Unit 4: Momentum, Work, Energy, Power

4.1 Momentum

Consider Newton's second law: $\vec{F}_{net} = m\vec{a}$

$\vec{F} = m\frac{\Delta \vec{v}}{\Delta t}$

rearrange and get $\vec{F}\Delta t = m\Delta \vec{v}$ ← change in momentum

impulse ↑

* $m\vec{v}$ is momentum, so $m\Delta\vec{v}$ is change in momentum
* $\vec{F}\Delta t$ is called impulse

* We give momentum the greek letter rho and thus $\vec{F}\Delta t = \Delta \vec{p}$ helps to illustrate that to change something's momentum, we need to impart a force to it for a period of time.

* The units of impulse are $N \cdot s$ which are equal to the units of momentum which are $kg \cdot m/s$

* Momentum and impulse are vector quantities meaning that they have both direction and magnitude.

* We give impulse the symbol $\vec{J}$

ex. Calculate the momentum of a 6.2 kg pumpkin rolling down the street with a velocity of 5.0 m/s West.

$$\vec{p} = m\vec{v}$$
$$= (6.2\,kg)(5.0\,m/s)$$
$$= 31\,kg\,m/s\,[west]$$

ex. A baseball of mass 0.14 kg is moving at 35.0 m/s. ← forward

a) Find its momentum

$\vec{p} = (0.14)(35)$

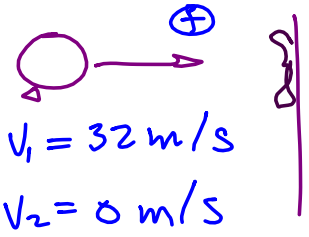
$= 4.9$ kg m/s [forward]

b) A bowling ball of mass 7.6 kg has the same momentum as the baseball above. What is its velocity?

$\frac{\vec{p}}{m} = \frac{m\vec{v}}{m} \Rightarrow \vec{v} = \frac{\vec{p}}{m} = \frac{4.9 \text{ kg m/s}}{7.6 \text{ kg}}$

$\vec{v} = 0.64$ m/s [forward]

ex. A 0.50 kg water balloon is thrown against a wall at 32 m/s coming to a stop. What is its change in momentum?

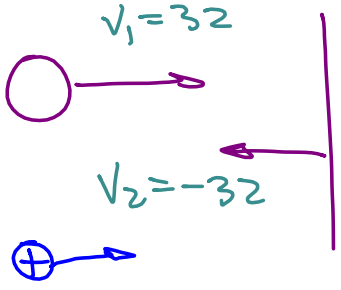


$\Delta\vec{p} = m\Delta\vec{v}$

$= (0.5)(0 - 32)$

$= -16$ kg m/s

ex. A 0.50 kg bouncy ball is thrown against a wall at 32 m/s and bounces back with the same speed. How does its change in momentum compare to that of the water balloon above?



$\vec{p} = m\Delta\vec{v} = m(\vec{v}_2 - \vec{v}_1)$

$= (0.5)(-32 - 32)$

$= 0.5(-64)$

$= -32$ kg m/s

(this makes sense since the wall would have to push back

practice: handout