



## Computer 22

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4. Prepare the Force Sensor for data collection.
  - a. Connect the Dual-Range Force Sensor to the computer interface.
  - b. Set the switch to the lowest setting.
  - c. Prepare the computer for data collection by opening the file “22 Inclined Plane” from the *Physical Science w Vernier* folder.
5. Slowly pull the wooden block up the inclined plane. The Force Sensor should be held parallel to, and about 2 cm above, the surface of the inclined plane, as shown in Figure 1. Once the block is moving at a steady rate, click  to begin data collection.
6. After the data have been collected, look at the graph displayed on the screen. If the graph is reasonably flat, proceed to Step 7. If there are big peaks and valleys, repeat Step 5.
7. Click the Statistics button, . Record the Mean (average) force (in N) required to pull the block up the inclined plane.

### Without an Inclined Plane

8. Now determine the force needed to lift the wooden block. Use the previous computer settings to get force readings as you slowly lift the block the same height as the inclined plane. Record the average force required to lift the block.

## DATA TABLE

Length of inclined plane	_____ m
Height of inclined plane	_____ m
Force (average) to pull the block up the inclined plane	_____ N
Force (average) to lift the block	_____ N

## PROCESSING THE DATA

1. Does it take more or less force to move the block using the inclined plane? Explain.

2. A formula for calculating work is

$$W = F \times d$$

where  $W$  = work (in N•m),  $F$  = force (in N), and  $d$  = distance (in m). Use this formula to calculate work done using the inclined plane. Here,  $F$  = the average force needed to pull the block up the inclined plane and  $d$  = the **length** of the inclined plane.

3. Calculate work done in lifting the block. Here,  $F$  = the average force needed to lift the block and  $d$  = the **height** of the inclined plane.

4. Does it take more or less work to move the block using the inclined plane?

5. A formula for calculating the efficiency of a machine is

$$\text{efficiency} = \frac{\text{work output}}{\text{work input}} \times 100$$

Use this formula to calculate the efficiency of the inclined plane. Here, work output = the work done lifting the block, and work input = the work done pulling the block up the inclined plane.

6. What causes the difference between the work needed to pull the block up the inclined plane and the work to lift it to the same height? Discuss ways to decrease this difference.

## **EXTENSIONS**

1. Study how changing the inclined plane slope changes force.
2. Design an experiment to study your answer to Question 6.
3. Determine the mechanical advantage of the inclined plane.

**TEACHER INFORMATION****An Inclined Plane**

1. The student pages with complete instructions for data collection using LabQuest App, Logger *Pro* (computers), EasyData or DataMate (calculators), and DataPro (Palm handhelds) can be found on the CD that accompanies this book. See *Appendix A* for more information.
2. We suggest that you include one of the extension ideas in the required part of this experiment.
3. The smooth-surface boards used for the inclined plane should be at least 0.5 m long. We use boards that are  $1.2 \times 0.25$  m.
4. A  $5 \text{ cm} \times 10 \text{ cm} \times 15 \text{ cm}$  piece of wood works well. Insert a hook in the center of one end. Other flat-surface objects can be substituted.
5. The Dual-Range Force Sensor has a low range,  $-10$  to  $10$  N, and a high range,  $-50$  to  $+50$  N. Students will use the low range for this experiment.
6. For even better results, you can have students *zero* the Force Sensor. They should position their Force Sensor horizontally on the inclined plane, as shown in Figure 1 of the student procedure.
7. Illustrate proper technique for pulling an object up an inclined plane with the force sensor before the experiment. Remind your students not to pull the object too fast.
8. Your students should get better results using the Force Sensor and average force values than with spring scales.

**SAMPLE RESULTS**

Length of inclined plane	xxxx m
Height of inclined plane	xxxx m
Force (average) to pull object	xxxx N
Force (average) to lift object	xxxx N

**ANSWERS TO QUESTIONS**

Answers have been removed from the online versions of Vernier curriculum material in order to prevent inappropriate student use. Graphs and data tables have also been obscured. Full answers and sample data are available in the print versions of these labs.