

## THE ELASTICITY OF A MECHANICAL SPRING

### Performance Standard 8A/8B/10A.I

Solve a real-world word problem with two variables in the answer accordingly:

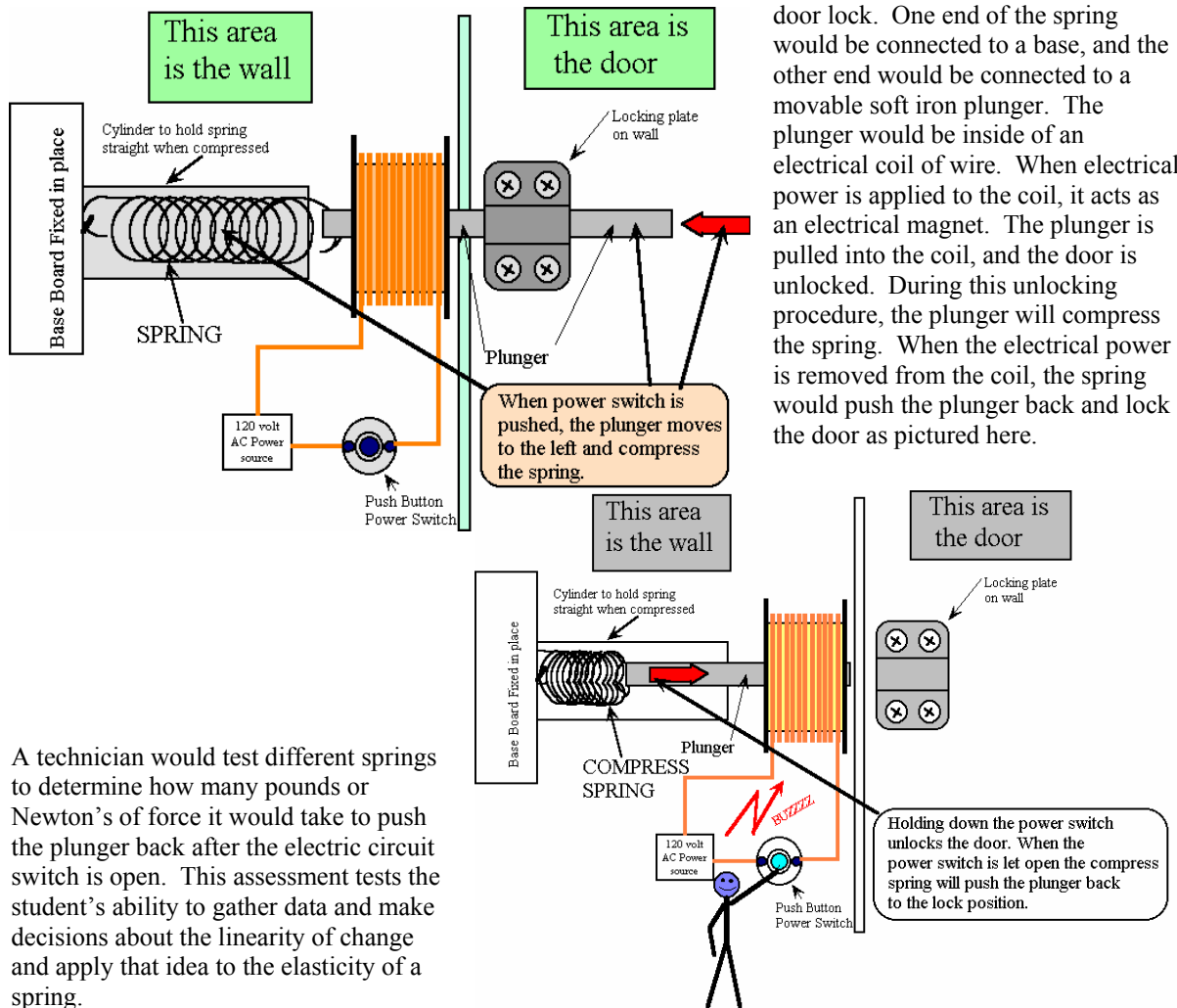
- *Mathematical knowledge:* solve a real-world word problem that meets given conditions and represent linear relationships.
- *Strategic knowledge:* use appropriate strategies to solve the problem.
- *Explanation:* explain completely and clearly what was done and why it was done.

### Procedures

1. **In order to describe numerical relationships using variables and patterns (8A); interpret and describe numerical relationships using tables, graphs and symbols (8B); and organize, describe and make predictions from existing data(10A),** students should experience sufficient learning opportunities to develop the following:

- Create a line of best fit from a set of ordered pairs or set of data points.
- Identify essential quantitative relationships in a situation and determine the class or classes of functions (e.g. linear, quadratic) that might model the relationships.
- Identify slope in an equation and from a table of values.
- Analyze two-variable data for linear or quadratic fit.

