Heading

Title

**Introduction**

**Purpose**

To investigate momentum in terms of the amount of inertia an object possesses and the movement of objects.

**Discussion**

Momentum is inertia in motion and can be mathematically described as the product of the mass of an object multiplied by its velocity, expressed ρ = m v. The variables are mass (m) of objects, speed (v) of objects, and the angle at which objects collide. Momentum will increase if the mass of objects or the speed the objects travel increase.

Momentum relates to the transfer of motion from one object to another, assume elastic collisions (no heat or KE is lost). When objects collide, the law of conservation of momentum applies, meaning that momentum before a collision equals the momentum after the collision.

**Hypothesis**

If a ball is rolled at constant speed and collides with a stationary softball, then the faster the ball rolls, the more the softball will move because the faster ball has more momentum (mv).

If balls of different mass are rolled at constant speed and collide with a stationary softball, then the more massive balls will move the softball more because the more massive ball has more momentum (mv).

**Materials** Stop Watch Tennis ball Golf ball Softball Baseball

 Masking Tape Mass Balance Meter stick

 1 m Shorter Track 2 m Longer Tracks

**Procedures**

1. Set up a “track system” using two 2 m motion cart tracks and a 1 m track. (*Be creative with materials, if necessary. For instance, 2” x 4”s work nicely.*).

Softball 1 m from end of 2 m track

1 m track as ramp

Tennis ball

O cm “Start”mark

1 m mark

2. Obtain a softball and a tennis ball to begin.

3. Set up two 2 m longer tracks to act as a “channel” for the various balls to travel down. Place the tracks parallel to each other and far enough apart so the softball has 1 cm clearance (*i.e. 1 finger width)* on each side when in-between the tracks. Also, designate the “Start” (0 cm) position and place the softball 1 m from that mark.

4. Use a shorter (1 m) track as a ramp to launch the tennis ball at a “constant velocity.” Do not allow the tennis ball to “bounce” too much.

5. Measure the amount of matter for each ball*. Record this in the Calculations and Data section*. Convert all your mass measurements to Newtons.

6. There are several tasks:

a. Mark the 1 m spot where the softball begins and measure the distance it travels after being hit by the other ball(s).

b. Roll the ball down the shorter track at the height specified so that it hits the softball.

c. Time the ball from the “*Start*” (0 cm) position to the softball and record in the data table.

Softball – measure the distance it moves

1 meter distance apart

from center of softball

Tennis ball

Motion Cart Tracks

*Start*

7. Raise the shorter track 30 cm on the far end and release the tennis ball so that it rolls down the track and in-between the longer tracks in order to hit the softball. Place something under the track to maintain the 30 cm height of the ramp.

8. Place the softball 1 m from the “*Start*” position and have the meter stick ready.

9. Use the tennis ball first and hold the ball at the top of the ramp.

10. Measure the time it takes for the tennis ball to roll the 1-meter distance from the “Start” position down the longer tracks to hit the softball. *Record the time in the Calculations and Data table*.

11. Measures the distance the softball is moved after the collision (*to the nearest tenth of a meter*).

12. Do THREE trials for the tennis ball rolled SLOWLY (30 cm ramp height)*. Record your results in the Calculations and Data section of the lab*.

13. Do THREE trials **again** for the tennis ball. However, this time roll the ball QUICKLY towards the softball by raising the end of the shorter track (ramp) to 60 cm height. *Record your results in the Calculations and Data section of the lab*.

14. Repeat the procedures using the golf ball.

15. Repeat the procedures using the baseball.

**Calculations and Data**

1. Use the formula  = mv to calculate the momentum for each type of ball rolled both slowly and quickly.

 a. You must use kilograms in your calculations. 1 kg = 1000 g

 b. SHOW YOUR WORK in the space provided.

