Physics Introduction Kit Study Guide

HOME SCIENCE TOOLS
THE GATEWAY TO DISCOVERY

665 Carbon Street, Billings, MT 59102
Phone 800.860.6272
www.homesciencetools.com

Physics is the area of science that deals with the properties and relationships of matter and energy. Physics includes the study of force, motion, work, heat, light, sound, electricity, magnetism, radiation, and atomic energy.

This kit focuses on mechanics, the part of physics that deals with force, motion, work and energy. In simplest terms, a **force** is a push or pull. In physics, a force is any influence that causes an object to move. Forces are measured in several different units, but for this study we will use the units of Newtons.

Motion is a change in the position of an object. When you hold out a ball and let go of it, the ball "falls" to the ground. The force of gravity actually pulls on the ball, moving it toward the ground. This is an example of both force and motion. The rate at which an object moves is called **speed**. Speed is expressed in units of distance per unit of time, e.g., meters per second or miles per hour. Speed in a particular direction is called **velocity**. The rate at which speed changes over time is called **acceleration**. The units for acceleration are distance per unit time squared (e.g., meters/second^2).

Work is defined as the distance an object is moved by a force. We will use Newton-meters or Newton-centimeters as the units for work in this study.

Energy is the capacity for doing work that an object or system of objects has at any point in time. There are many types of energy as will be explained later in this study.

This study covers these experiments and topics:

Scientific Method 2
Newton's First Law of Motion................ 3
Newton's Second Law of Motion 4
Newton's Third Law of Motion............... 6
Newton's Law of Universal Gravitation . 6
Pendulum.. 7
Falling Objects 8
Work and Energy 9
Levers 9
Balance..11
Inclined Plane 12
Pulleys 13
Teaching Tips for Young Children........ 15
Further Study...................................... 16

In addition to teaching basic principles of physics and Newton's laws of motion, this kit reinforces the scientific skills of observing, measuring, controlling variables, interpreting results, and forming conclusions.

Your physics kit contains many pieces. Take a few minutes to check that all the items have been included and to become familiar with the different components, using the following list: Spread the contents of your kit on a table and check each item off the following list as you locate and identify it.

Ring stand	½ Meterstick
Right angle clamp	Knife-edge clamp
Steel rod, ¼" x 10"	Fulcrum, wooden
Wooden ramp, 22"	Ball, steel
Pulley, single	Ball, wooden
Pulley, double	Paper clips, box
String, 25'	Washers, package
Hall's cart	Protractor
Spring scale	Mass, 100 g
Tape measure	Mass, 200 g
S-hook	Rubber bands

SCIENTIFIC METHOD

As you work through your study of physics you will apply the scientific method. The scientific method is an important tool used by scientists to develop knowledge about the physical world. In simple form, it consists of five basic steps that provide a general structure to get the most out of any scientific study or experiment.

1. Define the Problem - Before you start any experiment or study, ask "What do I want to know?"

2. Gather Data - This is the process of gathering background information related to the problem. The data helps you decide how to study the problem.

3. Form an Hypothesis – In this step you predict an answer to the problem based on the data gathered.

4. Perform & Interpret Experiments – This is the step where you design and perform experiments and then analyze experimental results to test your hypothesis.

5. Draw Conclusions – In this final step you make a reasoned judgement that addresses the problem you set out to solve.

The experiments in this study guide are designed around the scientific method. You will learn to work as a scientist if you follow the instructions carefully. Keep a science notebook to record problem statements, data gathered, predictions or hypotheses you make, experimental results, analysis of results, and conclusions. Remember to perform each experiment several times to ensure that the results are consistent. Be sure to think carefully about and answer each question in the procedures.

