

Energy Conservation in Collisions

- $K_{1,i} + K_{2,i} = K_{1,f} + K_{2,f}$???



(a) Approach



(b) Collision



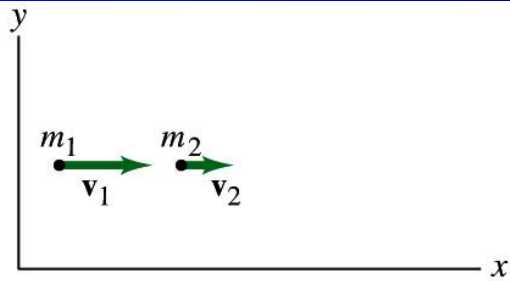
(c) If elastic



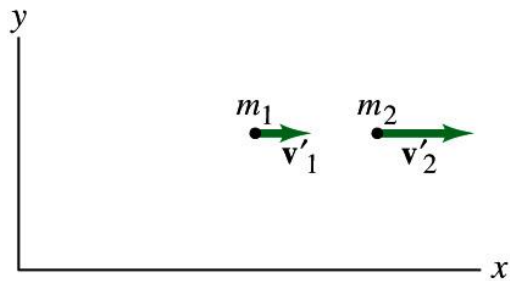
(d) If inelastic

Elastic Collisions

- $K_{1,i} + K_{2,i} = K_{1,f} + K_{2,f}$
- $\mathbf{p}_{1,i} + \mathbf{p}_{2,i} = \mathbf{p}_{1,f} + \mathbf{p}_{2,f}$



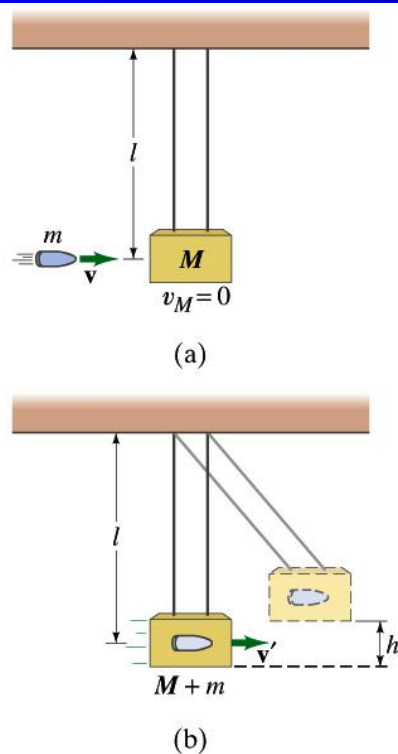
(a)



(b)

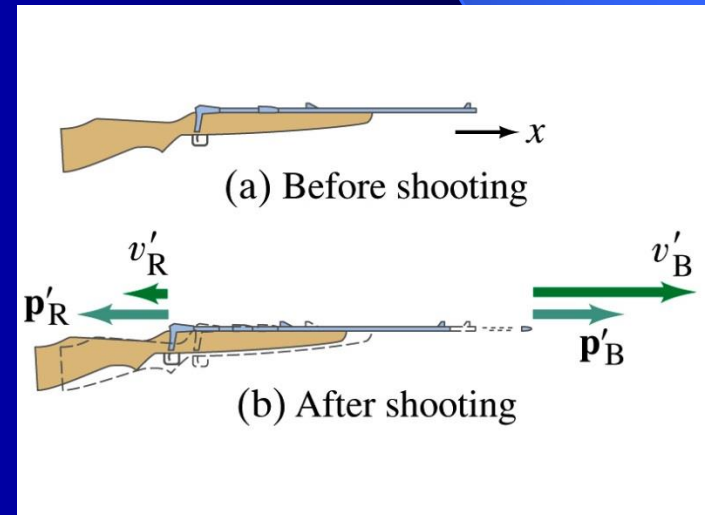
Inelastic Collisions

- $K_{1,i} + K_{2,i} > K_{1,f} + K_{2,f}$
- $\mathbf{p}_{1,i} + \mathbf{p}_{2,i} = \mathbf{p}_{1,f} + \mathbf{p}_{2,f}$



Calculation of Momentum

- Momentum: $\mathbf{p} = m\mathbf{v}$
 - Momentum is conserved!
 - $\mathbf{p}_{1,i} + \mathbf{p}_{2,i} = \mathbf{p}_{1,f} + \mathbf{p}_{2,f}$
 - $m\mathbf{v}_{1,i} + m\mathbf{v}_{2,i} = m\mathbf{v}_{1,f} + m\mathbf{v}_{2,f}$
 - Example: Recoil
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- $m_R = 5.0\text{kg}$, $m_B = 0.050\text{kg}$, $\mathbf{v}_{R,f} = 120\text{m/s}$
 - $m_B \mathbf{v}_{B,i} + m_R \mathbf{v}_{R,i} = m_B \mathbf{v}_{B,f} + m_R \mathbf{v}_{R,f}$
 - $0 + 0 = 0.050\text{kg} \cdot 120\text{m/s} + 5.0\text{kg} \cdot \mathbf{v}_{R,f}$
 - $\mathbf{v}_{R,f} = -1.2\text{m/s}$



