This is a full unit on Machines. It was taken from http://www.sedl.org/scimath/pasopartners/pdfs/machines.pdf

I have no idea who the author is or where the unit originated.

The unit is in its entirety as you see it in the following pages.

unit

3 Simple Machines

Prior Knowledge

The student has

1. found products of two single-digit factors using arrays
2. found a linear measure using inches and feet
3. added and subtracted three-digit numbers with renaming
4. found items in an encyclopedia
5. put words in alphabetical order
6. sequenced numbers through 1000
7. constructed graphs
8. identified geometric shapes
9. identified written text as a poem.

Mathematics, Science and Language Objectives

Mathematics

The student will

1. calculate weight of an object in space
2. compute averages
3. record data
4. explore measurements of sides of a right triangle
5. use even and odd numbers to estimate
6. multiply and divide using two-digit numbers and three- or four-digit products
7. calculate the perimeter and, without using pi, the circumference of a circle.

Science

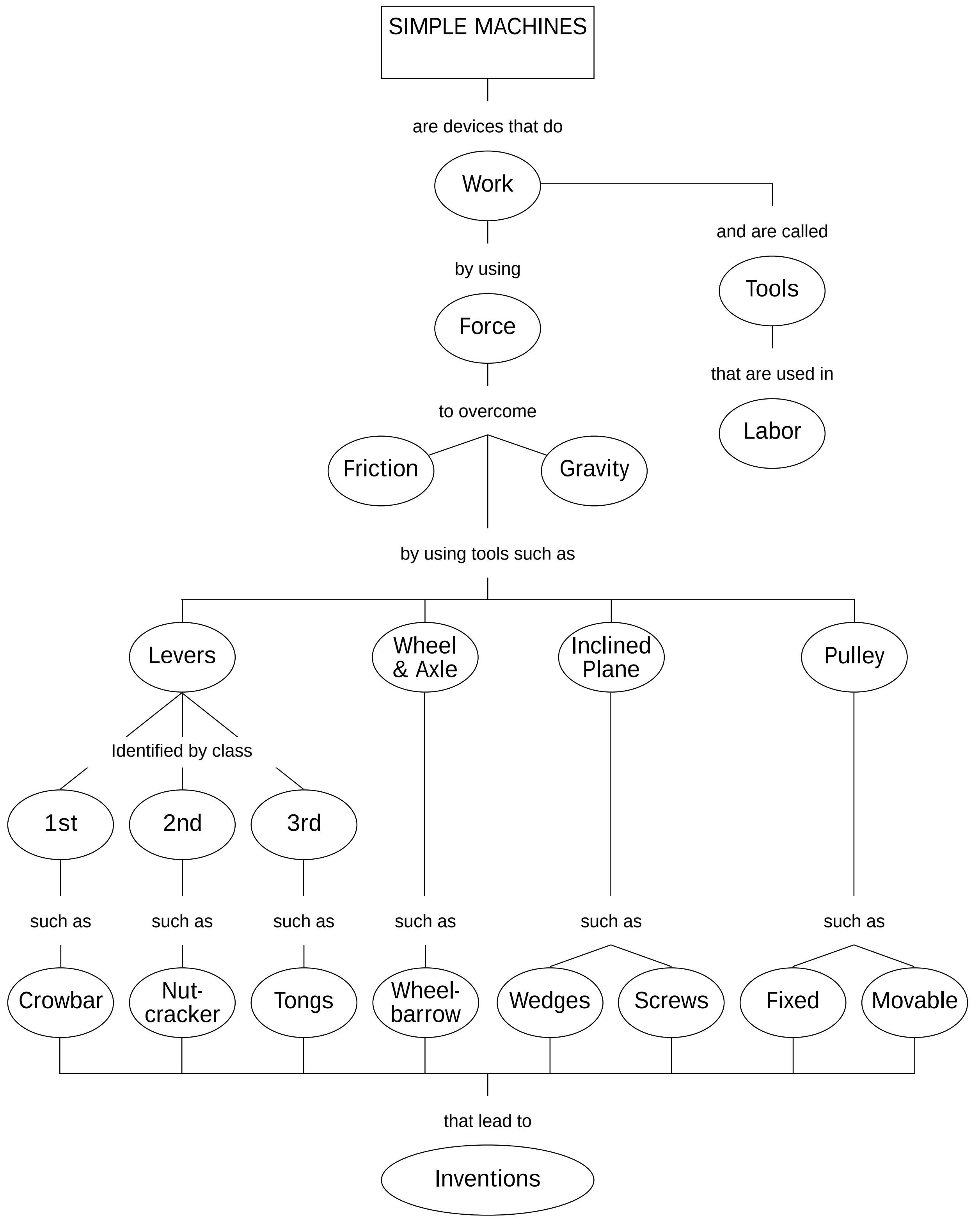
The student will

1. list and give examples of simple machines
2. give an example of a force, such as inertia, friction or gravity, overcome in work
3. construct at least one simple machine
4. predict the amount of force needed to move a resistance
5. name at least five inventors
6. associate at least three events of historical importance with the invention of three important machines.

Language

The student will

1. use related vocabulary to explain and describe the function of simple machines
2. use related books to illustrate, write, label and graph new concepts
3. write a book on simple machines
4. use related books in cooperative groups to help write a report on a simple machine
5. analyze related words for meaning.



SIMPLE MACHINES
are devices that do
Work
and are called
Tools
that are used in
Labor
by using
Force
to overcome
Friction
Gravity
by using tools such as
Levers
Wheel & Axle
Inclined Plane
Pulley
Identified by class
1st
2nd
3rd
such as
such as
such as
such as
such as
such as
Crowbar
Nut-cracker
Tongs
Wheel-barrow
Wedges
Screws
Fixed
Movable
that lead to
Inventions

C O N C E P T W E B

VOCABULARY

machine máquina	force fuerza	friction fricción	pliers pinzas, alicates, o tenazas
gravity gravedad	effort esfuerzo	resistance resistencia	fulcrum fulcro
pulley polea	inclined plane plano inclinado	fixed fijo, fija	hoist izar
wheel and axle rueda y eje	tool herramienta	device aparato	lever palanca
bicycle bicicleta	slide resbaladero	invention invención	broom escoba
scissors tijeras	wheelbarrow carrucha	tweezers pinzas	food press prensa para cocinar
crowbar barra	nutcracker cascanuez	hammer martillo	
seesaw sube-y-baja	pound martillar	nail clavo	

● ● ● Teacher Background Information

The world we live in is constantly exerting different **forces** on itself and on the beings that inhabit it. Forces make objects move; forces make objects change their direction; and forces make objects stop. These forces appear to be more important when they are acting on us as individuals, or when we want to use these forces to change our environment to suit our likes. Over long periods of time humans have learned how these forces work, and to some degree we have these forces under our control. Granted, we may be novices in the use of these forces, but we have been able to use them to accomplish many things.

For example, humans have changed their environment in many ways, by building structures for shelter, by clearing land and obtaining and conserving water to grow food on a relatively dependable cycle. This has been accomplished by sawing and lifting large trees, driving nails through hard wood, removing large rocks and pulling out large stumps. All of the changes have come about as humans have learned to control these **forces as "push"s or "pull"s.** When we accomplish a change, such as raising a heavy rock or chopping down a tree, we accomplish work. **Work produces change** — and change is the result of work.

Humans could not have accomplished many of these changes by using only the energy our relatively weak bodies can exert. Humans, however, have used their brains to design devices that have helped in bringing about these changes. A machine is but one example of how human intelligence has helped in making our lives on earth easier.

A machine is, in a very general sense, a combination of parts we use to overcome a **resistance** (which is also a force, like a large rock that needs to be removed) **by transferring or transforming energy,** usually that exerted by a human being. There are fundamentally three basic machines — the lever, the inclined plane and the wheel and axle. We sometimes refer to other combinations as simple machines, and these appear somewhat more complicated but in reality are combinations of the three basics.

In this unit, we will look at two major forces that machines help us overcome — **friction and gravity. Inertia,** on the other hand, is a characteristic of matter — it is the resistance of mass to being in motion or removed from motion. Consequently, if we want to move matter, or a mass, which is expressed as weight, we need to exert force on that matter to overcome inertia as well as **friction** and/or **gravity.** Usually, the forces we want to overcome we call the "resistance". The forces we use to overcome the **resistance** we call the **"effort".**

When we do work, we use **energy**. Energy changes in form, but it does not disappear. In using simple machines for human work, energy transfers from one object to another, or it changes in form as sound, heat or light energy.

Understanding how simple machines function is a big step in understanding how much of the world around us functions even in modern times, because the nature of matter and energy has not changed — only our understanding of it has.

Current emphasis on the importance of elementary students' learning and applying basic concepts of probability and statistics suggests that a fundamental concept such as the **average** be introduced at an early opportunity using intuitive approaches. The following set of activities has been designed and implemented at a third grade level with bilingual children whose education emphasizes language development as a major strategy to develop mathematics and science concepts.

The intuitive notion in this strategy is that finding the **average** is similar to taking individual sets, whose cardinal numbers we know, and then making the sets **even** (i.e., make the stacks level). The teacher may want to begin the lesson by discussing the idea of **making stacks, or sets, level.** Showing two or three stacks having different numbers of chips, the teacher points out that the stacks have different heights. These stacks are **uneven** (i.e., not level). The stacks are to have the same heights. The students, in a problem-solving approach, discover how to make any number of **uneven** stacks into **even** or level stacks. Introduce the following activities with these notions in mind.

Studying a machine created to help humans work is an important approach for introducing students to relatively sophisticated ideas of inertia, which is a property of matter, and ideas of forces that act upon matter. Concepts of friction and gravity lead to the more complex ideas that students will be able to understand when they have this background supported by experiences that relate "science" to the "real world."

L E S S O N   F O C U S

■ **LESSON ONE** *Simple Machines*

BIG IDEAS Simple machines are devices that help us do work. When we do work, we use energy; energy transfers or transforms, but it does not disappear.

■ **LESSON TWO** *Force and Work*

BIG IDEAS When we do work we use a force to overcome inertia, friction or gravity. We can measure work.

■ **LESSON THREE** *A Crowbar*

BIG IDEAS The three different kinds of levers have different fulcrum locations. We calculate work using multiplication.

■ **LESSON FOUR** *A Bicycle*

BIG IDEAS A wheel and axle is a machine that rolls its load by decreasing friction. We can estimate the perimeter (circumference) of a wheel.

■ **LESSON FIVE** *A Slide*

BIG IDEAS An inclined plane is a machine that changes the direction that force is applied and that helps decrease the effect of gravity, though it may increase friction. Different types of inclined planes form right triangles.

■ **LESSON SIX** *A Pulley*

BIG IDEAS A pulleys helps us change the direction of a force. A pulley transfers energy through distance (or **nothing in nature is free**).

■ **LESSON SEVEN** *Inventions*

BIG IDEAS An invention is a combination of simple machines, for example, a foot-pedal sewing machine or a car.

OBJECTIVE GRID

Lessons	1	2	3	4	5	6	7
Mathematics Objectives							
1. calculate weight of an object in space		•					
2. compute averages		•		•			
3. record data	•	•	•	•	•	•	
4. explore measurements of sides of a right triangle					•		•
5. use even and odd numbers to estimate				•			
6. multiply and divide using 2-digit numbers and 3- or 4-digit products				•	•		•
7. calculate the perimeter and, without using pi, the circumference of a circle.				•			
Science Objectives							
1. list and give examples of simple machines	•		•				•
2. give an example of a force, such as inertia, friction or gravity, overcome in work		•	•	•	•		
3. construct at least one simple machine			•				•
4. predict amount of force needed to move a resistance					•		
5. name at least 5 inventors							•
6. associate at least 3 events of historical importance with the invention of 3 important machines.							•
Language Objectives							
1. use related vocabulary to explain and describe the function of simple machines	•	•	•	•	•	•	•
2. use related books to illustrate, write, label and graph new concepts	•	•	•	•	•	•	•
3. write a book on simple machines	•						•
4. use related books in cooperative groups	•						
5. analyze related words for meaning.	•						

LESSON 1 *Simple Machines*

BIG IDEAS Simple machines are devices that help us do work. When we do work we use energy; energy transfers or transforms, but it does not disappear.

