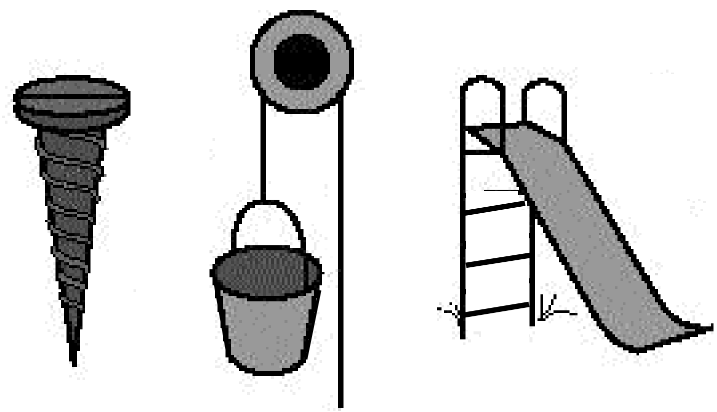
Theatre IV

Classroom Study Guide



The Wonderful World of Simple Machines

by Bruce Miller

Co-produced by The Carpenter Science Theatre Program at the Science Museum of Virginia

Study Guide compiled by Heather Widener

About the Play

This program offers a hands-on demonstration of the six types of simple machines: the lever, the inclined plane, the wedge, the screw, the wheel and axle, and the pulley. Simple machines are tools that make work easier by changing the direction or increasing the effect of a force. They are the basic components of all machines.

During the play you will meet Jake, Stella and Leslie, three avid science fans who take the audience on an exploration of the wonders of Simple Machines. Not only do the young scientists explore the six simple machines, but they also demonstrate the types of simple machines and how simple machines work.

THEATRE IV
Richmond · Cincinnati

SCIENCE MUSEUM OF VIRGINIA

Teacher Background: Forces and Simple Machines

Newton's First Law of Motion: A body in motion tends to stay in motion and a body at rest tends to stay at rest unless they are acted upon by an outside force.
Newton's Second Law of Motion: Force equals mass times acceleration.
Newton's Third Law of Motion: For every action (force) upon an object, there is an equal but opposite reaction (opposing force).

Scientific Definition of Work

The term "work" has a special meaning in science. Work, in science, is only done when force is exerted to move an object over a distance. Force is any pull or push on an object, and is usually measured in units called Newtons. Distance is the space through which the object moves, and is usually measured in meters. The mathematical formula for work is Work = Force x Distance. Work can be measured in units of newton-meters or joules. In science, work is done when a force moves an object over a distance. When using work over a defined system, there are always two aspects of the work being done: the work being put into the system (input) and the work coming out of the system (output). In theory, the work input should equal the work output. Of course, in real-life situations, you don't get a perfectly equal output because some energy is always lost in friction or in heat.

Machines make it easier to do work by changing the relationship between the force and distance involved in the work. There are three ways in which this change can happen.

- Sometimes when we use machines, we increase the distance over which a force is applied. In this case, we can then apply a smaller force over that distance. For example, a crowbar (a kind of lever) helps us open a tight seal.
- In other situations, we increase the applied force over a smaller distance. An example of this is peddling a bicycle-the bike wheels cover a greater distance than our feet.
- Sometimes we just change the direction of the force being applied. An example of this is using a pulley to lift a bucket of water.

All of these uses of simple machines make it easier for us to do work.

Mechanical Advantage

Mechanical Advantage is the ratio of the output force (resistance or load) to the input force (effort) acting on that load. For example, a pulley would have a mechanical advantage of 5 if a force of 10 lbs. could sustain a weight of 50 lbs.

Simple Machines

Machines are tools that are used to perform work (Remember, in science, work means moving objects over a distance.) Some machines, such as bicycles, are complex because they involve more than one simple machine. All complex machines are made up of a combination of the following simple machines.

The six types of simple machines are:

· the inclined plane	· the screw	· the wheel and axle
· the wedge	· the lever	· the pulley

Teacher Background: Forces and Simple Machines - continued

Inclined Plane

An inclined plane is any slanted surface used to move a load. Examples of inclined planes include slopes and ramps., such as a slope or a ramp. Ramps can be used to push a heavy load on wheels up into a truck, to help people in wheelchairs move around, to load luggage onto a plane, or to slide down on a playground. Inclined planes were used to move the huge stones that formed the pyramids in Egypt.

An Inclined plane doesn't move; it remains stationary and a load is transported across its surface. With an inclined plane, people can move a load with less force by increasing the distance over which the load is moved.

Wedge

A wedge is simply a moving inclined plane. Chisels, axes, knives, saws, a zipper, a doorstop, a fork, a plow, and razors are all examples of wedges. Wedges can help you grip things to be lifted, or tighten or hold things in place; but wedges are mostly used to push things apart.

