# Newton's Second Law

Guided Inquiry

Driving Question | Objective

What factors affect the acceleration of an object or system? Experimentally determine the relationship between an object’s or system’s mass, acceleration, and the net force being applied to the object or system.

Design and Conduct Your Experiment

It is your group’s responsibility to design and conduct an experiment whose data will support your answer to the driving question above. Use the answers to the guiding questions below to help guide your experiment design. After you have answered the guiding questions, write an outline of the equipment setup and procedure you will use to collect data, identifying the steps in sequence and the points at which each piece of equipment will be used.

Suggested Materials and Equipment

Although you have the freedom to design your procedure using any reasonable equipment at your disposal, the following equipment is recommended for your experimental setup.

|  |  |
| --- | --- |
| * Data collection system | * PASCO Cart Mass (2), 250-g |
| * PASCO Dynamics Track with feet1 | * PASCO Mass and Hanger Set |
| * PASCO Smart Cart2 | * Thread |
| * PASCO Dynamics Track End Stop3 | * Balance, 0.1-g resolution, 2,000-g capacity |
| * PASCO Super Pulley with Clamp4 | (1 per class) |
|  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| 1[www.pasco.com/ap08](http://www.pasco.com/ap08) | 2[www.pasco.com/ap37](http://www.pasco.com/ap37) | 3[www.pasco.com/ap11](http://www.pasco.com/ap11) | 4[www.pasco.com/ap13](http://www.pasco.com/ap13) |
|  |  |  |  |
| PASCO PAStrack | PASCO Smart Cart | PASCO Dynamics Track End Stop | PASCO Super Pulley with Clamp |

Guiding Questions

* 1. Based on the lab objective, what variables will you measure and what piece of equipment will you use to measure each variable?

* 2. How will you display your measurements so they can be analyzed to determine the relationship between the variables?

* 3. What variables will you change to get at least 5 different data points for the acceleration of your object or system? What variables must remain constant in order to get a consistent graph of acceleration?

* 4. Describe some potential errors that could prevent you from gathering accurate consistent data?

Experimental Design

Your goal is to experimentally determine the relationship between an object’s or system's mass, acceleration, and the net force being applied to the object or system. Use the responses to the Guiding Questions to help finalize your procedure and your equipment configuration.

Once you are convinced that your procedure will accomplish the experiment's objectives, record your experimental setup and procedure in the following sections.

Setup

Draw and/or describe your experimental setup such that a third party could recreate the same setup in an attempt to reproduce your experiment?

Procedure

Outline the procedure you will use in your experiment, listing all of the steps below. Your outline should be written such that a third party could follow the same procedure in an attempt to reproduce your experiment?

Collect Data

Perform your experiment and record all relevant data. Present your data below (or in an attached document) in a form that best suits the experiment format, such that a third party can understand your experimental results in an attempt to reproduce them.

Analysis Questions

* 1. Qualitatively, what effect did your object’s or system’s mass have on its acceleration? Support your answer with data.

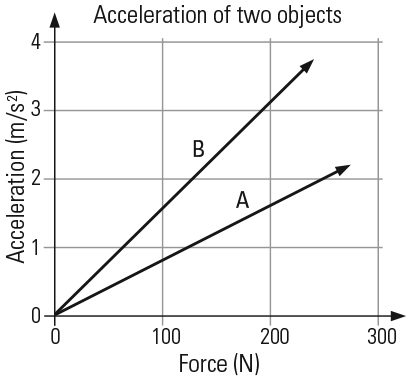
* 2. What is the relationship (inverse, proportional, equal, squared, et cetera) between the mass of your object or system and its acceleration? How do you know?

* 3. Qualitatively, what was the effect on your object’s or system’s acceleration as the net force acting on it increased? Support your answer with data.

* 4. What is the relationship (inverse, proportional, equal, squared, et cetera) between your object’s or system’s acceleration and the net force acting on it? How do you know?

* 5. There are two common mathematical expressions for Newton's Second Law. One of these expressions is given below. How does your data support this mathematical relationship?



Synthesis Questions

* 1. Two different carts are accelerated by a net force. The graph shows their respective accelerations as a function of this net force. What can you conclude about the mass of cart A compared to the mass of cart B? How do you know?

* 2. We know from experience that the harder we throw a ball (apply more force), the faster it will be moving (greater initial velocity resulting from acceleration). If you throw a 1 kg softball as hard as you can, and it is traveling at 20 m/s when it leaves your hand, how fast do you think a 5 kg shot put would travel with the same throw?

* 3. If we launch a rocket that has been designed to produce a constant force, will the acceleration at initial launch be the same as the acceleration just before the fuel is completely expended? Explain your answer.

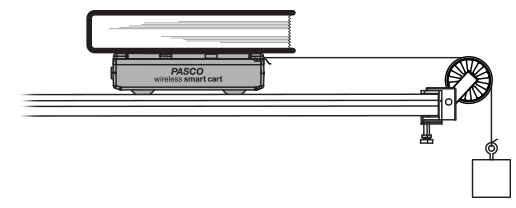
* 4. A 1,000.0 kg rocket is traveling straight up with its engine producing a force of 39,240 N. If the rocket experiences a retarding force from air resistance equal to –1,227 N, what is its acceleration?
* 5. A teacher challenges her students to find the mass of   
  their physics book using the system shown at right and their understanding of Newton's Second Law. Students measure the cart's acceleration due to three different hanging masses: 0.020 kg, 0.040 kg, and 0.060 kg. The acceleration and force data are provided in the table. The mass of the cart is 0.300 kg. Use the provided information to find the mass of the physics book. Show all of your work and explain your reasoning and process for deriving the book's mass.

Table: Acceleration of a cart with varying net force and constant mass

|  |  |  |
| --- | --- | --- |
| Trial | Net Force Acting on the Cart (N) | Acceleration of the Cart  (m/s2) |
| 1 | 0.196 | 0.131 |
| 2 | 0.392 | 0.261 |
| 3 | 0.588 | 0.392 |