Whole Group Work

Materials

Books: **Simple Machines** by A. Horvatic and **Family Pictures** by C. L. Garza
Filmstrip: "Discovering Simple Machines"
Pictures of people involved in different activities such as playing, riding bikes, sharpening pencils, etc.
Long stick or cut-off broom handle
For mobile: yarn, paper clips, rulers, straws, magazines, paper
Word tags: force, gravity, friction, machine, simple, inertia, energy, work, transfer, transform

Encountering the Idea

People have to work to have the things they need, such as food, shelter and houses. People, however, have always tried to find ways to get help to do this work. Early people trained and used animals to help them work. One reason is that animals — for example, oxen — are stronger and have more energy than humans, therefore exerting more force. At a later date, however, people invented simple devices called machines to exert, transfer or transform energy to do work for us. All of us today still use our own energy to get work done; but we have also used our **brains** to help us do some things that we might not be able to do by ourselves. For example: Let's ask Sandra (a small girl who has trouble doing the task) to lift this heavy box to the top of this table. Sandra, can you do it? No, it's too heavy?

Exploring the Idea

Okay, then let's try this experiment. Students do **Activity** — Let's Share the Work.

After the demonstration, tell students that one of the important discoveries in the history of human beings was the development of our ability to use objects found in our environment to help us work. We will also explore some important ideas related to **energy** in order to understand how to make work easier.

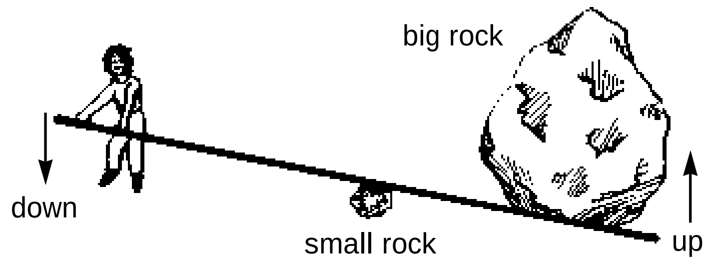
Getting the Idea

Show students the picture of the person moving a large rock. Tell them to observe that a small person can move a big rock if she uses a strong, long stick. Ask Sandra if she thinks she could raise the rock if she had a long stick. Again, ask for suggestions.

When the girl in the picture pushes down on the stick to move the rock, she is using energy. She is also doing work. Why? She is changing the place where the big rock was resting to a place higher up in the air with the aid of the stick. What does the big rock do to the stick? (It is pushing down with its mass.)

Yes, the rock is a force pushing down on the stick.

When the girl pushes down on the stick under the big rock, the stick pivots on a small rock or some other object, transferring the energy from the girl through the stick into the big rock and making the big rock move up.



What happens if the girl lets go of the stick? The rock will fall and transform its energy by crashing down with a noise. The rock transfers its energy by making a hole in the ground, making a loud noise as it hits and heating the ground around it. The energy transfers from the girl to the rock, and then if the rock falls, the energy goes back from the rock as sound, heat or motion energy.

Now, let's look at these magazine pictures. These people are all doing something. Let's name the activities. Each picture shows a force applied to something. Let's name the forces applied and how they are applied.

Devices that people use to help them work we call "machines".The strong stick together with the small rock shown in this picture form an example of a simple machine we call a **"lever".** People do work by exerting a force on something. The machine transforms or transfers the energy to do work. The girl pushed down and the big rock lifted up. Let's all do the same thing using a pencil to lift a book. What did you use as a pivot, or substitute for the rock?

At the **Mathematics Center,** students complete **Activity** — A Paper Fan is a Simple Machine.

Organizing the Idea

1. Filmstrip: "Discovering Simple Machines."
2. Students use the book **Family Pictures** to find examples of simple machines in the illustrations.
3. At the **Art Center** the students complete **Activity** —Simple Machines Mobile.

At the **Language Center,** students

1. practice dictionary skills by spelling, syllabication, naming parts of speech, multiple meanings and use of the pronunciation key with new words from this unit (force, gravity, friction)
2. analyze words related to the ideas they will learn in this unit. Tell the students that to "analyze" means to take words apart and then to study the parts to see how they fit to make a new word.

"Uni - corn". (Show picture and write on chalkboard.)
What does "uni" mean? What does it remind you of in Spanish? (One.)
What is "corn"? In Spanish, "cuerno" is "horn". Then, a unicorn is a one-horn animal.
Let's look at "bicycle." (Show picture, write it on chalkboard.)
What do you think cycle means? (Circle, wheel.) What about bi? (Two.) A bicycle has two wheels. A unicycle? (Shows picture.) What is a tricycle? Tripod? Triplets? Triangle?

Look in your dictionaries to find other words that start with the prefixes "uni", "bi", or "tri" and then make a list. Report to the class after we have completed work at the learning centers.

Applying the Idea

Describe how a nutcracker works. Where does the energy come from that cracks the nut? What is the work that is done?

Closure and Assessment

Define and/or illustrate a machine. Try to use words such as "energy", "work" and "friction" or "gravity" in your definition.

List of Activities for this Lesson

- ▲ Let's Share the Work
- ▲ A Paper Fan Is a Simple Machine
- ▲ Simple Machines Mobile

ACTIVITY
Let's Share the Work

Objective
The student understands the concept of work as using a force to move a mass over a distance and gives an example of work.

Materials
Large open box with several heavy books or other objects in it

Procedures
Students working in small groups help Sandra decide how to lift the box, but before we help her, let's try to see if we can:

1. have the groups look for one way to compare the task
2. give, write down and implement different suggestions; for example, two large students lift the box (or three or four students)
3. consider all the suggestions and give opinions as to which would be easier, more efficient, etc.

One suggestion could be that Sandra take one book out of the box at a time until she can lift the box by herself, then put all the books back in the box.

Getting the Idea

1. Ask the students: Regardless of which way we solved the problem, was the amount of work done the same? (Yes. Regardless of how we did it, we lifted the heavy box with its contents to the table.)
2. Did the box weigh the same when two, three or four people lifted it? (Yes, it weighed the same, but the people shared the work.)
3. When two people lifted the box, how much work did each one do? (1/2 each.)
4. When three people lifted the box, how much work did each one do? (1/3 each.)
5. When Sandra did the work by herself, how much work did she do? (All of it.)
6. When you were lifting the box to the table what force were you working against? (Gravity.)

One other thing that we have to remember: When we do work we use energy.

7. Who used energy in doing the work of lifting the box? (Yes, everyone who helped had to use energy to get the work done.)

Work, then, is defined as moving a mass over a distance.

8. What work was done here? (This box, this mass, we raised (moved) 38 inches.)

ACTIVITY

A Paper Fan Is a Simple Machine

Objective

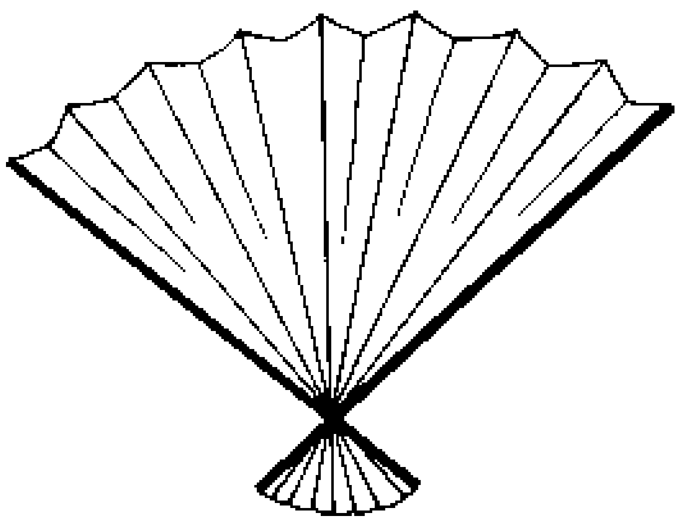
The student constructs a paper fan and describes it as a simple machine, indicating where the resistance is exerted, where the force is applied and where the fulcrum is located.

Materials

Sheet of construction paper; transparent tape; crayons

Procedures

1. Decorate an 8 1/2 X 11 sheet of paper in the style of a fan.
2. Fold the sheet of 8 1/2” X 11 paper in half along the width (the 8 1/2” side), then 1/2 again, 1/2 again and 1/2 again, making sharp creases.
3. There will be 16 strips of paper (or 15 creases).
4. Unfold the paper and refold it in an accordion pleat.
5. Secure with transparent tape one end of the newly folded paper.
6. Open up the unsecured part as a fan.
7. As you fan yourself, locate the resistance, the force applied to overcome the resistance and the fulcrum.
8. Discuss this with your group. When you think you have the correct answers, report to the class or to your teacher, giving them the reasons for your answers.



Getting the Idea

This paper fan is an example of a machine. What work does it do? (Air has mass and it moved, therefore the fan does work.)

ACTIVITY
Simple Machines Mobile

Objective

Students draw or identify simple machines from pictures in magazines.

Materials

Five to six pieces of yarn 20-22 centimeters long; paper clips; cutouts of simple machines on different-color tagboard[1]; drinking straws in different lengths depending on the shape you want to give to the mobile; magazines

Procedures

1. Cut several pieces of yarn 20 to 22 centimeters long.
2. Tie one end of each piece of string to a paper clip.
3. Select machines to depict and cut out of tagboard to hang.
4. Select a place to hang the mobile.
5. Hang the objects from a drinking straw with yarn. Loop the yarn once around the straw. Make half a knot. Pull the yarn tight. Clip the paper clip to each object.
6. Balance the objects by sliding the yarn on the straw.
7. Change the clip on each cutout as needed to make the mobile attractive.
8. Suggest to the students that they design and construct other mobiles, as they have time.

[1]Students can cut pictures of simple machines out of magazines and glue pictures on tagboard to use in the mobile, or they can draw their own designs of simple machines on pieces of tagboard and use those for the mobile.

LESSON 2 *Forces and Work*

BIG IDEAS When we do work we use a force to overcome inertia, friction or gravity. We can measure work.

Whole Group Work

Materials

Piece of carpet about three feet x three feet
Blow dryer
Book or song: **Wheels on the Bus** by P. O. Zelinsky
Books: **Friction** by E. Victor, **Force: The Power Behind Movement** by E. Laithwaite, and **Up, Down, and Around: The Force of Gravity** by M. Selsam
Word tags: force, gravity, friction, machine, simple, inertia, energy, work, transfer, transform, resistance

Encountering the Idea

A force is a “push” or a “pull”. We cannot do work without a force either pushing or pulling on something; machines help people exert energy in special ways to help them do work. We all know what work is — we move something or pick it up. Many of us do not like to do hard work if there is a machine that will help us do it more easily and quickly. Let’s read **Wheels on the Bus.** Why are the people riding the bus? (To get somewhere, go shopping, not have to walk.) Why don’t they walk? (It’s too tiring.) Why is it tiring? (It’s very far, takes too long; bus covers distance in shorter time.)

Bertha, please walk across the room. Are you doing work? Yes, how do you know you are doing work? For one, you are using energy; for another, you are moving your weight across the room. Now, suppose that I ask you to walk and carry this 10-pound load for one mile. That would really be a lot of work because you would not only have to move your body that has mass and that weighs around 90 pounds because **gravity is pulling** on it, but you would have to carry the load that also has mass and that weighs 10 pounds. You would have to carry 100 pounds for one mile.

