Answer on Question #65532 – Physics – Mechanics | Relativity

Question:

A proton undergoes a head on elastic collision with a particle of unknown mass which is initially at rest and rebounds with 16/25 of its initial kinetic energy. Calculate the ratio of the unknown mass with respect to the mass of the proton.

Solution:

Let v_{pi} is the initial speed of proton, v_{pf} is the final speed of proton, v is the speed of particle after collision, m_p is the mass of proto and m is the mass of particle.

From the conditions imposed on the energy of the proton we can find its final velocity:

$$E_{pf} = \frac{16}{25}E_{pi} \Rightarrow \frac{m_p v_{pf}^2}{2} = \frac{16}{25}\frac{m_p v_{pi}^2}{2} \Rightarrow v_{pf}^2 = \frac{16}{25}v_{pi}^2 \Rightarrow v_{pf} = \frac{4}{5}v_{pi};$$

The momentum of the system is saved so we can find an unknown particle velocity after collision:

$$m_p v_{pi} = -m_p v_{pf} + mv \Rightarrow m_p v_{pi} = -\frac{4}{5}m_p v_{pi} + mv \Rightarrow \frac{9}{5}m_p v_{pi} = mv \Rightarrow v = \frac{9}{5}\frac{m_p}{m}v_{pi};$$

The energy of the system is also saved and we can express a mass of particle through the mass of the proton:

$$\frac{m_p v_{pi}^2}{2} = \frac{m_p v_{pf}^2}{2} + \frac{mv^2}{2} \Rightarrow m_p v_{pi}^2 = \frac{16}{25}m_p v_{pi}^2 + mv^2 \Rightarrow \frac{9}{25}m_p v_{pi}^2 = mv^2 \Rightarrow \frac{9}{25}m_p v_{pi}^2 =$$

$$= m\left(\frac{9}{5}\frac{m_p}{m}v_{pi}\right)^2 \Rightarrow \frac{9}{25}m_p v_{pi}^2 = \frac{81}{25}\frac{m_p^2}{m}v_{pi}^2 \Rightarrow \frac{9m_p}{m} = 1 \Rightarrow m = 9m_p;$$

Answer:

$$\frac{m}{m_p} = 9.$$