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Problem 3.32 (R)

A body of rest mass m_0, *travelling initially at a speed of* 0.6 *c, makes a completely inelastic collision with an identical body initially at rest. We have to find* (a) *the speed of the resulting body and* (b) *its rest mass.*

Solution:

Energy of the body of rest mass m_0 moving with speed 0.6 *c* will be

$$E_1 = \frac{m_0 c^2}{\sqrt{1 - v^2/c^2}} = \frac{m_0 c^2}{\sqrt{1 - 0.6^2}} = 1.25 m_0 c^2.$$

As the second particle has the same rest mass and is at rest its energy will be

$$E_2 = m_0 c^2.$$

Initial total energy of the two particles will therefore be

$$E = 2.25 m_0 c^2.$$

The momentum of the incident particle is

$$p = \frac{m_0 v}{\sqrt{1 - v^2/c^2}} = \frac{m_0 \times 0.6c}{0.8} = 0.75c.$$

It is given that the collision is completely inelastic. In relativistic mechanics energy and momentum are conserved in all processes whether elastic or inelastic. Let the mass of the particle that results after the inelastic collision be *M* and let its velocity be *V*.

From the conservation of energy, we have

$$\frac{Mc^2}{\sqrt{1-V^2/c^2}} = 2.25 m_0 c^2.$$

From the conservation of momentum, we have

$$\frac{MV}{\sqrt{1-V^2/c^2}} = 0.75 m_0 c.$$

We thus find

$$V = \frac{0.75}{2.25} c = 0.33c.$$

And

$$M = 2.25 \times \sqrt{1-\frac{1}{9}} \times m_0 = 2.12 m_0.$$