Finish Reading chapter 7

7.7 - 7.8

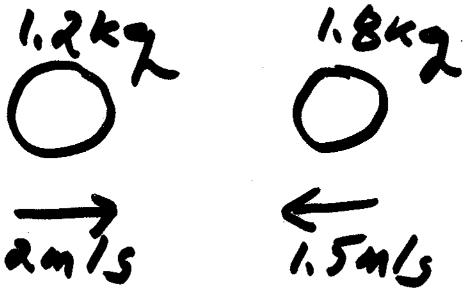
Exam 3 prep on class web page

Elastic Collisions

Conserve both momentum and Kinetic Energy

all collisions → conserve momentum

only elastic → also conserve Kinetic Energy 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 $\cancel{\frac{1}{2}} m_1 v_{1i}^2 + \cancel{\frac{1}{2}} m_2 v_{2i}^2 = \cancel{\frac{1}{2}} m_1 v_{1f}^2 + \cancel{\frac{1}{2}} m_2 v_{2f}^2$

2 equations, 2 unknowns

<u>Algebra</u>

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

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

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

put into ②

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

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

Quadratic equation

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

$$v_{2f} = -1.5\,m/s \quad \text{or} \quad 1.3\,m/s$$

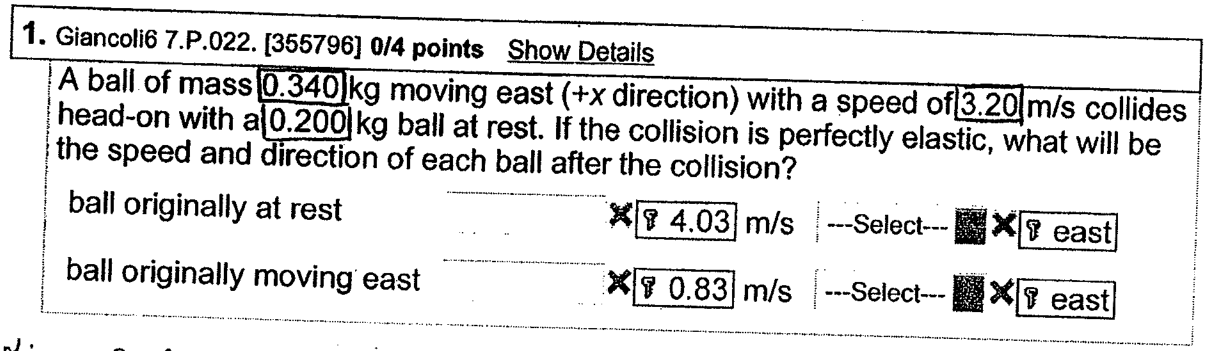
$$\boxed{v_{2f} = 1.3\,m/s}$$

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

put back into ①

$$\boxed{v_{1f} = -2.2\,m/s}$$

PHYS 2414 HW#8 SOLUTIONS



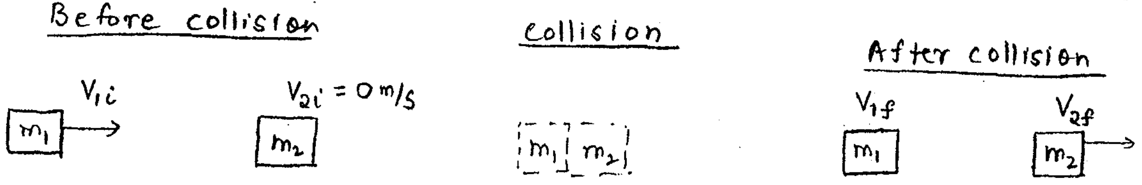
1. Giancoli6 7.P.022. [355796] **0/4 points** Show Details

A ball of mass 0.340 kg moving east (+x direction) with a speed of 3.20 m/s collides head-on with a 0.200 kg ball at rest. If the collision is perfectly elastic, what will be the speed and direction of each ball after the collision?

ball originally at rest ✗ 4.03 m/s ---Select--- ✗ east

ball originally moving east ✗ 0.83 m/s ---Select--- ✗ east

Sol:



Since collision is perfectly elastic both momentum and kinetic energy are conserved. i.e

$$(\vec{P}_{tot})_{initial} = (\vec{P}_{tot})_{final}.$$

$$K_{initial} = K_{final}.$$

$\vec{P} = m\vec{V}$ (kg m/s) depends on direction (vector)

$K = \frac{1}{2}mv^2$ (J) does not depend on direction of motion. (scalar)

Therefore,

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

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

{ Note: We can right away put $V_{2i} = 0$, which will simplify calculation. But we will do this algebra once keeping everything so that we can use it in other problems. }

Collect terms with mass m_1 on one side and terms with mass m_2 on other side in both equations.

$$m_1(V_{1i}-V_{1f}) = m_2(V_{2f}-V_{2i}) \qquad - ③$$

$$m_1(V_{1i}^2-V_{1f}^2) = m_2(V_{2f}^2-V_{2i}^2) \qquad - ④$$

divide ④ by ③ [This can be done excluding a rare case of $V_{1i}=V_{1f}$ and $V_{2i}=V_{2f}$.]

