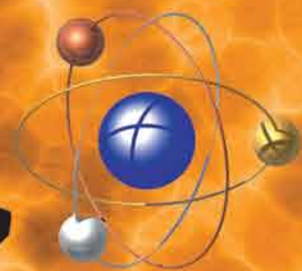
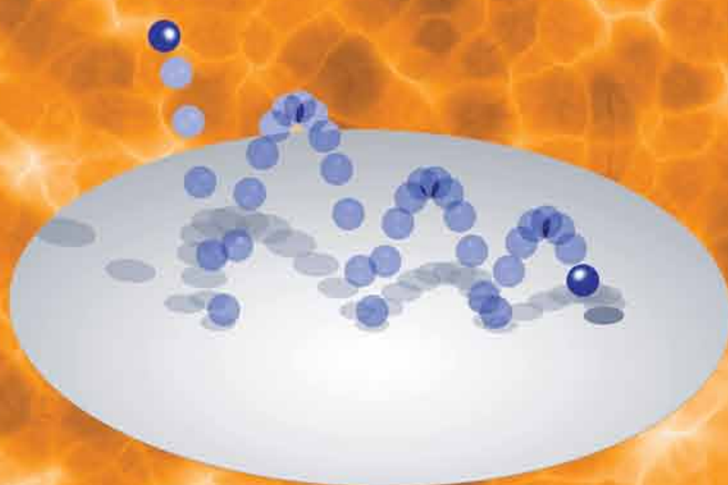
Real Science-4-Kids

PHYSICS



Level I

Teacher's Manual



Rebecca W. Keller, Ph.D.

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Physics

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Real Science-4-Kids: Physics Level I Teacher's Manual

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A Note from the Author

This curriculum is designed to give students both solid science information and hands-on experimentation. Level I is geared toward fourth to fifth grades. Much of the information in the textbook is very different from what is taught at this grade level in other textbooks. However, I feel that students beginning with the fourth grade can grasp most of the concepts presented here. This is a *real* science textbook, and so scientific terms are used throughout. It is not important at this time for the students to master the terminology, but it is important that they be exposed to the real terms used in scientific study.

Each chapter has two parts: a reading part in the student textbook and an experimental part in the laboratory workbook. In the teacher's manual, an estimate is given for the time needed to complete each chapter. It is not important that both the reading portion and the experimental portion be concluded in a single sitting. It may be better to teach these on two separate days, depending on the interest level of the child and the energy level of the teacher. Also, questions not addressed in the teacher's manual may arise, and extra time may be required to investigate these questions before proceeding with the experimental section.

Each experiment is a *real* science experiment and not just a demonstration. These are designed to engage the students in actual scientific investigation. The experiments are simple, but are written the way real scientists actually perform experiments in the laboratory. With this foundation, it is my hope that the students will eventually begin to think of their own experiments and test their own ideas scientifically.

Enjoy!

Rebecca W. Keller, Ph.D.

How to use this manual

This Physics Level I Teacher's Manual provides information that supplements the material covered in the Physics Level I Student Textbook and the Physics Level I Laboratory Workbook. It also contains comments that will aid the teacher in helping the students to perform the laboratory experiments, as well as providing answers to the review questions. The additional information in this teacher's manual is provided as supplementary material in case questions arise while the students are reading the text. It is not necessary for the students to learn this additional material since most of it is beyond the scope of this level. However, the teacher may find it useful when answering questions.

In this teacher's manual the laboratory section (or Experiments) and the review section are found at the end of each chapter. All of the experiments have been tested, but it is not unusual for an experiment to fail. Usually, repeating an experiment helps both student and teacher see where an error may have been made. However, not all repeated experiments work either. Do not worry if an experiment fails. Encourage the student to troubleshoot and investigate possible errors.

Getting started

Following this curriculum will be easier if, before you begin each experiment, you gather all of the materials needed for that lesson. A small shelf or cupboard or even a plastic bin can be dedicated to holding most of the necessary chemicals and equipment.