Screw

A screw is an inclined plane (or wedge) wrapped around a cylinder, forming a spiral of ridges (or "threads"). It is the circular version of the inclined plane. Examples of a screw are screws, bolts, drill bits and corkscrews.

Lever

A lever consists of an arm that is free to turn about a fixed pivot point called the fulcrum. The effort (or input force) is exerted upon one lever arm, and as a result, the other lever arm moves the load (or resistance). As the fulcrum moves closer to the load, the input force needed to lift the load becomes less. The input force (effort) moves a greater distance, and the load moves a shorter distance. As the fulcrum moves closer to the input force (or effort), the force needed to lift the load increases. The input force (oe effort) moves a shorter distance, and the load moves a greater distance. Levers are divided into three classes, according to the positioning of the effort and load and force in relation to the fulcrum.

- First Class Lever: When the fulcrum lies between the effort and the load, the lever is described as a first class lever (as in a see saw). Examples of first class levers include: a car jack, pliers, scissors, a balance scale, or a lever with a rock as its fulcrum trying to lift another rock.
- Second Class Lever: When the load arm lies between the effort and the fulcrum, the lever is described as a second class lever. A wheelbarrow, a bottle opener, and a nutcracker are all examples of a second class lever.
- Third Class Lever: When the effort lies between the fulcrum and the load, the lever is described as a third class lever. Examples of third class levers include: a fishing pole, a pair of tweezers, an arm lifting a weight, a person using a broom, a hockey stick, a tennis racket, a spade, or a shovel.

Wheel and Axle

The wheel and axle is similar to the lever family of simple machines. This is because a wheel and axle is a circular (first class) lever whose fulcrum is the axle. Therefore, the lever can rotate through an entire 360º. Examples of the wheel and axle include a water wheel, a windmill, gears, doorknobs, faucet handles, and steering wheels.

Teacher Background: Forces and Simple Machines - continued

Pulley

A pulley is a grooved wheel that turns freely on an axle. It allows a rope or chain to ride securely on it. The pulley is another example of a circular-type lever; fixed pulleys are considered first-class levers, and moveable pulleys are considered second class levers. A fixed pulley does not move, and it does not change the amount of force or distance put in or coming out - it merely changes the direction of movement between the input force and the output force. Examples of fixed pulleys can be found on flag poles, drapes, and sail masts. A movable pulley moves along a rope. Unlike a fixed pulley, it changes the distribution of force and distance between the input force and the output force. Moveable pulleys provide a mechanical advantage based on the number of supporting ropes in the pulley. A block and tackle is a compound pulley; in other words, it is a combination of a fixed and moveable pulley. This type of pulley has the advantage of both a fixed and a moveable pulley in that it can both change the direction of a force and change the distribution of force and distance within a system.

Fascinating Facts about Simple Machines

1. The great pyramids in Egypt were built using ramps, a type of simple machine.
2. To make pulling easier when using ropes and pulleys, you have to use at least two pulleys.
3. The windlass is like the rope and crank of a wishing well. It originated thousands of years ago in Babylon. The windlass has been used to haul ore from mines, to open and close heavy gates, and on boats to hoist sails and lift anchors.
4. All complicated machines can be broken down into a combination of simple machines.
5. Simple machines make work easier by increasing the distance over which a force is applied.
6. In the first century B.C., Vitruvius, a Roman engineer, invented the water wheel. Buckets were placed on the rim of the wheel and water falling into the buckets caused the wheel to turn.
7. The revolving spindle on a tape recorder is a type of simple machine, called a capstan.
8. Simple machines can change the amount and direction of forces.
9. Water wheels and windmills have been used for grinding grain, sawing lumber, or as sources of power in the manufacture of clothing, metal and paper.
10. The size and number of teeth on a gear determine the kind of work it can do. A force on a large gear will cause a small gear to turn faster, but with less force. A force on a small gear will turn the large gear more slowly, but it will have a greater force. The distance between the teeth of the gear is called the "pitch".
11. One of the first screw machines, invented in the third century B.C., is commonly attributed to the Greek mathematician, Archimedes. It was to irrigate the fields, and to pump water out of a ship's hold.
12. Did you know that the following are all examples of screws?
    1. snowblower,
    2. ship or airplane propeller
    3. pig feeder
    4. grain thresher
    5. meat grinder
13. Screws have also been used to press or fasten objects, such as in a book binding press, a vise, a screw hook, nut and bolt, an auger (hand drill), a monkey wrench, an ordinary screw, a jar lid, and a screw press for printing.

