Name _____ per _____ due date _____ mail box _____

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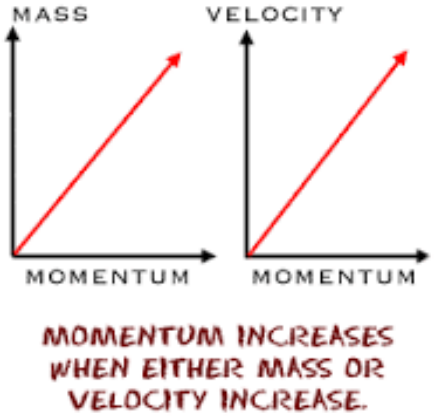
Rolling Momentum Lab

Today in lab, we will be experimenting with momentum and measuring the actual force of impact due to momentum of several rolling objects. You will be rolling these objects down a ramp into orange solo cups. The cups provided have a hollowed out area for the objects (*several different balls*) to enter, strike the interior wall of the solo cup and drive it forward. Thus, we can have crude way of measuring the force of momentum during an impact.



YOU WILL BE TASKED WITH THE FOLLOWING:

- Finding the mass of the various objects.
- Measuring how far the objects drive the solo cup forward
- Calculate speed **DATA TABLE I** for comparison
- Calculating momentum of the various objects
- Answering several pertinent lab questions
- Creating a diagram of the lab setup and relating it to Newton's 3rd Law of Motion

PROCEDURE:

Step 1. Measure the masses of the three balls and record in **DATA TABLE II:** ***Momentum of Various Balls.***

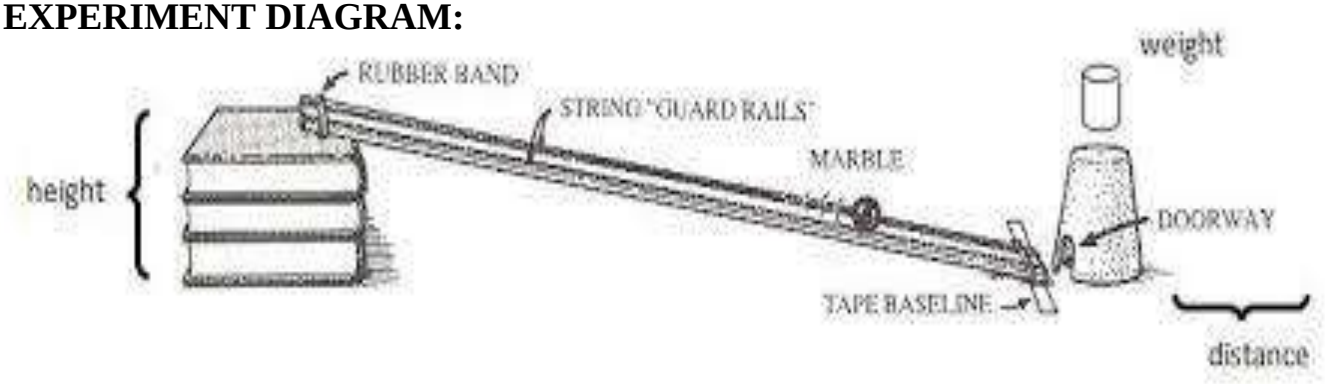
Step 2. Roll the balls by releasing them individually from the top of the ramp. Be sure to prepare the solo cup to *catch* each individual as it exits the ramp.

Step 3. Measure how far the Solo cup slides across the floor.

Step 5. Calculate the momentum of each rolled object, record in **DATA TABLE II.**

Step 4. Record the distance the cups slide **DATA TABLE III**.

EXPERIMENT DIAGRAM:

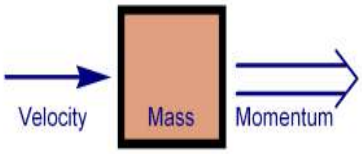


DATA TABLE I: *Speed of Various Balls*

	DISTANCE (meter)	TIME (seconds)	SPEED (m/sec)
Marble	**1.2m**	**1.4 sec**	**m/sec**
Golf Ball	**1.2m**	**1.55 sec**	**m/sec**
Ping Pong	**1.2m**	**1.8 sec**	**m/sec**

DATA TABLE II: *Momentum of Various Balls*

	MASS (grams)	VELOCITY (m/sec)	MOMENTUM g(m/sec)
Marble		**m/sec**	
Golf Ball		**m/sec**	
Ping Pong		**m/sec**	



DATA TABLE III: *Distances the Solo cup travels*

Distance (inches or cm)	Trial 1	Trial 2	Trial 3	Average
Marble				
Golf Ball				
Ping Pong				

LAB WRITE UP QUESTIONS:

1. In Step 3, you measured how far the Solo cup slides across the floor. One of the balls had just crashed into the cup causing it to slide. What law of motion are we studying here? _____

2. What is the relationship between the calculated momentum (DATA TABLE II) and the distance the solo cups traveled (DATA TABLE III)?

   _____

   _____

   _____

3. Consider Newton's Second Law which states that ***Force = mass x acceleration.*** Note this is very similar to the equation for momentum, ***Momentum = mass x velocity.*** Acceleration is simply increasing speed and velocity is simply speed with direction. You watched as each of the balls accelerate down the track toward the solo-cup. Why does it take longer for the solo cup to stop the golf ball as opposed to the ping-pong ball or the marble? **Discuss force, mass and acceleration**. Note: use DATA TABLE I (speed) for a rough estimate acceleration.

   _____

   _____

   _____

4. How would you find the *force* of the ping-pong ball rolling down the track?

   _____

   _____

5. The **force of friction** is what opposes the balls forward momentum and causes it to eventually come to a stop. You can think of friction in regard to Newton's Second Law too as a *force = mass x deceleration*. Describe where and how the force of friction is opposing momentum.

