Analyzing Newton's Second Law

Newton's second law of motion states that the net force on an object equals the product of its mass and its acceleration. Or, solving for acceleration, the acceleration experienced by an object equals the net force on it divided by its mass. More net force on an object, or less mass, results in more acceleration.

You will verify the law. You will observe how velocity changes over time (which lets you determine the acceleration). You will measure (or determine) the force, and also measure the mass of the object.

Since lab equipment varies in different classes, we will outline the basics of the lab. The specifics will depend on what equipment you have. Options include informal equipment (students pushing other students on a skateboard); a ball rolling down an inclined plane; a mass on a surface connected by a string to a tension scale; observation of a video (for instance, objects dropped on the moon); or the computer simulation in the virtual lab in this book.

There are some common elements you should be looking for and recording data about:

What is the net force (i.e., the total force) on the object? If there are multiple forces at play, determine the net force. Vary the net force, and then observe different accelerations. You may have to neglect small forces, such as air resistance, if they are too difficult to measure.

For example, if you have a mass on a surface connected by a string to a tension scale, try pulling harder and increasing the reading on the scale. If you are pushing a friend on a skateboard (who is wearing a helmet), try pushing just as hard, but with a lighter or more massive friend. If you are dropping a mass, you can double the gravitational force in your experiment by using an object with twice the mass.

Your observations need to include the following:

- The amount of mass that the net force is being applied to.
- The change in velocity of the object divided by the elapsed time. This is the acceleration.

The table below can help:

Initial velocity	Final velocity	Elapsed time	Change in velocity	Acceleration

You measure the velocity and note the time of the measurement. The elapsed time is the difference in time between two measurements of velocity. The average acceleration equals the change in velocity divided by the elapsed time. For example, if an object changes velocity from 1 m/s to 7 m/s in a time of 3 seconds, the acceleration is $(7\ m/s - 1\ m/s)/3s = 2\ m/s^2$.

When you have completed your measurements and calculations, answer the following questions:

- Is the acceleration constant for a given mass and net force? If not, what might account for changes?
- Newton's second law predicts that the acceleration equals the net force divided by the mass. Does the acceleration equal the net force divided by the mass? If not, what might account for any differences between your observations/calculations and those predicted by Newton's second law?
- In summary, do your data points support what Newton's second law states about the relationship between net force, mass, and acceleration?