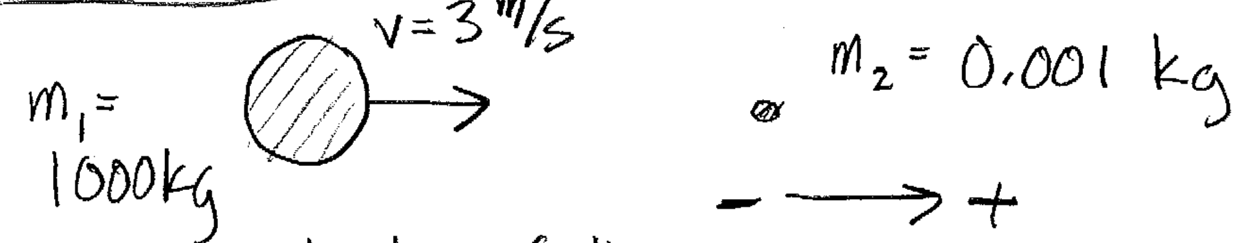
1-dimension



Elastic Collision

Finally, after collision

(A) $V_{2f} \cong 0$ m/s

(B) $V_{2f} \cong 3$ m/s

(C) $V_{2f} \cong 6$ m/s

(D) $V_{2f} \cong 9$ m/s

(E) Can't tell from info given

Answer : (C)

$$V_{1i} - V_{2i} = V_{2f} - V_{1f}$$

$V_{1i} \to V$, $V_{2i} \to 0$, $V_{2f} \to$ unknown, $V_{1f} \to \simeq V$ $(m_1 \gg m_2)$

$$V = V_{2f} - V$$

$$\boxed{V_{2f} = 2V = 2 \cdot 3\,\text{m/s} = 6\,\text{m/s}}$$

"slingshot"

more exactly

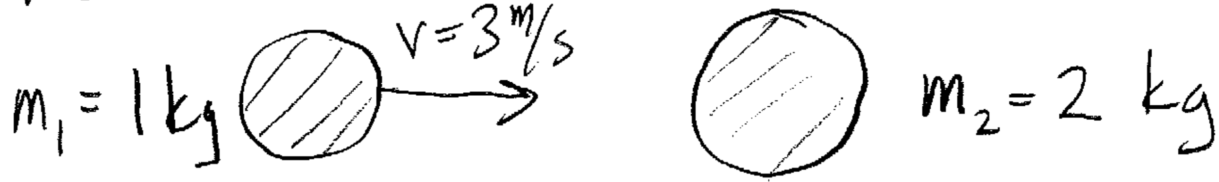
$$V_{2f} = \frac{(m_2 - m_1)}{m_1 + m_2} V_{2i} + \frac{2m_1}{m_1 + m_2} V_{1i}$$

$$V_{1f} = \frac{(m_1 - m_2)}{(m_1 + m_2)} V_{1i} + \frac{2m_2}{m_1 + m_2} V_{2i}$$

V_{xf} flips sign when $m_x < m_y$, compared to V_{xi}

no sign flip, $V_{\underline{\text{other}}\ i}$

1-d



(A) $V_{2f} = 6\,m/s$, $V_{1f} = -3\,m/s$

(B) $V_{2f} = 3\,m/s$, $V_{1f} = -1\,m/s$

(C) $V_{2f} = 2\,m/s$, $V_{1f} = 1\,m/s$

(D) $V_{2f} = -2\,m/s$, $V_{1f} = -1\,m/s$

(E) $V_{2f} = 2\,m/s$, $V_{1f} = -1\,m/s$

$$V_{2f} = \frac{(2-1)}{1+2}\cdot 0 + \overbrace{\frac{2\cdot 1}{1+2}}^{\frac{2}{3}}\cdot \overbrace{3\ \text{m/s}}^{v}$$

$$\boxed{V_{2f} = 2\ \text{m/s}}$$

quick way to get V_{1f}

$$V_{1i} - V_{2i} = V_{2f} - V_{1f}$$

$\uparrow$

$$v - 0 = \frac{2}{3}v - V_{1f}$$

$$\boxed{\begin{aligned} V_{1f} &= \frac{2}{3}v - v = -\frac{1}{3}v = -\frac{1}{3}\cdot 3\ \text{m/s} \\ &= -1\ \text{m/s} \end{aligned}}$$

or

$$V_{1f} = \frac{(1-2)}{1+2}\,\overbrace{3\ \text{m/s}}^{v} + \frac{2\cdot 2}{1+2}\,0\ \text{m/s}$$

$$= -\frac{1}{3}v$$

$$\boxed{V_{1f} = -\frac{1}{3}\cdot 3 = -1\ \text{m/s}}$$

Inelastic Collisions

$\boxed{1\text{-}d}$

Kinetic Energy disappears, but emerges in a new form.