Now, let’s think about this. Raul, please pull your desk across the floor. Can you do it? Now, place the desk on top of this piece of carpet and pull the desk across the carpet. Can you do it? Why was it easier to pull the desk across the floor? What did you feel when you were pulling the desk across the carpet? Yes, the carpet was making it stick. (If a student says that the carpet makes friction, acknowledge the comment and say that it is correct and will be discussed later in the lesson.) In this lesson we are going to discover how work, energy, force, friction and gravity relate. Before you go to your learning centers, we are going to do some interesting kinds of things that might surprise you.

Exploring the Idea

The students complete **Activity** — Kickball.

Back in class after playing kickball, students identify when they used their body force (which is also the inertia of the human body put into motion by the body's muscles) and gravity during the game. They complete the **Getting the Idea** phase of the activity.

Now, let's try a new situation. Let's use this eraser to erase this word. (Write a word in pencil on a piece of paper.) When I rub the word with the eraser, the eraser rubs out the word. Feel the eraser; how does it feel? (It got hot and so did the paper.) Friction is a force and can transfer energy of movement (moving the eraser back and forth) to heat energy. Let's put our hands together, squeeze them and rub. What happens? Why? (Friction transforms motion energy into heat.)

Tell students that we do work when we move an object that has mass. Mass has the characteristic of **inertia.** Roll a heavy object (a bowling ball); a student stops it but uses force to stop it. Roll the object again; this time a student changes the direction of the ball; again a student has to use force to do it. The students describe the force needed to move, stop and change the direction of the rolling object.

At the **Mathematics Center,** the students

1. complete the **Activity** — Fractions
2. complete **Activity** — Friction of Surfaces
3. complete **Activity** — Measuring Work.

Getting the Idea

We have studied two forces today. What are they? Gravity and friction. When we overcome a force, such as gravity or friction, we are doing work. When we work, we are usually moving against a force through a distance. Let's give some examples of the work we did in the experiments.

1. What work did Bertha do in walking across the room? Yes, she moved her weight by working against friction, but she also worked against her own inertia. Inertia is the property of matter that resists change from being at rest or from being in motion. For example, if we place a piece of wood on a table, it will stay there until some force, like a person pulling on the rubber band or a strong gust of wind, moves it. (Demonstrate with a blow dryer, if possible.) So, when we move our bodies, we are working against the inertia of our bodies. When we carry a load, we have to move the load against its own inertia.
2. What work did you do when you pulled the chair across the floor? Yes, you moved against the inertia of the chair and also against the friction of the floor.
3. What work did you do when you pulled the chair across the carpet? Yes, you used energy to move against the inertia of the chair but also against the greater friction of the carpet.
4. What work did you do when you were pulling on the wood block?

Tell students that sometimes the force that we overcome in doing work is the **resistance.** Remember — **a resistance is always a force** that is opposing the **effort** we exert when we do work. For example, when I shovel some dirt from the bottom of a hole to the top of the hole, what is the resistance? Yes, the dirt is the resistance but also the shovel, because I have to move both of them against their own inertia, and in bringing up the dirt I have to overcome gravity too.

Organizing the Idea

At the **Writing Center,** assign each student group to read in reference books on energy, force, friction, gravity, resistance, inertia and work. They report to the class and define and illustrate each term in their own words.

Applying the Idea

Using new words from the unit — force, gravity, friction, machine, simple, inertia, energy and work — write a paragraph using each of the words **or**

make an illustrated dictionary by putting all the words in alphabetical order, defining each (you may look in a dictionary to make sure you get the correct definition) and illustrating the word **or**

make an illustrated dictionary by putting all the words in alphabetical order, defining each (you may look in a dictionary to make sure you get the correct definition) and constructing a model of the word.

Design a rocket ship to go into space. Decide what forces you will have to overcome, then design the craft to overcome these forces.

Closure and Assessment

Oral Interview

Use your pencil as a tool to write. Write your name and as you write decide whether the pencil is a simple machine. Explain, verbally, why you think it is, or why you think it is not. If you prefer, you may explain your reasons to your group, and then after the group thinks you have the correct answer, explain it to your teacher.

List of Activities for this Lesson

- ▲ Kickball
- ▲ Fractions
- ▲ Friction of Surfaces
- ▲ Measuring Work

ACTIVITY
Kickball

Objective
Students experience three forces in playing kickball; students say that inertia, friction and gravity are forces operating in playing kickball.

Materials
Kickball
Pictures of people involved in different activities such as playing, riding bikes, sharpening pencils, etc.

Procedures
Students play a game of kickball. As students play, the teacher directs their attention to the energy they are using in playing ball. They have to have energy to kick the ball with force that they need to move the ball; they need the force to change the direction of the ball, and need force to stop the ball. Tell them that after the game you will ask them about the three different kinds of forces they are using in playing.

Getting the Idea

After the game:

1. Tell students that a **force is a push or a pull.** What is the push in playing when you kick the ball? Your foot is a push against the ball. What is the force your foot feels when you kick it? You are kicking against the mass, the matter of the ball. The resistance you feel in kicking the ball is the **inertia of the ball.**
2. Ask the students what happened when they kicked the ball into the air. Was there another force acting on the ball? Yes, gravity pulled it down. **Gravity is a pull,** so gravity is also a force. When you stop a falling ball with your foot or your head, how can you tell that gravity is a force? (It hits you hard, and you know it is a force because it pushes against you.) When a ball falls, we say that gravity pulled it and caused it to fall.
3. What happens when you roll a ball on tall grass? Does it go fast or slow? What causes it to slow down? (Friction.) **Is friction a force?** How do you know? (It pushed against the ball and made it stop.)

Energy is what we need to exert a force.

Display pictures of people involved in different activities such as playing, riding bikes, sharpening pencils, etc. Define energy, force, gravity and friction while pointing to pictures illustrating each. Have students identify other examples of the forces found in the pictures.

ACTIVITY
Fractions

Objective

The student use fractions to measure the length of an object to the nearest one-eighth of an inch.

Materials

Rulers or measuring tapes marked in inches
Laminated strips of thick paper (one inch by 13 inches), marked in inches to simulate a ruler
Various objects to measure length
One screwdriver (or some other tool) of the same size for each group

Encountering the Idea

Each of you will work in groups to find the lengths of these objects. First, however, each group finds the length of the screwdriver. Using the laminated rulers, each group measures the same-size tool.

What is the length of the screwdriver? Some of you are saying it is eight inches, others say it is $8\frac{1}{2}$ inches and some of you say it is closer to nine inches.

It is true that the screwdriver is longer than eight inches, but is it shorter than nine inches? Yes, but what do you suppose we can do to get closer to its true measurement? Yes, one way is to cut the inches into smaller parts such as $\frac{1}{2}$ or $\frac{1}{4}$.

Exploring the Idea

Let's use the strips to measure the length of the screwdriver again. Take your marker and draw how you would cut the inch to get closer to the length of the screwdriver.

0 1 2 3 4 5

0 | 1 | 2 | 3 | 4 | 5

0 | | | 1 | | | 2 | | | 3 | | | 4 | | | 5

Getting the Idea

Sometimes when we have to measure the length of objects, we want to get as close as possible to their true length. To do that we cut the unit of length into smaller equal parts to help us. Some of you cut the unit into halves, others into fourths and some into eighths.

Some of you said the screwdriver measured $8\frac{1}{2}$ inches, and some of you said it measured, 8 $\frac{2}{4}$ inches. How can you show with your strips if $\frac{1}{2}$ and $\frac{2}{4}$ are the same?

We say that $\frac{1}{4}$ and $\frac{3}{12}$ are two ways of showing the same fraction. We say that they are **equivalent fractions.** Other names for $\frac{1}{4}$ are $\frac{5}{20}$, $\frac{6}{24}$, and what others? Can you find a pattern between the **numerator** and the **denominator** for all the fractions that are other names for ¼?

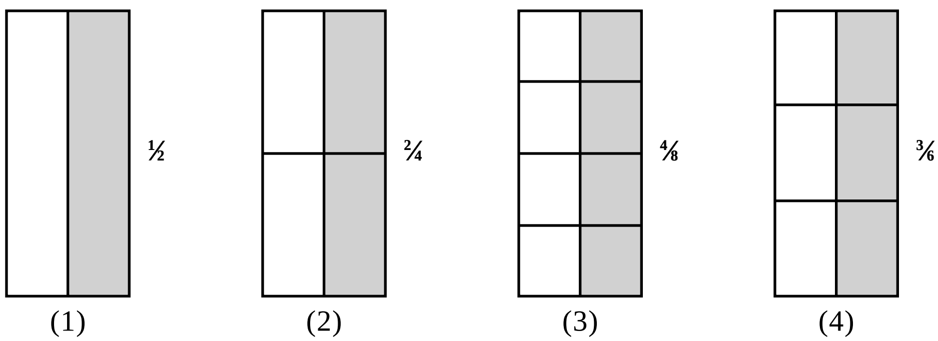
Organizing the Idea

Students mark their number strips with ½, ⅓, ¼ and mark their equivalents on the strips. For example, the students mark 2/4, 3/6 etc. to show the different names of the basic fraction ½.

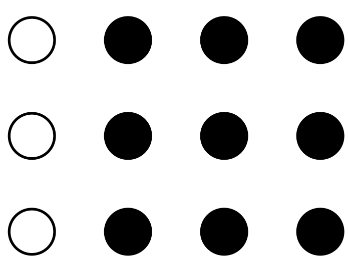
Applying the Idea

Fractions are numbers we can use when we want to talk about parts of things. In the activities below, you can see that there are many ways to use fractions.

1. Suppose you have a candy bar that you want to share with your friend. You can cut the candy bar in half like this (1). You can take the white part and your friend the brown part. Are the two parts the same? You can also divide the candy like this (2). You take two parts white and your friend takes two parts brown.



2. Maria's mother told her to go to the store to buy one pound of pecans for a cake she was making. At the store, the clerk told Maria that all she had were bags of ¼ pound each. What should Maria do?
3. Are 2/4, 3/6 and 4/8 all other names for ½? Draw other different pictures for ½ and write fractions for those pictures.
4. Suppose there are 12 people on a team. Three players are injured. What fraction, or what part, of the team is injured? (3/12, and also ¼).



Assessing the Idea

1. In your own words, tell what equivalent fractions are.
2. Use the laminated strips to show some equivalent fractions for ⅔ and ⅛. Using these paper clips (some are bent to the point that we can no longer use them), tell the fraction of the paper clips that we can't use.
3. Write three equivalent fractions for 3/5, ¼, 5/10.

ACTIVITY

Friction of Surfaces

Objective

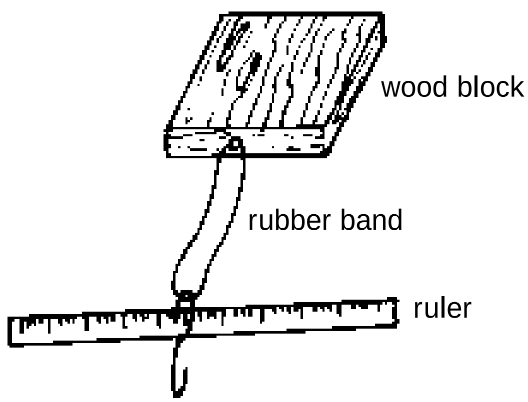
The student demonstrates that overcoming a force such as friction is work.

Materials

Two wood blocks of the same size; thumbtacks; thin rubber band; paper clips; sheets of sandpaper; waxed paper; aluminum foil; construction paper; centimeter ruler

Procedures

1. Place a wooden block on a wood surface.
2. Fasten a rubber band to it with a thumb tack.
3. Hook the rubber band with an opened paper clip.
4. Hold the rubber band end over the end of a ruler.
5. Pull the rubber band very slowly. Observe and record where the rubber band end is over the ruler.
6. Measure how far the band stretches before the block moves. Make the reading before the block begins to move. Read the ruler to the nearest centimeter.
7. Perform the same experiment on other surfaces.