Materials at a Glance

Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
tennis ball yarn or string (10 ft) paper clip marble	Slinky several paper clips 1-2 apples 1-2 lemons or limes 1-2 bananas spring balance scale or food scale yardstick or tape measure tape	small to medium size toy car stiff cardboard wooden board (more than 3 ft long) straight pin or tack small scale or balance 1 banana, sliced 10 pennies yardstick or tape measure tape	several glass marbles of different sizes steel marbles of different sizes cardboard tube, 2-3 ft long scissors black marking pen ruler letter scale or other small scale or balance	10-20 copper pennies aluminum foil paper towels salt water (2-3 Tbl salt per cup of water) voltmeter 2 plastic-coated copper wires, 4"-6" long duct tape (or other strong tape) scissors wire cutters

Experiment 6	Experiment 7	Experiment 8	Experiment 9	Experiment 10
small glass jar with lid aluminum foil paper clip duct tape (or other strong tape) plastic or rubber rod (or balloon) silk fabric scissors ruler	4 ft insulated electrical wire 12v battery insulating materials (e.g., styrofoam, plastic, cloth) small light bulb electrical tape several small resistors scissors wire cutters	metal rod (like a screwdriver) electrical wire 10-20 paper clips 12v battery electrical tape scissors wire cutters **Optional Materials** thin magnet that can be cut iron filings 1/4 C corn syrup shallow dish iron nail	2 prisms (glass or plastic) flashlight metal can, open at both ends aluminum foil rubber band laser pointer long wooden craft stick colored pencils duct tape (or other strong tape) [see beginning of Chapter 9 for optional materials]	student selected materials

Laboratory safety

Most of these experiments use household items. Extra care should be taken while working with all materials in this series of experiments. Outlined below are some general laboratory precautions that should be applied to the home laboratory:

Never put things in your mouth without explicit instructions to do so. This means that food items should not be eaten unless tasting or eating is part of the experiment.

Wear safety glasses while using glass objects or strong chemicals such as bleach.

Wash hands before and after handling all chemicals.

Use adult supervision while working with electricity and glassware, and while performing any step requiring a stove.

Contents

Chapter 1: What Is Physics?

Time Required

Text reading	30 minutes
Experimental	1 hour

Materials

tennis ball
yarn or string (10 ft)
paper clip
marble

Overall Objectives

This chapter will introduce the students to a fundamental concept in physics called *physical laws*. The students will also examine the *scientific method*.

1.1 Introduction

In this section the students begin their inquiry into physics by making observations about the physical world. Begin a discussion by asking the students to describe several observations they have made.

For example:

- *What happens when you put on the brakes while riding a bicycle? Do the tires stop immediately? Do they skid?*
- *What happens when you throw a ball into the air? Does it reach the clouds? Does it come down in the same spot?*
- *What happens when you turn on a flashlight? How far can you see the light? Can you see the beam from a flashlight in the daytime?*

Encourage the students to discuss as many observations as they can think of. There are no "right" answers and, at this point, it is not important to know the reasons why something happens.

1.2 The basic laws of physics

Ask the students what a *law* is, such as a law against driving too fast or a law against stealing. Ask them if these laws are ever broken and, if so, why are they broken.

Ask the students some questions about what they have consistently observed in the physical world. For example:

- *Have you ever thrown a ball and have it not come down (except when it gets stuck somewhere like in a tree)?*
- *Does ice always float?*
- *Does the sun always come up in the morning?*

Explain that laws in physics differ from the kinds of laws that govern our country. In physics a law is an overall principle or relationship that remains the same and is not broken.

1.3 How we get laws

Have a discussion with the students about how we make laws for our country, city, or state. Discuss how the making of city, state, or federal laws involves a long process where several people decide what kinds of laws to make. Because there are different people making the laws, some laws are different from city to city or from state to state. For example, the speed limit is different in different states because the governments of the states don't agree on what the speed limit should be. Explain that governmental laws are laws we make ourselves and, because of this, the laws sometimes differ.

