**Newton’s Second Law Inquiry**

**Name: \_**

**Hypothesis:**

1. If you apply a greater *net force* on an object, do you expect the object’s acceleration will be different? If so, how will the object’s acceleration to be different?
2. You have two boxes with one box having a greater mass than the other. If you push so that the net force on each box is equal, do you expect the acceleration of the two boxes to be different? If so, how do you expect the accelerations to be different?

***Experiment 1:*** *Varying the Net Force*

You are looking at real experimental data where the net force, acting on the same object, is varied between trials. Below is a table of values for each trial and a graph of the values.

|  |  |  |
| --- | --- | --- |
|  | **Net Force (N)** | **Acceleration (m/s2)** |
| **Trial 1** | 0.69 | 1.69 |
| **Trial 2** | 1.18 | 2.77 |
| **Trial 3** | 1.67 | 4.25 |

1. The graph appears linear, so let’s try to model the graph as a linear relationship.
   1. What does the dependent variable represent in this graph?
   2. What does the independent variable represent in this graph?
   3. What is the vertical intercept? *(use a ruler/straight edge to help find it)*
2. Using the slope intercept definition (y = mx + b), write an equation for your dependant variable in terms of your independent variable. Use your answers from question 1 to help set up the equation. Represent the slope as m for now. (We will determine what the slope is equal to in the following questions.)
3. Using the fact that the total mass in each trial is 0.420 kg, multiply the total mass of the cart by the acceleration of the cart in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Acceleration (m/s2)** | **m\*a (m = 0.420 kg)** | **Net Force (N)** |
| **Trial 1** | 1.69 |  | 0.69 |
| **Trial 2** | 2.77 |  | 1.18 |
| **Trial 3** | 4.25 |  | 1.67 |

1. What do you notice about the values for Fnet and m\*a for each trial?
2. What is the slope of the graph equal to? Rewrite the equation you wrote in Question 2 now that you know what the slope is equal to.
3. Based on the equation you built in Question 5, what is 1 Newton equal to in terms of other units?
4. What would the Fnet versus a graph look like if the mass of the object experiencing the net force was greater? What would the Fnet versus a graph look like if the mass of the object was less? (Sketch how these graphs would look in the space below)

***Experiment 2:*** *Varying the Mass*

You are looking at real experimental data where the same net force acts on objects with different masses. The acceleration of the object in each trial is tabulated and plotted below with the corresponding mass.

|  |  |  |
| --- | --- | --- |
| **Trial** | **Mass (kg)** | **Acceleration (m/s2)** |
| 1 | 0.370 | 1.38 |
| 2 | 0.420 | 1.21 |
| 3 | 0.470 | 1.05 |
| 4 | 0.520 | 1.03 |

1. Does the relationship look as linear as the first experiment? Explain.
2. When the same net force is applied, what happens to the object’s acceleration as the object’s mass increases?
3. Using the equation you developed in Question 5, rearrange the equation for acceleration in terms of mass.
4. Looking at the equation you found in Question 10 and the graph for y = 1/x (given below), what shape do you expect the acceleration versus mass graph to look like? Draw this in the space below.

Diagram, engineering drawing

Description automatically generated

1. Compare the graph you drew in Question 11 to the acceleration versus mass plot above. Do you see any similarities between the two graphs? Explain.
2. Based on your analysis in this experiment, does the equation you built in Question 5 also hold in this experiment? Explain.

**Enrichment:**

*In any measurement we take, there is uncertainty in the value we receive. We usually give an uncertainty with our measurement in the following form: Measurement ± Uncertainty. We can think of any measured values as a range of values on a number line. Within this range, we are confident that the actual value we are measuring exists.*

Measured Value

+ uncertainty

- uncertainty

Somewhere within this range the actual value probably lies

*We can use uncertainties to help us compare two values (such as an experimental value to an actual value). If the differences between the two values is* ***less than the uncertainty****, then the values can be considered equal or the same. If the difference is* ***greater than the uncertainty****, then there is a likely chance that the values are different.*

Looking at the experimental data below for Experiment 1, calculate the magnitude (absolute value) of the difference between Fnet and m\*a for each trial. Compare the difference you just calculated to the uncertainty for each trial. Does each trial show that Fnet equals m\*a?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Net Force** | **m\*a** | **Difference** | **Uncertainty** | **Equal (Y/N)** |
| 0.69 | 0.70 |  | 0.05 |  |
| 1.18 | 1.16 |  | 0.04 |  |
| 1.67 | 1.79 |  | 0.09 |  |