Answer on Question #76287, Physics / Mechanics | Relativity

A neutron of mass 1.67 ×10^-27 kg moving with a velocity 1.2×10^7 ms^-1 collides head-on with a deuteron of mass 3.34×10^-27 kg initially at rest. If the collision were perfectly elastic, what would be the speed of deuteron after the collision?

Solution

$m_n = 1.67 \cdot 10^{-27}$kg

$\upsilon_{1n} = 1.2 \cdot 10^{7}$m/s

$m_d = 3.34 \cdot 10^{-27}$kg

$\upsilon_{1d} = 0$

υ_{2d} - ?

To answer this question we should use two laws:

1) The law of conservation of momentum:

$$m_n \times \upsilon_{1n} + m_d \times \upsilon_{1d} = m_n \times \upsilon_{2n} + m_d \times \upsilon_{2d}$$

as $\upsilon_{1d} = 0$ (deuteron was initially at rest.)

then $m_d \times \upsilon_{1d} = 0$

and the equation of the law of conservation of momentum is:

$$m_n \times \upsilon_{1n} = m_n \times \upsilon_{2n} + m_d \times \upsilon_{2d}$$

2) Energy conservation law:

$$\frac{m_n \times {\upsilon_{1n}}^2}{2} + \frac{m_d \times \upsilon_{1d}^2}{2} = \frac{m_n \times \upsilon_{2n}^2}{2} + \frac{m_d \times \upsilon_{2d}^2}{2}$$

as $\upsilon_{1d} = 0$,then $m_d \times \upsilon_{1d}^2 = 0$

and the equation of energy conservation law is:

$$\frac{m_n \times {\upsilon_{1n}}^2}{2} = \frac{m_n \times \upsilon_{2n}^2}{2} + \frac{m_d \times \upsilon_{2d}^2}{2}$$

Solve the system of two equations:

$$\begin{cases} 1.67 \times 10^{-27} \times 1.2 \times 10^{7} = 1.67 \times 10^{-27} \times \upsilon_{2n} + 3.34 \times 10^{-27} \times \upsilon_{2d} \\ \dfrac{1.67 \times 10^{-27} \times 1.2 \times 10^{7}}{2} = \dfrac{1.67 \times 10^{-27} \times \upsilon_{2n}}{2} + \dfrac{3.34 \times 10^{-27} \times \upsilon_{2d}}{2} \end{cases}$$

$$\begin{cases} 1.2 \times 10^{7} = \upsilon_{2n} + 2 \times \upsilon_{2d} \\ (1.2 \times 10^{7})^2 = \upsilon_{2n}^2 + 2 \times \upsilon_{2d}^2 \end{cases}$$

$$\begin{cases} \upsilon_{2n} = 1.2 \times 10^{7} - 2 \times \upsilon_{2d} \\ (1.2 \times 10^{7})^2 = (1.2 \times 10^{7} - 2 \times \upsilon_{2d})^2 + 2 \times \upsilon_{2d} \end{cases}$$

$$\begin{cases} \upsilon_{2n} = 1.2 \times 10^{7} - 2 \times \upsilon_{2d} \\ (1.2 \times 10^{7})^2 = (1.2 \times 10^{7})^2 - 2 \times 2 \times 1.2 \times 10^{7} \times \upsilon_{2d}^2 + 4 \times \upsilon_{2d}^2 + 2 \times \upsilon_{2d} \end{cases}$$

$$\begin{cases} \upsilon_{2n} = 1.2 \times 10^{7} - 2 \times \upsilon_{2d} \\ 6 \times \upsilon_{2d}^2 = 2 \times 2 \times 1.2 \times 10^{7} \times \upsilon_{2d} \end{cases}$$

$$\begin{cases} \upsilon_{2n} = 1.2 \times 10^{7} - 2 \times \upsilon_{2d} \\ \upsilon_{2d} = 8 \times 10^{6} \end{cases}$$

$$\begin{cases} \upsilon_{2n} = -4 \times 10^{6} \\ \upsilon_{2d} = 8 \times 10^{6} \end{cases}$$

$\upsilon_{2d} = 8 \times 10^{6}$ m/s

$\upsilon_{2n} = -4 \times 10^{6}$ m/s (minus before value of speed means that a neutron changed its direction on the opposite after perfectly elastic collision) .

Answer: 8×10^{6}m/s