Lab: Net Force, Mass and Acceleration

Open the interactive. Use the interactive to investigate how force, mass, and acceleration are related by completing the following lab activity.

Purpose
The purpose of this experiment is to
a) determine the relationship between acceleration and net force
b) determine the relationship between acceleration and mass.

Experimental Setup
The simulated apparatus consists of a wagon on a frictionless surface, attached to a hanging mass by a string that rests on a frictionless pulley. The mass of the wagon and hanging block can be adjusted using the sliders.

Experiments
With the mass of the wagon set at 100 g (0.10 kg) and the hanging mass of 1 g (0.001 kg), press the “Start” button. Observe the movement of the wagon and the hanging mass. You can always replay the trial by pressing the “Reset” button and then hit the “Start” button again. Note: the distance the wagon moves is 1 metre.

a) What happened once the “Start” button was pressed?
b) Compare the movement of the wagon to the movement of the hanging mass.
c) Since the wagon and the hanging mass are attached together, they experience the same movement. They travel the same distance in the same amount of time. Both objects seem to be speeding up. If you can find the object of one object, then you will know the acceleration of the other. You already know the displacement travelled by the wagon and the time this took (see the screen), so you can use the equation \( \Delta d = v_1 \Delta t + \frac{1}{2} a(\Delta t)^2 \) to find the acceleration. Both the wagon and the hanging mass have zero initial velocity, since the system was initially at rest. Rearrange the equation to solve for acceleration, remembering to use \( v_1 = 0 \). The equation then becomes \( a = \frac{2\Delta d}{(\Delta t)^2} \) to calculate acceleration, as required during the experiment. You do not need to include the direction, as you are interested in the magnitude of the acceleration. Remember that \( \Delta d = 1 \text{ m} \).

Part 1: The Relationship Between Acceleration and Net Force
You will change the mass of the hanging mass, but leave the mass of the wagon constant. Before doing the activity, first predict what will happen to the motion of the system as the mass of the hanging mass increases.

Step 1: Using a 100 g (0.10 kg) wagon and a 1 g (0.001 kg) hanging mass, run the experiment and record the data in a data table like the one that is shown below.
**Step 2:** Repeat step 1 three (3) more times, but change the value of the hanging mass (suggested values are 2.0 g, 4.0 g, and 6.0 g). Be sure to record the mass values in kilograms on the table. Your data table should be complete, except for the column labelled “F\text{hanging mass}”.

**Step 3:** We are studying the relationship between force and acceleration in this part of the experiment and so must calculate the magnitude of the force that is causing the motion. In this case, the weight of the hanging mass causes the system to accelerate. Recall that the force due to gravity (weight) of an object, \( F_g \), is calculated by multiplying the mass by \( g \) (acceleration due to gravity), which is 9.8 N/kg near the surface of the earth. Thus, \( F_{\text{hanging mass}} = m_{\text{hanging mass}} \times g \). Note: the net force on the system is equal to the \( F_{\text{hanging mass}} \).

**Observations**

<table>
<thead>
<tr>
<th>Trial</th>
<th>( m_{\text{wagon}} ) (kg)</th>
<th>( m_{\text{hanging mass}} ) (kg)</th>
<th>( F_{\text{hanging mass}} ) (or net force) (N)</th>
<th>( \Delta d ) (m)</th>
<th>(s)</th>
<th>( a ) (m/s(^2))</th>
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**Analysis**

a) Print out a sheet of graph paper and graph acceleration versus net force. Acceleration should be on the vertical axis.

b) Describe the relationship between acceleration and the net force

c) Draw a straight line through your points (through the origin). What would be the units of the slope of the line?

d) Determine the slope of the line. What do you think the slope represents?

**Part 2: The Relationship Between Acceleration and Mass**

You will change the mass of the wagon, but keep the mass of the hanging mass constant.

**Step 1:** With the hanging mass set at 1 g and the wagon set at 100 g, run the experiment and record the data table like the one that follows.

**Step 2:** Repeat step 1 three (3) more times, but change the mass of the wagon. Suggested values at 120 g, 140 g and 160 g.

**Step 3:** Create a data table as shown below with a column labelled “1/mass” or “1/m”.
Observations

<table>
<thead>
<tr>
<th>Trial</th>
<th>( m_{\text{wagon}} ) (kg)</th>
<th>( 1/m_{\text{wagon}} ) (1 kg)</th>
<th>( m_{\text{hanging mass}} ) (kg)</th>
<th>( \Delta d ) (m)</th>
<th>( \Delta t ) (s)</th>
<th>( a ) (m/s²)</th>
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Analysis

a) Print out a sheet of graph paper and graph acceleration versus mass of the wagon. Acceleration should be on the vertical axis.
b) Describe the relationship between acceleration and the mass of the wagon.
c) Print out a sheet of graph paper and graph acceleration versus \( 1/m_{\text{wagon}} \). Acceleration should be on the vertical axis.
d) Describe the relationship between acceleration and \( 1/m_{\text{wagon}} \).
e) Which graph shows a trend that could be modelled with a line?
f) Draw a line through the points on the graph from the above question. What are the units of the slope of the line?
g) Determine the slope of the line. What do you think the slope represents?

Conclusion

Refer to the purpose and state the results of this experiment.