Ask the students if they think physical laws are laws we make ourselves. Do physical laws differ from state to state or country to country? Do they think that a baseball hit from a ballpark in Alaska or Hawaii might be able to reach the clouds? Will ice float in Arizona, but sink in New Jersey? The answer is "no," a ball will not reach the clouds in Alaska or Hawaii, and "yes," ice still floats if it's in New Jersey.

Explain to the students that physical laws are not laws we make up ourselves. They are regularities that scientists have discovered in the way things behave. The physical world is ordered, reliable and consistent. This orderliness means there are underlying physical laws, or general principles, that we can discover to better understand the world.

Explain to the students that physical laws are described by mathematics. Because the universe is ordered, mathematics can be used to precisely describe the laws that govern it.

1.4 The scientific method

Although scientific investigation began with Aristotle over two thousand years ago, the foundations of the scientific method were not established until the 13th century by Roger Bacon and further elucidated in the 17th century by Rene Descartes.

The scientific method has 5 steps:

1. *observation*
2. *formulating a hypothesis*
3. *experimentation*
4. *collecting results*
5. *drawing conclusions*

The first step in the scientific method is *observation*. Have a discussion with the students about how observations are made. Give some examples of observations that use sight, hearing, taste, smell, or touch. For example:

- *Salt is poured on icy roads when it snows.*
- *Lemons are sour. Oranges are sweet.*
- *The sky is blue.*

- *Ice cubes float in soda, water, and milk.*
- *Thunder is loud when lightning is close.*
- *Steel balls or marbles are sometimes cold, but cotton balls are not.*

Have the students turn these observations into questions:

- *Why is salt poured on icy roads when it snows?*
- *Why are lemons sour but oranges sweet?*
- *Why is the sky blue?*
- *Why do ice cubes float in soda, water, and milk?*
- *Do ice cubes float in oil?*
- *Why is thunder loudest when lightning is closest?*
- *Why are steel balls or marbles sometimes cold, but cotton balls are not?*

Explain that after making observations and asking questions about those observations, the next step in the scientific method is *formulating a hypothesis*. Hypotheses are guesses. That is, from observations and the questions about those observations, a statement can be made about why something is or behaves in a certain way. Although a scientist attempts to make a good guess, the hypothesis may prove to be incorrect. For example:

- *Salt is put on roads to make rubber tires sticky.* (Salt is actually used to lower the freezing temperature of ice, causing the ice to melt.)
- *Lemons are sour because they have no sugar.* (Lemons have some sugar, just less sugar than oranges.)
- *Oranges are sweet because they have sugar.*
- *The sky is blue because all of the other colors get absorbed by water in the atmosphere.* (The sky is actually blue because of light scattering, called Raleigh scattering.)
- *Ice cubes float because they repel soda, water, and milk.* (Ice cubes float because ice is less dense than liquid water.)
- *Ice cubes will not float in oil.*
- *Ice cubes will float in oil.*
- *Thunder is louder when it is closer because the sound hits our ears sooner and has less chance to go someplace else if we are close.* (Thunder travels as a sound wave, and

the farther we are from the thunder, the more the sound gets dampened as it hits molecules in the air while it is traveling.)

- *Steel balls and marbles sometimes feel cold in our hands because they allow heat to exchange and cotton balls do not allow heat to exchange.*

These are some examples of hypotheses. Explain to the students that not every hypothesis is correct, and when scientists formulate a hypothesis, they do not already know the correct answers. A scientist is making an educated guess.

The next step in the scientific method, *designing an experiment,* will help determine whether or not the hypothesis is correct. Explain that because a hypothesis is a guess, a scientist must do something, like design an experiment, to test whether or not the hypothesis is correct.