Discussion

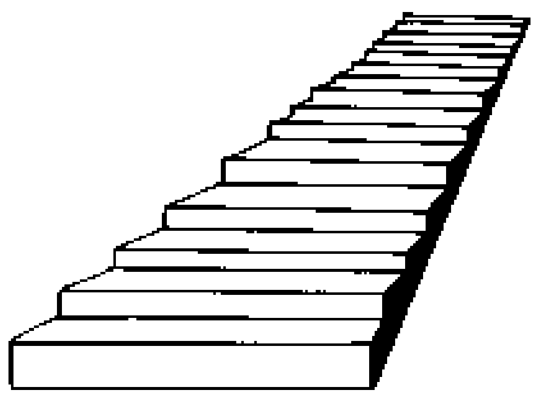
1. What mass did we move?
2. What distance did the mass move?
3. What work did we do in this experiment?
4. What force did you overcome when you did this work?

ACTIVITY
Measuring Work

Objective
Students calculate work done by moving various weights over a distance.

Materials
Plastic bag filled with dirt to weigh a pound
Foot ruler or tape ruler to use to measure distances across the room
Scale to weigh various objects in the classroom

Procedures
1. Stand the ruler on the table or the floor.
2. Raise the one-pound weight to the top of the ruler.
3. Raise the one-pound weight six inches. How much work did you do? (1/2 foot-pound.)
4. Raise the weight two feet. How much work did you do this time? (two foot-pounds.)
5. Select various objects in the room. Weigh them. Determine the amount of work you do in carrying that object a measured distance.
6. Each person weighs herself/himself. Climb a set of stairs. How much work did you do to get to the top?



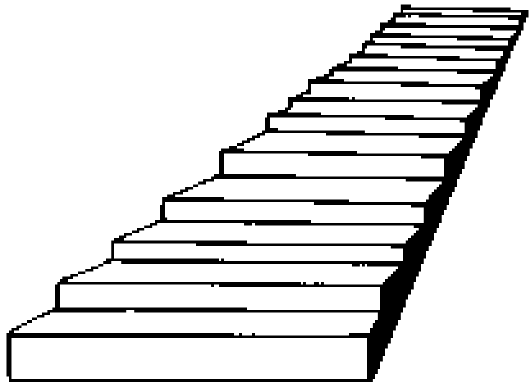
Getting the Idea

Finding the amount of work you do in climbing stairs is a little tricky. To find the work you did, did you multiply your weight times the distance along the line along the steps? NOT!

There is a small problem in calculating the work in this situation because if you climbed a set of stairs you can't measure the distance along the stairs but can measure from the floor to the top of the stairs (the dark line), as in the picture shown above. If you can't climb up the side of the stairs to measure the height, then you need to find the vertical distance another way. The students work in their groups to find a solution.

If you haven't figured it out, try this. Measure the height of each step and add to get the total vertical distance. Or if all the steps are the same height, measure one of them and multiply by the number of steps!

Remember: The amount of work you do to raise one pound a distance of one foot straight up is called one foot-pound. You did _____ foot-pounds of work in walking up the set of stairs.



Applying the Idea

Suppose you need to carry 100 pounds of computer paper up the set of stairs in the problem above. Find one way to make your work easier.

Assessing the Idea

1. What is work? Give examples.
2. What two things do you need in order to do work?
3. What provides the force when you are riding a bicycle? In a car?
4. Write your own definition of work.

LESSON 3 *A Crowbar*

BIG IDEAS The three different kinds of levers have different fulcrum or pivot locations. We calculate work using multiplication.

Whole Group Work

Materials

As many as possible of the tools listed in **Activity** — Is This a Machine?
Chart showing the types of levers with diagrams of each type
Word tags: resistance, fulcrum, effort

Encountering the Idea

Here is a broom. Is a broom a machine? Is this shovel a machine? This crowbar and these tongs, are they machines? What about a fishing pole? How do we know when something is a machine? We said that a machine helps us in doing our work by helping us transfer or transform energy to do work. In this lesson, we are going to discover how each of these tools helps us in our work and why we say they are machines.

Exploring the Idea

At the **Science Center,** the students begin Part 1 of **Activity** — Is This a Machine?

At the **Mathematics Center,** the students complete **Activity** — Seesaw Math.

Organizing the Idea

Students complete Part 2 of **Activity** — Is This a Machine?

At the **Writing Center,** students write the names of the tools in alphabetical order in their word bank.

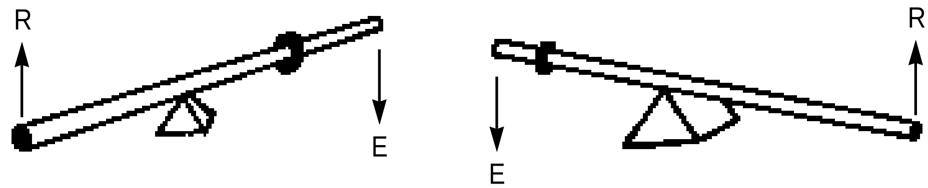
At the **Library Center:**

1. Students look for more examples of levers in magazines and books. They also include on their list tools found around the school or house. The students may refer to the chart showing the three types of levers with examples of each.

   The idea is that the students think through the examples in order to classify them, rather than memorize the specific definition of each type of lever.
2. Students read and discuss **A Book About the Lever** by H. Wade.

Applying the Idea

1. Name at least three jobs done around the house or school with levers. Describe the way the levers work.
2. Draw a seesaw; locate the fulcrum. Where are the resistance and the effort located? (The fulcrum is between the resistance and the effort; in this case either end of the seesaw is the effort or the resistance depending on the direction.)



For example: One washer is at the end of a rod, but the fulcrum is placed so that the other end of the rod rests on the table. We can move the fulcrum so that the seesaw will balance (as best as possible since the wedge marks on the rod may not make for a perfect balance). Ask the students: Would this be a winning combination since there was one fewer washer used?

The students discuss: What weight on the side opposite the washer made the seesaw balance? (The rod has weight that will balance against the washer.)

Closure and Assessment

1. Draw a lever showing where you would place two objects in relation to the fulcrum to make them balance, one object of two pounds and one of four pounds. Label the type of balance your lever is and locate the fulcrum, the resistance and the effort.
2. The student selects an example of the lever she/he uses the most and writes about it, describing it, what type it is and how she/he uses it.
3. Look around the playground and at home and list and/or draw all the levers you can find. If you can, label their class.

List of Activities for this Lesson

▲ Is This a Machine?

▲ Seesaw Math

ACTIVITY
Is This a Machine?

Objective
The student identifies the force exerted to overcome the resistance in a given lever.

Materials
Ball and bat; broom; shovel; crowbar; fishing pole; pliers; hedge clippers; tongs; paper cutter; tennis racket; garlic press; car jack; seesaw; hammer; wheelbarrow; hockey stick; tweezers; scissors; golf club; canoe and paddle; cart; nutcracker; bottle cap opener

Procedures
Part 1

Students examine each of the tools and then take turns demonstrating to the members of their groups how to use each tool. The students complete the parts of the chart labeled: Tool, Resistance, Force Used (Effort) and Work Done.

1. Determine the force overcome — the resistance — on each tool (for example, with the broom, the inertia of the dirt on the floor).
2. Determine the force used to overcome the resistance (the hand pushing on the broom handle).
3. Determine the work done (moving the dirt from one place to another).

Tool	Resistance	Force Used (Effort)	Work Done	Fulcrum
pliers	nail	hand squeezing on the handles	pulled out the nail	bolt on the pliers

Part 2

Students complete the chart by locating the "fulcrum" for each lever.

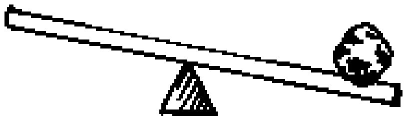
Tell students that a **lever** is one of the simplest machines man has invented. We have already examined some levers. The students name each of the tools examined in the activity.

Ask students to see if the tools are alike and different in some ways. These are all levers, but they are somewhat different. After the students have had an opportunity to look for differences, help them organize the levers in some way.

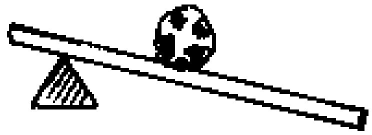
Suggest this: In a **first-class** lever, the fulcrum is between the load (resistance) and the effort (force). One example is the crowbar. The girl lifting the big rock exerts **effort** on one end of the bar, the rock is the **resistance,** and the small rock that provides a pivot is the **fulcrum.**

In a **second-class** lever, the load or the resistance is between the fulcrum and the effort. One example is a nutcracker. The resistance is the nut, the effort is the hand pressing on the handles, but the fulcrum is the screw on the edge of the nutcracker.

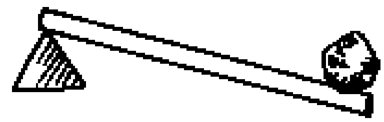
In a **third-class** lever, the effort is between the load and the fulcrum, as with a pair of tongs.



First Class

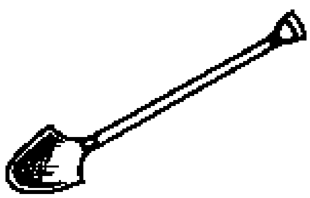


Second Class

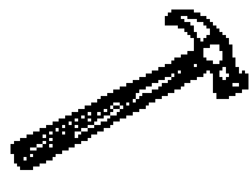


Third Class

At the **Art Center,** the students make diagrams of tools showing where the resistance is located, and where the forced we use in work is located.



Shovel



Hammer

ACTIVITY

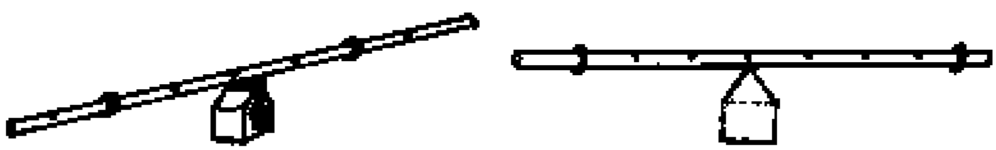
Seesaw Math (The Game)

Materials

Students construct the game and compete in groups of four. For each group:
One yard-long dowel rod 1/2-inch diameter
One empty 1/2-pint milk carton
Several same-size and same-weight metal washers or counters with a hole that fits the dowel rod without slipping

Preparation

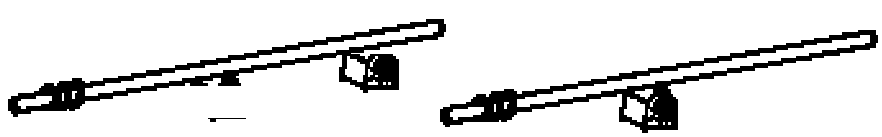
1. Cut a wedge shape on a dowel rod (one yard in length) at its center.
2. Cut a wedge shape on the dowel every inch to the right and every inch to the left of the center wedge. Do not label the marks. After working with the seesaw, the students may want to label the marks. They may do so if that is one of their strategies to win the game.
3. Use the milk carton as the fulcrum by placing one of the wedges on the rod on top of the carton to form a seesaw.



Before playing the game, the children:
1. explore and explain to each other what they did to make the seesaw balance
2. record their observations
3. discuss the rules with the other groups.

The Game

1. The teacher demonstrates: Put the center cut on the fulcrum. Put washers on the seesaw on both sides to make it balance. Put three on one side and make the seesaw balance in different ways.
2. Place the washers at different distances from the fulcrum and again make the seesaw balance.



