Core Ideas of Unit 1 – Spacetime: Overview

One of the central organizing principles of this course is the concept of wristwatch time. To study the motion of any object, put a wristwatch on it and map the ticks of the watch as it moves through spacetime. The time recorded by the watch is called the "interval" in this chapter but is more formally known as the *Proper Time*.

As the object and wristwatch move through spacetime, its motion is tracked by two sets of *observers* in relative motion with respect to one another. Oftentimes, one set of observers moves with the object. Each of the observers denotes the coordinate distance the object moves, s, and the coordinate time it took to move that distance, t, between two or more ticks of the watch. Call the values measured by the two sets of observers moving with respect to one another, $(s_1, t_1) and\ (s_2, t_2)$; these coordinates denote the spacetime separation of two *events*. It turns out that observers moving with respect to one another always get different values for the space and time separations s and t! That is the bad news. The good news is that when the two observers calculate the interval defined by the equation below, they get the same value. Furthermore, that value is exactly equal to the square of the time ticked off the object's wristwatch!

$$t_1{}^2 - s_1{}^2 = t_2{}^2 - s_2{}^2 \equiv\ interval^2$$

In order for the above equation to make sense, s and t, have to be measured in the same units. This is accomplished by defining the speed of light to be equal to 1 instead of 299,792,458 m/s. If distance is measured in meters, time is measured in the number of seconds it takes light to go one meter, one meter of time. If time is measured in years, distance is measured in light-years. In both cases, the speed of light is just

$$c = \frac{Distance\ Light\ Traveled}{Time\ it\ took\ Light\ to\ Travel\ that\ Distance} \equiv 1$$

With this convention, the speed of an object is dimensionless and is its value is the fraction of the speed of light at which the object moves.

The first step in becoming a competent relativist is to have internalized that the speed of light is 1!

Assignment for Unit 1

1) Keeping the core ideas in mind, carefully read through **Chapter 1: Spacetime: Overview** in its entirety.
2) Now start re-reading the chapter with pencil and paper in hand.
3) Sample Problem 1.1 on page 8 as an example of the core ideas. In this problem, the wristwatch is worn by the rocket and one set of observers ride with the rocket and the other set are in the laboratory. Keeping that in mind, try to answer questions a) through f) WITHOUT looking at the solutions!
4) Sample Problem 1.2 on page14 is more of the same. For the proton, rock, and starship identify the object wearing the wristwatch and the two observers measuring s and t as the object moves through spacetime. Now try to answer questions a) through c) WITHOUT looking at the solutions!
5) Before moving onto the exercises and problems, take some time to study the analogies in Box 1.1 on pages 16 and 17.
6) Do practice exercises 1.1 through 1.7. If you run into difficulty, feel free to ask for help.
7) Do problems 1.9 through 1.12. If you run into difficulty, feel free to ask for help.
8) When finished with the practice exercises and problems, bring them by my office. If everything looks okay, you will be given a quiz to test your mastery of the material in Unit 1.