classic: Franck-Hertz Experiment

$$e^- + \text{Atom} = e^- + \text{Atom}^*$$

excited

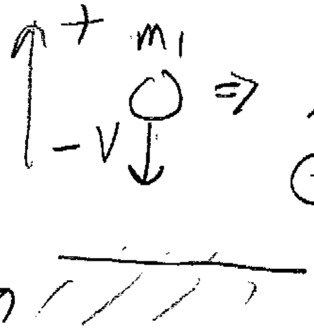
Quantification Challenge

(1) Coefficient of restitution.

elastic: $V_{1i} - V_{2i} = V_{2f} - V_{1f}$

or $$\frac{V_{2f} - V_{1f}}{V_{1i} - V_{2i}} = \cancel{1} \rightarrow c < 1$$

"coefficient of restitution.



$$\frac{-U}{-V-0} = c$$

earth

$m_2 = \infty$

$V_{2i} = 0 = V_{2f}$

$$\boxed{U = cV}$$

$c \approx 95\%$.

(2) Total Inelastic Collision.

$$V_{2f} = V_{1f} \Rightarrow V_{2f} - V_{1f} = 0 \,!$$

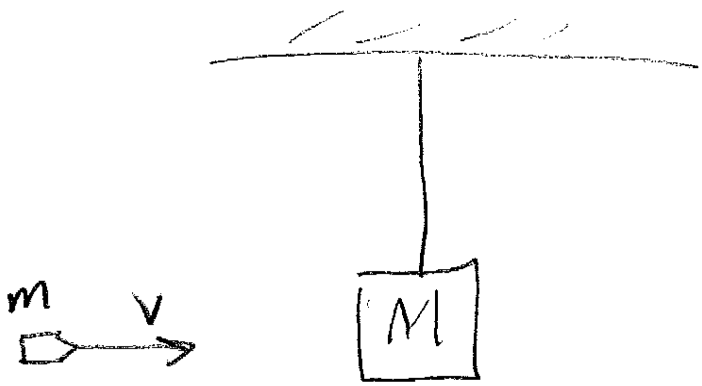
$$C = 0 \,!$$

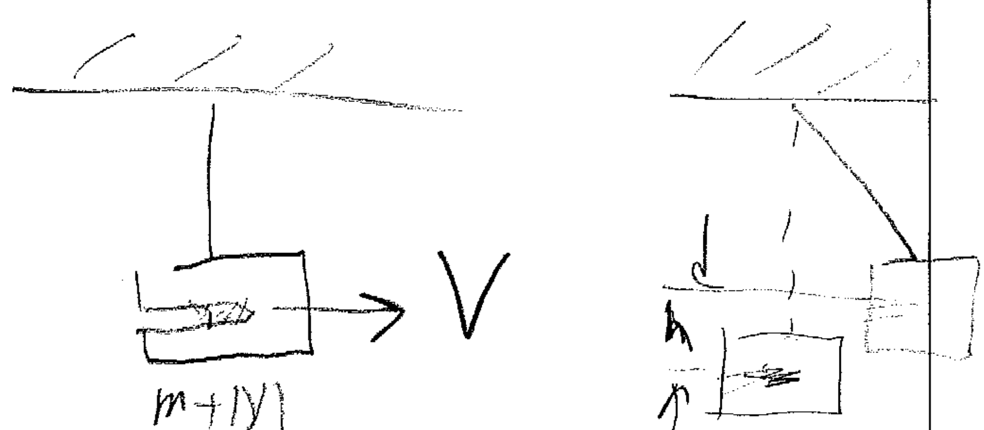
momentum still conserved.

$$m_1 V_{1i} + m_2 V_{2i} = (m_1 + m_2) \underbrace{V_{1f}}_{= V_{2f}}$$

$$V_{1f} = \frac{m_1}{m_1 + m_2} V_{1i} + \frac{m_2}{m_1 + m_2} V_{2i}$$

Measuring Bullet Speed





$$mv = (M + m) V \qquad V = \frac{m}{m + M} v$$

$$\frac{1}{2}(\cancel{M+m})V^2 = (\cancel{M+m})gh$$

$$h = \frac{V^2}{2gh} = \left(\frac{m}{m+M}\right)^2 \frac{v^2}{2g}$$

suppose... $v = 10^3$ m/s

$m = 10$ gm $= 0.01$ kg

$M = 10$ kg

$g = 9.8$ m/s^2

$$h = \left(\frac{10^{-2}}{10^{-2}+10}\right)^2 \cdot \frac{10^6}{2 \cdot 9.8}$$

$$\cong \frac{10^{-6} \cdot 10^6}{20} \simeq .05 \text{ m}$$

$\simeq 5$ cm

(exact... 5.09 cm)

Second Dimension (+ 3rd)

"Billiards"