Using the example in this section of the textbook, have a discussion with the students about the way in which an experiment can be designed to test the boy's hypothesis that salt makes rubber sticky. Or, help the students think of ways they might test for sugar in a lemon or test some other hypothesis. For example:

- *Lemon juice could be collected and the water evaporated. Sugar might be visible in the remaining residue.*
- *Lemon juice residue could be compared to orange juice residue.*
- *Ice cubes could be placed in several different liquids, such as water, milk, soda, and oil, to determine if ice cubes always float.*

Tell the students that sometimes it is difficult to design experiments and not every question can be answered. For example, it may be difficult for a student to design an experiment to test conclusively whether or not lemons have sugar. The residue may contain other chemicals that do not allow one to say with certainty whether or not a lemon has sugar. Also explain that there is not necessarily one right way to do an experiment although there are certain procedures that, when included, will usually make the experiment better. For example, controls are used to make sure the experimental setup is working properly. Controls can be either positive or negative.

A positive control tells the scientist what the results of an experiment might look like if the hypothesis is true. For example, if lemon juice contains sugar, and if it is possible to evaporate the water from the lemon juice leaving the sugar behind, then a scientist might want to know what sugar would look like when it has been separated from water by evaporation. To find out, a positive control made only of sugar and water could be used. The scientist would mix sugar and water together, let it evaporate, and then examine the residue. He could then compare this control with his experiment and find out if the residues looked similar. If they did, he might conclude that there is sugar in lemon juice.

To discover what the results of an experiment should *not* look like, a scientist can use a negative control. Also, if a positive control might be confusing, it can be helpful to use a negative control. For example, it may not be easy to tell the difference between salt water and sugar water. A scientist might set up a negative control where salt is used instead of sugar. If evaporated salt water looks similar to evaporated sugar water, then it won't be easy to tell if the residue from the lemon juice is sugar or salt. Some other test is needed, such as tasting the residue.

Once an experiment has been designed, *results are collected* as the experiment is carried out. This is the next step in the scientific method. Explain to the students that it is very important that all of the results be recorded. This includes results that the students did not expect. Sometimes major scientific discoveries are found by getting results that were not at all expected. A good scientist has a keen sense of observation and does not let what she expects to happen determine what she records. Some possible results for lemon juice might be:

- *No residue was found after the water evaporated.*
- *Residue was found.*
- *The residue did not taste like anything.*
- *The residue tasted salty (or sweet, or sour).*

The final step in the scientific method is *drawing a conclusion*. In a conclusion the scientist evaluates the results of the experiment and tries to make a statement regarding the hypothesis. For example, if residue was found in lemon juice and the residue tasted sweet, the scientist can conclude that the hypothesis that "lemons have no sugar" may not be correct. At this point, the scientist needs to determine how conclusive the data are and check the reliability of the experimental set up. It is important that the conclusions be valid and not state something that the data haven't shown.

1.5 Summary

Go over the summary statements with the students. Discuss any questions they might have.

Experiment 1: It's the law!

Date: ________

Objective

In this experiment we will use the scientific method to determine Newton's First Law of Motion.