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

$$\Rightarrow \frac{\cancel{(V_{1i}-V_{1f})}(V_{1i}+V_{1f})}{\cancel{(V_{1i}-V_{1f})}} = \frac{\cancel{(V_{2f}-V_{2i})}(V_{2f}+V_{2i})}{\cancel{(V_{2f}-V_{2i})}}$$

using $a^2-b^2=(a+b)(a-b)$

$$\Rightarrow V_{1i}+V_{1f} = V_{2f}+V_{2i} \qquad - ⑤$$

Solve for V_{1f}

$$\boxed{V_{1f} = V_{2f}+V_{2i}-V_{1i}} \qquad — Ⓐ$$

Plug in V_{1f} in eq ①

$$m_1V_{1i}+m_2V_{2i} = m_1(V_{2f}+V_{2i}-V_{1i}) + m_2V_{2f}$$

$$m_1V_{1i}+m_2V_{2i} = \underline{\underline{m_1V_{2f}}} + m_1V_{2i} - m_1V_{1i} + \underline{\underline{m_2V_{2f}}}$$

solving for V_{2f},

$$\underline{\underline{m_1V_{2f}}} + \underline{\underline{m_2V_{2f}}} = \underline{m_1V_{1i}} + m_2V_{2i} - m_1V_{2i} + \underline{m_1V_{1i}}$$

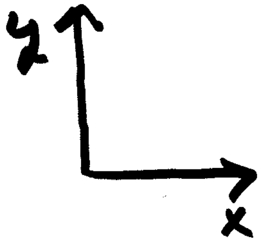
$$V_{2f}(m_1+m_2) = 2m_1V_{1i} + (m_2-m_1)V_{2i}$$

$$\boxed{V_{2f} = \frac{2m_1V_{1i} + (m_2-m_1)V_{2i}}{(m_1+m_2)}} \qquad - Ⓑ$$

Once we have number for V_{2f} we can plug-it back in Ⓐ to get V_{1f}.

momentum is a vector

$\vec{p}_i = \vec{p}_f$ (if no external forces)



x: $p_{ix} = p_{fx}$

y: $p_{iy} = p_{fy}$

Throw a ball

Do I have a change in momentum?

yes external force (gravity)

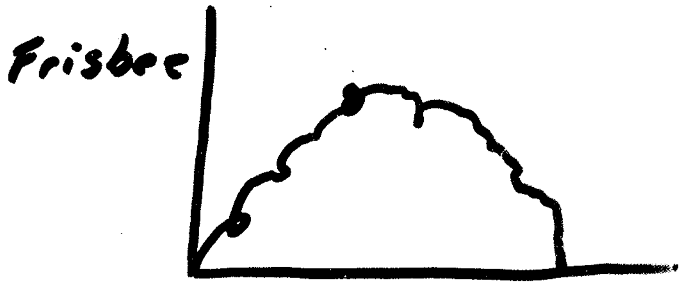
Do I have a change in momentum in

x-direction? NO

y-direction? yes

Center of Mass

Sometimes motion not simple (frisbee) → wobbling, spinning

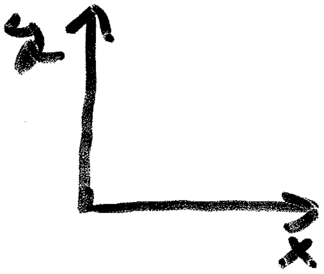


How do we describe motion? There is a single point on all objects that behaves as a single particle subjected to such forces

