Cornell University

Department of Physics

Phys 116 April 26, 2005

Mechanics and Special Relativity, Spring 2005

Homework Assignment # 11

(Due **Friday, May 6**, before the lecture.)

Lectures and Reading Assignments:

Readings are from *"An Introduction to Mechanics"* by Kleppner and Kolenkow.

- Lec 39, 4/29 (Fri): Relativistic Momentum and Energy. **Sec. 13.1, 13.2 (pp. 490–500).**
- Lec 40, 5/2 (Mon): Massless Particles. **Sec. 13.3, 13.4 (pp. 501–512).**
- Lec 41, 5/4 (Wed): Four-Vectors and Minkowski Space. **Sec. 14.1– 14.3 (pp. 516–527).**

Problems:

Numbered problems are from *"An Introduction to Mechanics"* by Kleppner and Kolenkow, Chapter 12 (pp. 484–487) and Chapter 13 (pp. 512–513).

1. Consider the tale of the physicist who is ticketed running a red light and argues that because he was approaching the intersection, the red light was Doppler shifted and appeared green. How fast would he have been going? ($\lambda_{\text{red}} \sim 650\text{nm}$, $\lambda_{\text{green}} \sim 530\text{nm}$)
2. Problem 12.7
3. Problem 13.1
4. A "dream power plant" is an imaginary device which is capable of converting the rest energy of the fuel into electric energy with 100% efficiency. Compute the amount of fuel required to keep a 100 W light bulb going for 1 year.
5. How much energy does it take to accelerate a particle of rest mass m_0 from rest to a velocity of $0.99c$? How about $0.9999c$? Based on these results, explain why a massive particle ($m_0 \neq 0$) can *never* move at exactly the speed of light.
6. To study properties of subatomic particles, physicists accelerate and collide particles such as protons and electrons. In this problem, we will consider two examples of such experiments.
   (a) A proton of energy $E = 10$ GeV collides with a stationary proton (the so-called "fixed target" experiment). The protons stick together, forming a "composite" particle X. Find the rest energy (in GeV) of the X particle.
   HINT: The rest energy of the proton is approximately equal to 1 GeV. Units: 1 GeV $= 10^9$ eV; 1 eV $= 1.6 \times 10^{-19}$ J.
   (b) Two protons of energy $E = 5$ GeV each collide head-on ("collider" experiment). Again, the protons stick together, forming a "composite" particle Y. Find the rest energy (in GeV) of the Y particle.

(c) If the goal of the experiment is to discover a new particle with a large rest mass, which of the two experimental approaches discussed above would be more effective?

7. Problem 13.8

8. Problem 13.10