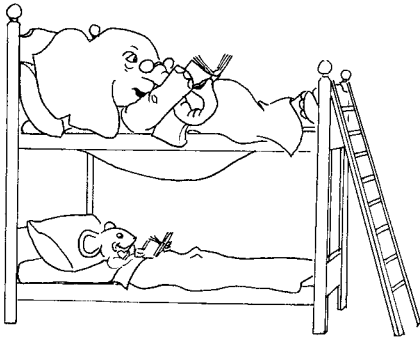


Lesson 4 Inclined Plane

Lesson 4 —Day 1



Max and Elmer share a room. Max is afraid of heights, so he likes to sleep on the bottom bunk. Elmer likes to sleep on the top bunk to be near the stars.

Materials:

SP Lesson 4 Day 1

8.5"x11" paper or cardstock

stack of books 4 to 6 inches tall

a firm ruler or thin firm piece of wood

an orange or solid rubber ball

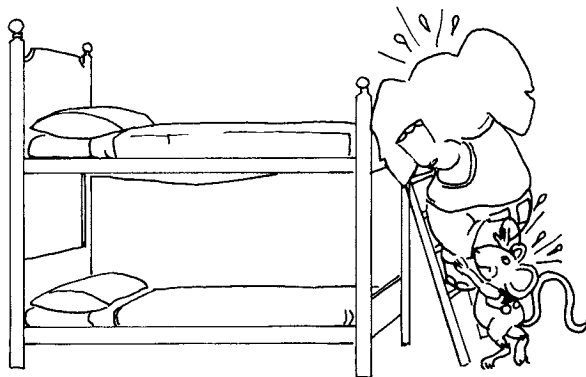
Tools in Time

Vocabulary Words:

Hand out vocabulary strip for this lesson. Encourage your students to use the words while talking about the material and in their written work.

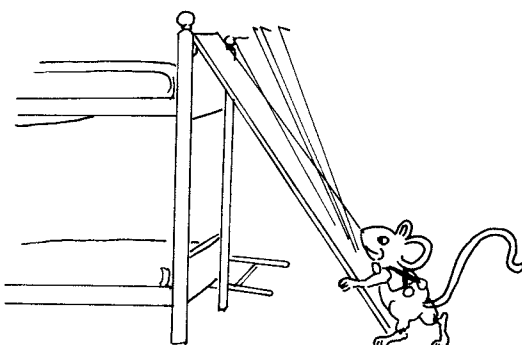
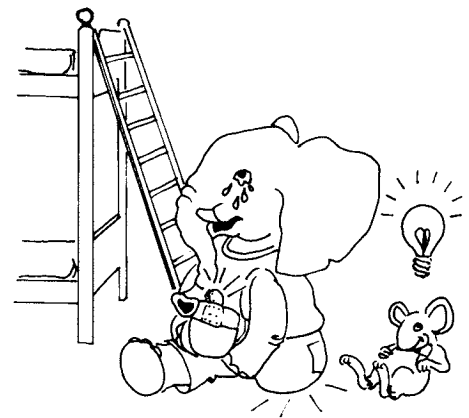
ramp
inclined plane
slanted

Today, Elmer has a very sore toe and cannot walk. So, Max must help Elmer get up to the top bunk. Max is little, and Elmer is big and heavy. How can Max help Elmer get to the top bunk?

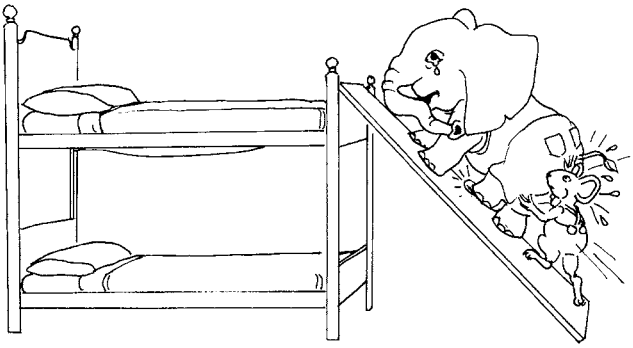


Max tries to push Elmer up the ladder, but he cannot move Elmer. Max does not have enough force to push a load as heavy as Elmer up to the top bunk. How can Max help Elmer get up to the top bunk?

