

An Inclined Plane

An inclined plane is a slanted surface used to raise objects. The sloping floor of a theater, a road over a mountain, and a ramp into a building are examples of inclined planes. In this experiment, you will use a computer-interfaced Force Sensor to measure the force needed to lift an object and the force needed to pull the same object up an inclined plane. You will then calculate and compare work done in raising the object to the same height by lifting it and pulling it up an inclined plane.

OBJECTIVES

In this experiment, you will

- Use a computer-interfaced Force Sensor to measure force.
- Compare forces.
- Calculate work and efficiency.
- Make conclusions using the results of the experiment.

MATERIALS

computer
Vernier computer interface
LoggerPro
Vernier Force Sensor
smooth board (at least 0.5 m long)

wooden block with a hook
books
metric ruler
paper clip

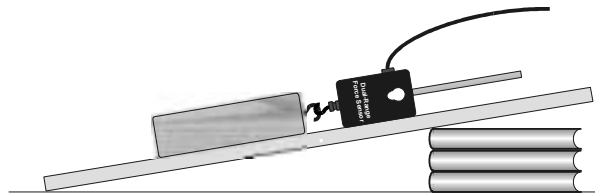




Figure 1: Using the Dual-Range Force Sensor

PROCEDURE

Using an Inclined Plane

1. Set up a stack of books as shown in Figure 1.
2. Get a board and set up an inclined plane as shown in Figure 1. Measure the length of the board (in meters) and record this value in the data table. Measure and record the height of the inclined plane (in meters).
3. Get a wooden block with a hook on one end. Partly straighten a paper clip—leaving a hook at each end. Use the paper clip to attach the wooden block to your Force Sensor.

Experiment 22

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 Computers* 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.

Experiment 22

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

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1. We suggest that you include one of the extension ideas in the required part of this experiment.
2. The smooth-surface boards used for the inclined plane should be at least 0.5 m long. We use boards that are 1.2×0.25 m.
3. 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.
4. The student procedure has directions for using the Dual-Range Force Sensor. Instructions for using the Student Force Sensor can be found in the word-processing files included on the CD that comes with this book. See *Appendix A* for more information about these files.
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. If you have Student Force Sensors, there is only one range with a single calibration value.
6. For even better results, you can have students *zero* the Force Sensor. They can do this immediately after completing Step 4 of the procedure. They should position their Force Sensor horizontally on the inclined plane, as shown in Figure 1 of the student procedure, and click on the Logger Pro button.
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.

