Collisions and Momentum

Momentum

- momentum is a way of describing the quantity of motion of an object

- momentum depends on the mass and velocity of the object and so is a vector

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

unit are kg•m/s

Example

- Determine the momentum of a 1150 kg car moving south at 24.0 m/s.

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

$$\vec{p} = (1150\text{kg})(24.5\text{m/s})$$

$$\vec{p} = 27600 \text{ kg} \bullet \text{m/s south}$$

$$\vec{p} = 2.76 \text{ x } 10^4 \text{ kg} \bullet \text{m/s south}$$

The direction of the momentum vector will be the same as the velocity

Impulse

- impulse is the change in momentum, units are N•s (newton•seconds) or kg•m/s

- when a net force acts on an object, its motion will change (speed up, slow down or change direction)

- the change in momentum will depend on the force and the amount of time

$$\Delta \vec{p} = \vec{F}\,\Delta t$$

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

The foot is applying a force to the ball for a certain length of time. The ball's momentum will change (an impulse)

- the force required to stop or start an object depends on the time required
- long times = small forces (seatbelts, airbags)
- Short time = large forces

Example

- Wile E. Coyote's rocket has a thrust of 27.9 N and has fuel for 40.0 s. If the total mass is 58.0 kg, determine the impulse acting on him and then calculate his final velocity. Assume he starts from rest.

$$\Delta \vec{p} = \vec{F}\,\Delta t$$

$$\Delta \vec{p} = 27.9\text{N}(40.0\text{s})$$

$$\Delta \vec{p} = 1116\ \text{N} \bullet \text{s}$$

Impulse = 1.12 x 10^3 N•s Right

Example

- Determine Wile's final velocity.

- Impulse = 1116 N•s Right
- $v_i = 0$
- m = 58.0 kg

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

$$1116\ \text{N} \bullet \text{s} = \vec{p}_f - 0$$

$$1116\ \text{N} \bullet \text{s} = \vec{p}_f$$

$$1116\ \text{N} \bullet \text{s} = m\vec{v}$$

$$\frac{1116\ \text{N} \bullet \text{s}}{58.0\text{kg}} = \vec{v} = 19.2\text{m/s}\ \text{right}$$

Another form of the 2nd Law

- Acceleration and the 2nd law formulas can be combined into 1 formula

$$\vec{F} = \frac{m(\vec{v}_f - \vec{v}_i)}{\Delta t}$$

Example

- A 75.0 kg person is in a car moving at 30.0 m/s [North]. If the car brakes to a stop in 5.00 s, determine the force on the person.

$$\vec{F} = \frac{m(\vec{v}_f - \vec{v}_i)}{\Delta t}$$

$$\vec{F} = \frac{75.0kg(0m/s - 30.0m/s)}{5.00s}$$

F = 450 N south

$$\vec{F} = \frac{-2250kg \bullet m/s}{5.00s} = -450N$$

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