

# Chapter 7

## Momentum and its Conservation



## Warmup

While watching the movie write down the definition of the word momentum and note whether it is a scalar or a vector.

<http://ionaphysics.org/movies/HSWVMomentum.rv>

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

$$F = ma$$

$$F = m \Delta v / \Delta t$$

$$F \Delta t = m \Delta v$$

$$I = \Delta p$$

**Impulse = change in momentum =  $\Delta p$**

**In this book the symbol for impulse is I**



You are sitting at a baseball game when a foul ball comes in your direction. You prepare to catch it bare-handed. To catch it safely, should you move your hands toward the ball, hold them still, or move them in the same direction the ball is moving? Explain.

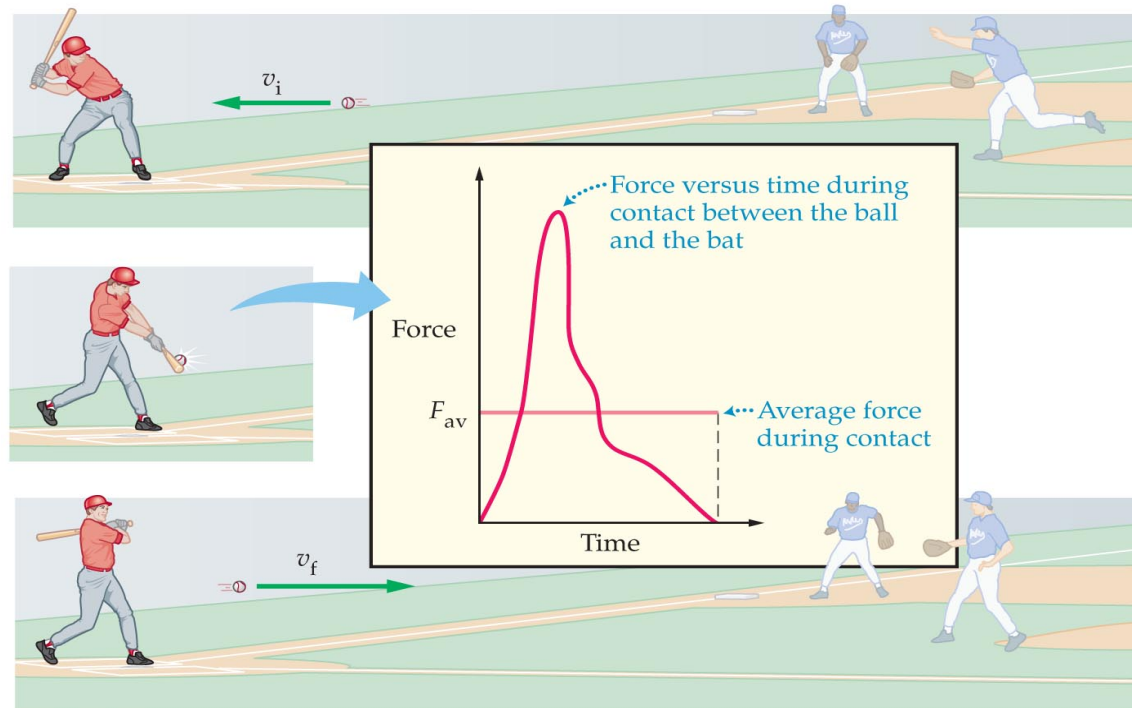
Devise a scientific reason why

1. There are mats on the wall of the gym.
2. There are plastic sand barriers before toll booths.
3. There are mats on the floor under gymnastics equipment.
4. Car dashboards used to be metal. They are padded now.
5. People bend their knees when jumping down off a chair.

A 0.11 g bullet leaves a pistol at 323 m/s, while a similar bullet leaves a rifle at 396 m/s. Explain the difference in exit speeds of the two bullets, assuming that the forces exerted on the bullets by the expanding gasses have the same magnitude.

A 0.145 kg baseball is pitched at 42 m/s. The batter hits it horizontally to the pitcher at 58 m/s. Find the change in momentum of the ball.

If the ball and bat are in contact for  $4.6 \times 10^{-4}$  seconds, what is the average force during contact?









This video is a good review of impulse-momentum.

