Scientific Inquiry and Modeling
The Process of Scientific Inquiry

CONCEPT EXPLORATION

Scientists use evidence to develop predictive models about nature. You will use this process throughout the year in finding out about the nature of the physical world. Today we will focus on the characteristics of this process.

Have you ever had a coin or other precious treasure roll under the couch? You reach and squirm trying to grab the thing from under the couch but you just can't get it. Imagine if you could easily lift the couch and grab the treasure without straining at all! Today's investigation deals with reducing the force required to lift an object. You will develop an idea (model) to address a challenge, and then test that idea.

Engagement Question

1. What could you do to make it easier to lift a couch?

The Challenge

You will attempt to figure out how to lift a given object by applying less force than the weight of the object. You will be using a single pulley and some string.

Your Ideas about the Challenge

1. What kinds of things are you going to try? Diagram arrangements that you think might work in the space below.

2. Why do you think this arrangement is going to "make it easier" to lift the mass? What about your set up(s) will allow you to apply less force than the weight? It is important for you to record your explanation even though your ideas may not be correct. What matters is that you can see how your ideas develop as you proceed through the investigation.

At each lab station you will find the following materials:
a pulley, a ring stand, some string, a weight, a spring scale, and a C-clamp.

The Investigation

a. Weigh the given object by suspending it from the spring scale. Record its weight (in the units given on the spring scale) in the data section that follows.
b. Set up the pulley and string in the manner(s) you diagramed above.
c. Use the spring scale to determine the force required to lift the object. Record this in the data tables that follow.
d. Measure how high the object is lifted at the same time that you measure how much string you are pulling on to lift the object. Record both of these in the data section that follows.

There are two kinds of observations that you can make. ***Qualitative*** observations are those that are personal to you ("It feels easier to lift when it's set up like this"). ***Quantitative*** observations are those in which you use numerical measurements. Quantitative observations have an advantage in that different observers can agree easily on a numerical measurement ("The applied force is 3 lbs. with this set up"). You will be recording quantitative observations n the data table that follows

Data Tables

Weight of given object (be sure to include the units)

Set Up 1			Set Up 2		
Applied Force	Height object was lifted	Amount of string you pulled	Applied Force	Height object was lifted	Amount of string you pulled

3. Was any arrangement effective at producing a smaller applied force than the weight of the object? If so which one was effective?

4. Think about the most effective set ups. How did the length of string you pulled through the system compare to the height the object was lifted?

5. Why do you think that your most effective set up decreased the amount of force you had to apply to lift the object? What was it about this set up that made it easier?

6. Evaluate the following student statement about the investigation you performed. Identify ideas that are consistent with your observations and others that are not consistent with your observations.

"No matter how you use the pulley you end up applying more force than if I just simply lifted the object straight up with the spring scale. If I lifted the weight without the pulley, the spring scale showed 10 lbs. If I used the pulley, the spring scale showed a little more than 10 lbs. of force. "

Check your work with your teacher. ☐

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CONCEPT DEVELOPMENT

In the last investigation, you found that, by using pulleys, it was possible to lift an object with a smaller amount of force than the weight of the object being lifted. In this activity, you will conduct a scientific investigation for a pendulum. You may have seen the mass in a grandfather clock swing back and forth. The teacher will attach a mass to a string and demonstrate the action of a pendulum.

Engagement Question

You've been on a swing in the playground. The playground swing is basically a pendulum.

1. Suppose you wanted each swing back and forth to take as much time as possible, what could you do to change the time?

The Challenge

Each group of student will design a series of tests to determine which **variable*** will cause a significant change in the time it takes a simple pendulum to swing back and forth (oscillate).

* A **variable** is a characteristic of a system that can be changed. An **independent variable** is a characteristic that the scientist decides to alter. He or she then looks for a change in the **dependent variable.** If a significant change in the **dependent variable** occurs when the **independent variable** is altered, a relationship between the two variables may exist.

Your Ideas about the challenge

2. What are two things that you could alter that might affect the time it takes the pendulum to swing back and forth (the dependent variable)?

3. Would it be okay to change both of your independent variables at the same time during your investigation? Why or why not?

4. Why would the use of a different mass affect the time for your pendulum to swing back and forth?

5. Why would a change in the length of your pendulum affect the time it takes the pendulum to swing back and forth?

At each lab station you will find the following materials:
5 masses, a length of string, a meter stick, a ring stand, and a stopwatch

The Investigation

a. Set up the pendulum using a mass, a length of string, and a ring stand. Record the mass in the data section that follows.
b. Time 10 back and forth swings of the pendulum. Divide the time that you receive by 10. Record this value in the data section that follows.

c. Repeat part “b” 4 more times using 5 different masses in all. Make sure that you don’t change the length of the pendulum in any way.

Data

Trial	1	2	3	4	5
Mass (g)					
Average Time (s)					

The Investigation (continued)

a. Set up the pendulum using a mass, a length of string, and a ring stand. Measure the length of your pendulum and record this in the data section that follows.
b. Time 10 back and forth swings of the pendulum. Divide the time that you receive by 10. Record this value in the data section that follows.
c. Repeat part “a” and “b” 4 more times using 5 different lengths in all. Make sure that you don’t change the mass in any way.

