

Section 18: Linear Momentum

Why a karate expert can sever a thick piece of lumber with the blow of his bare hand?

Why a fall on a wooden floor is not nearly as damaging as a fall on a cement floor?

Why is "following through" important in golf, baseball and boxing?

To answer these questions we need to understand momentum and impulse.

Consider:

1. Would you rather be hit with a slow or fast-moving baseball? Why?

2. Would you rather be hit with a ping pong ball or a bowling ball at the same speed? Why?

Less Momentum

There are two properties of an object which determine the effect that an object will have when it crashes into something else:

- **mass** and
- **velocity**

The **momentum** of a body is the product of its mass and velocity.

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

where **m** is the mass of the object in kg
v is the velocity in m/s
p is the momentum in kg·m/s

Note momentum is a vector quantity and must have a direction. The direction of an object's momentum is the same as the direction of its velocity.

Note: if mass is constant, $p \propto v$.
if velocity is constant, $p \propto m$.

Examples:

1. What is the momentum of a 2.0×10^3 kg car that has a velocity of 12.8 m/s [E]?

$$\begin{aligned} p &= mv \\ &= (2000 \text{ kg})(12.8 \text{ m/s [E]}) \\ &= 25\,600 \text{ kgm/s [E]} \\ &= 2.6 \times 10^4 \text{ kgm/s [E]} \end{aligned}$$

2. What is the velocity of a 50.0 g bullet that has a momentum of 24.75 kg.m/s [N]?

$$\frac{p}{m} = \frac{mv}{m}$$

$$\frac{24.75 \text{ kg}\cdot\text{m/s [N]}}{0.050 \text{ kg}} = v$$

$$0.050 \text{ kg}$$

$$495 \text{ m/s [N]} = v$$

3. What is the momentum of a 2.0 kg bowling ball traveling at 20.0 km/h [W]?

$$\begin{aligned} p &= mv \\ &= (2.0 \text{ kg})(5.56 \text{ m/s [W]}) \\ &= 11 \text{ kg}\cdot\text{m/s [W]} \end{aligned}$$

Do: question 1 page 278 and
questions 28 - 33 page 307