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**Newton’s Second Law of Motion**

In this experiment, force will be applied by rolling balls of different masses down a ramp. A wooden, metal, glass and rubber sphere will be used to vary the force used. A paper cup cut lengthwise will be used to measure the acceleration by measuring how far the cup travels. The cup will be placed at the bottom of the ramp to catch the balls. A second part of this experiment will use a constant force (rubber ball), and the mass of the object at rest (the cup) will be varied by adding washer to the top of the cup.

**Materials:**

1 ramp

4 balls (wooden, glass, plastic, and rubber)

Paper cup cut in half lengthwise

3 medium-size washers

Meter stick

Graph paper

Three textbooks

Masking Tape

Triple-beam Balance

**Hypothesis: (Read Step 1 of procedure before writing anything!)**

Part 1 Hypothesis:

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Part 2 Hypothesis:

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**Procedure:**

**Part 1:**

1. Read the entire procedure for both Part 1 and Part 2. Then create a hypothesis for each part.
2. Use a triple-beam balance to record the mass of each of the spheres. Record masses in data table.
3. Make an inclined plane using the ramp and three text books.
4. Place half a cup at the end of the ramp in such a way that it serves as a tunnel into which the sphere will roll to with the closed end of the cup facing away from the incline.
5. Measure 10 cm from the top of the ramp and mark this spot with a piece of masking tape. This is your starting line so label it 0 cm.
6. Measure the distance between this piece of masking tape and the bottom of the ramp. Record measurements.
7. Place a meter stick flat on the table so that it extends from the bottom of the ramp.
8. Place the wooden sphere atop the ramp in such a way that the front of it is aligned with the strip of masking tape.
9. Release the wooden sphere and allow it to descend down the ramp.
10. Measure the length of time it takes for the wooden sphere to roll down the incline.
11. Measure the distance the cup moves.
12. Make observations concerning the descent of the sphere.
13. Record your data and repeat step 9-12 two more times for the wooden sphere.
14. Calculate the average time of descent.
15. Calculate the average distance by how far the cup moved.
16. Calculate the average speed during the descent.
17. Repeat steps 8-16 using the other three spheres.

**Part 2:**

1. Tape one washer onto the outside of the cup (on top).
2. Measure the cup’s new mass.
3. Place the cup at the bottom of the ramp as before.
4. Repeat steps 8-16 with the rubber sphere only.
5. Repeat steps 19-22 with two and then three washers.

**Data and Observations:**

**Data Table:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sphere** | **Mass of Cup and Washers** | **Mass of Sphere (g)** | **Ramp Length (cm)** | **Time(s)** | | | **Average Time (s)** | **Average Speed (cm/s)** | **Distance Traveled by Cup (cm)** | | | **Average Distance Traveled by Cup (cm)** |
| **Trial** | | | **Trial** | | |
| **1** | **2** | **3** | **1** | **2** | **3** |
| **Wooden** |  |  |  |  |  |  |  |  |  |  |  |  |
| **Glass** |  |  |  |  |  |  |  |  |  |  |  |  |
| **Plastic** |  |  |  |  |  |  |  |  |  |  |  |  |
| **Rubber** |  |  |  |  |  |  |  |  |  |  |  |  |
| **1 Metal Washer** |  |  |  |  | | |  |  |  | | |  |
| **2 Metal Washers** |  |  |  |  | | |  |  |  | | |  |
| **3 Metal Washers** |  |  |  |  | | |  |  |  | | |  |

1. Construct a **bar graph** of the **mass** of the sphere (x-axis) versus the **average time** it took for each of the spheres to roll down the ramp (y-axis).
2. Construct a graph of the **mass** of the sphere (x-axis) versus the **average distance traveled by the paper cup without washers** (y-axis) for the four different spheres that were used.
3. Construct a graph of the **mass of the paper cup** (x-axis) versus the **average distance traveled by the paper cup** (y-axis) for the **rubber** sphere.

\*YOU MUST USE PENCIL ON ALL GRAPHS. REMEMBER TO TITLE YOUR GRAPH AND THE AXIS.\*

**Conclusion:**

1. How does the mass of the moving object (mass of the sphere) affect the speed of the sphere?
2. How does the force of the moving object (type of sphere) affect the distance traveled by the cup?
3. How does the mass of the object at rest (cup without/with washers) affect how far it travels with hit by each of the different spheres?
4. Describe the relationship between force (mass of the ball) and the distance the cup moved.
5. Describe the relationship between the mass of the cup and the distance the cup moved.
6. Do you agree with Newton’s 2nd Law of Motion?
7. Did your results support your hypothesis? Explain.