2. BE SURE TO INCLUDE UNITS FOR ALL MEASUREMENTS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Tennis ball | Golf ball | Baseball | Softball |
| Mass in g |  |  |  |  |
| Mass in kg |  |  |  |  |
| Newtons |  |  |  |  |

\_\_\_ g x 1 kg/1000 g = \_\_\_ kg

\_\_\_ kg x 10 = \_\_\_ N

**Tennis Ball**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Distance ball traveled | Time | VelocityV = d/t | Mass | Momentum = mv | Distance Softball moved |
| Tennis ball - slow |  |  |  |  |  |  |
| Tennis ball - fast |  |  |  |  |  |

Calculations:

**Golf Ball**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Distance ball traveled | Time | VelocityV = d/t | Mass | Momentum = mv | Distance Softball moved |
| Golf ball - slow |  |  |  |  |  |  |
| Golf ball - fast |  |  |  |  |  |

Calculations:

**Baseball**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Distance ball traveled | Time | VelocityV = d/t | Mass | Momentum = mv | Distance Softball moved |
| Baseball - slow |  |  |  |  |  |  |
| Baseball - fast |  |  |  |  |  |

Calculations:

 Be sure you show work for your velocity and momentum calculations in the spaces provided.

1. Compare the momenta you calculated in terms of how massive each ball was (*smaller mass to larger mass*).

2. Compare the momenta you calculated in terms of velocity (*quicker versus slower*).

**Conclusions and Questions**

1. What is the scientific term for the amount of matter a substance contains? How does this term relate to inertia?

2. What was the relationship between the momentum of a moving ball and the distance the softball was moved? Give evidence to support your answer.

3. Place the three balls (tennis, golf, baseball) in order in terms of momentum. Which had the greatest momentum? Which had the least momentum? Give evidence to support your answer.

4. Why did the baseball have more momentum than the tennis ball even though they traveled at about the same velocity? Give evidence to support your answer.

5. How did you observe Newton’s third law of motion during this activity?

**Calculations and Data**

BE SURE TO INCLUDE UNITS FOR ALL MEASUREMENTS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Tennis ball | Golf ball | Baseball | Softball |
| Mass in g | 59 g | 45 g | 141 g | 184 g |
| Mass in kg*Divide grams by 1000* | 0.059 kg | 0.045 kg | 0.141 kg | 0.184 kg |
| Newtons*Multiply kg by 10* | 0.6 N*rounded up* | 0.45 N | 1.4 N | 1.8 N |

**Tennis Ball**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Distance ball traveled | Time | VelocityV = d/t | Mass | Momentum = mv | Distance Softball moved |
| Tennis ball - slow | 2 m | 1.3 s | 1.5 m/s | 0.059 kg | 0.09 kg m/s | 0.4 m |
| Tennis ball - fast | 2 m | 0.8 s | 2.5 m/s | 0.15 kg m/s | 0.9 m |

Calculations: v = d/t = 2 m / 1.3 s = 1.5 m/s p = mv = (0.059 kg)(1.5 m/s)

 v = d/t = 2 m / 0.8 s = 2.5 m/s p = mv = (0.059 kg)(2.5 m/s)

**Golf Ball**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Distance ball traveled | Time | VelocityV = d/t | Mass | Momentum = mv | Distance Softball moved |
| Golf ball - slow | 2 m | 1.3 s | 1.5 m/s | 0.045 kg | 0.07 kg m/s | 0.2 m |
| Golf ball - fast | 2 m | 0.8 s | 2.5 m/s | 0.11 kg m/s | 0.6 m |

Calculations: v = d/t = 2 m / 1.3 s = 1.5 m/s p = mv = (0.045 kg)(1.5 m/s)

 v = d/t = 2 m / 0.8 s = 2.5 m/s p = mv = (0.045 kg)(2.5 m/s)

**Baseball**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Distance ball traveled | Time | VelocityV = d/t | Mass | Momentum = mv | Distance Softball moved |
| Baseball - slow | 2 m | 1.3 s | 1.5 m/s | 0.14 kg | 0.21 kg m/s | 1.0 m |
| Baseball - fast | 2 m | 0.8 s | 2.5 m/s | 0.35 kg m/s | 2.2 m |

Calculations: v = d/t = 2 m / 1.3 s = 1.5 m/s p = mv = (0.14 kg)(1.5 m/s)

 v = d/t = 2 m / 0.8 s = 2.5 m/s p = mv = (0.14 kg)(2.5 m/s)

*Calculations continued*

 Be sure you show work for your velocity and momentum calculations in the spaces provided.