   _____

   _____

   _____

6. How could we create a scenario where the marble would cause the cup to slide equally as far as the golf ball caused it to slide? **Discuss the variable to increase and how you would accomplish this.**

   _____

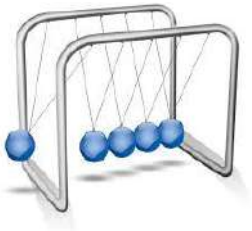
   _____

   _____

7. Is there a height or length of ramp we might increase or change so that our ping-pong ball might attain significant enough momentum to drive the solo-cup forward as far as the marble does? **State your opinion and explain:**

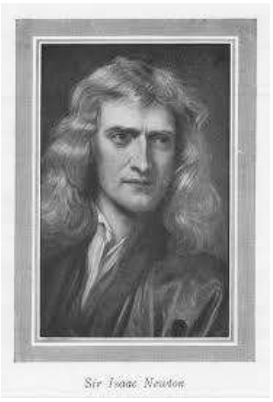
_____
_____
_____

8. Consider the Newton's cradle. Is momentum transferred during our experiment in quite the same way or in another way? **Explain:**



_____
_____
_____
_____
_____

Another way to understand collisions is through Newton's 3rd Law, which tells us that "for every *action*, there is an equal and opposite *reaction*". When the car collides with a guard rail, the car exerts a force on the guard rail in the direction that the car is traveling. Meanwhile for every *action* there is a *reaction*. The guard rail exerts an equal and opposite force on the car in the opposite direction. This is the reason that after the car collides with an object that, it sometimes often is deflected and moves in a new direction.



9. Use Newton's 3rd Law to describe our scenario. Describe the initial action, reaction and relate it to Newton's 3rd Law. **Be sure to explain which part is action, reaction and how the forces were exerted.**

_____
_____
_____
_____
_____

10. **Draw a diagram** of the experiment setup (similar to page 2)

Draw:

- **ramp**
- **text book**
- **ball with vector arrow**
- **solo-cup**

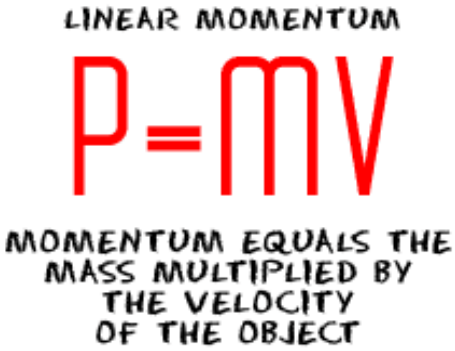
Label:

- **acceleration "zone" of the ball**
- **Action & Reaction points (with words and arrows)**
- **distance "friction zone" (where the cup is sliding)**

Be certain and make sure it is clear in which direction forces are being applied.
At a minimum, you need the 7 things listed above. Be creative & don't worry about scale.

LAB READING MATERIAL

Momentum = mass x velocity



The amount of momentum an object has depends both on its *mass* and *how fast it is going*. For example, a heavier with more mass object, going the same speed as a lighter object (less mass) will have greater momentum. Sometimes when moving objects collide into each other, momentum can be transferred from one object to another.

A *collision* follows the *Law of Conservation of Momentum*, which states "the total amount of momentum before a collision is equal to the total amount of momentum after a collision." A classic collision example may be observed in a game of pool. Watch a moving cue ball hit a resting pool ball. At impact, the cue ball stops and transfers all of its momentum to the other ball, resulting in the hit ball rolling with an initial speed of that of the cue ball.

Another type of *collision*, the total momentum of the system is conserved, but the total kinetic energy of the system is not conserved. Instead, the kinetic energy is transferred to another kind of energy such as heat. A dropped ball of clay demonstrates an extremely different kind of collision. It does not bounce at all and loses its momentum. Instead, all the energy goes into deforming the ball into a flat blob.

In either example, a quantity (*a number*) for momentum can be measured by taking the product of mass and velocity.

Momentum = mass x velocity

Ex: *Mass of a ball = 5 grams, (Speed or Velocity) = 25 ft/s*

5g x 25ft/s = 125 **grams per foot per second** or 125**g per ft/s**

Prep: Answer the follow from the reading and knowledge attainted during class.

1. Define momentum.

2. Why does it take a large truck longer to stop than a compact car, even though both are traveling at the same velocity?

3. The product of the mass and velocity of an object is called_____.

4. Explain the law of conservation of momentum.

5. Which of the following has the smallest amount of momentum?
   a. A loaded truck driven at highway speed
   b. A track athlete running a race
   c. A baby crawling on the floor
   d. A jet airplane being towed toward an airport.

6. What is the equation used to calculate momentum?

7. Calculate the momentum of a 2.5kg puppy that is running with a velocity of 4.8m/s south. Show all your work below.

8. If a cue ball hits a billiard ball so that the billiard ball starts moving and the cue ball stops, what happens to the cue ball's momentum?
   a. Some of the cue ball's momentum has transferred from the billiard ball.
   b. All of the cue ball's momentum has transferred from the billiard ball.
   c. All of the cue ball's momentum has transferred to the billiard ball.
   d. Some of the cue ball's momentum has transferred to the billiard ball.

9. What usually happens to momentum when objects collide?
   a. Momentum of each object remains the same.
   b. Momentum of each object increases.
   c. Momentum of each object becomes equal
   d. Momentum transfers from one object to another.

10. How is the collision of a cue ball and a billiard ball an example of Newton's 3rd law?