Center of Mass

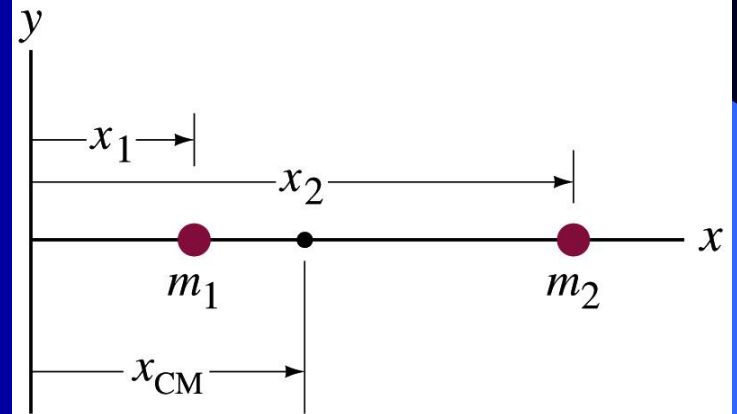


(a)



(b)

$$x_{CM} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2} = \frac{m_1 x_1 + m_2 x_2}{M}$$



More general:

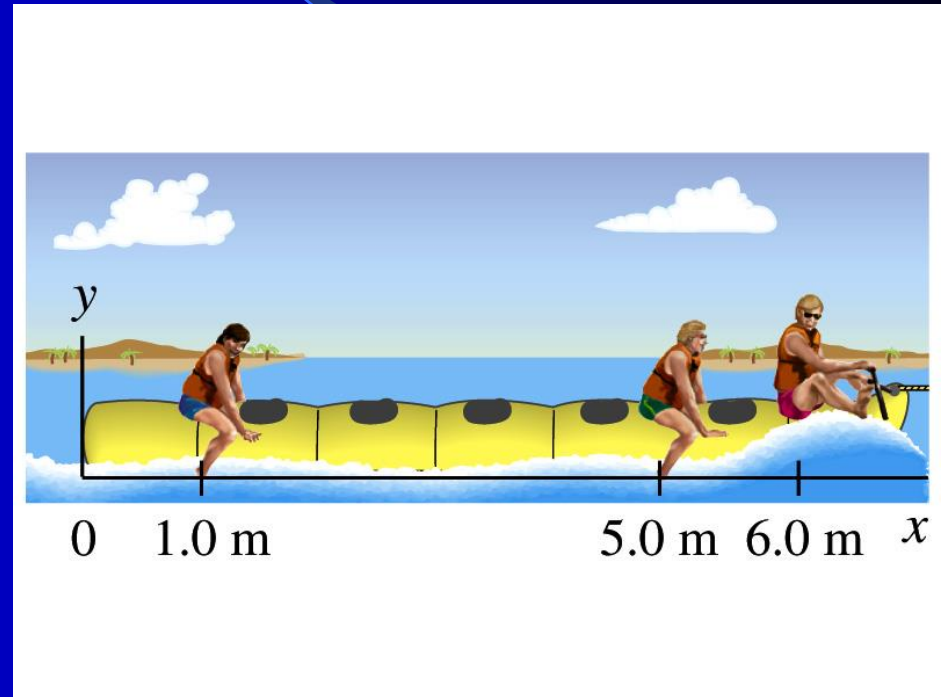
$$x_{CM} = \frac{m_1 x_1 + m_2 x_2 + \dots + m_N x_N}{m_1 + m_2 + \dots + m_N} = \frac{\sum_{i=1}^N m_i x_i}{M}$$

Example

Three people on a raft

All have mass m

$$x_{CM} = \frac{mx_1 + mx_2 + mx_3}{m + m + m} =$$
$$\frac{m(x_1 + x_2 + x_3)}{3m} = \frac{x_1 + x_2 + x_3}{3}$$



$$x_{CM} = 4\text{m}$$

How about in 2 or 3d?

Treat each component separately!

$$\mathbf{r}_i = (x_i, y_i, z_i)$$

$$x_{CM} = \frac{\sum_{i=1}^N m_i x_i}{M}$$

$$y_{CM} = \frac{\sum_{i=1}^N m_i y_i}{M}$$

$$z_{CM} = \frac{\sum_{i=1}^N m_i z_i}{M}$$

$$\mathbf{r}_{CM} = (x_{CM}, y_{CM}, z_{CM})$$