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Bouncing Balls: Understanding Momentum

# Background

In many sports there are lots of types of collisions. Whether it is a bat hitting a baseball, heading a soccer ball, or two football players running into each other. To understand the physics of these collisions we can look at Newton’s Third Law which states, “for every action there is an equal and opposite reaction.”

Think of two football players colliding. When a linebacker hits another player, they are exerting

a force on them in the direction they are running. At the same time, the other play is exerting the same force on the other player but in the opposite direction. If you ever got hit with a dodgeball, you may notice that after it hits you it flies off in another direction. This is you pushing against the dodgeball.

We can use Newton’s Laws to understand a concept called **momentum**. Momentum is a way we measure mass in motion. It depends on the mass of an object and its speed.

From Newton’s third law, we can know that the force is always conserved before and after a collision but in the opposite direction. From Newton’s Second Law, we know that force depends on mass and acceleration (F=ma) and acceleration is just a measure of speed over time.

Therefore, since force is conserved, then **momentum** must also be conserved.

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## See it in Action

In this experiment, we want to see how mass affects an object's momentum.

### *Materials*

* 3 balls of different sizes (eg. tennis ball, ping pong ball, baseball, basketball, etc.)
* Meter stick or measuring tape
* A hard surface to drop onto (tile, wood, cement)

### Procedure

1. Determine the masses of your ball. If you don’t have a scale, the mass of some common balls is listed below. Record your data in the data collection table below. Make sure your mass is in kilograms (kg).

|  |
| --- |
| **Common Masses of Different Ball Types** |
| **Ball Type** | **Average Mass (kg)** |
| Baseball | 0.149 |
| Ping Pong Ball | 0.003 |
| Tennis Ball | 0.056 |
| Soccer Ball | 0.430 |
| Basketball | 0.624 |
| Golf Ball | 0.046 |
| Lacrosse Ball | 0.150 |

1. Tape your meter stick or measuring tape to the wall so that zero is closest to the ground.
2. Have a partner drop one of the balls from 1 meter while you look at the meter stick to record how high the ball bounces. Record the height it bounces in the table below. Make sure your measurement is recorded in meters.
3. Repeat step 3 two more times with your other balls.

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| --- |
| **Data Collection Table** |
| **Ball Type** | **Mass (kg)** | **Surface 1 bounce height (m)** |
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|  |  |  |
|  |  |  |

### Calculating Velocity

To calculate velocity, we use the following formula:

Velocity = √2gh

Where g is acceleration (9.82 m/s2) and h is the height in meters from which you dropped the ball.

Calculate the velocity for each ball below and answer the question below

|  |  |
| --- | --- |
| **Ball Type** | **Velocity** |
|  |  |
|  |  |
|  |  |
| Does velocity depend on the mass of the ball? |  |

### Calculating Momentum

Momentum is just a measurement of mass in motion. It can be represented by the formula:

p = m \* V

where p = momentum, m = mass, and V = velocity.

Calculate the momentum for each ball before the collision and answer the question below.

|  |  |
| --- | --- |
| **Ball Type** | **Momentum** |
|  |  |
|  |  |
|  |  |
| Why is the momentum different for each ball? |  |
| How does momentum affect the bounce height?  |  |

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