Max is very tired, but no work has been done because Elmer, the load, did not move. Then Max gets an idea.

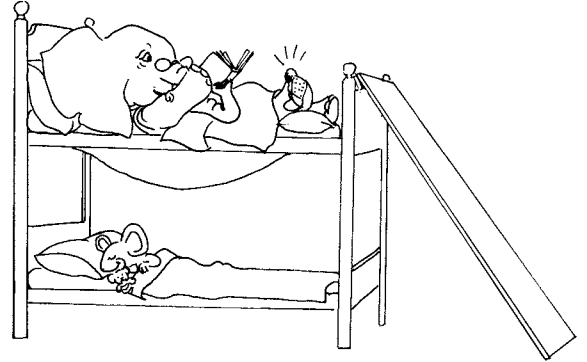


Max finds a board and leans it against the bed to make a **ramp**. The ramp that Max is making is called an inclined plane. An **inclined plane** is a simple tool. It is a **slanted** surface used to raise or lower an object.

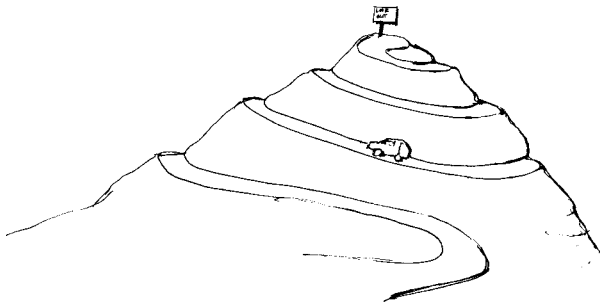
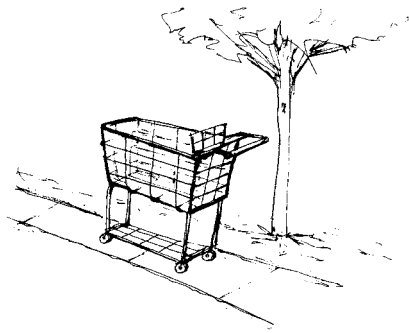
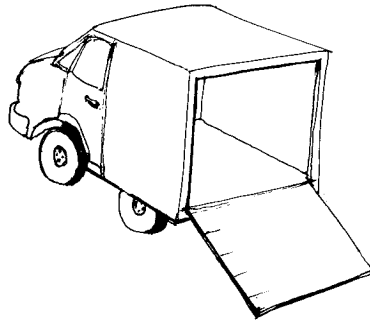
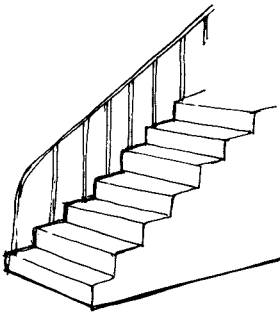


With the inclined plane, Max uses less force to push Elmer, the load, up the ramp than it takes to lift Elmer straight up to the top bunk. The inclined plane magnifies Max's force so he can do work that he could not do otherwise.

Pushing Elmer up the inclined plane took effort for Max. He had to use force. But the amount of force he used was much less than if he had lifted Elmer straight up to the top bunk.



We use inclined planes every day. A staircase is a slight variation of the inclined plane.

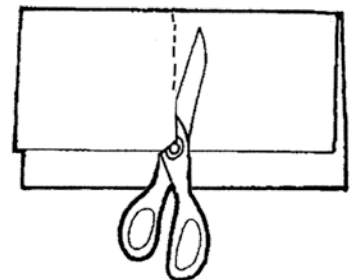


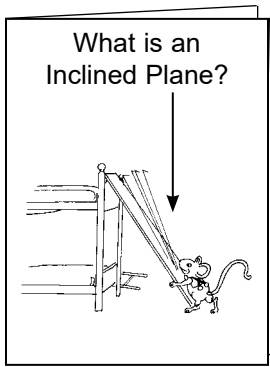
Even a road that winds around a mountain is an inclined plane. If you imagine taking the road off the mountain and unwinding it, the road will form a large, inclined plane.