Theatre IV's The Wonderful World of Simple Machines

Suggested Classroom Activities

Language Arts

1. Vocabulary Development - Word Attack Bingo: The attached resource sheet contains key words used in the play. As these may be unfamiliar to students, the following are suggested activities for vocabulary development or enrichment:

- Copy and laminate the resource sheet so students may use wipe pens to play Bingo by identifying the word whose definition is read aloud.
- Ask students to illustrate and define each term, and create a Science Dictionary to use in class.
- Ask students to write a play summary, using at least 10 words from the chart.
- Ask students to choose a simple machine and illustrate it on a poster. Share and post class illustrations for reference.
- Ask students to create a game of "Concentration." Students may illustrate examples of each term and create game cards using index cards.
- Ask students to create a sketch of a scene from the play, and label items in the scene with words from the chart.

2. The Ancient Egyptians and Simple Machines: The attached resource sheets may be used with students as they learn about how the ancient Egyptians used simple machines to build pyramids. Students may read this informative text, answer the questions that follow, and sequence and illustrate a poster showing the steps involved in pyramid building.

Social Studies

1. Visions of an Inventor: Leonardo Da Vinci - This internet activity guides students through a site from the Boston Museum of Science and explores the life of Leonardo Da Vinci, focusing on his role as an inventor. The attached resource sheet may be used as students work their way through this interactive and informative web site.

2. How Machines Change our Lives - Ask students to use a Social Studies text or other media resource to research the effect of a new invention on people's lives. Suggestions include the McCormick Reaper, the steam engine, and the cotton gin. Students may use the attached graphic organizer to record ideas as they read.

Mathematics / Science

1. Problem Solving: It's Real Work! Students may use the attached resource sheet to apply mathematical principles to real-life problems involving the use of simple machines.

2. Friction: This science lab allows students to test the effects of friction by pulling a block over different textured surfaces. Students use the Scientific Method by hypothesizing, following written procedures, recordng observations, and drawing conclusions.

3. Graphing the Effects of Friction: As an extension of the Friction lab, students are asked to create a bar graph of the amount of work done by pulling the block over different surfaces. Students must remember to include all graphing components, including a title, a labeled x-axis, and a labeled y-axis. Further extension includes asking students to interpret what the graphs illustrate about friction.

Suggested Classroom Activities - Mathematics / Science (continued)

4. Friction: Wanted or Unwanted? In the attached classification activity, students are given a variety of situations where friction would either be wanted or unwanted. This activity may be extended as students brainstorm further examples of times when friction is wanted and times when friction is unwanted.
5. The Screw - To help students understand that a screw is an inclined plane wrapped around itself, ask students to make "screws" by cutting a piece of paper into a right triangle, coloring along the triangle's hypotenuse, and wrapping it around a pencil. The attached resource sheet may be used as a model or as a student resource sheet.

Discussion and Journal Topics

1. Write a science fiction story about an imaginary planet, one where friction does not exist. What would life be like on your planet? How would people survive? Be sure to name your planet!
2. Pretend you could go back in time to ancient Egypt, during the time that the Great Pyramid at Giza was built. If you could take one modern machine to help the Egyptians build the pyramid, what would it be? Why?
3. Be an inventor! Think of a machine that would help you at school or at home. What simple machines would make up your invention? What purposes would it serve? Be sure to give your invention a name, and include a sketch along with your description.
4. Compare a machine used in colonial times with one that performs the same task today. How are they the same? How are they different? How is today's machine more complex and efficient?
5. Go on a scavenger hunt. How many simple machines can you find at work in your home or classroom? Keep a list. Can you find 50? 100?
6. Read about an inventor, such as Benjamin Franklin, Thomas Edison, or Benjamin Banneker. Write a letter to that inventor telling how their invention is useful today. Include a few questions you would like to ask about the invention!
7. Choose a simple machine and write a fantasy story about what life would be like without that machine. For example, what would life be like without the wheel and axle? The lever?
8. Write a paragraph comparing and contrasting devices that are and are not machines.
9. Is reading a book an example of work? Explain your ideas, with support from your science class experiences and textbook.
10. Explain how a baseball bat, a golf club, and a hockey stick are examples of levers. What other examples of levers do you use in everyday life? Extension: classify these into First, Second, and Third Class Levers.
11. Why do you think it is important for scientists to ask questions that begin with, "I wonder what would happen if…?" Can you think of ten questions beginning with this phrase?

Suggested Reading

Ardley, Neil. Muscles to Machines: Projects with Movement. Aladdin Books: New York, 1990.

Ardley, Neil. The Science Book of Machines. Gulliver Books: New York, 1992.

Cole, Joanna. The Magic School Bus Plays Ball: A Book about Forces. Scholastic: New York, 1997.

de Pinna, Simon. Science Projects: Forces and Motion. Steck-Vaughn Co., Austin, TX, 1998.

Friedhoffer, Bob. Physics Lab in a Hardware Store. Franklin Watts Publishing: New York, 1996.

Friedhoffer, Bob. Physics Lab in a Housewares Store. Franklin Watts Publishing: New York, 1996.

Macaulay, David. The Way Things Work. Houghton-Mifflin Company: New York, 1988.

McGrath, Susan. Fun with Physics. National Geographic Society: Washington, DC, 1986.