Hypothesis

____

____

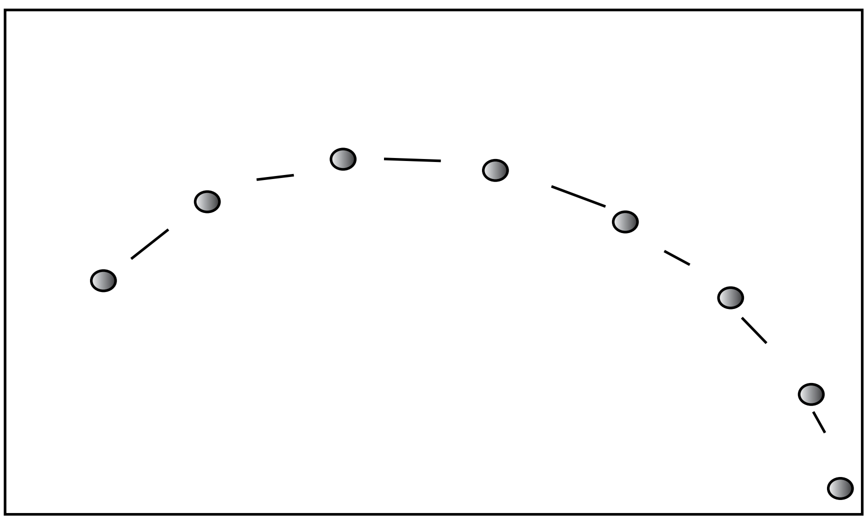
Materials

tennis ball
yarn or string (10 ft)
paper clip
marble

Experiment

PART I

❶ Take the tennis ball outside, and throw it as far as you can. Observe how the ball travels through the air. In the space below, sketch the path of the ball.



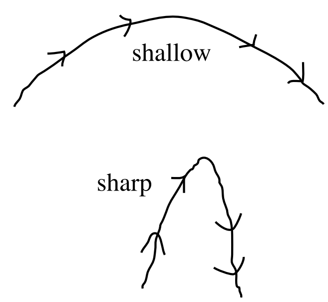
In this experiment the students will discover Newton's First Law of Motion by observing the motion of a tennis ball and a marble.

Newton's First Law of Motion is also called the Law of Inertia. The students will look more carefully at motion and inertia in Chapter 4. However, in this experiment the objective is to show the students that, by observation, they can discover physical laws.

Newton's First Law of Motion can be stated as:

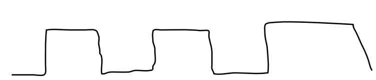
> *A body will remain at rest or in motion until it is acted on by an outside force.*

In the first part of this experiment, the students are to observe how a ball flies through the air. They should notice that the ball will go up and come down in some kind of arc every time they throw it. The arc can be shallow or sharp depending on how they throw the ball.



Challenge them to throw the ball so that it won't come down.

Ask them if they can get the ball to go up and down in a different pattern , such as:

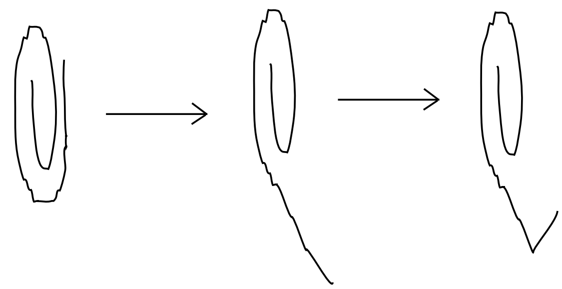


By attaching a string to one end of a tennis ball, the students will be able to observe a difference in how the ball will travel once it is thrown.

The method shown is only one way to attach a string to a tennis ball. Several other methods were tried, but it seems that the paper clip works the best. It is somewhat difficult to puncture the tennis ball with the paperclip, so supervise the students. It might help to put a small hole in the tennis ball with a penknife, ice-pick, or awl before inserting the paper clip.

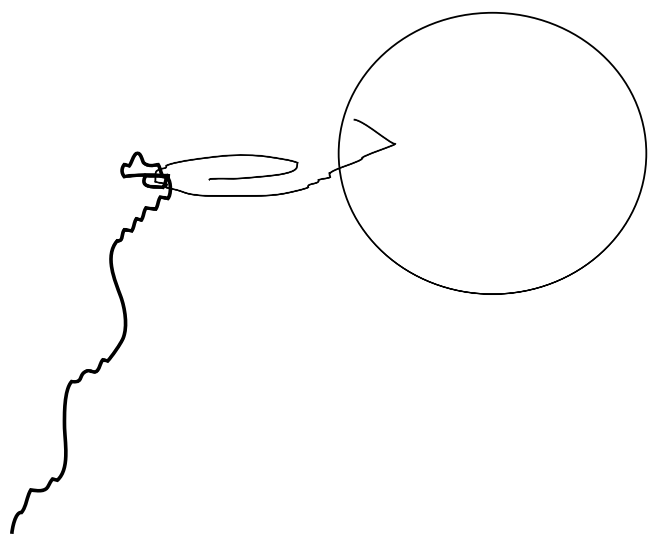
If you do not want to puncture the tennis ball, the string can be wrapped several times around the ball and secured with tape.