A technician may need to know the elasticity of a spring. For example: A spring could be used in an electrical door lock. One end of the spring would be connected to a base, and the other end would be connected to a movable soft iron plunger. The plunger would be inside of an electrical coil of wire. When electrical power is applied to the coil, it acts as an electrical magnet. The plunger is pulled into the coil, and the door is unlocked. During this unlocking procedure, the plunger will compress the spring. When the electrical power is removed from the coil, the spring would push the plunger back and lock the door as pictured here.



A technician would test different springs to determine how many pounds or Newton's of force it would take to push the plunger back after the electric circuit switch is open. This assessment tests the student's ability to gather data and make decisions about the linearity of change and apply that idea to the elasticity of a spring.

Permission to reprint requested.

Students should also have experience with linear relationships, gathering data and finding lines/curves of best fit prior to this assessment.

2. Provide each student a copy of the “The Elasticity of a Mechanical Spring” task sheet; a ruler; a slotted weight set; a spring; a paper towel cardboard cylinder; 6x32 threaded rod, washer and two #6 x 32 nuts; a board with a small hole; graph paper; and the task scoring rubric. Have students review and discuss the task and how the rubric will be used to evaluate it.
3. Have the students work in teams to gather data, but they may work individually to find the equation of the function of best fit.
4. Use the materials provided and the laboratory set-up shown to determine the relationship between the mass applied and the amount the spring has been compressed. Make all measurement in either the Metric or the U.S. Customary system. Do not mix measurement systems.
  - a. Set up a table to record your data. You will need to add increments of force until you have completely compressed the spring. Add increments in the appropriate amounts so that you have at least 5 to 10 data points. Record the force applied and the length of the spring at each interval in your data table.
  - b. Plot the data from your table on the graph paper provided. Make sure to identify and label the independent and dependent variables appropriately.
  - c. When the graph is completed, determine if the graph is linear or nonlinear. If the graph is linear, determine the line of best fit and the slope of the line. If the graph is nonlinear, use other forms of regression to determine the class of function that best seems to fit the situation.
  - d. Compare the graphs of the regression equation of best fit from step c with the plot of the data points. Describe any similarities and differences and why they may exist.
5. Evaluate each student’s work using the rubric and its guide to determine the performance level. Give each student a score in each of the three categories, scoring each part of the problem separately. Minor errors in computation include making errors in the actual addition or multiplication or rounding incorrectly. Major errors include using the wrong operation or formulas. The students’ explanations should include how they found these answers as well as why these answers are correct.

The key idea here is for students to understand linear and/or nonlinear relationships well enough to identify situations where linear and/or nonlinear relationships occur in the real world.

#### **Examples of Student Work**

- [Meets](#)
- [Exceeds](#)

#### **Time Requirements**

- Three class periods

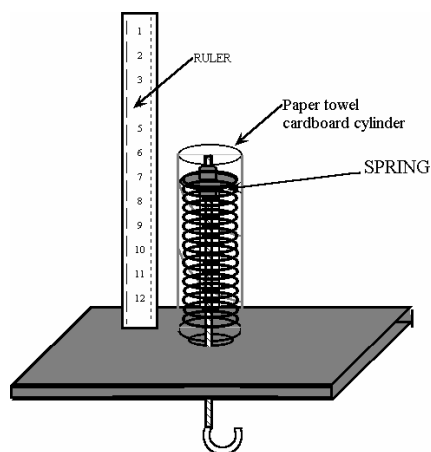
#### **Resources**

- Copies of the “The Elasticity of a Mechanical Spring” task sheet
- Ruler
- Slotted weight set from science department
- Spring
- Paper towel cardboard cylinder
- 6 X 32 threaded rod
- One finder washer
- Two #6 X 32 nuts
- Small board with hole in center
- Graph paper
- Mathematics Rubric