3. Tell the students that the rules of the game are these:
   - each team has a complete set of washers, rod and carton
   - the object of the game is for one team to place a set of three washers, say, on one side of the seesaw and another team (after team consultation) to place one more or one less washer on the opposite side to make the seesaw balance in only one attempt
   - the first team to beat the challengers (the ones who place the washers) gets to set up the next set of washers and also to decide how many washers they will set up
   - if the first team doesn't make the seesaw balance, the next team gets a turn, until a team wins.
4. Make some rules about how you can lift a heavy load. When you report to the entire class be sure you have reasons for your rules.

LESSON 4 *A Bicycle*

BIG IDEAS A wheel and axle is a machine that rolls its load by decreasing friction. We can estimate a wheel's perimeter (circumference).

Whole Group Work

Materials

Books: **Exploring Uses of Energy** by E. Catherall, **Let's Find Out About Wheels** by M.C. Shapp, **Wheels: A Tale of Trotter Street** by S. Hughes and **Unconventional Invention Book** by B. Stanish

Large, empty spool of thread; unsharpened pencil or a rod; scissors; lightweight cardboard box; balloon; box of drinking straws; 20 pencils; 20 marbles, same size

Encountering the Idea

Show students a wheel and axle consisting of the spool with the rod inserted in the center. Ask the students if they think it is a machine. Ask them if they think it is a lever. No, levers don't use a wheel. After a discussion, ask them to list the characteristics of a device that would help us decide if it is a machine. Although a machine requires that we exert effort, it is a device that still makes work easier.

Can this wheel with the rod help us in our work? How? Is it easier to roll something than it is to pick it up and carry it?

Exploring the Idea

Before working at the learning centers, the students in a whole group activity make a **Rolling Cart,** as described below.

Materials

Many of these materials can be brought from home. For each student:

four empty spools of thread; two unsharpened pencils; an empty box (e.g. large matchbox); small objects to put in the box; masking tape or four to eight clamps; Super Glue

Procedures

1. Put one pencil through the holes in two spools.
2. Put a clamp on the outside and inside of each spool to keep the pencil from moving from side to side.
3. Make a second axle with the other two spools and pencil.
4. Glue each end of the box to the length of one of the pencils.

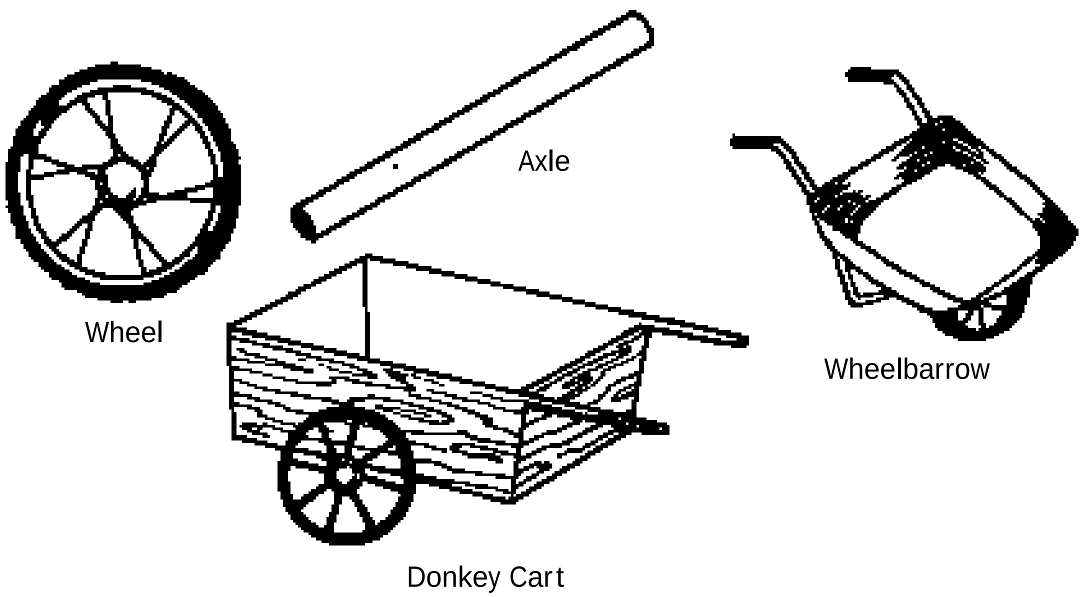
At the **Mathematics Center:**

1. Complete **Activity** — Circumference of a Wheel.
2. Complete **Activity** — Let's Get Even. Students need to be do this activity before the other activities in the **Science Center** to get the required background.
3. Complete **Activity** — Average Speed.

At the **Science Center,** the students have a choice to complete either or both racers. Complete **Activity** — Tin Can Racers, and/or complete **Activity** — Spool Racers.

Getting the Idea

Read to the class **Wheels: A Tale of Trotter Street.** After reading and discussing the book, tell the students how a wheel and axle, another type of simple machine, has two parts, as the name says. One part of the machine is the wheel, and it has a shape like a circle. The other part is the axle, which has a shape like a cylinder. The wheels of a wheelbarrow are an example of a wheel and axle. Many times two wheels combine with one common axle to roll things from one place to another. An example is a donkey cart.



Show a picture of a bicycle. A bicycle is an example of a machine that has two wheels and two axles; it is not a simple machine, however. Ask the students to describe the bicycle. (Has two wheels; wheels turn on an axle; the chain looks like a belt on a pulley, etc.) What geometric shapes do you see in a bicycle? In a unicycle?

Organizing the Idea

At the **Writing Center** students make a list of the characteristics of a lever and of a wheel and axle. Add to this list as the students learn about other simple machines. They can choose a simple machine and write a poem or a riddle describing it. For added interest, the student can write the poem or riddle on the inside of a large outline of the selected machine.

At the **Library Center,** students research the history of the wheel and report to their groups and to the class. The students also look for pictures of simple machines and name the various geometric shapes they see in the machines.

Applying the Idea

At the end of the lesson, the students race the cars they construct by completing **Activity** — Car Races. They have acquired all the understanding necessary to determine a racing winner.

Closure and Assessment

Problem Solving

The student makes a list of things that roll or are circle-shaped. Then he/she selects one from the list and explores ways to use it as part of a wheel and axle.

Student constructs a toy that uses a wheel and axle to move.

List of Activities for this Lesson

▲ Tin Can Racers

▲ Spool Racers

▲ Circumference of a Wheel

▲ Let's Get Even

▲ Average Speed

▲ Car Races

ACTIVITY

Tin Can Racer

Objective

The student builds a racer from various objects found in the house and uses the racer to obtain data from which to make decisions.

Materials

For each student or student group:

Coffee can with the bottom intact and one or two plastic reclosing lids

Large, strong rubber band or section cut from a bicycle inner tube

Wooden dowel or sturdy chopstick; a smaller piece should be smaller than the diameter of the can bottom, and a larger piece should be approximately 10 cm long with one end rounded

Metal washers

Twine, wire or a twist tie

Procedures

To make the tin can racer:

1. Drill holes in the precise center of the coffee can bottom and plastic lids. The holes must be large enough so the rubber band will thread through them easily; the edge of the hole in the can bottom must be smooth so it won't cut the rubber band.
2. With the lids on the can, thread the rubber band through the holes so that its loops protrude from both ends of the can.
3. Push the shorter wooden dowel or stick through the loop of rubber band protruding from the can bottom.
4. Punch two small holes in the can bottom on either side of the stick and tie the stick securely to the can bottom with twine, wire or a twist tie.
5. Thread the other loop of the rubber band through the holes in several washers. There must be a sufficient number of washers to keep the longer stick, which is added in Step 6, from rubbing against the edge of the can. Later, you can increase or decrease the number of washers.
6. Place the longer wooden dowel or stick through the loop with the washers.

To give the racer the needed energy to roll:

Hold the can firmly in one hand and rotate the rod with the other hand. When the rubber band has wound tightly, the racer is ready to go.

Students customize their racers with names, colors, slogans, etc.

ACTIVITY
Spool Racers

Objective
The student builds a racer from various objects found in the house and alters the design of the racer to observe and discover the function of the different parts of the racer.

Materials
For each student or student group:
spool — the size that holds 200 yards of sewing thread
rubber band
two wooden kitchen matches
small chunk of soap with a hole cut through the middle and carved into a rough disk about four mm smaller than the flat end of the spool

Procedures
To make the spool racer:
1. Pass the rubber band through the center of the spool.
2. Through one end of the rubber band, firmly anchor a short piece of matchstick. Its length should be less than the diameter of the flat end of the spool.
3. Thread the other end of the rubber band through the hole in the disk-shaped piece of soap.
4. Place a longer piece of match stick (the stick minus the head) in the loop of the rubber band that you threaded through the disk of soap.

To give the racer the needed energy to roll:
Twist or “wind up” the rubber band by holding the spool firmly in one hand and rotating the stick with the other.

Observations
1. Are the racers reliable?
2. What is the function of the soap?
3. Why is the longer match stick important?
4. What happens if we cut notches on the edges of the spools?

ACTIVITY

Circumference of a Wheel

Objective

The student estimates the circumference of a wheel by multiplying the diameter by three and “adding a little bit more.”

Materials

At least 10 bottle or jar caps of various sizes for each student group
A tape measure

Procedures

Tell the student groups that the class will estimate the perimeter, or distance, around a circle, but that the accepted word for perimeter of a circle is “circumference.” Students are to note the word “circumference” has in it the root “circum,” which means "around”. Remind the students that the diameter of the circle is the measure of the line that starts at a point on the circle, passes through the center of the circle and ends at the opposite edge.

1. Students locate the diameters of each of the caps.
2. The students measure and record the circumferences of the caps using the tape measure.
3. The students measure and record the diameter of the circular object.

Note: The following are suggestions to make to the problem-solving teams to help them continue pursuing the problem.

ESTIMATING CIRCUMFERENCE

Diameter inches	What Happened to It to Get to This?	Circumference
17		53½
22		69
5		15½

4. Students speculate what other names for 53 involve 17 (e.g., 17 x 3 = 51).
5. Suggest that students will have to add a large number to a number like 17 to get to 53.
6. Suggest that starting with the smaller lids might help students estimate, since the numbers are smaller.
7. Suggest that students might need an operation such as multiplication to get to larger numbers faster than by addition.
8. After the students start to try multiplication, they may want to try multiplying in sequence, first with two, then three, then four, to get some ideas.
9. Frequently remind students that the task is to **estimate** the circumference only.

ACTIVITY
Let's Get Even

Objective

The student finds the average of three given numbers.

Materials

For each student or student pair:

one trading chip board with 20 - 30 chips; one game chart; Cuisenaire rods —

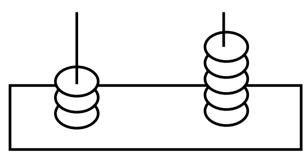
10 orange, 20 white, five yellow (or some other manipulative to use in fraction form)

Procedures

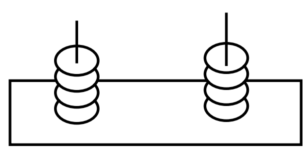
The teacher shows students the trading chip board and the chips. Place two stacks of chips on the board. The teacher tells the students that these two stacks are not even or level. Then the teacher shows the students two level stacks and says that the stacks are even.

The students complete the activities.

1. Make two stacks, one having three chips and the other five chips.



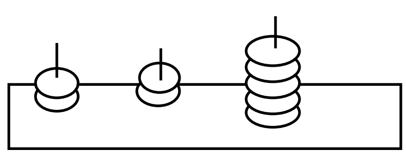
Make the stacks even, or level.

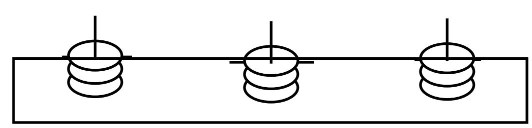


The stacks are now level. How many chips are there in each equal stack?

