Newton’s second law of motion explains the relationship among force, mass, and acceleration. In this activity, you will study the relationship between acceleration and mass, while keeping force constant. A car carrying different masses will be pulled across a table by a hanging weight—the constant force. Average velocity will be determined with the use of a stopwatch and an air track with marked distances. You will plot a graph of average velocity versus mass, and then use the graph as you make conclusions about the relationship between mass and acceleration.
Newton's Second Law Lab

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**Materials:**
- air track
- hanging mass
- 3 masses to be applied to car
- car
- string
- stopwatches
Newton's Second Law Lab

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- string
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**Procedure:** (See lab handout)
Newton's Second Law Lab

Data:

Table 1. Masses of Car

<table>
<thead>
<tr>
<th></th>
<th>grams (g)</th>
<th>kilograms (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car + Mass 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car + Mass 1 &amp; 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car + Mass 1, 2, &amp; 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Trial Runs

<table>
<thead>
<tr>
<th>Trials</th>
<th>Distance (cm)</th>
<th>Distance (m)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Newton's Second Law Lab

Data:

Table 3. Trials of Cars With Increasing Mass

<table>
<thead>
<tr>
<th>Trial</th>
<th>Time (s) Car + Mass 1</th>
<th>Time (s) Car + Mass 1 &amp; 2</th>
<th>Time (s) Car + Mass 1, 2, &amp; 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Newton's Second Law Lab

**Data:**

Table 4. Average Velocities of Cars

<table>
<thead>
<tr>
<th></th>
<th>Distance (m)</th>
<th>Avg Time (s)</th>
<th>Avg Velocity (?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car + Mass 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car + Mass 1 &amp; 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car + Mass 1, 2, &amp; 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Newton's Second Law Lab

Procedure:

1. Determine the distance the car will travel on the air track by using the graduations already marked on the track. Record this distance in your data table.

2. Find the mass of each of the three weights to be added to the car and determine the mass of the car itself. Record these masses in your data table.

3. Attach a mass to a string. The mass will hang over the edge of the table as shown in the figure above. Attach the other end of the string to the car. This will be your constant force.

4. To reduce friction, attach plastic tape at the place where the string passes over the track's edge.
Newton's Second Law Lab

Procedure:

5. Using a stopwatch, determine the time it takes for the car to reach the end of the track for three practice runs. Each recorded time should be within 0.5 seconds of each other.

6. Conduct five trials of the car plus mass one by recording the time it takes for the car to reach the end of the track. Use your stopwatch to record the time individually and enter these times in your data table. Find the average of these times and record in your data table to two decimal places.

7. Conduct five trials of the car plus masses one and two. Use your stopwatch to record the time individually and enter these times in your data table. Find the average of these times and record in your data table to two decimal places.

8. Conduct five trials of the car plus masses one, two, and three. Use your stopwatch to record the time individually and enter these times in your data table. Find the average of these times and record in your data table to two decimal places.
Newton's Second Law Lab

Procedure:

9. Calculate the average velocity of your trials by dividing the known distance by the averaged times and record in your data table to two decimal places.
Newton's Second Law Lab

Analysis:

1. Generate a graph of average velocity vs. mass with a title and labeled axes.

2. What is the relationship between average velocity and mass?

3. What is the relationship between average velocity and the car's acceleration? Explain this relationship.

4. Do the results of this lab agree with what you have learned about Newton's 2nd Law? Why or why not?

5. Which is easier to accelerate, a sports car or a large van? Explain why.

6. Create two scenarios that would cause the acceleration of the car to increase in this experiment.

7. Draw a free body diagram of the car accelerating on the track and include the necessary force arrows.
Newton's Second Law Lab

**Conclusion:** (You know what to do. If not, look at the inside cover of your lab notebook.)