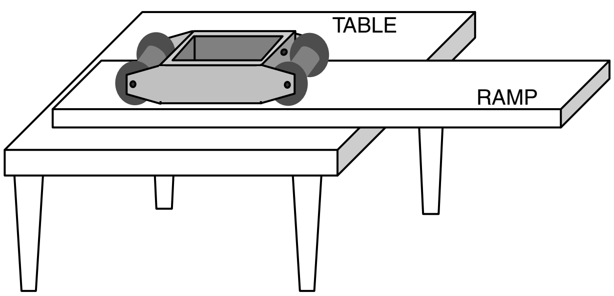
Newton's first law of motion states that "**Every body remains in a state of rest or uniform motion in a straight line unless acted upon by an external force**." The first part of this law means that an object that is not moving will not start moving unless acted upon by a force (a push or pull) that is separate from the object. The second part of this law means that once an object is moving in a straight line at a constant speed, it will not change direction or speed unless acted upon by an external force. You can test this physical law with the following experiments.

OBJECTS AT REST REMAIN AT REST

Experiment 1

The problem statement for this experiment is this: “Do objects at rest really remain at rest unless acted upon by an external force?”

1. Set the wooden ramp on a table with about 12” of the ramp extending over the edge of the table.
2. Place the Hall’s cart on the part of the ramp that is over the table. The cart at this point is in a state of rest. ***What do you predict will happen if the ramp is pulled out from under the cart?*** Write down this hypothesis in your science notebook.



3. Standing to one side, quickly jerk the ramp out from underneath the Hall’s cart. Try this 4-5 times. Record your observations.
4. Analyze your results. ***What happens to the cart when the ramp is removed? Was your hypothesis correct? Does the cart follow Newton’s first law for a body at rest?*** Record your results and conclusions in your science notebook.

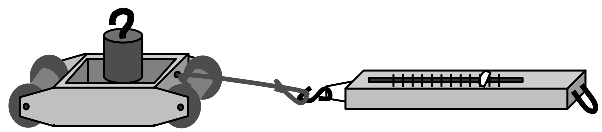
When you quickly pull the ramp out from under the cart, the cart falls to the table. It does not move with the ramp. Because the cart is at rest, it continues at rest while you move the ramp, consistent with Newton’s first law.

FORCE TO MOVE OBJECTS FROM REST

Experiment 2

Now let’s determine how the force required to start moving a stationary object compares to the force to keep an object moving. Our problem statement is this: “Is the force required to move an object from rest different from the force required to keep an object moving?”

1. Cut a piece of string about 8” long. Tie one end to the front of the Hall’s cart and tie a loop in the free end.
2. Put the 200 gram (g) mass in the Hall’s cart.
3. Push the cart back and forth on a table and think about the problem statement. ***Do you think the force required to move the cart from rest is the same, less than, or greater than the force required to keep the cart moving?*** Write down this hypothesis in your science notebook.
4. Zero the spring scale and attach the hook on the spring scale to the string loop on the cart.



5. Tug on the spring scale several times to start the cart moving from rest. Note and record the spring scale reading each time.
6. Now jerk on the spring scale several times to rapidly start the cart moving from rest. Note and record the spring scale readings.
7. Finally, pull the cart across a table or floor at a constant speed several times. Note and record the spring scale readings each time. Try this step again, pulling the cart at a faster speed and record your results.
8. Analyze your results. ***Which takes more force, to start an object moving from rest or to keep an object moving? Which takes more force, to start an object moving slowly or to start it moving quickly? Was your hypothesis correct? Does the cart follow Newton’s first law for a body at rest?*** Record your results and conclusions in your science notebook.

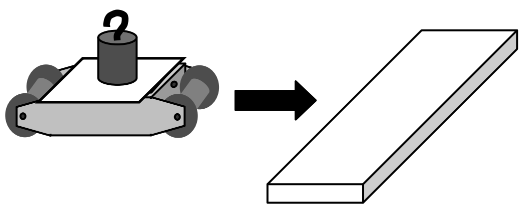
The tendency of objects at rest to stay at rest or moving objects to continue moving is called **inertia**. More force is required to overcome the inertia of a body at rest than to maintain the inertia of a moving object. Without **friction**, no force would be required to keep an object in motion.