What is an Inclined Plane? Book

Hand out SP Lesson 4 Day 1 and 8.5"x11" paper or cardstock.

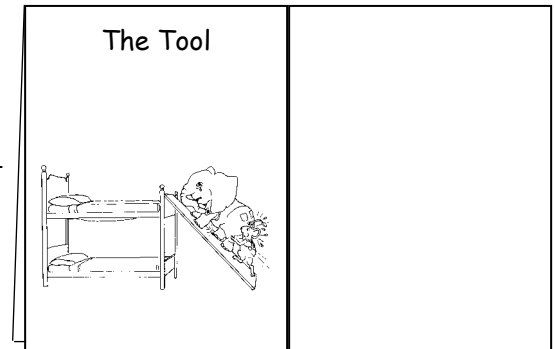
Make a Large Question and Answer Book by folding the paper into a Hamburger. Fold it in half again like a Hamburger. Open that fold and cut the crease along the top tab to the fold.





Fold back into a Hamburger. Cut out and glue 4A and, on the cover, title the book *What is an Inclined Plane?*

Open the book. Cut out and glue image 4B on the first tab. Title it *The Tool*.



Under the tab:



Draw an inclined plane. Draw a load on the inclined plane. Draw arrows showing the direction that the load moves on the tool. Arrows should go up and down on the inclined plane.



Describe an inclined plane. *Ex:*

An inclined plane is a slanted surface used to raise or lower an object.



Define an inclined plane and describe how it works. *Ex:*

An inclined plane is a ramp or slanted flat surface tilted at an angle, with one end higher than the other. The inclined plane reduces the amount of force needed to move an object, making it easier to lift or lower it.

You will add to this book in the next lesson.

Inclined Plane Activity

Materials: stack of books 4 to 6 inches tall, a firm ruler or thin firm piece of wood, an orange or a solid rubber ball

Prop the ruler on the books so that one end rests on the top of the books and the other rests on the table. With two fingers, grasp the object and lift it to the top of the stack of books. Place the object back on the table and, with two fingers, roll or slide the object up the inclined plane.

Which way was easier to move the object? You may think it was easier to lift the object. Would you think the same if the object were much heavier or the height that you had to lift it was greater?

Tools in Time

Cut out and glue image 4C to the appropriate place in the *Tools in Time* Book. Draw a line from the picture to the timeline and label.

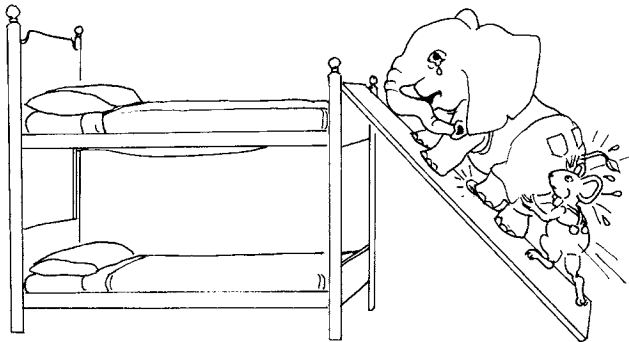
Lesson 4

—Day 2

An inclined plane is a **ramp**, a tilted, flat surface with one end higher than the other. Inclined planes help us raise or lower an object.

Without the inclined plane, Max could not have lifted Elmer to the top bunk. Max did not have the force needed to do that work.

An inclined plane spreads the force out over a longer distance. Max had to push Elmer a longer distance than if he had lifted Elmer straight up. However, Max used less effort than he would have without the inclined plane.



The force used to push a load on an inclined plane is called the **input force**.

Using a tool to do work gives Max a **mechanical advantage**. That means that the tool allows him to do work with less effort.