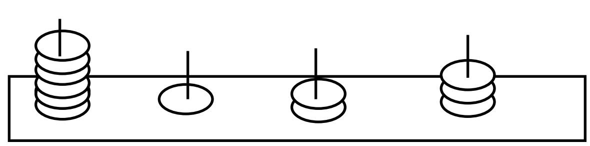
There are four chips in each stack.

2. Suppose this time there are three stacks having three, seven and two chips. Make the stacks even and say how many are in each even stack.
3. Three stacks with two, two, five. Show picture before and after.



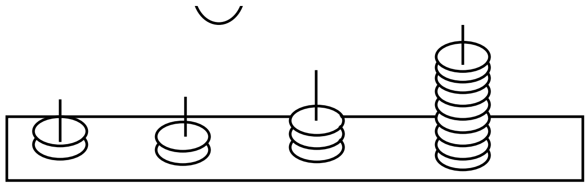


4. Four stacks with six, one, two, three.



[1] A board with pegs to allow the students to place chips in various stacks.

5. Four stacks with two, two, three, nine.

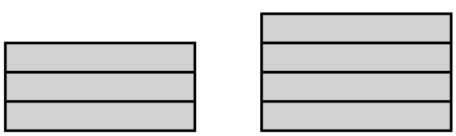


Let's organize what we did in this game by putting the information on a chart. As you use the chart look for a pattern that may help you make correct decisions quickly.

How Can We Get Even?

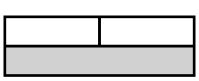
Activity	Number in each Stack	Number of Stacks	Total Number of Chips	Number of Chips to Make the Stacks Even

6. After you have completed **Step 5** do the following:
   If you have found a **fast** way to make the stacks even, write it down here and show it to another group after they have completed **Step 5,** or show it to your teacher.
7. Use the orange and yellow Cuisenaire rods to form stacks. Make one stack of three and one of four orange rods. Now make two even stacks. You may use the orange and white rods to make the equal stacks.

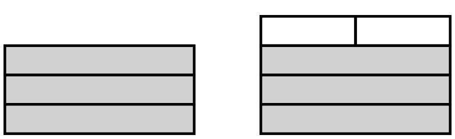


You may use other rods if you need to, to make the stacks equal.

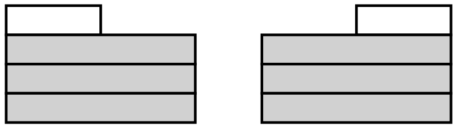
At this point, encourage the students to solve the problems **on their own initiative.** If they need some suggestions, the students may continue as follows:



Try lining up 2 of the yellow rods with the orange rod. Can you see a way to make the 2 stacks even by using the yellow rods?



Trade 2 of the yellow rods for one of the orange rods and make the 2 stacks level. If you do that, how tall is each stack?



Each stack is now 3½ rods tall.

8. If you have five stacks of two, three, five, five and six orange rods, how high will the stacks have to be to have even stacks? Explain and draw a picture of how you solved this problem.
9. Elise found a fast way to make the stacks even first by adding all the stacks and then dividing by the number of stacks. Do you think Elise's system works?

Look for patterns in your chart to check if Elise is correct.

How Can We Get Even?

Activity	Number in each Stack	Number of Stacks	Total Number of Chips	Number of Chips to Make the Stacks Even

ACTIVITY
Average Speed

Objective
Students apply the concept of "average" by looking for a way to assign an "average" speed.

Materials
For each student: the racer the student constructed; copy of the chart to record times

Procedures
Seven cars race in three heats.

Phase 1
How can we find the fastest car?
1. Is it the one with the single fastest trial?
2. What about the car that has trials of four, four, five seconds?

Car	Heat 1	Heat 2	Heat 3	Average
1	3	7	4	
2	6	5	6	
3	4	3	4	
4	6	4	5	
5	4	4	5	
6	5	5	6	
7	7	6	4	

Phase 2
Procedures
1. Students race cars as before, but in two heats instead of three.
2. Look for a method to assign an "average" speed to each car.
3. Students justify this method to their group and report to the class.
4. Identify the winning car.

Phase 3
Students continue races with four heats, five heats, as time permits.

ACTIVITY
Car Races

Objective
Students calculate several averages and apply the concept to predictions about future events.

Materials
Race car for each student or student group
Digital clock or stopwatch that shows seconds
Chart showing race times and averages
A distance marked on floor tiles for the race (about four meters)

Procedures
1. Each student or student group races the car three times.
2. Calculate the average time to travel the marked distances.
3. Answer the following questions after collecting the data.

Car Owner	Time 1st race	Time 2nd race	Time 3rd race	Average for 3 races

1. Whose car was the fastest?
2. Whose car was the slowest?
3. What was the average time for all the cars?
4. Whose car had the single fastest time?
5. Whose car had the single slowest time?
6. Whose car had an average time equal to the whole group (class) average time?

[1]Instructions for construction of a race car given in **Activities —** Tin Can Racer and Spool Racers.

LESSON 5 *A Slide*

BIG IDEAS An inclined plane is a machine that changes the direction that force is applied and that helps decrease the effect of gravity, though it may increase friction. Different types of inclined planes form triangles.

Whole Group Work

Materials

Book: **Hump, the Escalator** by D. Faubron
Per student group:
Large solid boxes, one about six inches high and the other about one foot high; a large screw and other screws; pictures of the pyramids; picture of a spiral staircase; shovel; plywood board, one yard X two yards; small piece of board; books to make an inclined plane; paper brads; doorstop; picture of a tooth; spring scales; toy cars; rubber bands; rulers; screwdriver; tack; nail; knife; chisel

Encountering the Idea

Read the story of Paul Bunyan to the class. Students note that Paul Bunyan used a tool. Ask the students if the tool he used was a lever. A wheel and axle? What tool did Paul Bunyan use? Yes, an axe. Is an axe a machine?

Rosa, please walk up this ramp. Now, walk up this higher one. Which is easier to climb, the steep one or the one that is not so steep? Is this ramp a machine?

Robert, here is a piece of wood I need attached to this larger piece of wood. What could I use to attach them? Yes, I can use a hammer and a nail, or I can use a screw and a screwdriver. Is a hammer a machine? Is a screwdriver a machine? One of the students demonstrates using a nail to attach the two pieces of wood.

What questions do we need to ask to decide if a device is a machine? Yes: Does the device help us overcome a force? Does the device help us transfer energy? In our investigations today, we will discover if these two devices are machines, how they work and what forces they overcome.

Exploring the Idea

At the **Science Center,** the students complete

1. **Activity** — Moving Heavy Objects
2. **Activity** — Using an Inclined Plane
3. **Activity** — Wedge: the Double Plane, as below.

Procedures

1. Provide each student group the following tools: shovel, tack, nail, doorstop, picture of a tooth, knife, chisel.
2. The students examine each of the tools and decide how they work. They describe how the tool does the work.

3. The students draw a picture of what they think the device does.
4. They decide how the devices are alike.

4. **Activity** — What is a Screw?, as below.

Procedures

1. Provide a large screw to each student group.
2. Ask each group to examine the screw closely and describe it. What does it look like? If you were a tiny ant on the tip of the screw, what would it look like to you? Yes, a screw is an example of an inclined plane. It looks different because the plane circles around itself. Is a screw a machine?
3. What forces does the screw overcome? (It has to break the material by overcoming the forces that bind the wood fibers together. It also overcomes the friction of the screw against the wood, which causes the wood and the screw to get hot.)
4. How do we transfer energy in using the screw?

Getting the Idea

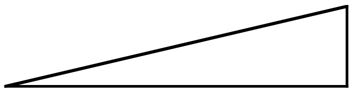
Part 1

The inclined plane is one of the simplest machines that we know. It helps people raise heavy things or lower them more easily. Any board or flat surface that leans against something can become an inclined plane. An inclined plane, as it slants on a base, forms a triangle.

In the picture shown below, a stone is raised from ground level to the top of the plane as it might have been done when the pyramids were being built. Many people, pulling on stout ropes, were able to raise stones that would have been too heavy for them to lift without the inclined plane. Also the workers used logs as rollers (wheels)!

Discussion

1. When you are sliding down the slide and you go very fast, or you have on very thin clothing, what do you feel? (Gets hot.) What causes the heat? (Friction, because the surface of the slide resists the body going down the slide.) What can you put on the slide if you want to go faster? (Some kids spill dirt down the slide; what happens?)
2. What work did the slide do? (It is moving your body weight down to the ground — moving a mass a distance.)

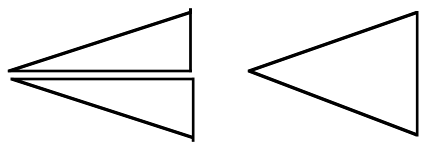


We know the ancient Egyptian pyramids were built by men using inclined planes to raise the heavy stones that they needed to build these huge monuments. The Egyptians built the pyramids many thousands of years ago — in 300 B.C.

Part 2

Another simple machine we call a “wedge”. A wedge is two inclined planes placed back to back to look like a triangle.

Wedges do many things that require lifting an object, cutting or splitting something or holding something in place. Examples of common wedges are: a shovel to dig into the dirt, a tack to hold up paper on a bulletin board, a nail to hold a board in place, a doorstop to hold a door open, an axe to split wood or a tooth to chew a piece of meat.



Part 3

Students give and draw examples of the screw such as: spiral staircases, roads that wind around a steep hill, vises for workbenches, clamps to hold things together, adjustable piano stools, adjustable parts of wrenches, propellers for airplanes and boats, etc. On the pictures, students color the part that shows the screw.

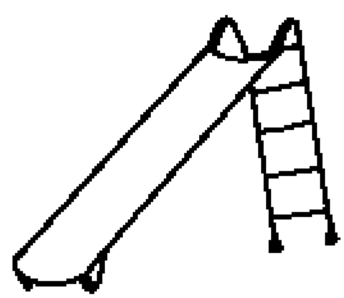
Organizing the Idea

At the **Drama Center,** the class divides into three groups — the Inclined Planes, the Wedges and the Screws. Each group reports, using pantomime, how to use each tool and the work each tool does.

At the **Art Center,** students draw several different objects and color the part that shows a wedge. Describe how we use each of these objects as a wedge. Where can you see a triangle shape? Where is the point of the wedge?

At the **Writing Center,** the students complete the following:

Have you seen this in your schoolyard? What is it?



Unscramble these words:
dlsie ____________ elpna _____________ glenatri ____________
elsipm _________ ihcmaen ________

Applying the Idea

Problem Solving with Calculators

Working in pairs, students solve the following:

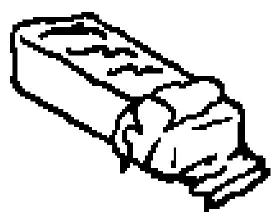
1. Two loggers use axes to split logs. One logger can split 20 logs in 15 minutes. Another logger can split 30 logs in 15 minutes. How many more logs does the second logger split in one hour than the first logger? Students discuss different ways to solve the problem.
2. How long will it take the two loggers working together to split 200 logs? Students discuss different ways to solve the problem. Can a chart showing how many logs each logger splits each hour help us solve the problem?
3. When students have finished, they help write a “directions” paragraph about what they did to solve the second problem. Write their contributions on the board. Encourage them to use signal words like “first”, “next”, "then” and “last”. After the class is satisfied with the paragraph’s sequential order, volunteers read the paragraph.

Closure and Assessment

Robert, suppose you needed to carry a refrigerator up to the second floor of a house, what would you do?

Which inclined plane do you use to do the following?

core an apple



cut a candy bar

split a log

Reconvene students for closure and assessment. Read to the children the poem in **Childcraft Encyclopedia,** Vol. 7, pp. 94-95. Students identify the words used as nouns in the poem. Students write a sentence for each animal shown on the escalator. The students write in journals about the escalator as a machine and underline each noun.