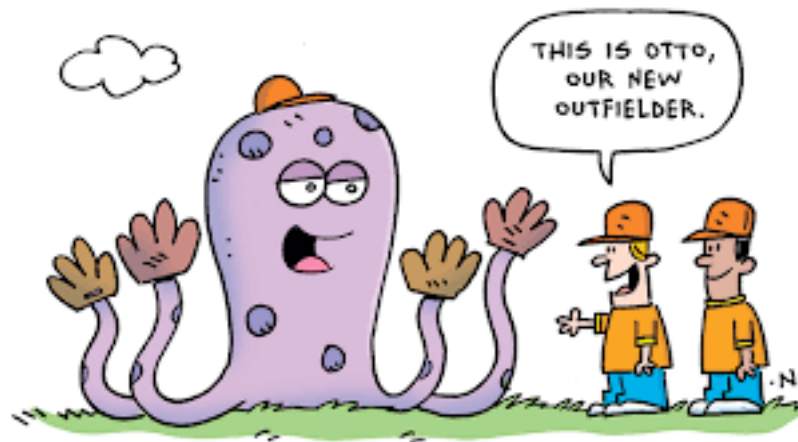
[https://www.youtube.com/watch?v=E13h1E\\_Pc00](https://www.youtube.com/watch?v=E13h1E_Pc00)

A 0.145 kg baseball is moving at 35 m/s when it is caught by a player.

a. Find the change in momentum of the ball.

b. If the ball is caught with the mitt held in a stationary position so that the ball stops in 0.050 s, what is the average force exerted on the ball?

c. If instead the mitt is moving backward so that the ball takes 0.50 s to stop, what is the average force exerted by the mitt on the ball?



A hockey puck has a mass of 0.115 kg and strikes the pole of the net at 37 m/s and bounces back in the opposite direction at 25 m/s. A. What is the impulse on the puck?  
B. If the collision takes  $5.0 \times 10^{-4}$  s what is the average force on the puck?



## Collisions and Explosions:

Watch this video on conservation of momentum

<https://www.youtube.com/watch?v=M2xnGcaaAi4>

Then try this experiment

<http://ionaphysics.org/classroom/Physlets2/IonaPuzzles/FindMass/Find%20the%20Mass.html>

**For this experiment assume the following:**

**Speeds are in m/s**

**Each line on the stick = 1 m**

**How fast is Car #1 moving before the collision?**

A 95 kg (209 lb) fullback running at 8.2 m/s collides in midair with a 128 kg (282 lb) defensive tackle moving in the opposite direction. Both players end up with zero speed. How fast was the defensive tackle moving originally?

Marble C with mass 5.0 g moves at a speed of 20 cm/s. It collides with a second marble D with mass 10.0g moving at 10 cm/s in the same direction. After the collision, marble C continues with a speed of 8.0 cm/s in the same direction. What is the speed of marble D after the collision?

Two lab carts are pushed together with a spring mechanism compressed between them. Upon release, the 5.0 kg cart repels one way with a velocity of 0.12 m/s, while the 2.0 kg cart goes in the opposite direction. What is the velocity of the 2.0 kg cart?



A 50.0 g projectile is launched with a horizontal velocity of 647 m/s from a 4.65 kg launcher moving in the same direction at 2.0 m/s. What is the launcher's velocity after the launch?

**Anthony is standing on a frictionless surface when one of his friends throws him a shotput. It is moving horizontally at 2.5 m/s. Rather than letting it hit his face and give him a black eye, he catches it in his hands. Assume it was a 16 pound shot, so it had a mass of 7.3 kilograms. After catching it, Anthony and the shot move together at 0.26 m/s horizontally. What is Anthony's mass?**

A 0.115 kg hockey puck, moving at 35.0 m/s strikes a .365 kg jacket that is thrown onto the ice by a fan. The puck and jacket slide off together. Find their speed.

A 92 kg fullback running at 5.0 m/s attempts to dive directly across the goal line for a touchdown. Just as he reaches the line, he is met head-on in mid air by two 75 kg linebackers, both moving in the opposite direction. One is moving at 2.0 m/s and the other at 4.0 m/s. They all become entangled as one mass.

Does the fullback score a touchdown?

Two roller-bladers face each other at rest on a flat parking lot. Lemuel has a mass of 32 kilograms and Igor has a mass of 45 kilograms.

When they push off against one another Igor acquires a speed of 0.55 m/s. Find Lemuel's speed.

Here we will return to a demonstration which you saw earlier in the chapter.

The question is a challenge. If you understand conservation of momentum you should be able to solve the challenge. Click the link to begin.

<http://ionaphysics.org/classroom/Physlets2/IonaPuzzles/FindMass/Prelude.html>