Morris, Ann. Tools. Lothrop, Lee, and Shepard Books: New York, 1992.

Richards, Jon. Diggers and other Construction Machines - Look Inside Machines to See How they Work. Cooper Beech Books: Brookfield, CT, 1999.

Wilkinson, Phillip. Super Structures - How Things Work from the Inside Out. Dorling Kindersley: London, 1996.

Wilson, Anthony. Visual Timeline of Transportation: From the First Wheeled Chariots to Helicopters and Hovercraft. Dorling Kindersley: New York, 1995.

Suggested Web Sites

Bill Nye the Science Guy - Episode Guide to Simple Machines - This page gives teacher background on simple machines. http://nyelabs.kcts.org/teach/episodeguides/eg10.html

Boston Museum of Science - This page, located within the Museum's web site, includes brief descriptions and photos of simple machines. http://www.mos.org/sln/Leonardo/InventorsToolbox.html

Canada Science and Technology Museum- This site includes background information, lesson ideas, and student activities related to Simple Machines. http://www.science-tech.nmstc.ca/english/schoolzone/machines2.cfm

Physics and Astronomy Lesson Plans - This site contains 58 lesson plans related to Force and Motion. http://www.physics.rutgers.edu/hex/visit/lesson/lesson_links1.html

Playground Physics - This site includes lessons using common playground equipment to teach students about forces and simple machines. http://lyra.colorado.edu/sbo/mary/play/

Simple Machines - In this activity, students learn definitions and identify examples of simple machines. Students investigate various compound and complex machines and locate examples of each simple machine. http://www.plainfield.k12.in.us/hschool/webq/webq8/jjquest.htm

Simple Machines Learning Site - This site teaches elementary students about the six simple machines. Each machine page contains information and activities for students to use. Links provide teachers with ideas, resources, and lesson plans. www.coe.uh.edu/archive/science/science_lessons/scienceles1/finalhome.htm

Simple Machines: Levers - This site includes information about simple machines and levers, with illustrations and activities for students to complete online. http://trackstar.scrtec.org/main/display.php3?option=text&track_id=4793

The Catapult Museum Online - This site includes descriptions of ancient weaponry and catapults. http://www.nzp.com/02contents.html

The Science Museum of Virginia - This site includes activities and lesson plans for all areas of science, including lessons on simple machines and forces. www.smv.org/

Vocabulary Development - Word Attack BINGO!

The Ancient Egyptians and Simple Machines

The people of ancient Egypt built giant stone structures as burial tombs for their kings. The king's mummy was placed inside the tomb along with many treasures, jewels, and furniture - anything that the king, or Pharaoh, might need. It was important to the Egyptians that these tombs remain safe from thieves, so they built their tombs as huge pyramids. The king's burial place was deep inside the pyramid, and the pyramid had mazes of hallways, dead-end passages, and escape shafts to protect the king and his belongings.

The largest pyramid was built for King Khufu, at Giza, near Cairo. It has a square base of 756 feet on each side and reaches to a height of 450 feet. The Great Pyramid probably contains more than two million stone blocks, each weighing anywhere from 2 to 70 tons. It is taller than the Statue of Liberty, thirty times larger in mass than the Empire State Building, and it can be seen from the moon! It is the oldest structure in the world, and is one of the Seven Wonders of the Ancient World.

It is amazing that the pyramids were built before the invention of modern machinery! The Egyptians had no large machines with which to build their pyramids. They had to use their hands to make these giant structures, but they did use the help of some simple machines. Each huge block was quarried out of the earth, moved, cut with chisels to exact measurements, and put into place with the help of ramps. It is thought that as many as 100,000 men used ropes, sleds, levers, and ramps to build just one pyramid in about twenty years.

How did they do it? Scholars believed that they used the following methods. As the stones were quarried, or dug, from the ground, each was placed on a wooden rocker and then placed onto a wooden sled. It was then pulled to its place on the pyramid. As each level of the pyramid was complete, workers made dirt ramps to reach the next level. Once all the stones were in place, the pyramid had to be smoothed out (its sides were uneven, like a staircase). To do this, workers moved the dirt ramps away and stood on a wooden framework while they used chisels to remove the corners of the blocks. Once the pyramids were smoothed out, they were covered with special slabs of stone (most of which have been removed over time). Then, the grand tomb was ready to be their pharaoh's resting place! To learn more about Egypt and the pyramids, visit this website:
http://www.richmond.edu/~ed344/webunits/egypt/Pyramids.html.

Comprehension: The Ancient Egyptians and Simple Machines

Answer each question in complete sentences. Use information from the reading to help you.