To determine the ideal mechanical advantage for an inclined plane, divide the length of the board by the height of the incline. Here is the formula:

$$\text{Ideal Mechanical Advantage} = \frac{\text{Length of board}}{\text{Height of the incline}}$$

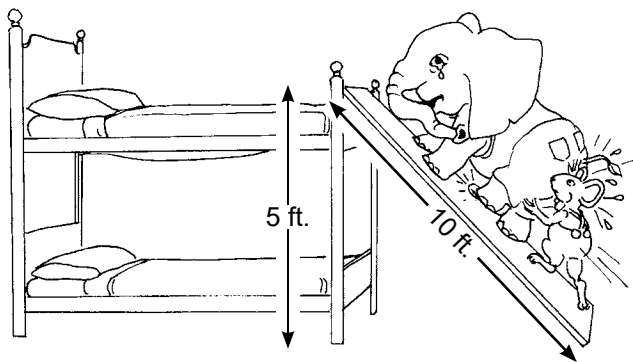
Materials:

SP Lesson 4 Day 2
What is an Inclined Plane? Book
a board to use as an incline
load with string used in Lab 3-1
a longer board to use as an incline
a force meter
Lab Book
lab cards
Tools in Time

Vocabulary Words:

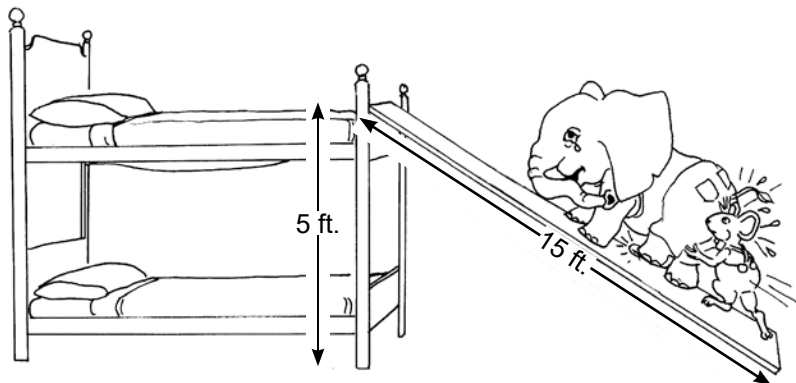
Hand out vocabulary strip for this lesson. Encourage your students to use the words while talking about the material and in their written work.

ramp
input force
mechanical advantage



The ideal mechanical advantage of this inclined plane is 10 divided by 5 = 2. This number can be used to compare the mechanical advantages of different inclined planes.

If Max used a longer board for his inclined plane and kept the height the same, the mechanical advantage would be greater. With the longer ramp, Max could use less force to get Elmer to the top bunk, but it would be a longer distance for Max to push Elmer.



The ideal mechanical advantage of this inclined plane is 15 divided by 5 = 3. Compare this number with the one for the previous inclined plane. This inclined plane has a higher ideal mechanical advantage.

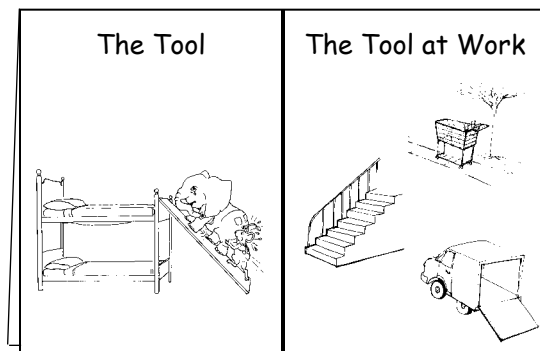
The amount of work is the same with both ramps, but the longer ramp allows work to be done with less effort. Elmer gets to the top bunk when either inclined plane is used, but Max is not as tired when he uses the longer one.

The formula for the ideal mechanical advantage is called "ideal" because friction is always a factor that lessens the mechanical advantage. Therefore, we calculate what the advantage would be without friction under ideal conditions.

