Core Ideas of Unit 7 – Trekking Through Spacetime

This chapter introduces spacetime diagrams. For me, these diagrams are an essential way to make sense of special relativity. If you make the effort, you will be surprised by the clarity that can be produced by a carefully drawn spacetime diagram that maps the relevant events defining a given situation.

The path an object follows through spacetime is called the objects "worldline." Each point on the worldline corresponds to the passage of that object through a certain place in space at a given time. In other words, the worldline shows where and when that object has been and how it got from one spacetime point to another. To make the where and when more concrete, the worldline needs to be projected onto the space and time coordinates of a specific free-float reference frame.

The Principle of Maximum Aging is important because it explains the Twin Paradox but more importantly acts as the bridge that connects special to general relativity in the book **Exploring Black Holes** by the same authors that wrote this text.

The factor, $\gamma(v) = \frac{1}{\sqrt{1-v^2}}$, which played a central role in the Lorentz transformation equations shows up in this chapter as the "stretch" factor.

At the end of the chapter, the authors wax elegantly about the primacy of events in spacetime. Each pair of events is separated by the invariant interval which has the same value for all free-float observers who catalog the space and time separation between those two events. This invariance overshadows the fact that different free-float observers measure different space and time intervals between those same two events. Although this perspective has merit, in the end it is usually much more straightforward to analyze a given situation by defining some preferred free-float from which to observe the relevant events.

Assignment for Unit 7

1) Keeping the core ideas in mind, carefully read through **Chapter 5: Trekking Through Spacetime** in its entirety.
2) Now start re-reading the chapter with pencil and paper in hand.
3) Spend some time familiarizing yourself with the information contained in the spacetime diagram in figure 5.1.

4) Be able to explain the connection between figures 5.2 and 5.3 in section 5.2, **Same Events: Different Free-Float Frames**. How is the "invariant interval" connected to the invariant "hyperbola?"
5) Can the worldline of an object whose velocity is changing be plotted in a free-float frame? Defend your answer with an example.
6) There is much useful information in sections 5.5 and 5.6, **Length Along a Path** and **Wristwatch Time Along a Worldline**. Work through these sections slowly and thoughtfully.
7) What is the proper time along a path traversed by a light beam? What does this say about wristwatch time for a photon?
8) Do **Sample Problem 5.1**, a straightforward example of the dependence of wristwatch time on path.
9) Work through section 5.8, **Stretch Factor**. When two free-float reference frames pass one another, be sure you can explain whose clocks run slow. How does stretch factor enter into the Twin Paradox? What is the connection between slow clocks and short meter sticks?
10) Do **Sample Problem 5.2**. Note that you can use the Lorentz transformation equations to find the coordinates of the various events in the rocket frame. The solution in the book uses the stretch factor and the invariant interval and assumes that some/many/all readers skipped the section on the Lorentz transformations.
11) Do **practice exercises 5.1, 5.2, and 5.3**.
12) Do **problems 5.4 through 5.8**.
13) 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 7.