1. Why did the people of Ancient Egypt build stone pyramids? ______________________________
____

2. In the space below, make a sketch of an Egyptian pyramid.

3. Name some of the machines and tools used by the Egyptians to build their pyramids.
____
____

4. How did the Egyptians manage to lift the huge blocks from one level of the pyramid to the next?

a.) with pulleys	c.) with an earth moving machine
b.) with ramps made of dirt	d.) by pushing the stone

5. If you could give the Ancient Egyptians one tool to help them with their pyramid building, what would it be? ____

6. Why did you choose the tool that you chose?____
____

7. What did you learn about the largest stone pyramid? ___________________________________
____

8. If you could ask the ancient Egyptians one question about their miraculous work, what would you ask them?____
____

Sequencing: The Ancient Egyptians and Simple Machines

After reading about how the Ancient Egyptians built their pyramids, cut and paste the following steps in order. Then, illustrate each step and create an informative poster about pyramid building!

Once one level of the pyramid was complete, workers built dirt ramps up to The next level.	Once all levels of the pyramid were complete, workers topped the pyramid with a stone that was shaped like a small pyramid, called a capstone.
Once moved onto the rocker, the limestone blocks were cut to exact measurements, using copper chisels.	After shaping the blocks, workers painted marks on the blocks to tell where each would be placed in the pyramid.
The quarried blocks of limestone were moved onto a wooden rocker.	The Egyptians quarried large blocks of limestone from the earth.
After they built the dirt ramps, workers could then use more sleds to put the next level of stones in place.	Then, the blocks were carefully moved into place on the pyramid by using ramps and sleds.

Sequencing: The Ancient Egyptians and Simple Machines
Teacher Answer Key

After reading about how the Ancient Egyptians built their pyramids, cut and paste the following steps in order. Then illustrate each step and create an informative poster about pyramid building!

The Egyptians quarried large blocks of limestone from the earth.	The quarried blocks of lime-stone were moved onto a wooden rocker.
Once moved onto the rocker, the limestone blocks were cut to exact measurements, using copper chisels.	After shaping the blocks, work-ers painted marks on the blocks to tell where each would be placed in the pyramid.
Then, the blocks were carefully moved into place on the pyra-mid by using ramps and sleds.	Once one level of the pyramid was complete, workers built dirt ramps up to The next level.
After they built the dirt ramps, workers could then use more sleds to put the next level of stones in place.	Once all levels of the pyramid were complete, workers topped the pyramid with a stone that was shaped like a small pyramid, called a capstone.

Visions of an Inventor: Leonardo Da Vinci

Go to http://www.mos.org/sln/Leonardo/LeoHomePage.html and read the introduction about Leonardo Da Vinci.

What three adjectives might you use to describe a man like Leonardo?

1. ___________________
2. ___________________
3. ___________________

To find out some background about Leonardo's home and family, click on "What?Where?When?" at the bottom of the page. Read about Renaissance Italy.

What is special about the town of Vinci? (Click on Vinci to find out!)

____

____

Now, let's find out about Leonardo the inventor. Go back by clicking the red "L," then go to the bottom of the page and click on "Inventor's Workshop."

Name two machines that were in use during Leonardo's time.

1. ____________________
2. ____________________

Why did Leonardo want to understand how each machine part worked? _________________________

____

____

Click on "The Elements of Machines." Sketch those listed below:

Wheel and Axle	Wedge
Lever	Gear

Visions of an Inventor: Leonardo Da Vinci (continued)

Next, click on "Gadget Anatomy." Remember how Leonardo Da Vinci wanted to figure out what simple machines made up other machines? Here's your chance to test yourself - click on the elements that you see in each machine pictured.

What elements make up a Wing-Handled Corkscrew? ____

____

____

Now try this! Click on "Inventor's Workshop," then go to the bottom and click on "Leonardo's Mysterious Machinery."

On this page, you can play a game of identifying Leonardo's Mysterious Machinery. Look at each of eight sketches by Leonardo and try to guess what type of machine each sketch describes.

Tell about one of his sketches here. ____

____

____

How do we use some of the same ideas about simple machines today? Find out by going back to "Inventor's Workshop" and clicking "Visions of the Future."

Why were so many of Leonardo's wonderful ideas forgotten? __________________________________

____

Name two simple machines that help make up a helicopter, a tank, and a plane.

Helicopter: ______________________ ______________________
Tank: ______________________ ______________________
Plane: ______________________ ______________________

Be sure to click on each photo to see how Leonardo sketched his ideas about these machines. In the space below, sketch out your own ideas for a new invention. What simple machines would make up your invention? How would it be used?

Visions of an Inventor: Leonardo Da Vinci - Teacher Answer Key

Go to http://www.mos.org/sln/Leonardo/LeoHomePage.html and read about Leonardo Da Vinci.

What three adjectives might you use to describe a man like Leonardo? **Answers will vary, but may include keen, quick, gentle, creative, artistic.**

To find out some background about Leonardo's home and family, click on "What?Where?When?" at the bottom of the page. Read about Renaissance Italy.