❷ Now, take the string or yarn and, using the paper clip, attach it to the tennis ball. To do this, open the paper clip up on one side and curve the end as follows:

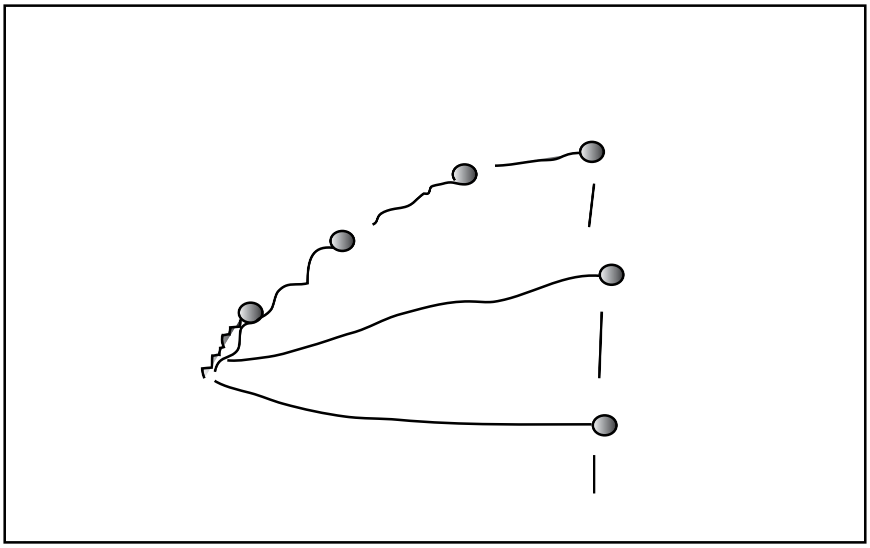


❸ Put the extended curved end of the paper clip into the tennis ball by gently pushing and twisting.

❹ Next, tie the string to the end of the paper clip.



❺ Holding onto one end of the string, again throw the ball into the air as far as you can. Note how the ball travels and, in the space below, record what you see. Do this several times.



Part II

❶ Take the marble and find a straight, clear path on a smooth area of the floor or outdoors. Roll the marble, and record how it travels. Note where and how it stops or changes direction. Do this several times, and record your observations in the next box.

The trajectory of the tennis ball will now be different. When the students throw the ball, it will begin similarly, but when the string has reached its full length, the ball will abruptly stop and fall to the ground.

Have the students throw the ball several times. Ask them if they can change how the ball falls to the ground. They should notice that if they shorten the string, the ball does not travel as far as when the string is longer. They should also notice that if they do not throw the ball very far and it does not reach the end of the string, the ball will travel almost as if there were no string attached to it.

Without telling them the answer, help the students see that the ball's trajectory only changes when the string can act on it.

In Part II, the students will examine how a marble rolls. Have them roll the marble on a smooth surface. They should notice the marble traveling mostly straight. Have them compare this with a marble rolling on a rough surface. Discuss with the students why they think the marble may travel differently.

You can also have the students place obstacles in front of the marble, such as small building blocks. They should be able to observe the marble traveling straight on a smooth surface until it contacts an obstacle.