## THE ELASTICITY OF A MECHANICAL SPRING

### Student Task Sheet

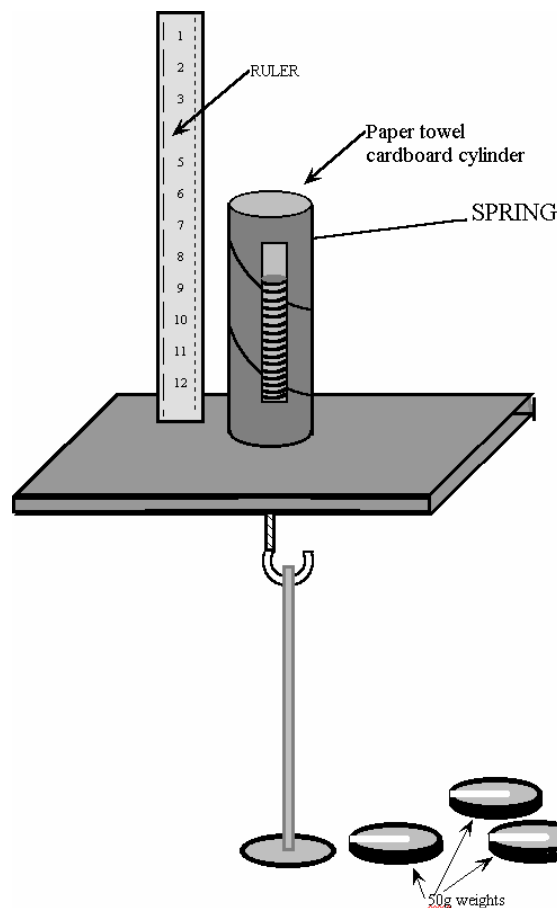
Use the materials provided and the laboratory set-up shown to determine the relationship between the mass applied and the amount the spring has been compressed. Make all measurement in either the Metric or the U.S. Customary system. Do not mix measurement systems.



**Figure 1\***

\*Permission to reprint requested.

**Figure 1 & 2 show how to assemble the lab materials, how to apply the weights and measure the distance displaced in order to gather data.**



**Figure 2\***

- a. Set up a table to record your data. You will need to add increments of force until you have completely compressed the spring. Add increments in the appropriate amounts so that you have at least 5 to 10 data points. Record the force applied and the length of the spring at each interval in your data table.
- b. Plot the data from your table on the graph paper provided. Make sure to identify and label the independent and dependent variables appropriately.
- c. When the graph is completed, determine if the graph is linear or nonlinear. If the graph is linear, determine the line of best fit and the slope of the line. If the graph is nonlinear, use other forms of regression to determine the class of function that best seems to fit the situation.
- d. Compare the graphs of the regression equation of best fit from step c with the plot of the data points. Describe any similarities and differences and why they may exist.

## MATHEMATICS RUBRIC

NAME \_\_\_\_\_ DATE \_\_\_\_\_

- Exceeds standard (must receive a 4 in each area)
- Meets standard (must receive all 3's or a combination of 3's and 4's)
- Approaches standard (must receive all 2's or any combination which may include a 3 or a 4)
- Begins standard (has no 3's or 4's but not all 1's)
- Absent (has all 1's and 0's)

	<b>Mathematical Knowledge</b>	<b>Strategic Knowledge</b>	<b>Explanation</b>
<b>4</b>	<ul style="list-style-type: none"> <li>• Wrote the right answer.</li> <li>• Used math words correctly to show understanding of how math works.</li> <li>• Worked it out with no mistakes.</li> <li>• Used the right math words and labeled the answers.</li> </ul>	<ul style="list-style-type: none"> <li>• Identified all the important parts of the problem, and knew how they went together.</li> <li>• Showed all the steps used to solve the problem.</li> </ul>	<ul style="list-style-type: none"> <li>• Wrote what was done and why it was done.</li> <li>• If a drawing was used, all of it was explained in writing.</li> </ul>
<b>3</b>	<ul style="list-style-type: none"> <li>• Knew how to do the problem, but made small mistakes.</li> </ul>	<ul style="list-style-type: none"> <li>• Identified most of the important parts of the problem.</li> <li>• Showed most of the steps used to solve the problem.</li> </ul>	<ul style="list-style-type: none"> <li>• Wrote mostly about what was done.</li> <li>• Wrote a little about why it was done.</li> <li>• If a drawing was used most of it was explained in writing.</li> </ul>
<b>2</b>	<ul style="list-style-type: none"> <li>• Understood a little, but made a lot of big mistakes.</li> </ul>	<ul style="list-style-type: none"> <li>• Identified some of the important parts of the problem.</li> <li>• Showed some of the steps used to solve the problem.</li> </ul>	<ul style="list-style-type: none"> <li>• Wrote some about what was done or why it was done but not both.</li> <li>• If a drawing was used, some of it was explained in writing.</li> </ul>
<b>1</b>	<ul style="list-style-type: none"> <li>• Tried to do the problem, but didn't understand it.</li> </ul>	<ul style="list-style-type: none"> <li>• Identified almost no important parts of the problem.</li> <li>• Showed almost none of the steps used to solve the problem.</li> </ul>	<ul style="list-style-type: none"> <li>• Wrote or drew something that didn't go with the answer.</li> <li>• Wrote an answer that was not clear.</li> </ul>
<b>0</b>	<ul style="list-style-type: none"> <li>• No answer attempted.</li> </ul>	<ul style="list-style-type: none"> <li>• No strategy shown.</li> </ul>	<ul style="list-style-type: none"> <li>• No written explanation.</li> </ul>
<b>Score</b>			