What is special about the town of Vinci? (Click on Vinci to find out!) **This is the town where Leonardo Da Vinci was born and where he grew up.**

Now, let's find out about Leonardo the inventor. Go back by clicking the red "L," then go to the bottom of the page and click on "Inventor's Workshop."

Name two machines that were in use during Leonardo's time. **Water wheels, Archimedes' screws.**

Why did Leonardo want to understand how each separate machine part worked? **Leonardo developed a unique new attitude about machines. He reasoned that by understanding how each separate machine part worked, he could modify them and combine them in different ways to improve existing machines or create inventions no one had ever seen before.**

Click on "The Elements of Machines." Sketch those listed below: **Sketches will vary but should include the main characteristics of these machine "elements." Wheel and Axle, Wedge, Lever, Gear**

Next, click on "Gadget Anatomy." Remember how Leonardo Da Vinci wanted to figure out what simple machines made up other machines? Here's your chance to test yourself - click on the elements that you see in each machine pictured.

What elements make up a Wing-Handled Corkscrew? **Wheel and Axle, Screw, Rack and Pinion, Lever**

Now try this! Click on "Inventor's Workshop," then go to the bottom and click on "Leonardo's Mysterious Machinery."

On this page, you can play a game of identifying Leonardo's Mysterious Machinery. Look at each of eight sketches by Leonardo and try to guess what type of machine each sketch describes.

Tell about one of his sketches here. **Answers will vary.**

How do we use some of these same ideas today? Find out by going back to "Inventor's Workshop" and clicking "Visions of the Future."

Why were so many of Leonardo's wonderful ideas forgotten? **Though his notes suggest that he wished to organize and publish his ideas, he died before he could accomplish this important goal. After his death, his notebooks were hidden away, scattered, or lost, and his wonderful ideas were forgotten.**

Name two simple machines that help make up a helicopter, a tank, and a plane. **Answers will vary but may include elements such as wheel and axle, gears, or wedge.**

Be sure to click on each photo to see how Leonardo sketched his ideas about these machines. In the space below, sketch out your own ideas for a new invention. What simple machines would make up your invention? How would it be used? **Answers will vary.**

How Machines Change our Lives

Machine Characteristics	Effect on Society

Problem Solving: It's Real Work!

As you know, in science, work is done when force is used to move an object over a distance. The mathematical equation for work is:

Work = Force x Distance, or (W = F x D)

Force can be measured in newtons (named for the famous scientist, Sir Isaac Newton), and distance can be measured in meters. Therefore, work can be measured in units called newton-meters (or N-m). Use what you know about simple machines and work to complete the problems that follow.

1. The inclined plane makes work seem easier by increasing the distance and reducing the force required to lift an object. On moving day, James and Cameron need to lift their couch onto the moving van, which is two meters high. Which of the following inclined planes could help James and Cameron lift their couch?

   a.) An inclined plane with a length of 2 meters
   b.) An inclined plane with a length of 1 meter
   c.) An inclined plane with a length of 6 meters

2. In the space below, explain your answer choice. ____

____

3. If you pull a block across a distance of two meters, and your spring scale tells you that you used three Newtons of force, how much work have you done? Show your work below.

4. If you know that you have done ten N-m of work, and you know that the distance that you moved your block was five meters, how much force (in newtons) did you use? (Remember: the opposite of multiplication is division!)

Problem Solving: It's Real Work! - Teacher Answer Key

As you know, scientific work is done when force is used to move an object over a distance. The mathematical equation for work is:

Work = Force x Distance, or (W = F x D)

Force can be measured in newtons (named for the famous scientist, Sir Isaac Newton), and distance can be measured in meters. Therefore, work can be measured in units called newton-meters (or N-m). Use what you know about simple machines and work to complete the problems that follow.

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   a.) An inclined plane with a length of 2 meters
   b.) An inclined plane with a length of 1 meter
   c.) An inclined plane with a length of 6 meters

2. In the space below, explain your answer choice. **Answers will vary but should include ideas about the height of the moving van in relation to the length of the ramp. A longer ramp will allow a shallow incline so that the couch may be lifted using less force (distance increases so force decreases).**

3. If you pull a block across a distance of two meters, and your spring scale tells you that you used three Newtons of force, how much work have you done? Show your work below.

2meters x 3newtons = 6newton-meters of work

4. If you know that you have done ten N-m of work, and you know that the distance that you moved your block was five meters, how much force (in newtons) did you use? (Remember: the opposite of multiplication is division!)
10Nm divided by 5m equals 2newtons of force being used. This problem uses the same equation as Problem #3, only the inverse operation.

FRICTION

Problem: How does friction affect work?

Hypothesis: To move an object across a surface easily, the surface should be
________________________.

