Homework #8; Phys 110A; Due Wed. 4/12

1. The Heart of Gold spaceship launches a shuttle, travelling at 0.8c relative to the ship. A bomb in the shuttle is set to explode 2 minutes after launch. After it explodes, a large piece of shrapnel flies out (in the same direction, away from the original ship) at 0.6c relative to the shuttle. (Or at least, relative to the shuttle just before it exploded!).

A) Draw a spacetime diagram of these events from the shuttle's reference frame. Put the original launch of the shuttle at the origin. Label the worldlines of the ship, the shuttle, and the shrapnel. Label the spacetime-locations of the launch and the explosion; use light-minutes for your spatial units. Also pick an arbitrary event "Q" that lies on the worldline of the shrapnel, after the explosion. Find the spacetime-coordinates of this event, too.

B) Use the **Galilean** transformations to see what the same events would look like from the Heart of Gold's reference frame, in a universe where special relativity wasn't true. Draw a new spacetime diagram in this frame, labeling all the same things and events, with new spacetime-coordinates. Don't forget to transform event "Q" as well.

C) How fast is the shrapnel travelling, in your second diagram? (Use the distance and time between the explosion and "Q" to calculate it; don't just use velocity addition -- although your answer should agree with common-sense velocity addition. It might not agree with your relativistic intuition, since we're not using special relativity here.)

D) Now, go back to your original diagram, and use the **Lorentz** transformations to see what the same events would look like from the Heart of Gold's reference frame, in a universe where special relativity **was** true. Draw a new spacetime diagram in this frame, labeling all the same things and events, with new spacetime-coordinates. Don't forget to transform event "Q" as well.

E How fast is the shrapnel travelling, in your part-D diagram? (Use the distance and time between the explosion and "Q" to calculate it.) Check that your answer is consistent with the velocity-addition law given in the book, and that the shrapnel is travelling less than the speed of light.

F) In your part-D diagram, how long did it take for the original 2-minute bomb to explode? Explain why this answer makes sense.

2. Show that for any event, at spacetime location (x,y,z,t), the quantity $x^2+y^2+z^2-c^2t^2$ is the same in all reference frames (using the Lorentz transformations).

3. List as many different ways as you can in which classical Electromagnetism seems to violate the principle of relativity. You should be able to think of at least 3!