

Momentum: Rocket Ball Launcher

Introduction:

Any object that is moving has a momentum. Momentum is the product of the mass and the velocity. Larger and heavier objects will have a higher momentum than lighter and smaller objects. In this lab you will be applying this force to two different size balls. Both balls will hit the ground the same speed, however the momentum from the larger ball is transferred to the smaller ball, increasing the velocity of the small ball greatly.

Materials:

- At least 2-3 balls of different sizes
- Meter stick

Procedure:

1. Stack one ball on top of the other (the small ball should be touching the larger ball); hold at any distance above the ground
2. Release both of the balls at the exact same time; ensure that when they hit the ground, the smaller ball is still on top when they hit the ground.
3. If possible measure the height of the smaller ball after it “rocks” off. Try at least 3 different trials.

Mass of smaller ball (g): _____

Mass of larger ball (g): _____

	Trial 1	Trial 2	Trial 3
Height of the Ball Bounce			

4. Next, try releasing the two balls together from varying heights and measure the difference heights the smaller ball bounces.

Drop Distance 1: .5 m

	Trial 1	Trial 2	Trial 3
Height of the Ball Bounce			

Drop Distance 2: 1 m

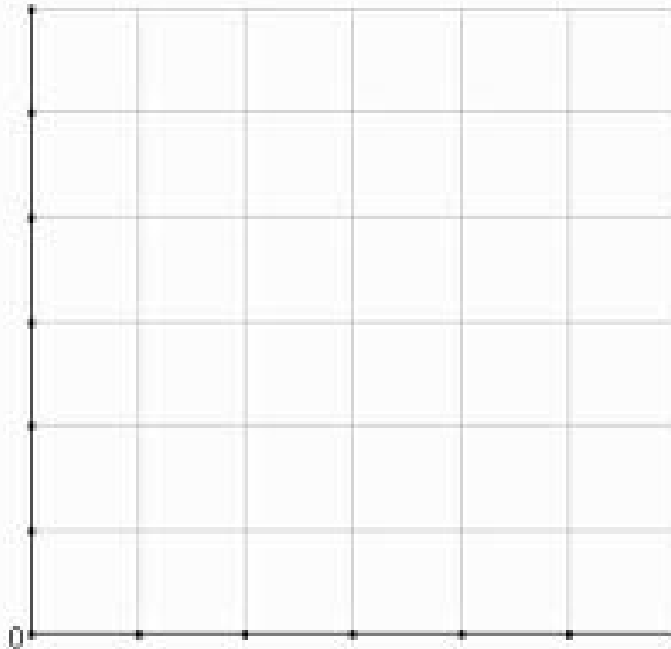
	Trial 1	Trial 2	Trial 3
Height of the Ball Bounce			

Drop Distance 3: C1.5 m

	Trial 1	Trial 2	Trial 3
Height of the Ball Bounce			

*You can also try switching to different types of balls.

5. Create a graph comparing the height you dropped the balls from to the average height of the smaller ball's bounce.



Momentum can be defined as “mass in motion”. Since all objects have mass, if those objects are moving they have momentum.

$$\text{Momentum (p)} = \text{Mass} \times \text{Velocity}$$

In a collision, such as with the balls used in the experiment, the momentum was transferred from one ball to the other. Although the balls were traveling with the same momentum, when they hit the ground, all of the momentum was transferred to only the smaller ball. The heavier ball had more momentum than the smaller ball, and since they were traveling with the same velocity, when they hit the ground, all of the larger ball's momentum was transferred to the smaller ball causing it to rocket off.

Momentum is also a vector quantity. A scalar quantity only has magnitude, so we don't need to worry about direction. But, a vector quantity involves both direction and magnitude. In simplified terms, it means that if your 2 objects are moving opposite directions one of the velocities will have to be a negative value, to account for the difference in direction.

Calculations:

1. Calculate the momentum of each ball before it hits the ground.
2. Assuming the large ball's momentum was all transferred to the smaller ball, what would be the momentum of the smaller ball after the bounce.
3. Given the momentum of the smaller ball, what would the velocity of the smaller ball be?
4. What do you think would happen if you used an even larger ball?
5. What do you think would happen if the smaller ball were actually heavier than the larger ball? Such as a baseball versus a beach ball?

6. If a car has a momentum of 2.04×10^4 kg m/s and a velocity of 18 m/s, what is its mass?

7. A 15,000 kg tugboat is moving East at 6.0 m/s. A 1.2×10^5 kg barge is moving West at 1.2 m/s. Which object's momentum has the greatest magnitude? If these 2 objects collided, which way would the system move?

8. Which has more momentum, a 1000 kg car moving 1 m/s or a 70 kg person sprinting at 8 m/s?

9. A 1500 kg car traveling at 15 m/s collides with a 500 kg moose, which is at rest. If the moose is knocked backward at 20 m/s, what happens to the car?

10. Given the following data, solve for momentum of each object (next page)

<u>Object</u>	<u>Mass (kg)</u>	<u>Velocity (m/s)</u>	<u>Momentum (kgm/s)</u>
1) Bird	.04	19	
2) Football player	100	10	
3) Skier	60	20	
4) Bullet	.004	600	
5) Frog	.9	12	
6) Meteorite	.1	1,000	
7) Baseball	.14	30	
8) Wagon	2	3	
9) Satellite	3,000	8,000	

Solutions:

6. If a car has a momentum of 2.04×10^4 kg m/s and a velocity of 18 m/s, what is its mass?
113.3 kg
7. A 15,000 kg tugboat is moving East at 6.0 m/s. A 1.2×10^5 kg barge is moving West at 1.2 m/s. Which object's momentum has the greatest magnitude? If these 2 objects collided, which way would the system move?
90,000 kgm/s – tugboat 144,000 kgm/s - barge
They would move West b/c the barge has more momentum
8. Which has more momentum, a 1000 kg car moving 1 m/s or a 70 kg person sprinting at 8 m/s?
1,000 kgm/s – car; 560 kgm/s – person
car has more momentum
9. A 1500 kg car traveling at 15 m/s collides with a 500 kg moose, which is at rest. If the moose is knocked backward at 20 m/s, what happens to the car?
It is moving the same direction at 8.33 m/s
10. Given the following data, solve for momentum of each object (on next page)

<u>Object</u>	<u>Mass (kg)</u>	<u>Velocity (m/s)</u>	<u>Momentum (kgm/s)</u>
1) Bird	.04	19	.76
2) Football player	100	10	1,000
3) Skier	60	20	1200
4) Bullet	.004	600	2.4
5) Frog	.9	12	10.8
6) Meteorite	.1	1,000	100
7) Baseball	.14	30	4.2
8) Wagon	2	3	6
9) Satellite	3,000	8,000	24,000,000