Materials:

Spring Scale
Meter Stick
Blocks (any type, of uniform size)
Four different surface areas for testing

Procedures:

1. Using one block and a spring scale, carefully drag the block across a surface a distance of one meter. Record the amount of force that was needed to pull the block across the surface.
2. Multiply the distance pulled (1 meter) times the force needed, in Newtons, to calculate the amount of work done in Newton-meters (Nm).
3. Follow procedures 1 and 2 for the other three surfaces. Pay special attention to the resistance, or friction, that each surface exerts on the block.

Observations:

Object and Surface	Distance	Force	W ork
One block pulled accross a _______			
One block pulled accross a _______			
One block pulled accross a _______			
One block pulled accross a _______			

Conclusions:

1. Rank the surfaces according to the amount of work required (use your chart to help). What do you notice about the different surfaces?

2. Are you surprised by what you observed? What did you find out about friction?

Friction: Wanted or Unwanted?

Cut & sort the following situations according to whether friction, or resistance, would be wanted or unwanted.

Mike is skating fast towards the goal to score a shot in hockey - he needs to beat the defender!	You are riding your bicycle and notice a car suddenly back out in front.
It just snowed! It's time for everyone to go sleigh riding!	Jim's dad's car engine is overheating - he must need an oil change.
Mary is doing some woodworking, and needs to smooth out the edges of the chair she built.	Your hands are cold in the winter-time so you decide to rub them together while waiting for the school bus.
Jessica is writing a story in class. She realized she has made a mis-take and needs to erase it.	Your family is driving in a rainstorm and suddenly the car in front of you stops!
Shawna is trying to saw pieces of wood to make a new dog house for her puppy.	You are on a water slide!
You are going roller blading and want a well-paved area so that it will be more fun.	Soccer players wear cleats so that they won't slide around on the field.

Friction: Wanted or Unwanted? - Teacher Answer Key

Cut & sort the following situations according to whether friction, or resistance, would be wanted or unwanted.

Wanted Friction

- You are riding your bicycle and notice a car suddenly back out in front.
- Soccer players wear cleats so that they won't slide around on the field.
- Mary is doing some woodworking, and needs to smooth out the edges of the chair she built.
- Jessica is writing a story in class. She realized she has made a mistake and needs to erase it.
- Shawna is trying to saw pieces of wood to make a new dog house for her puppy.
- Your hands are cold in the wintertime so you decide to rub them together while waiting for the school bus.
- Your family is driving in a rainstorm and suddenly the car in front of you stops!

