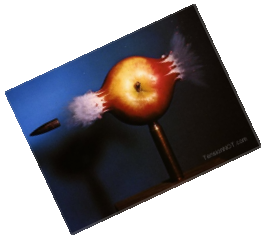
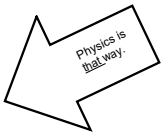
8.3 Conservation of Linear Momentum





1. Pertinent Review

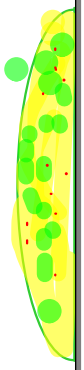
Crash the spaceship with greater momentum into the alien planet!

m = 1.8 kg
v = 140 m/s

252 kg m/s

m = 220 kg
v = 1.25 m/s

275 kg m/s



Conservation of Linear Momentum

In a conservative process (no friction), initial and final momentum are equal:

$$\begin{aligned} |p_1| &= |p_2| \\ \Delta p &= 0 \end{aligned}$$

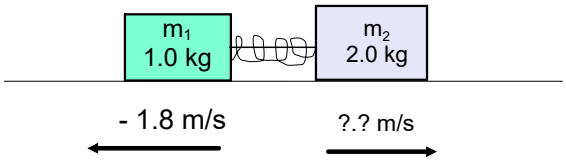
Net force equals zero: no acceleration changes momentum.

This also applies to a system:

$$\begin{aligned} |P_1| &= |P_2| \\ \Delta P &= 0 \end{aligned}$$

2. Example

Two masses (m_1 = 1.0 kg, m_2 = 2.0 kg) are connected by a compressed spring and a rope.
The rope is cut and they fly apart, giving m_1 a velocity of 1.8 m/s in the negative direction. What's the velocity of m_2?



2. Example

Conservation of momentum: initial static system vs. final moving system (small p vs. capital P).

$$p_1 = P_2$$

$$0\,kg\,\frac{m}{s} = |p_1 + p_2|$$

$$|p_1| = |p_2|$$

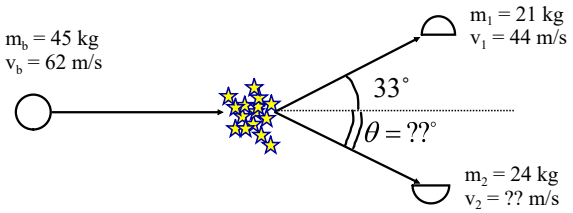
$$|m_1 v_1| = |m_2 v_2|$$

$$|v_2| = \left|\frac{m_1 v_1}{m_2}\right| = \left|\frac{1.0\,kg \bullet -1.8\,\frac{m}{s}}{2.0\,kg}\right| = 0.90\,\frac{m}{s}$$

Warning!!
Long Example Ahead!!

3. Example: More Parts

A 45 kg bomb (subscript = b) goes 62 m/s along x-axis. It explodes into a 21 kg piece (subscript = 1) going 44 m/s at 33°. What are the speed and direction of piece 2 (subscript = 2)?



3. Example: More Parts

Find x and y fragment momenta.

Start with X:

$$|p_{1x}| = |p_{2x}|$$

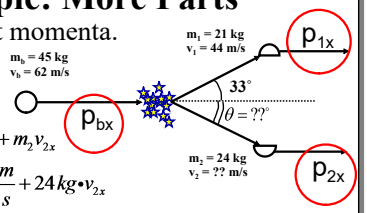
$$p_{bx} = m_b v_b = p_{1x} + p_{2x} = m_1 v_{1x} + m_2 v_{2x}$$

$$45\,kg \cdot 62\frac{m}{s} = 21\,kg \cdot \cos 33^\circ \cdot 44\frac{m}{s} + 24\,kg \cdot v_{2x}$$

$$2790\,kg\frac{m}{s} = 775\,kg\frac{m}{s} + 24\,kg \cdot v_{2x}$$

$$2015\,kg\frac{m}{s} = 24\,kg \cdot v_{2x}$$

$$\frac{2015\,kg\frac{m}{s}}{24\,kg} = v_{2x} = 84\frac{m}{s}$$



Note: x components are in same direction: absolute values don't matter.

3. Example: More Parts

Then Y:

$$|p_{1y}| = |P_2 y|$$

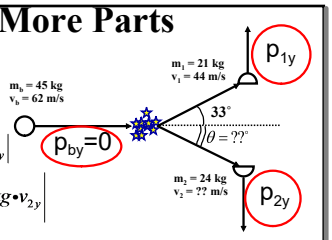
$$p_{by} = 0 = |p_{1y} + p_{2y}| = |m_1 v_{1y} + m_2 v_{2y}|$$

$$0\,kg\frac{m}{s} = \left|21\,kg \cdot \sin 33^\circ \cdot 44\frac{m}{s} + 24\,kg \cdot v_{2y}\right|$$

$$0\,kg\frac{m}{s} = \left|503\,kg\frac{m}{s} + 24\,kg \cdot v_{2y}\right|$$

$$\left|503\,kg\frac{m}{s}\right| = |24\,kg \cdot v_{2y}|$$

$$\left|\frac{503\,kg\frac{m}{s}}{24\,kg}\right| = |v_{2y}| = \left|21\frac{m}{s}\right| = -21\frac{m}{s}$$

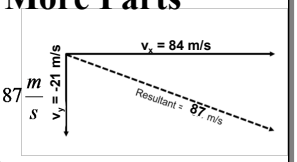


Note: y component of fragment 2 is in -y direction: add negative sign

3. Example: More Parts

Use Pythag. to find velocity:

$$v_2 = \sqrt{x^2 + y^2} = \sqrt{\left(84\frac{m}{s}\right)^2 + \left(21\frac{m}{s}\right)^2} = 87\frac{m}{s}$$



Inverse tangent for direction:

$$\theta = \tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{-21\frac{m}{s}}{84\frac{m}{s}}\right) = -14^\circ = 346^\circ$$

Homework

8.3 Problems in your Booklet
Due: next class