This point is called

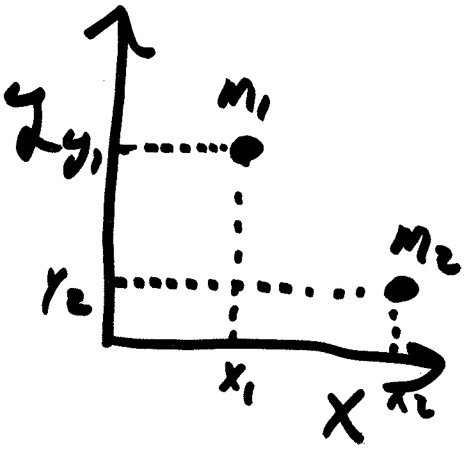
Center of Mass

Define Center of Mass



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

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



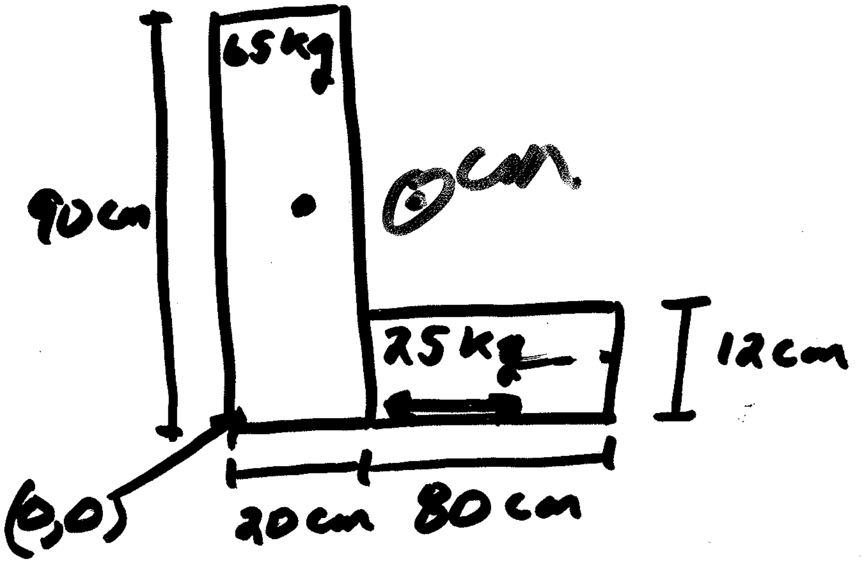
$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

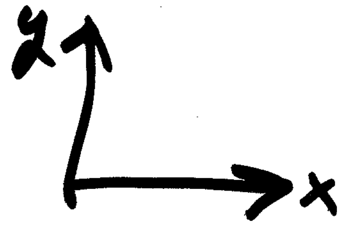
$$y_{cm} = \frac{m_1 y_1 + m_2 y_2}{m_1 + m_2}$$

Find center of mass for

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

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



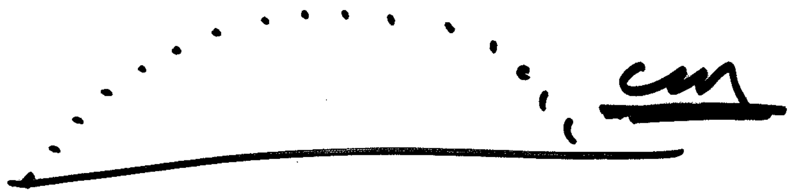


$$x_{cm} = \frac{65kg \cdot 10cm + 25kg \cdot 60cm}{65kg + 25kg}$$

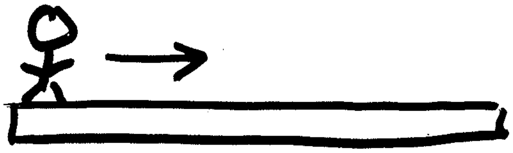
$$y_{cm} = \frac{65kg \cdot 45cm + 25kg \cdot 6cm}{65kg + 25kg}$$

$x_{cm} = 24$ cm

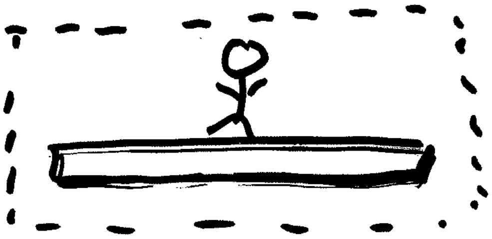
$y_{cm} = 34$ cm



For complicated systems apply "Physics" to center of mass



Raft is at rest, then moves to left. Person at rest, then moves to right → acceleration

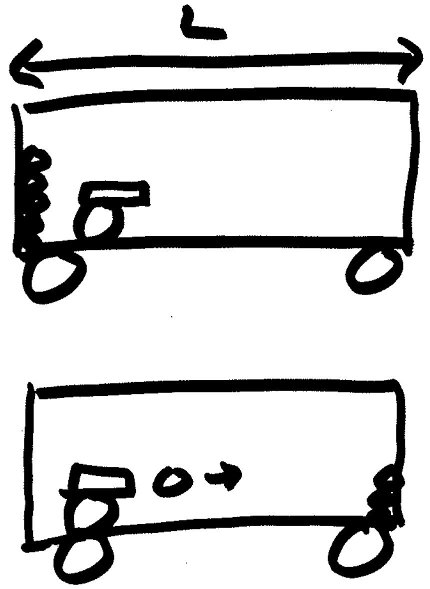


No net forces $\Sigma F = 0 \Rightarrow a = 0$

Explan!!

Center of mass does not move!

A train car holds a cannon and cannonballs it shoots them across the car. what is the maximum distance train car can move?



mass of cannonballs much larger than mass of train car and cannon

A) it won't move

B) can move any distance as long as cannon balls being shot

C) cannot be determined

D) length of train car (L)