OBJECTS IN MOTION REMAIN IN MOTION

Experiment 3

We can also test Newton's first law with respect to objects in motion. Our problem statement is this: "Do objects in motion really continue in motion unless acted upon by an external force?"

1. Place the wooden ramp on the floor.
2. Tape a piece of cardboard over the hole in the Hall's cart.
3. Put the 100 g mass on top of the cardboard as illustrated. **What do you think will happen to the 100 g mass when you push the cart so that it collides with the edge of the ramp?** Record your hypothesis.



4. Gently push the cart so that it collides with the edge of the ramp. You must push the cart gently enough so that the mass does not move until the cart hits the ramp. Repeat 4-5 times.
5. Analyze your results. ***What happens to the 100 g mass when the cart is acted upon by the external force of the ramp? Was your hypothesis correct? Does the mass follow Newton's first law?*** Explain why.

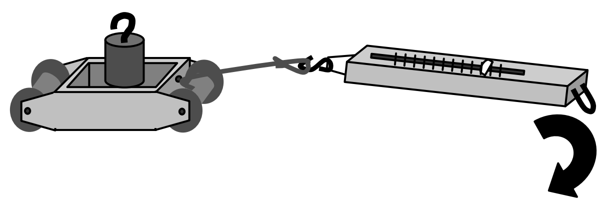
You can repeat this experiment using the 200 g mass or even a stack of washers. When the cart is pushed toward the ramp, the cart and mass move in a straight line until the cart hits the ramp. The cart stops but the inertia of the moving mass keeps the mass moving forward. This is why people not wearing seat belts are often thrown through the front windshield in auto accidents.

FORCE TO CHANGE SPEED OR DIRECTION OF A MOVING OBJECT

Experiment 4

This final experiment with Newton's first law has to do with the force required to change the speed or direction of a moving object. Our problem statement is this: "Does it take more force to change the speed or direction of a moving object than it does to maintain the initial speed of the object?"

1. Use the same setup as in Experiment 2 with the cart, 200 g mass, string, and spring scale.
2. Think about the force required to accelerate or increase the speed of the cart once it is in motion. ***Will this force be greater or less than the force required to maintain the initial speed of the cart?*** Think about the force required to change the direction of the cart once it is in motion. ***Will this force be greater or less than the force required to maintain the initial speed of the cart?*** Predict your answers to these questions and write them down as hypotheses.
3. Start the cart moving at a slow speed by pulling on the spring scale. Then quickly pull harder to accelerate the speed of the cart. Repeat this several times while reading the spring scale. Record the maximum force reading on the spring scale each time.
4. Now experiment with changing the direction of the cart. Again start the cart rolling slowly by pulling on the spring scale and then pull the scale in a wide arc to change the direction of the cart. Try this several times, changing direction as quickly as you can without tipping the cart over. Record the maximum force to change the direction each time.



5. Analyze your results. Which takes more force, to accelerate the cart or to maintain its initial speed? Does it take more force to change the direction of the cart or to maintain the direction of the cart? Were your hypotheses correct? Is the force required to change the speed or direction of a moving object consistent with Newton's first law? Record your results and conclusions in your notebook.

You will find that more force is required to increase the speed of a moving object than to maintain the initial speed. More force is also required to change the direction of a moving object than to maintain the initial direction. Consistent with Newton's first law, it takes an external force to change the speed or direction of an object moving at a constant speed or in a straight line.

NEWTON'S SECOND LAW OF MOTION

Newton's second law of motion states, "**The force required to accelerate an object is proportional to the mass of the object and the acceleration given it**." This means the force required to increase the speed of an object quickly (high acceleration) will be greater than the force required to increase the speed of an object slowly (low acceleration). Likewise, the force required to