a) Yes, elastic collision = KE is conserved

b)

1a

$\vec{J} = \vec{P_2} - \vec{P_1}$

$= m\vec{V_2} - m\vec{V_1}$

$= (1.2)(10) - (1.2)(-25)$

$= 42 Ns$

b)

$\vec{J} = \vec{F}\Delta t$

$42 = \vec{F}(0.02)$

$F = 2100$

$= 2.1 kN$

2a

Mass of moose : $m_m = 500\,kg$

mass of car : $m_c = 1000\,kg$

$$m_c v_i = (m_c + m_m) v_f$$

$$v_f = \frac{m_c v_i}{(m_c + m_m)}$$

$$K_f = \frac{1}{2}(m_c + m_m) v_f^2$$

$$= \frac{1}{2}(m_c + m_m)\left(\frac{m_c v_i}{m_c + m_m}\right)^2$$

$$= \frac{1}{2}\frac{(m_c v_i)^2}{m_c + m_m}$$

$$\frac{\Delta K}{K_i} = \frac{K_i - K_f}{K_i} = 1 - \frac{K_f}{K_i}$$

$$= 1 - \frac{m_c}{m_c + m_m}$$

$$= 1 - \frac{1000}{1000+500} = \frac{1}{3}$$

$$\approx 33\%$$

$$K_i = \frac{1}{2} m_c v_i^2$$

By CM, $P_0 = P$

$$m_1 v_{c0} + m_m v_{m0} = (m_c + m_m) v_{c1}$$

$$v_{c1} = \frac{m_c}{m_c + m_m} v_{c0}$$

$$= \frac{2}{3} v_{c0}$$

% original KE loss $= \dfrac{KE_0 - KE_f}{KE_0} \times 100$

$$= \frac{\frac{1}{2} m_c v_{c0}^2 - \frac{1}{2}(m_c + m_m) v_{c1}^2}{\frac{1}{2} m_c v_{c0}^2} \times 100$$

$$= 33\%$$

b)

$$1 - \frac{1000}{1000+300} = \frac{3}{13}$$

$$\approx 23\%$$

c) percentage loss decreases

3a)

$$3.5g = 0.0035kg$$

$$m_b v_i = m_{(b+2)} v_2$$

$$(0.0035)v = (1.8035)(1.4)$$

$$v = 721.4 m/s$$

$$\approx 721 m/s$$

b)

$$m_b v_0 = m_b v_i + m_{(b+c)} v_1$$

$$(0.0035)v_0 = (0.0035)(721.4) + (1.20)(0.630)$$

$$= 937.4$$

$$\approx 937 m/s$$

A 10.0 g marble slides to the left at a speed of 0.400 m/s on the frictionless, horizontal surface of an icy New York sidewalk and has a head-on, elastic collision with a larger 30.0 g marble sliding to the right at a speed of 0.200 m/s. Find the velocity of each marble (magnitude and direction) after the collision. (Since the collision is head-on, all motion is along a line.).

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answers

30.0 g marble moves left at 0.100 m/s. 10.0 g marble moves right at 0.500 m/s;

$m_1 = 0.01\,kg \qquad m_2 = 0.03\,kg$

$T_0 : \quad V_{2_0} = 0.2\,m/s \qquad V_{1_0} = 0.4\,m/s$

$m_2 \longrightarrow \qquad \longleftarrow m_1$

$T_1 : \quad V_{21} \longrightarrow \qquad V_{11} \longrightarrow$

By CM $\quad P_0 = P_1$

$$0.01 \times \underbrace{(-0.4)}_{-V_{1_0}} + 0.03 \times 0.2 = m_1 V_{11} + m_2 V_{21}$$

$$V_{21} = 0.667 - 0.333\,V_{11}$$

By Ck for elastic collision,

$$\frac{1}{2} \times 0.01 \times 0.4^2 + \frac{1}{2} \times 0.03 \times 0.2^2 = \frac{1}{2} \times 0.01 \times V_{11}^2 + \frac{1}{2} \times 0.03 \times V_{21}^2$$

$$1.4 \times 10^{-3} = 5 \times 10^{-3} \times V_{11}^2 + 15 \times 10^{-3} \times (0.667 - 0.333\,V_{11})^2$$