1 Relativistic Energy, Momentum, and Speed

(*based on Taylor 15.62*)

A particle with rest mass 12 MeV/c^2 has a kinetic energy of 1 MeV. What are its momentum (in MeV/c) and speed (as a fraction of the speed of light)?

2 Relativistic Kinetic Energy

(*based on Taylor 15.58*)

(a) What is a particle's speed (as a fraction of the speed of light) if its kinetic energy T is equal to its rest energy?

(b) *Sensemaking: Check Dimensions* Show that the dimensions of your answer to part (a) are appropriate and balance across the equals sign.

(c) What a particle's speed (as a fraction of the speed of light) if its relativistic energy E is equal to n times its rest energy?

(d) *Sensemaking: Examine the behavior of functions* Plot β as a function of n. Does this functional behavior make conceptual sense? Explain.

3 Particle Decay

(*based on Taylor 15.74*)

A particle a is traveling along the positive x axis of frame S with speed $0.5c$ decays into two identical particles, $a \to b + b$, both of which continue to travel on the x axis.

(a) If $m_a = 2.5m_b$, find the speed of either b particle in the rest frame of particle a. *Sensemaking: Compare the classical and relativistic physics* How does your result compare to what you would expect classically? Conceptually, how do you account for the difference?

(b) By making the necessary transformation on the result of part (a), find the velocities of the two b particles in the original frame S. *Sensemaking: How do these velocities compare to the results you found in part (a)? Does the comparison make conceptual sense?*

4 Mass of Higgs Boson

(*based on Knight 36.42*)

One of the important ways that the Higgs boson was detected at the Large Hadron Collider was by observing a type of decay in which the Higgs - which decays too quickly to be observed directly - is immediately transformed into two photons emitted back-to-back. Two photons, with momenta 61.8

GeV/c, were detected. What is the mass of the Higgs boson in GeV/c^2, kg, in multiples of proton mass? *Sensemaking: Compare Quantities* How does your answer compare to the experimental results from CERN?