Math Activity — **Discover Science**, Scott Foresman, pp. 132-133.

List of Activities for this Lesson

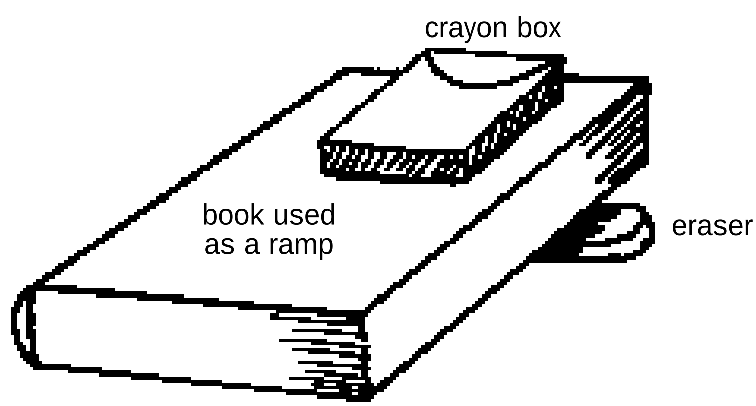
- ▲ Moving Heavy Objects
- ▲ Using an Inclined Plane

ACTIVITY
Moving Heavy Objects

Objective
The student describes how an inclined plane functions to produce work.

Materials
For each group of three:
a book, a crayon box, an eraser

Procedures
Use a book to make a ramp. Place an eraser under one end of the book. Place the crayon box at the top of the ramp (the book). Now without touching the box, try to move the box down the ramp. You can use objects to help you. After the students have moved the crayon box up and down the ramp, have them suggest how they could make the box easier to move (greasing bottom, inclining the ramp more, attaching wheels at the bottom).



At the **Language Center,** the students write a report in their journals about how people move heavy objects.

ACTIVITY
Using an Inclined Plane

Objective
Students examine the graph data for heights of one, two, three, five and six books. Students predict the number of centimeters the rubber band will stretch for four books, and then test their predictions.

Materials
Six books; board; rubber band; spring scale or ruler; paper clips; toy car or roller skate

Procedures
1. Make an inclined plane by placing the board on one book.
2. Place a roller skate on the board.
3. Hook a bent paper clip around the tied shoelace of the roller skate.
4. Attach a rubber band.
5. Measure and record with a ruler the length of the **unstretched** rubber band.
6. Pull the skate slowly up the board.
7. Measure and record with a ruler or spring scale how much the rubber band stretches.
8. Repeat steps with height of two books, then five and six books.
9. Record what you find on a graph.
10. Predict and then test your prediction using four books for the ramp.
11. With your student group, write a rule about using inclined planes. Show the rule to another group and defend your reasons for stating the rule your way. Show it to the teacher and to the other members of the class.

LESSON 6 *A Pulley*

BIG IDEAS A pulley helps us change the direction of a force. A pulley transfers energy through distance (or **nothing in nature is free**).

Whole Group Work

Materials

Books: “The Elevator”, in **Childcraft Encyclopedia**, Vol 1., p. 214 and **The Simple Facts of Simple Machines** by E.J. & C. Barkin

Small pulley; meter stick; string; pail; sand; spring scale; wire; cotton spools; hook; toy bucket with heavy objects; a pulley hung from the ceiling

Word tags: pulley, direction

Encountering the Idea

Aak a student to lie flat on her/his stomach on a table and to pull up the toy bucket full of heavy objects. Secure a stout rope to the handle of the bucket so the student can raise it to table level. Ask students to give suggestions about how to raise the bucket in an easier way. If students suggest various ways to help, accept them and record them on the board for later reference. Tell the students you will ask them the same questions again at a later time.

Exploring the Idea

At the **Science Center,** students complete **Activity** — The Pulley, as below.

Procedures

1. Fill a pail about 1/4 full of sand.
2. Lift the pail with the spring scale; record the weight in the pail.
3. Attach one end of the string to the meter stick; run the string through the pulley.
4. Attach the free end of the string to the spring scale.
5. Hook the pail onto the pulley; lift the pail using the scale; record the weight.
6. Compare the two forces used to lift the pail.
7. Design your own experiment using several pulleys at the same time.
8. Write a rule about how to use a pulley, or several pulleys.
9. Share your findings with your teammates and with your teacher.

Students complete **Activity** — Make Your Own Pulley, as below.

Procedures

1. Bend about eight inches of wire into a triangle shape; push the ends into a spool.
2. Bend the two protruding ends of the wire together.
3. Hang your pulley from a suitable place.

4. Tie one end of the string to the handle of the load (resistance).
5. Wind the other end of the string over the cotton spool.
6. Raise the load one foot. Record how much string you used to lift the load one foot.
7. Raise the load to different heights. Can you find a pattern?
8. Make a rule about the use of pulleys and the force needed to raise a given weight to a given distance.

Students complete **Activity** — Pulleys and the Direction of Force.

Getting the Idea

A pulley is a machine we make from a belt, rope or chain that wraps around something like a tree branch, a rod or a wheel. A fixed pulley helps to change the direction of the load, as you saw in this demonstration. A movable pulley, however, helps the person do work by moving the load.

Let's see if you have been able to solve the problem with which the lesson began. How can Betty raise that tub of heavy objects to the table? You think we could use the pulley that we hung from the ceiling? How can we do that? Attach the bucket and have Betty sit on the table, instead of lying on it on her stomach, and have her pull down. In what direction is the bucket going? Yes, it is going up — **but Betty is pulling down!** Yes, a pulley is a very simple machine, but it can do very important things — change the direction in which we have to apply the force, for one.

What did you discover when you completed **Activity** — The Pulley? A pulley — the name says what you do to it — you pull it. It is a machine that, in its simplest form, makes you use equal force, but you can do a very important job: change the direction of the load. With a fixed pulley, you pull down and the load goes up. When you use several pulleys, you can use less force, but you lose distance.

At the **Writing Center,** students read about and then discuss how an elevator works. Students write a poem about elevators.

Science Activities: Read the definition in **Science Horizons,** Silver Burdett, pp. 198-199. Students will do the problem solving on p. 199. They will write out a solution. They will gather in groups of three or four to discuss solutions.

Organizing the Idea and Assessing the Idea

Written Assessment

Make a list of the way we use pulleys around the house or the school.

Performance and/or Written Assessment

Is an elevator a simple machine? Why, or why not? Draw and/or write a paragraph to defend your position.

List of Activities for this Lesson

▲ Pulleys and the Direction of Force

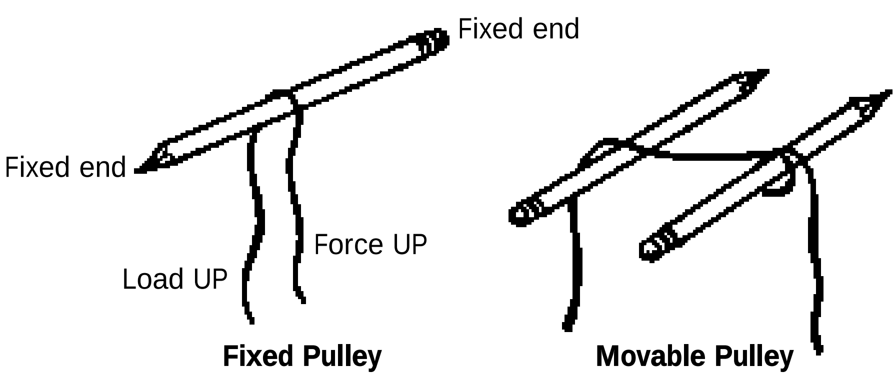
ACTIVITY
Pulleys and the Direction of Force

Objective
The student describes how a pulley works.

Materials
Empty margarine tub with two holes cut out on top and bottom
Piece of heavy-duty string or yarn (to make a handle for the margarine tub and to make the pulley belt)
Pencil or one-inch thick dowel rod to secure the pulley

Procedures
1. Drape yarn or string over a pencil or rod while keeping the pencil or rod still. Students pull on the string to raise the tub. Place items in the tub and lift them.
2. Tie one end of the string onto the pencil and loop the string through the tub handle, then over the pencil or rod. Students pull on the string to raise the tub. Use the same items to fill the tub again, and lift the tub. Students discuss the effort required in each case.
3. The students also discuss that if you use a pulley to raise the tub, then you pull down on the rope.

Discussion
1. Which is a fixed pulley? Movable?
2. Experiment with more pencils (or rods) to make the effort to raise the tub easier.



3. Now let's try to solve this problem: Can a person pull a 100 pound weight with only 50 pounds of effort to a height of three feet? Explain how.
4. Students use the idea of a pulley to raise and lower a flag. They complete **Activity** — Class Flag, as below.

Class Flag Activity

Materials

Long pole with stand; two pulleys (can be purchased at a hardware store)
Stout rope and tape or pins to secure the flag on the rope

Procedures

1. Teams of four students each design a class flag.
2. Class votes on one of the flags as the class flag (or use each flag sequentially for several weeks).
3. One team makes a flag pole.
4. Another team makes the flag.
5. Students take turns hoisting the flag and bringing it down daily.

LESSON 7 *Inventions*

BIG IDEAS An invention is a combination of simple machines, for example, a foot-pedal sewing machine or a car.

Whole Group Work

Materials

Book: **The Way Things Work** by D. MacAulay
Scissors; hand drill; toy crane; pencil sharpener; a jack-in-the-box toy
Different objects the students can bring from home, such as tin cans, rubber bands, plastic lids from margarine tubs, screws, string, rods and anything else thay can use to make their invented toys

Encountering the Idea

Tell the students that the lesson will begin with an activity. During the first part of the activity, the students examine the toy and make comments to each other about how the toy works. They are to describe it using new terms to discuss parts of the toy that work like simple machines. After they have had an opportunity to study the toy, they separate into groups for the writing part of the activity.

Activity — Jack In the Box

Display a jack in the box toy. Students examine the toy. The students hypothesize as to how the toy works. If possible, the jack-in-the-box has one side removed to show the inside. Students turn the crank to see how it works. Students dictate a hypothesis about how or why the toy works They dictate sentences about how it works. The teacher writes them on the strips of poster board for easy ordering. Then the students sequence the sentences that explain how the toy works. They write the sequence in paragraph form.

- Close the lid so that the spring with the doll will go down.
- Turn the handle so that the band can move.
- The bumps on the band make music when they turn and hit metal prongs.
- The song ends and one large bump hits the catch that opens the lid.

At the **Mathematics Center,** the students:

1. complete **Activity** — Buy a Toy
2. complete **Activity** — Right Triangles

At the **Writing Center:**

1. after constructing their inventions in the **Organizing the Idea and Assessing the Idea** part of this lesson, students write an advertisement telling about their wonderful new toy! What does it do? How does it work? Why would children want to play with it?
   Children exchange advertisements and peer-edit them.
2. students in teams of three or four research an inventor or invention. The teams give oral reports about the inventor, make posters or role-play a scene

they write. Each team contributes to a chart that lists Inventor and Invention, date of invention, inventor's country of origin.

At the **Social Studies Center:**

1. the students make a time line putting invention dates in chronological order from oldest to newest.
2. using a drawing of a world map, students locate the inventors' countries. Students write each inventor's name on the appropriate country.

Organizing the Idea and Assessing the Idea

Students think about what kind of toy or machine to make from some of the objects brought from home. Your toy or machine should have moving parts. Draw a design of your new toy. Show the moving parts. Build a model of your toy. After building your toy, measure its parts and write the measurements next to your drawing. Tell the rest of the class about your invention.

List of Activities for this Lesson

- ▲ Buy a Toy
- ▲ Right Triangles

ACTIVITY
Buy a Toy

Objective
The student finds a product by performing multi-step addition and/or multiplication problems requiring regrouping and renaming.