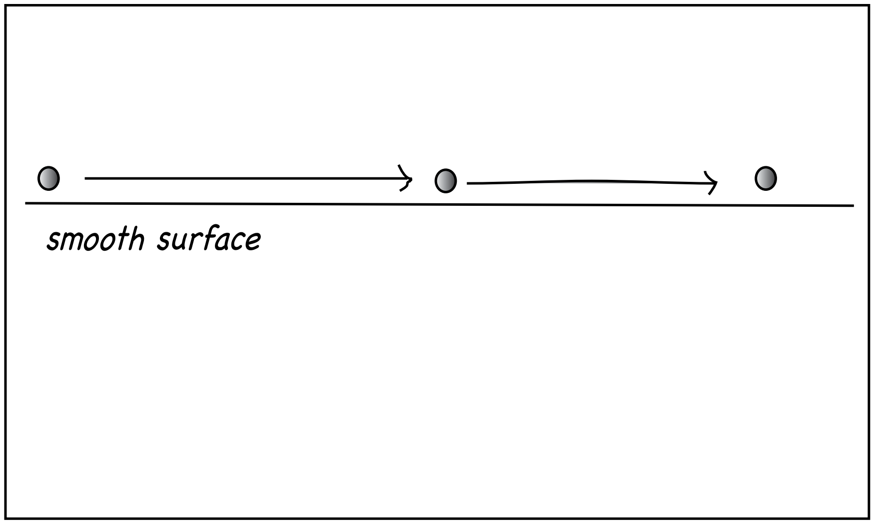
Again, help the students see that the marble's trajectory is not changed unless it is contacted by something — like a rough surface or a building block.

Help the students draw conclusions based on the data they have collected.

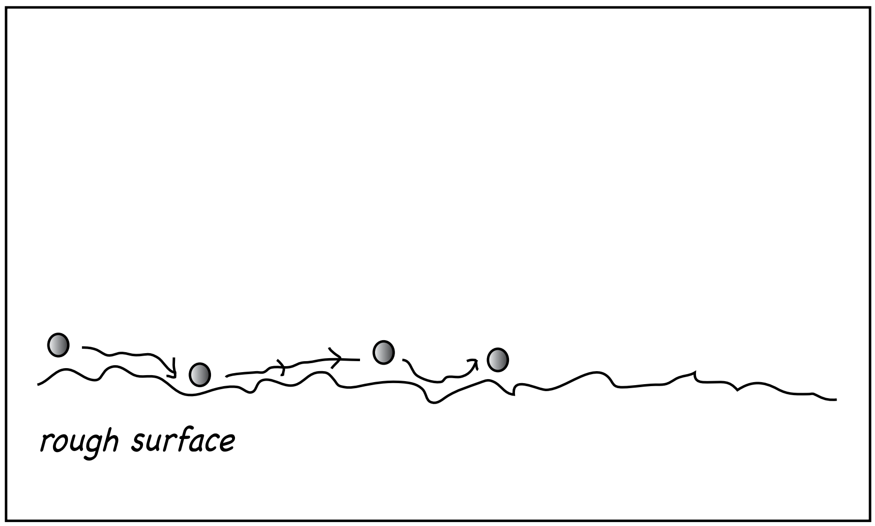
Some possible conclusions are:

- *The tennis ball goes up and always comes down.*
- *The string keeps the tennis ball from going all the way up because it pulls the tennis ball back.*
- *The marble travels on the smooth surface in a straight line, but the rough surface keeps the marble from traveling straight.*
- *The marble on a smooth surface changes direction only when it hits a block.*

After the students have thought about their data and drawn some conclusions, discuss Newton's First Law of Motion. Show them how they were able to observe the same things that Newton observed and that they too could *discover* a fundamental law of physics.



❷ Repeat Step 1 using a rough surface on which to roll the marble.



Conclusions

Draw some conclusions about your results and record them below.

Review

Define the following:

physics: *the study of how things move and behave in nature*

physical law: *a precise statement about how things behave in the physical world*

List the 5 steps of the scientific method

observation

forming a hypothesis

experimentation

collecting results

drawing conclusions