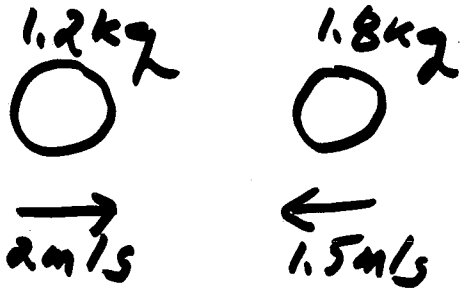
ex) A ball of mass 1.2 kg moving to the right at 2.0 m/s collides with a ball of mass 1.8 kg moving at 1.5 m/s to the left. If the collision is <u>elastic</u> what are the velocities of the balls after the collision?



$m_1 = 1.2\,kg$
$m_2 = 1.8\,kg$
$v_{1i} = 2.0\,m/s$
$v_{2i} = -1.5\,m/s$
$v_{1f} = ?$
$v_{2f} = ?$

conserve momentum!

(1) $m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$

conserve Kinetic Energy

(2) $\frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2 = \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2$

2 equations, 2 unknowns

<u>Algebra</u>

① $v_{1f} = \dfrac{m_1 v_{1i} + m_2 v_{2i} - m_2 v_{2f}}{m_1}$

$v_{1f} = \dfrac{(1.2\,kg)(2\,m/s) + (1.8\,kg)(-1.5\,m/s) - (1.8\,kg)(v_{2f})}{1.2\,kg}$

$v_{1f} = -0.25\,m/s - 1.5\,v_{2f}$

↳ put into ②

$(1.2\,kg)(2.0\,m/s)^2 + (1.8\,kg)(-1.5\,m/s)^2 =$

$(1.2\,kg)(-0.25\,m/s - 1.5 v_{2f})^2 + (1.8\,kg)(v_{2f})^2$

$8.85\,kg\text{-}m^2/s^2 = 0.75\,kg\text{-}m^2/s^2 +$

$.9\,kg\text{-}m/s\,v_{2f} + (2.7\,kg)(v_{2f})^2 + (1.8\,kg)(v_{2f})^2$

$$4.5\,v_{2f}^2 + 0.9\,v_{2f} - 8.775 = 0$$

Quadratic Equation

$ax^2 + bx + c$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$V_{2f} = \frac{-0.9 \pm \sqrt{(0.9)^2 + 4 \cdot 4.5 \cdot 8.775}}{2 \cdot 4.5}$$

$$V_{2f} = \frac{-0.9 \pm 12.6}{9}$$

$V_{2f} = -1.5$ m/s or 1.3 m/s

which one correct?

$V_{2i} = -1.5$ m/s so $V_{2f} \neq -1.5$ m/s

so

$V_{2f} = 1.3$ m/s

$V_{1f} = -2.2$ m/s

Conserve momentum

momentum is a vector

$$\vec{p}_i = \vec{p}_f$$

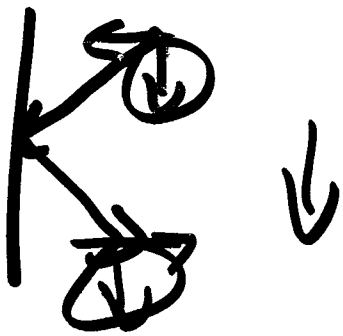
x: $p_{ix} = p_{fx}$ $\quad$ y: $p_{iy} = p_{fy}$

external forces

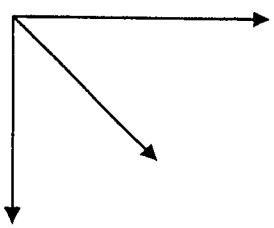
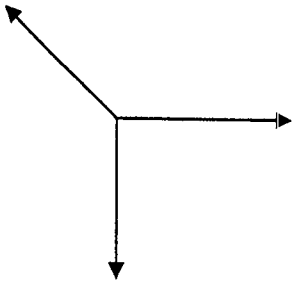
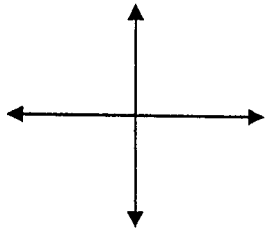
Do I have a change in momentum? yes (y)

