

1 Relativistic Energy, Momentum, and Speed

(based on Taylor 15.62)

A particle with rest mass $12 \text{ MeV}/c^2$ 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, $a \rightarrow b + b$, 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?