3.6: Footnotes

1. An entertaining account of this form of quackery is given in **Voodoo Science: The Road from Foolishness to Fraud**, Robert Park, Oxford University Press, 2000. Until reading this book, I hadn't realized the degree to which pseudoscience had penetrated otherwise respectable scientific organizations like NASA.
2. Although the definition refers to the Celsius scale of temperature, it's not necessary to give an operational definition of the temperature concept in general (which turns out to be quite a tricky thing to do completely rigorously); we only need to establish two specific temperatures that can be reproduced on thermometers that have been calibrated in a standard way. Heat and temperature are discussed in more detail in section 2.4, and in chapter 5. Conceptually, heat is a measure of energy, whereas temperature relates to how concentrated that energy is.
3. It's not at all obvious that the solution would work out in the earth's frame of reference, although Galilean relativity states that it doesn't matter which frame we use. Chapter 3 discusses the relationship between conservation of energy and Galilean relativity.
4. From Joule's point of view, the point of the experiment was different. At that time, most physicists believed that heat was a quantity that was conserved separately from the rest of the things to which we now refer as energy, i.e., mechanical\ energy. Separate units of measurement had been constructed for heat and mechanical of energy, but Joule was trying to show that one could convert back and forth between them, and that it was actually their sum that was conserved, if they were both expressed in consistent units. His main result was the conversion factor that would allow the two sets of units to be reconciled. By showing that the conversion factor came out the same in different types of experiments, he was supporting his assertion that heat was not separately conserved. From Joule's perspective or from ours, the result is to connect the mysterious, invisible phenomenon of heat with forms of energy that are visible properties of objects, i.e., mechanical energy.
5. If you've had a previous course in physics, you may have seen this presented not as an empirical result but as a theoretical one, derived from Newton's laws, and in that case you might feel you're being cheated here. However, I'm going to reverse that reasoning and derive Newton's laws from the conservation laws in chapter 3. From the modern perspective, conservation laws are more fundamental, because they apply in cases where Newton's laws don't.
6. Système International
7. There is a mathematical loophole in this argument that would allow the object to hover for a while with zero velocity and zero acceleration. This point is discussed on page 910.
8. There is a hidden assumption here, which is that the sun doesn't move. Actually the sun wobbles a little because of the planets' gravitational interactions with it, but the wobble is small due to the sun's large mass, so it's a pretty good approximation to assume the sun is stationary. Chapter 3 provides the tools to analyze this sort of thing completely correctly --- see p. 142.
9. Some historians are suspicious that the story of the apple and the mistake in conversions may have been fabricated by Newton later in life. The conversion incident may have been a way of explaining his long delay in publishing his work, which led to a conflict with Leibniz over priority in the invention of calculus.
10. Subsection 6.1.5 presents some evidence for the Big Bang theory.
11. Many kinds of oscillations are possible, so there is no standard definition of the amplitude. For a pendulum, the natural definition would be in terms of an angle. For a radio transmitter, we'd use some kind of electrical units.