What is an Inclined Plane? Book

Hand out: SP Lesson 4 Day 2, **What is an Inclined Plane? Book.**

Cut out and glue 4A on the second tab and title it *The Tool at Work*.



Under the tab:



Copy the list of examples found on the front tab: *stairs, sidewalk, truck ramp*



Name each example found on the front tab. Give an example of where you would find each. *Ex:*

stairs – two or more storied buildings

sidewalk – hills

truck ramp – delivery trucks



Explain how each example is used. *Ex:*

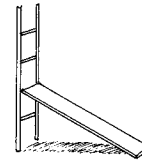
stairs – advancing to the upper floors of houses and buildings that have more than one floor.

sidewalks – moving objects like shopping carts or baby carriages up and down steep ground.

truck ramps – loading and off-loading objects from vehicles

Close the *What is an Inclined Plane?* Book and store it in the reclosable bag.

Work and the Inclined Plane Lab 4-1



Materials: a board, load with string used in Lab 3-1, a longer board, force meter, Lab Book, lab cards

Write the name of the lab and the date on a lab card.

Cut out and glue 4B-4E, one each, on the front of four additional lab cards.

How does the length and/or height of a ramp affect the amount of force needed to raise a load?

Predict how different lengths and heights of a ramp will affect the force needed to raise a load. "A longer ramp uses (more/less) force to lift the load. A higher ramp uses (more/less) force to lift the load." Record your prediction on the first lab card.

Attach the force meter to the pulling string. Use the shorter board as a ramp placed at a lower level on a stair or stack of books. Pull the book up the ramp using the force meter. Elevate the end of the same ramp to a higher level and complete the same procedure. On the lab card, record the amount of force needed to raise the book in each case.

Now take the longer board and place it at the lower level used in the first pull. Pull the book up the ramp using the force meter. Raise this longer ramp to the higher level and complete the same procedure.

Compare the amount of force needed to complete each job in the lab. Which inclined plane required the most force to raise the load? Which one required the least amount of force? Use the force meter measurements to determine which inclined plane made work the easiest and why. Compare the conclusions with the predictions.

Record your conclusion on the first lab card. Share these cards with two people in the next 24 hours. Show each person the pictures on the front and ask them to make predictions about the force needed for each job. Place the cards in the Lab Book for Lab 4-1.

Tools in Time

Cut out and glue images 4F-G to the appropriate places in the *Tools in Time* Book. Draw lines from the pictures to the timeline and label.

Lesson 4

—Day 3

Collect materials to complete activities you choose.

8.5"x11" paper or cardstock

plastic bottle

soft-boiled egg

Choose one or more activities to complete today.

1. Investigate how ancient Egyptians built the pyramids. Although we do not know for sure how these huge structures were built, the inclined plane probably played a large role in the process. Speculate how the inclined plane could have helped in building these structures. Draw pictures to illustrate your ideas. Research current theories. Compare and contrast them to your own.
2. Describe stairs as inclined planes. Measure the height of a stair step on several sets of stairs and record the measurements. Does there seem to be a standard measurement for stairs? Explain.
3. Read and discuss *Inclined Planes to the Rescue (First Facts)* by Sharon Thales (gr. 1-3).
4. Investigate the use of inclined planes in building codes for handicapped access. What angles are used for these ramp constructions, and why?
5. Ramps are most often used for moving heavy things up. Another way ramps can be used is to make a trip downwards more gentle. A great way to illustrate this is to drop a soft boiled egg into a pan from 6"–12" high. It would break. How could you lower this in more gently? Use a non-steep ramp to slide it gently down into the pan.

6. Technology Book

Cut out Lesson 4 image on the Technology Images page and glue it at the top of the next page of your Technology Book.

Cutting materials have progressed from stone axes to metal tools to lasers used in surgery. Investigate cutting tools through the timeline of technology and report your findings. Start your search with, "What is a technology timeline of cutting tools?"

Tool Tidbit

A bone folder is a dull-edged tool that bookbinders use to make crisp, clean folds in paper. Today, they are made not only of bone, but plastic, wood, or metal.

