

## Note on “Relativistic Mass”

Both Eisberg & Resnick and Feynman use the terms “relativistic mass” and “rest mass.” Unfortunately, the distinction between the two terms tends to cause some confusion. In fact, modern usage tends to frown upon the term “relativistic mass.” For example, A.P. French and Griffiths do not use that terminology.

“Rest mass” is exactly what we normally think of as mass. To distinguish it from “relativistic mass,” Eisberg and Resnick denote “rest mass” by  $m_0$ . I usually will *not* do that, however, but will simply use the symbol  $m$  for rest mass, which I will generally refer to simply as “mass.” When I write the symbol  $m$ , I will *always* mean “rest mass,” which again is just the same concept of mass that you have always dealt with.

“Relativistic mass” is defined to be

$$m_{\text{rel}} = \frac{m}{\sqrt{1 - v^2/c^2}}$$

which clearly is not a constant, depending not only on the mass but also on the velocity of the particle. Most modern physicists prefer that the term “mass” refer to an intrinsic, invariant property of an object, or system of objects, and not have anything to do with how fast it is going.<sup>1</sup>

Now, the “relativistic energy” of a moving particle is given by

$$E = \frac{mc^2}{\sqrt{1 - v^2/c^2}}$$

which is just the “relativistic mass” times a constant  $c^2$ . There is no real point in having two names, “mass” and “energy,” for two physical quantities that differ only by a constant factor! Therefore, modern usage usually dispenses with the term “relativistic mass,” in favor of “relativistic energy.” Unfortunately, even though the current edition of Eisberg and Resnick is as recent as 1985, it still uses the old terminology.<sup>2</sup>

Again, the main thing to be clear about is that whenever I use the term mass or the symbol  $m$ , I mean the rest mass, which is the ratio of force to acceleration in the frame in which the object is at rest. Thus it is the same concept of mass that you are familiar with from introductory mechanics, *except that it generally is not conserved*. (“Relativistic mass,” being essentially the same thing as relativistic energy, *is* conserved, but is not invariant—see the footnote below.)

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<sup>1</sup> Note that in relativity rest mass is invariant (the same in all reference frames), but it is *not* conserved (unchanging with time), since mass can be converted to energy and vice versa. Relativistic energy, on the other hand, is not invariant but is conserved. In classical mechanics, mass is both invariant and conserved, while energy is not invariant but is conserved. Be sure to understand the difference between the terms “invariant” and “conserved,” as they are used in physics.

<sup>2</sup> The old terminology, “relativistic mass,” originated with Einstein, but even he eventually stated that it is preferable to use the term “relativistic energy” instead.