Special Relativity Exercises 2:

SPACETIME DIAGRAMS (I)

In this exercise you will sketch various spacetime diagrams. These are just rough sketches—they need not be drawn with a ruler.

[easy] 1. Sketch the spacetime diagram of a car, starting from rest, accelerating to a maximum speed, coasting at a constant speed for some time, and then decelerating to rest again.

[medium] 2. Sketch the spacetime diagram of a planet orbiting the Sun. Assume that the planet mass is much less than the mass of the Sun. (Show both the planet and the Sun in the diagram.)

[hard] 3. Sketch the spacetime diagram of **Bob**, who walks around the block at constant speed, pausing for a few moments at each corner.

[easy] 4a. Sketch the parabolic trajectory of a baseball through space (from the pitcher to the back catcher) with the ***x*** axis as the horizontal axis and ***y*** axis as the vertical axis. Based on your experience, estimate reasonable numbers for the range (***x*** distance) and maximum height (***y*** distance) of the ball.

4b. Sketch the same trajectory, except now in spacetime. That is, sketch the baseball's worldline in ***t***, ***x***, ***y*** coordinates.

[medium] 5. Sketch the worldline in the more natural ***ct***, ***x***, ***y*** coordinates, in which both space and time are treated on the same footing, and measured in the same units (metres). Notice that the curved parabola from **question *1b*** is now stretched to nearly a straight line. What do you think the slight curvature of this line might mean (physically or geometrically)?

[hard] 6. Consider the simplest case of a baseball thrown straight upwards, reaching a maximum height ***h***, and then falling back to the ground. Using Newtonian kinematics, determine the elapsed time. Sketch the baseball's parabolic worldline in ***t***, ***y*** coordinates, and then the corresponding stretched parabola in ***ct***, ***y*** coordinates. Mathematically approximate the stretched parabola as an arc of a large circle of radius ***R*** (with both

curves having the same height and chord). Assuming that ***h*** is very small compared to ***R***, make a reasonable approximation for ***R*** as a function of ***c*** and ***g*** (freefall acceleration near Earth's surface, $9.8\frac{\text{m}}{\text{s}^2}$). Observe that ***R*** is independent of **h**. Based on your answer in **question 2**, why must this be so?