Core Ideas of Unit 10 – Collide. Create. Annihilate.

The concept of momenergy is applied to systems of particles. The sum of the individual masses of the particles is an isolated system is typically less than the mass of the system calculated by,

$$M_{system}^2 = E_{system}^2 - P_{system}^2$$

$$\vec{P}_{system} = \sum \vec{p}_{particles} \ \ and \ E_{system} = \sum E_{particles} \ \ but \ M_{system} \neq \sum M_{particles}$$

Although the individual energies and momenta of the particles in a system can change during interaction between the particles, the momentum, energy, and mass of the system remain unchanged, they are conserved. This becomes a very valuable tool for analyzing collisions between particles.

The chapter ends with a dizzying array of exercises, 41 altogether. Consequently, many of those exercises will not be explicitly assigned. But I encourage you to read through all the exercises to see if any of the unassigned exercises tempts you to make an extra effort!

Assignment for Unit 10

1) Keeping the core ideas in mind, carefully read through **Chapter 8: Collide. Create. Annihilate.** in its entirety.
2) Now start re-reading the chapter with pencil and paper in hand.
3) In Section 8.2, **Three Modest Experiments**, pay extra attention to the second experiment involving the inelastic collision. Note that practice problem 7.2 portended this issue, namely that the rest mass of a system is usually <u>not</u> equal to the sum of the rest masses of the constituent particles. Can you give an example of a system where the sum of rest masses is equal to the rest mass of the system?
4) Carefully read Section 8.3, Mass of a System of Particles. Study figures 8.3 and 8.4 which show the same collision from the perspective of two different free-float reference frames. Make sure you understand why the velocity of the particle on the left is 15/17 when calculated by observers in a reference frame in which the particle on the right is stationary. In this reference frame, what is the velocity of the laboratory?

5) Do Sample Problem 8.1. This problem summarizes valuable information about the relationship between energy, momentum, and mass for a system of particles.
6) Use conservation of momenergy to verify the "after" picture for the collision between a photon and electron depicted in figure 8.6.
7) Do Sample Problem 8.2.
8) Verify that the "polyelectron" created in figure 8.8 moves with velocity 4/5.
9) The Box 8.1 describes some common particles that are important in physics. Note that it is now believed that neutrinos are not massless but have very, very, small but undetermined masses.
10) Show that the numbers for the energy and momentum before and after collision of two protons in figure 8.9 are consistent with the conservation of momenergy.
11) Read Box 8.2 and then apply those steps to Sample Problems 8.3 and 8.4.
12) Work through Sample Problem 8.5. This problem gives some perspective on the massive amounts of energy available from the nuclear reactions taking place in the Sun.
13) The dialog, **Use and Abuse of the Concept of Mass** at the end of the chapter is extremely valuable. Take your time digesting the questions and answers about the role of mass in relativity and its connection to the momenergy 4-vector.
14) Do exercises 8.1, 8.5, 8.6, 8.7, 8.9, 8.13, 8.19, 8.23, 8.27, 8.29, and 8.41.
15) When finished with exercises, bring them by my office. If everything looks okay, you will be given a quiz to test your mastery of the material in Unit 10.