Data

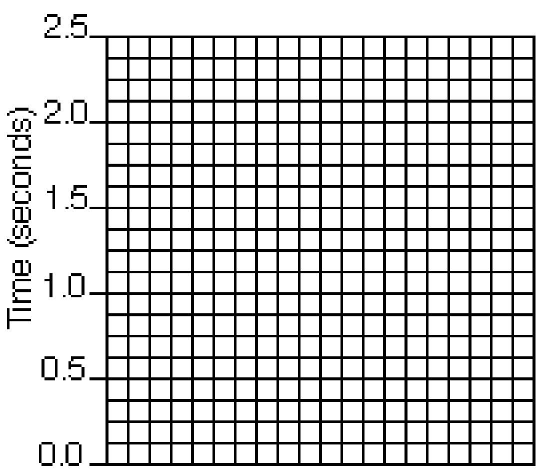
Trial	1	2	3	4	5
Length (cm)					
Average Time (s)					

6. Examine the data. Does the time seem to be more affected by mass or by length?

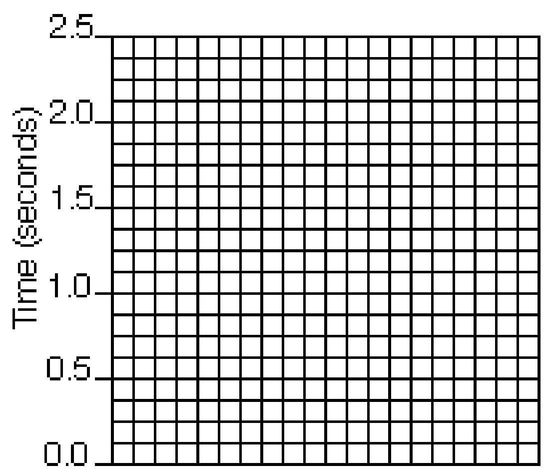
It can be difficult to tell by simply looking at the numbers. Scientists often represent data graphically to get a better idea about the amount and type of change observed when an independent variable is altered. Graph the data on the provided grids that follow. Plot the dependent variable **time** on the y axis, and the independent variable on the x axis.

You will need to figure out an x-axis scale for the graphs that will allow you to include all of your data and will start with “0” at the origin. You may draw a line through the data points to represent any observed trends in the data.

Mass vs. Time



Length vs. Time



7. In which graph does the time appear to be more significantly affected by the independent variable?

8. What is it about the graph that suggests that one independent variable has a greater affect on the time than the other?

9. If you wanted to build a grandfather clock that had a very long period (took a long time to swing back and forth) what feature would the clock have?

10. Evaluate the following student statement about the investigation you performed. Identify ideas that are consistent with your observations and others that are not consistent with your observations.

"Both the mass and the pendulum length affect the time. The length has a bigger affect. The mass causes the time to change too, just not as much.""

Check your work with your teacher.

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CONCEPT REFINEMENT

Review
You have now had two laboratory experiences involving the process of scientific inquiry. This homework/worksheet will review and refine the ideas addressed in the previous activities.

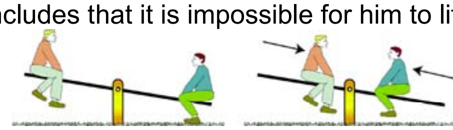
In the first activity, you examined a variety of pulley arrangements to determine if it was possible to reduce the force required to lift an object. You tested each model (idea) to see if it fit the criteria, and rejected those models that were not supported by the evidence.

In the second activity, you examined the motion of a pendulum. Your challenge was to determine the most important independent variable that would affect the time of one back and forth swing. You developed at least two ideas about things that would affect the oscillation time. At one point in the investigation, you were asked if it was reasonable to vary both of these factors in the same experiment, and you decided that it would be difficult to know which thing was changing the time if you did this. You then tested these ideas independently and identified the variable that had the greatest affect on the time.

The following sections will describe investigations conducted by students. It will be your job to evaluate their experimental design and describe the strengths and weaknesses of their efforts.

Sample Investigations

Steve believes that it is impossible for a small person to lift a big person on a playground teeter totter. He weighs 120 pounds, and his friend weighs 180 pounds. They sit on the teeter totter as the diagram below indicates. Steve then slides toward the center and asks his friend to slide toward the center at the same time. He is unable to lift his friend in this new position. He concludes that it is impossible for him to lift his friend.



1. Do you agree with Steve's conclusion? If not, what should Steve have done differently or taken into consideration?

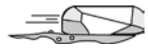
Check your work with your teacher.

Mary thinks that heavy objects fall faster than light objects. She drops a rock and a feather at the same moment and observes the time taken by each to reach the ground. After conducting 20 trials she observes that the rock always reaches the ground first. She concludes that heavy objects fall faster than light objects.

2. Do you agree with Mary's conclusion? If not, what should Mary have done differently or taken into consideration?

Check your work with your teacher.

Keisha thinks that a force has to be constantly applied in order to keep an object moving at a steady speed. She remembers that she has to keep pulling in order to drag a chair across the floor, or move a couch across the carpet. Marcus shows Keisha that an ice cube on a smooth floor keeps moving at a steady speed even after he's finished pushing it. Keisha says that Marcus' experiment doesn't matter, she still believes that you have to keep pushing to keep something moving.



3. Do you agree with Keisha's conclusion? If not, what should Keisha have done differently or taken into consideration?

Check your work with your teacher. ☐

Roland's little 5 year old brother Michael thinks that he will never grow up. Roland tells his little brother to compare his height to a doorknob. Michael compares his height to the doorknob for 5 days. Michael concludes that he is not growing.

4. Do you agree with Michael's conclusion? If not, what should Michael have done differently or taken into consideration?

Check your work with your teacher. ☐