Do I have a change in p_x? no

" p_y? yes

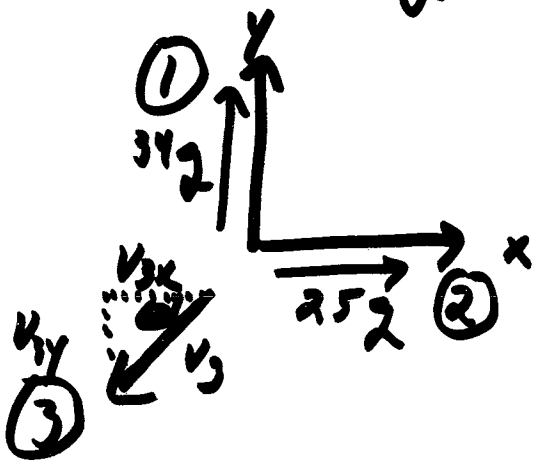


A firecracker at rest explodes into many pieces of approximately equal mass. Which of the following diagrams show the possible velocities the pieces have?

- A) 
B) 
C) 

A) A
B) B
C) C
D) More than one of the above
E) All of the above

ex) A firecracker of mass 100g at rest explodes into 3 parts. One part with mass = 25g moves along x-axis at 75 m/s. Another part of mass 34g moves along y-axis at 52 m/s. What is velocity of 3rd part?



$p_{x_i} = 0$

$p_{y_i} = 0$

mass of 3rd part

$100g - 25g - 34g = \underline{41g}$

$x: m_2 v_2 + m_3 v_{3x} = 0$ $\quad v_{3x} = \frac{-m_2 v_2}{m_3}$

$y: m_1 v_1 + m_3 v_{3y} = 0$ $\quad v_{3y} = \frac{-m_1 v_1}{m_3}$

$v_{3x} = -46 \text{ m/s}$

$v_{3y} = -43 \text{ m/s}$

$v_3 = \sqrt{(-46 \text{ m/s})^2 + (-43 \text{ m/s})^2}$

$= \boxed{63 \text{ m/s}}$

$\tan\theta = \frac{v_{3y}}{v_{3x}} \Rightarrow$ $\boxed{\theta = 43^\circ \text{ below negative } x\text{-axis}}$

Center of Mass

Sometimes motion not simple

(frisbee) → wobbling, spinning

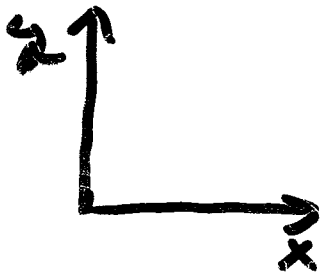
How do we describe motion?

There is a single point on all objects that behaves as a single particle subjected to such forces

This point is called

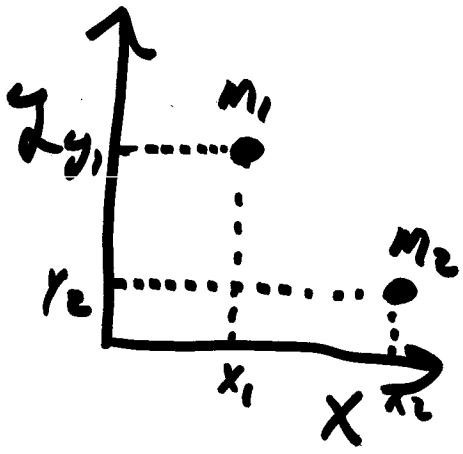
Center of Mass

Define Center of Mass



$$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$$

$$y_{cm} = \frac{\sum m_i y_i}{\sum m_i}$$



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

$$y_{cm} = \frac{m_1 y_1 + m_2 y_2}{m_1 + m_2}$$