Materials
Commercial catalogs (J.C. Penney's, Sears, etc.)
Construction paper for cutouts
Toy $100, $10, $1 bills and various coins

Procedures
1. Using commercial catalogs, students cut out and paste on a piece of construction paper various toys they'd like to purchase.
2. On the back of the cutouts, they use coin and dollar bill stamps to show how much each toy costs.
3. They make a list of the toys they will buy and find the cost of all the toys.
4. The students calculate how much it would cost to buy the same list of toys for five children who will soon be having a birthday.
5. Next, the students calculate the cost for 10 children.
6. The students discuss different ways to work the problems.
7. Students compare their totals and how much it would take to buy the same set of toys for five and then for 10 children.
8. The students look for a way to combine the problems so that fewer calculations are necessary.

If the total is $57.29 for the list of toys a student wants, and the student needs to buy sets of toys for five children he/she may explore:

combining the number of $10 bills needed, then the number of $1 bills, dimes and pennies, and then regrouping: five $10s; seven $1s; two dimes and nine pennies; etc.

adding 57 dollars and 29 cents five times and then placing the decimal point appropriately to show dollars and cents, or other ways that students themselves may be able to explain to the class.

In finding the cost for 10 children, have the students note the relationship between the cost for one set of toys, then for 10 sets. They should see a pattern if they draw tables or charts and list the coins.

ACTIVITY
Right Triangles

Objective

The student says that inclined planes form right triangles and draws the triangle to show the inclined plane.

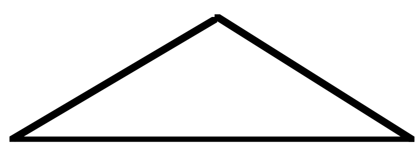
Materials

For each team of three students: paper or cardboard; three paper brads.

1. Mark the strips in inches and punch a hole in the center of the strip at every inch.
2. To make a triangle or inclined plane, connect the strips two at a time at the holes and align to make an inclined plane.
   Adjust each triangle so that one of the angles is a right angle (makes a corner).
3. The students make all the different triangles they can; use only the ones that make a right angle in this activity.
4. Measure each side from the first fastened hole to the second fastened hole. Some examples are the following:

Numbers	Relation to each other and to the right angle?
3, 4, 5	Five is longest side opposite. Three is shortest side opposite.
6, 8, 10	
9, 12, 15	

5. Students measure the lengths of each side and record the results.
6. Students make statements about their observations; i.e. the longest side is opposite the right angle.
7. If you make a triangle like this does it include an inclined plane? Color the inclined plane so it will show.



UNIT ASSESSMENT

Performance and Oral Assessment

The student creates an invention and is able to give an oral presentation as to its function.

Performance Assessment

1. Students working in small groups select machines, simple or otherwise (one per group) and report on how this machine helps people on earth overcome gravity and helps them do work. For example, they may select airplanes, trains, pulleys, carts, etc. to talk about.
2. Describe and/or draw pictures of people moving heavy objects up and down a ramp (truckers loading ramp, airplane ramp, furniture mover's ramp).

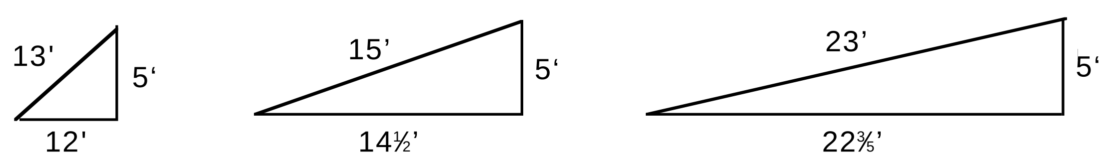
Written Assessment

1. Complete the following:

________ is done when we overcome a _________, like inertia, friction or gravity.

A ______ helps us do work by overcoming resistance, or force. For example, when we use a shovel to take dirt out of a hole, then we use it like a __________ , but when we use it to dig the hole, then we are using it like a _______ . When we walk from one place to another the forces we have to overcome are ____________ and __________. When we run very fast outside in the playground, we also have to overcome ________ resistance. That is why we get tired.

2. Given a list and pictures of simple machines, the student classifies them by type of machine.
3. Given drawings of different-size inclined planes and a load to carry up any one of the ramps, the student will select one of the ramps and explain why he/she selected that ramp.



(Students can select any one of the ramps, provided they give reasons: I only had a short 13-foot ramp; I was in a hurry; I only had a little space to work in and it had to fit it in; I didn't want to walk 23 feet, and I could get a 15-foot ramp; I'm wimpy and would rather walk a small hill than a steep one, etc.)

References

Unit Bibliography

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Mallinson, G. C., Mallinson, J. B., Froschauer, L., Harris, J. A., Lewis, M. C., & Valentino, C. (1991). Where do gears go? *Science horizons: Texas Teacher Edition 3* (p. 192). Morristown, NJ: Silver Burdett and Ginn.

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Meyer, C., & Pickens, K. (1989). Bicycle jeopardy. *Sing and learn* (pp. 10-11). Charthage, IL: Good Apple.

Meyer, C., & Pickens, K. (1989). Ride your bike! *Sing and learn* (p. 9). Charthage, IL: Good Apple.

Meyer, C., & Pickens, K. (1989). We are known as the inventor. *Sing and learn* (p. 29). Charthage, IL: Good Apple.

Stanish, B. (1982). Design a cycle. *Unconventional invention book* (pp. 78-79). Charthage, IL: Good Apple.

Tolman, M. N., & Morton, J. O. (1986). *Physical science activities for grades 2-8: Science curriculum activities library, Book II* (p. 145). West Nyack, NY: Parker Publishing Company.

Annoted Children's Books

Ancona, G. (1983). *Monster movers.* New York: Dutton.
A book on how 16 large haulers work.

Ardley, N. (1984). *Action science: Force and strength.* New York: Franklin Watts.
Shows how force and strength are an important part of your life. Great activities for the student to do.

Ardley, N. (1984). *Why things are: The Simon and Schuster color illustrated question and answer book.* New York: Julian Messner.
This is a question and answer book on a wide variety of science topics.

Barrett, N. (1990). *Picture Library: Trucks.* New York: Franklin Watts.
Focuses on the bigger trucks — tractor-trailer, dump trucks, liquid cargo carriers, and fire trucks.

Barton, B. (1979). *Wheels.* New York: Thomas Y. Crowell.
Describes the history of wheels and their importance through the ages.

Barton, B. (1987). *Machines at work.* New York: Thomas Y. Crowell.
Depicts workers using a variety of machines at a construction site.

Bendick, J. (1984). *A first book of automobiles* (rev. ed.). New York: Franklin Watts.
Different types of cars are presented, with special materials on traffic problems and pollution.

Billout, G. (1979). *By camel or by car: A look at transportation*. Englewood Cliffs, NJ: Prentice Hall.
A simple discussion of how various vehicles can move across different surfaces.

Broekel, R. (1983). *A new true book: Trucks.* Chicago: Children's Press.
An overview of types of trucks. Has many color photographs.

Burton, V. L. (1939). *Mike Mulligan and his steam shovel.* Boston: Houghton Mifflin Company.
Describes the functions of a steam shovel. It contains action verbs and labels for the different parts of the steam shovel.

Bushey, J. (1985). *Monster trucks and other giant machines on wheels.* Minneapolis, MN: Carolrhoda Books.
Tree crushers and the Crawler Transporter that moves the space shuttle are two of the machines featured.

Catherall, E. (1991). *Exploring uses of energy.* Austin, TX: Steck-Vaughn Library.
This book is divided into knowledge and understanding sections, followed by exploration by means of simple projects or experiments. The topics are also sequenced from easiest to more complex.

Cole, J. (1983). *Cars and how they go.* New York: Thomas Y. Crowell.
In a picture book format, a simple description of cars and how they operate is presented.

Garza, C. L. (1990). *Family pictures. Cuadros de familia.* San Francisco: Children's Book Press.

A collection of paintings by Carmen Lomas Garza which depicts memories and life of a Mexican American in South Texas. This book is written in both Spanish and English.

Goor, R. & N. (1982). *In the driver's seat.* New York: Thomas Y. Crowell.
How it feels to operate such vehicles as a tank and a Concorde.

Gramatky, H. (1939). *Little toot.* New York: G. P. Putnam's Sons.
This is a colorful, illustrated story about a tugboat and his adventures on the river where he lived.

Horvatic, A. (1989). *Simple machines.* New York: E. P. Dutton.
Describes and explains the work of a lever, wheel, inclined plane, screw, and wedge.

Hughes, S. (1991). *A tale of Trotter Street: Wheels.* New York: Lothrop, Lee & Shepard Books.
A young boy receives "wheels" for his birthday, but not the kind he expected.

James, E. & Barkin, C. (1975). *The simple facts of simple machines.* New York: Lothrop, Lee & Shepard Books.
Shows how simple machines use power effectively.

James, S. (1989). *The day Jake vacuumed.* New York: Bantam.
This is a very colorful, easy-to-read book about a little boy, Jake, who is asked to vacuum by his mother. Jake ends up vacuuming everything in sight, including his family.

Laithwaite, E. (1986). *Science at Work: Force. The power behind movement.* New York: Franklin Watts.
Uses photographs, illustrations, and diagrams to explain the concepts of force and related subjects. Concepts addressed are gravity, friction, wheels, inclined planes and lots more.

Liberty, G. (1960). *The first book of tools.* New York: Franklin Watts.
This book traces man's toolmaking history from the earliest know implements of the stone age to their modern descendents. Explains six simple machines.

Kerrod, R., & Bull, P. (1987). *Science alive: Moving things.* Morristown, NJ: Silver Burdett Press.
This activity book explains that movement is a form of energy and is produced by the action of force. The simple illustrations are easy to understand.

MacAulay, D. (1988). *The way things work.* Boston: Houghton Mifflin Company.
Written for readers of all ages, it is particularly useful for those who find technology intimidating and who wish it were less so.

Rockwell, A., & H. (1972). *Machines.* New York: Macmillan.
Describes simple machines such as levers and wheels.

Shapp, M. & C. (1962). *Let's find out about wheels.* New York: Franklin Watts.
A simple approach to the concept of wheels and their friction.

Smith, E. B. (1983). *The railroad book.* Boston: Houghton Mifflin Company.
This story describes different parts of the train and the different cars.

Turner, E. S., & Hester, T. R. (1985). *A field guide to stone artifacts of Texas Indians.* Austin, TX: Lone Star Books.
Shows Indian arrowheads of the Texas Indians. Gives a Texas meaning to prehistoric man and the tools he made.

Victor, E. (1961). *Friction.* Chicago: Follett.
Easy to read, very informative book with carefully controlled vocabulary.

Wade, H. (1977). *The lever.* Milwaukee, WI: Raintree Children's Books.
A simple explanation of how a lever works.

Zelinsky, P. O. (1990). *Wheels on the bus: With pictures that move.* New York: Dutton Children's Books.
Adapted and illustrated by the author, this version of the traditional song has parts that move.

Other References

Branley, F. M. (1986). *Gravity is a mystery.* New York: Thomas Y. Crowell.

Cobb, V. (1988). *Why doesn't the earth fall up? and other not such dumb questions about motion.* New York: Lodestar Books, E. P. Dutton.

Darby, G. (1961). *What is a simple machine?* Chicago: Benefic Press.

Gardner R. (1990). *Experimenting with inventions.* New York: Franklin Watts.

Graham, I. (1987). *Inventions.* New York: The Book Wright Press.

Haines, G. K. (1987). *Which way is up?* New York: Atheneum.

Selsam, M. (1977). *Up, down, and around: The force of gravity.* Garden City, NJ: Doubleday & Company.

Ubell, E. (1964). *The world of push and pull.* New York: Atheneum.

Walpole, B. (1987). *Fun with science: Movement.* New York: Warwick Press.