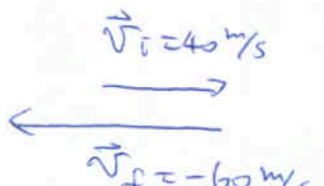
PHYSICS 1A (a) Quiz 4 Version A.

Solutions

①

impulse $\vec{I} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i = m\vec{v}_f - m\vec{v}_i = m(\vec{v}_f - \vec{v}_i)$

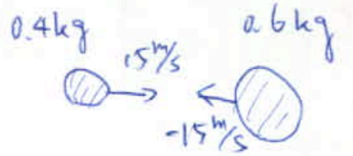


$$= 0.2\,(-60 - 40) = -20\,(kg \cdot m/s)$$

$$|\vec{I}| = 20 \Rightarrow \boxed{d.}$$

②

Before collision



After collison

momentum conservation: $\underbrace{0.4 \times 15 + 0.6 \times (-15)}_{\text{before collison}} = \underbrace{(0.4 + 0.6) \times (-v_f)}_{\text{after collision}}$

$$v_f = \frac{(0.6 - 0.4) \times 15}{0.4 + 0.6} = \frac{0.2 \times 15}{1} = 3\,(m/s) \Rightarrow \boxed{b.}$$

③

The collision is elastic, exploit momentum and kinetic energy conservation laws.

Momentum conservation: $20 \times 0 + 10 \times 3 = 20\,V_{20f} + 10\,V_{10f}$ ①

Kinetic energy conservation: $\frac{1}{2}20 \cdot 0^2 + \frac{1}{2}10 \cdot 3^2 = \frac{1}{2} \cdot 20\,V_{20f}^2 + \frac{1}{2} \cdot 10 \cdot V_{10f}^2$ ②

from ①: $V_{10f} = \frac{30 - 20V_{20f}}{10} = 3 - 2V_{20f}$ insert into ②

$$\frac{1}{\cancel{2}}\cdot 10\cdot 3^2 = \frac{1}{\cancel{2}}\cdot 20\, V_{20f}^2 + \frac{1}{\cancel{2}}\cdot 10\,(3 - 2V_{20f})^2$$

$$9\cancel{0} = 2\cancel{0}\, V_{20f}^2 + 1\cancel{0}\,(9 - 12V_{20f} + 4V_{20f}^2)$$

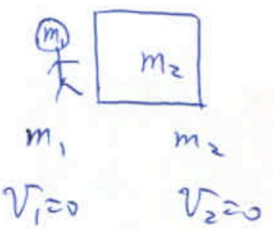
$$\cancel{9} = 2V_{20f}^2 + \cancel{9} - 12V_{20f} + 4V_{20f}^2$$

$$6V_{20f}^2 - 12V_{20f} = 0 \qquad V_{20f}(V_{20f} - 2) = 0$$

$$\Rightarrow V_{20f} = +2 \left(\tfrac{m}{s}\right) \Rightarrow \boxed{d.}$$

④

Before push



After push

Momentum is conserved. $\underbrace{0}_{\text{before push}} = \underbrace{-m_1 V_{1f} + m_2 V_{2f}}_{\text{after collision}}$

$$V_{1f} = \frac{m_2}{m_1} V_{2f} = \frac{350}{60}\times 0.9 = 5.3\left(\tfrac{m}{s}\right) \Rightarrow \boxed{b.}$$

⑤ When the ball was shot, the potential energy of spring is converted to the kinetic energy of the ball.

$$\frac{1}{2} k x^2 = \frac{1}{2} m v^2$$

$$\frac{1}{2} k (2x)^2 = \frac{1}{2} k (4) x^2 = 4\left(\frac{1}{2} k x^2\right) = 4 \frac{1}{2} m v^2$$

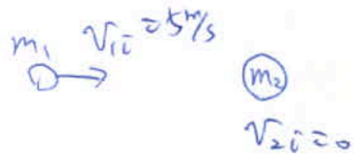
$$= \frac{1}{2} m \, 4 v^2 = \frac{1}{2} m (2v)^2$$

The speed is doubled. $\Rightarrow$ $\boxed{a.}$

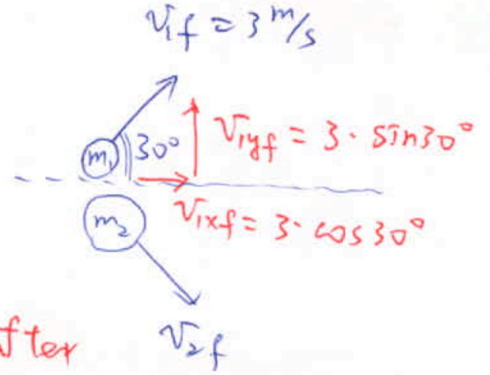
(6.)

The momentum is conserved along x and y directions.

Before collision



After collision



before | after

X: $m_1 V_{1i} = m_1 V_{1xf} + m_2 V_{2xf}$ ---- ①

y: $0 = m_2 V_{1yf} + m_2 V_{2yf}$ ---- ②

from ①: $1 \times 5 = 1 \times 3 \cos 30° + 2 \times V_{2xf}$

$$v_{2xf} = 1.2 \; (m/s)$$

from ②: $0 = 1 \times 3 \sin 30° + 2 V_{2yf}$

$$V_{2yf} = -0.75 \; (m/s)$$

$$V_{2f} = \sqrt{V_{2xf}^2 + V_{2yf}^2} = 1.42 \; (m/s) \Rightarrow \boxed{c}.$$

⑦

$$\Delta E = U_f - U_i = -\frac{GMm}{R+3R} - \left(-\frac{GMm}{R}\right)$$

$$= \frac{GMm}{R}\left(1 - \frac{1}{4}\right) = \frac{3}{4}\frac{GMm}{R} = \frac{3}{4}\frac{(6.67 \times 10^{-11}) \times (5.98 \times 10^{24}) \times 500}{(6.37 \times 10^{6})}$$

$$\cong 2.34 \times 10^{10} \; (J) \Rightarrow \boxed{d.}$$

⑧ $V_i = 12$ $V_f = 0$, all the kinetic energy is lost.

$$\frac{1}{2} m V_i^2 = \frac{1}{2}\left(\frac{8000}{9.8}\right) 12^2 = 5.9 \times 10^4 \; (J) \Rightarrow \boxed{b}.$$