_\_ c

c) you: vyou = \_\_\_\_\_\_\_\_ c

d) \* near bottom of screen: v\*bottom = \_\_\_\_\_\_\_\_ c

2. According to the Train Reference Frame, are the Ground Reference Frame’s three clocks synchronized ? Should they be ? Why or why not ? If not, explain using words and diagrams which of your three clocks should read the *earliest* time.

3. According to the Train Reference Frame, are the train’s three clocks synchronized ? Should they be ? Why or why not ? If not, explain using words and diagrams which of the train’s three clocks should read the *earliest* time.

4. Continue moving the simulation forward in time, noticing when each of the light flashes reaches your position on the screen, and when each flash reaches the train passenger. Repeat your measurements of information about events E1-E6, this time as viewed from the Train Reference Frame. When you’re done, check your results by comparing them to the software’s Event Table.

## Event Table

|  |  |  |  |
| --- | --- | --- | --- |
| Event Label | What Happens in the Event | Event’s Coordinates  in Ground RF | Event’s Coordinates  in Train RF |
| E1 |  | XG= c-s | XT= c-s |
| TG= s | TT= s |
| E2 |  | XG= c-s | XT= c-s |
| TG= s | TT= s |
| E3 |  | XG= c-s | XT= c-s |
| TG= s | TT= s |
| E4 |  | XG= c-s | XT= c-s |
| TG= s | TT= s |
| E5 |  | XG= c-s | XT= c-s |
| TG= s | TT= s |
| E6 |  | XG= c-s | XT= c-s |
| TG= s | TT= s |

# Followup Questions

Use your Event Table to answer the following questions.

1. According to the Ground Reference Frame, the two lightning bolts strike the train at the same time. Does an observer in the Train Reference Frame agree that the two lightning bolts strike the train simultaneously ? If not, which bolt does the train passenger say struck the train first ? Is there any physical reason why the Train Reference Frame observer must agree with the Ground Reference Frame observer about the simultaneity of those two events ? Explain.

2. According to the Ground Reference Frame, the two light flashes reach the ground observer at the same time. Does an observer in the Train Reference Frame agree that the two flashes arrived at the ground observer simultaneously ? If not, which flash does the train passenger say arrived there first ? Is there any physical reason why the Train Reference Frame observer must agree with the Ground Reference Frame observer about the simultaneity of those two events ? Explain.

3. Find an example of two events that the train passenger observes to happen in one sequence, but the ground observer observes them to happen in the reverse sequence. Does this difference in observations violate any physical law ? Explain.

4. How can the ground observer explain why the light flashes did not reach the train passenger simultaneously ? Use a sequence of *well annotated* diagrams from the Ground Reference Frame to show this. Hint: start from the fact that, according to the ground observer, the two lightning bolts strike the train simultaneously.

5. (This is a difficult question, but it brings together many of the important things we hope you learned from this lab) How can the train passenger explain why the ground observer claims that the two lightning bolts struck simultaneously ? Use a sequence of well annotated diagrams from the Train Reference Frame to show this. Hint: you will need to use the fact that, according to the Train Reference Frame, the two lightning bolts *do not* strike the train simultaneously. Any correct explanation must also use the fact that the ground clocks are not synchronized, according to the Train Reference Frame.