1. Compare the momenta you calculated in terms of how massive each ball was (*smaller mass to larger mass*).

 *The smaller the mass (golf ball), the lower the momentum. This makes sense because momentum is mass times velocity so mass directly affects momentum.*

2. Compare the momenta you calculated in terms of velocity (*quicker versus slower*).

 *The faster the ball rolled, the higher the momentum. This makes sense because momentum is mass times velocity and velocity indicates how fast an object moves.*

**Conclusions and Questions**

1. What is the scientific term for the amount of matter a substance contains? How does this term relate to inertia?

 *The scientific term for the amount of matter a substance contains is mass. Mass is the measure of the amount of inertia an object contains. For example, the softball (mass = 184 grams) has more inertia than the golf ball (mass = 45 grams).*

2. What was the relationship between the momentum of a moving ball and the distance the softball was moved?

 *The momentum of a moving ball and the distance the softball traveled is a direct relationship, meaning that the greater the momentum, the greater the distance the softball was pushed. This was observed with the golf ball versus the baseball. The baseball had greater momentum (0.56 kg m/s) than the golf ball (0.18 kg m/s) and the softball traveled 2.2 m when the baseball hit it versus 0.6 m when the golf ball hit it at the quicker roll.*

3. Place the three balls (tennis, golf, baseball) in order in terms of momentum. Which had the greatest momentum? Which had the least momentum? Give evidence to support your answer.

 *The order of momentum for the balls in this lab is as follows: the baseball had the greatest momentum (0.56 kg m/s), the tennis ball had a middle momentum (0.24 kg m/s), and the golf ball has the least momentum (0.18 kg m/s) when the ball was rolled faster.*

4. Why did the baseball have more momentum than the tennis ball even though they traveled at about the same velocity? Give evidence to support your answer.

 *The baseball (mass = 141 grams) had more momentum than the tennis ball (mass = 59 grams) even though they traveled ta about the same velocity because of the mass. This makes sense because momentum is mass times velocity so mass directly affects momentum.*

5. How did you observe Newton’s third law of motion during this activity?

*Newton's third law states that forces come in equal and opposite pairs, meaning for every action, there is an equal and opposite reaction. This was demonstrated in this lab when the balls (tennis ball, golf ball, baseball) that were rolled (action) struck the softball and the transfer of momentum caused a two-part reaction with the softball: the “action” balls rebounded and the softball was pushed a certain distance.*

action

reaction

**Final Summary**

*This lab demonstrated Momentum which is inertia in motion. It can be stated mathematically as mass times the velocity of an object. This means that momentum will be affected by an objects mass and its velocity.*

*We observed that the smaller the mass (golf ball = 45 grams), the lower the momentum (0.09 kg m/s) as compared to the baseball (mass = 141 grams and a momentum of 0.28 kg m/s) when the ball was rolled slowly. This makes sense because momentum is mass times velocity so mass directly affects momentum.*

*We also observed that the faster the ball rolled (greater velocity), the higher the momentum. This makes sense because momentum is mass times velocity and velocity indicates how fast an object moves. When the objects were rolled faster (~4 m/s compared to 2 m/s), the momentum was greater.*

*Newton's third law was demonstrated in this lab when the balls that were rolled (action) rebounded back off the softball (reaction). Also, the softball when hit (action) rolled a certain distance (reaction).*

*Lastly, possible errors in this lab included not rolling the three balls at similar speeds, not measuring the distances accurately, and miscalculating.*