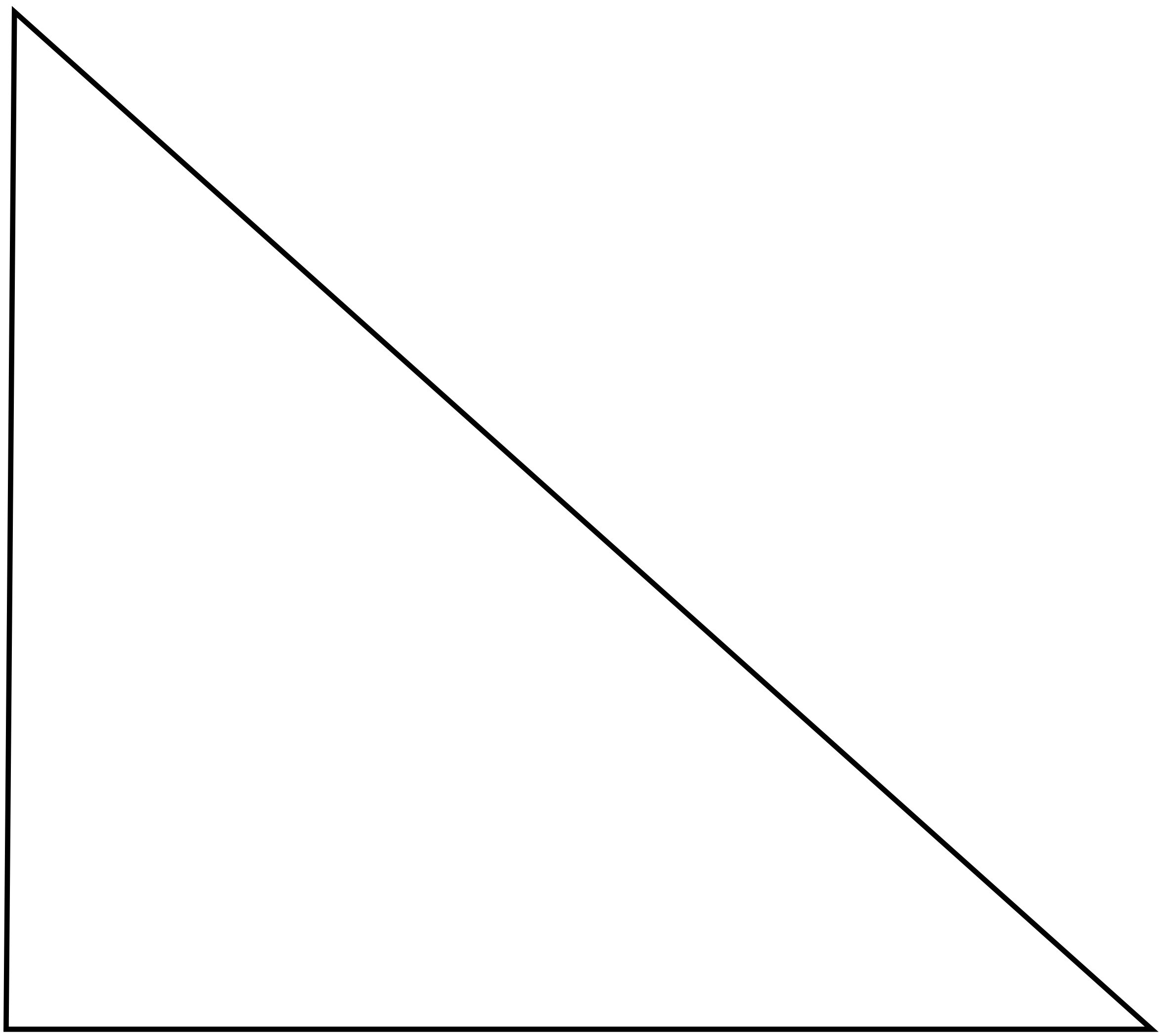
Unwanted Friction

- Mike is skating fast towards the goal to score a shot in hockey - he needs to beat the defender!
- It just snowed! It's time for everyone to go sleigh riding!
- You are going roller blading and want a well-paved area so that it will be more fun.
- Jim's dad's car engine is overheating - he must need an oil change.
- You are on a water slide!

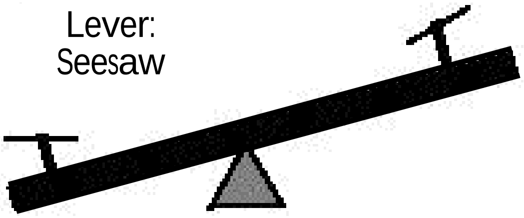
The Screw

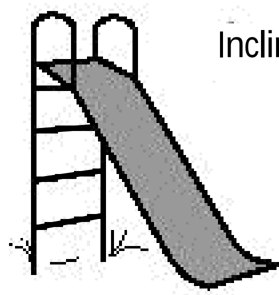
Did you know that a screw is simply a type of inclined plane - one that is "wrapped around itself?" Try your hand at making your very own screw by following these directions.

1. First, color or highlight along the triangle's longest side (called the hypotenuse).
2. Then, carefully cut out your triangle.
3. After cutting out your triangle, carefully paste or tape one of the sides that make up the right angle (not the side that you colored) to a pencil or dowel rod.
4. Next, roll the triangle around your pencil or dowel, and tape the tip of your triangle down. Now you have your very own screw - an inclined plane wrapped around a cylinder!

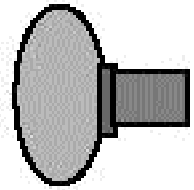


Lever:
Seesaw

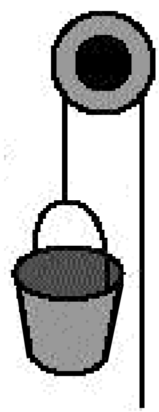




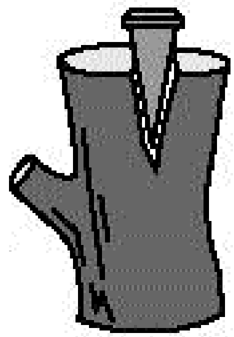
Inclined Plane:
Slide



Wheel & Axle:
Doorknob

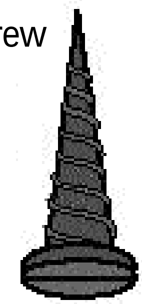


Pulley:
Wishing Well



Wedge:
Wood Splitter

Screw:
Household Screw



The Science Museum of Virginia is the flagship institution for informal science education in the Commonwealth of Virginia. Over the last decade, the museum has concentrated on building partnerships for education, both in its traveling outreach programs and through collaborations with other institutions, like the collaboration between the Science Museum's Carpenter Science Theatre program and Theatre IV.

Theatre IV is the second largest theatre for young audiences in the nation and is the Children's Theatre of Virginia. We encourage your comments about *The Wonderful World of Simple Machines,* please send your letters to:

Theatre IV, 114 West Broad Street, Richmond, VA 23220

If you need to reach Theatre IV by phone, please call **1-800-235-8687**.

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Theatre IV gratefully acknowledges First Union for their sponsorship of these educational materials. We would also like to thank our other major supporters: The National Endowment for the Arts; the Virginia Commission for the Arts; the Cincinnati Institute of Fine Arts; the Ohio Arts Council.

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