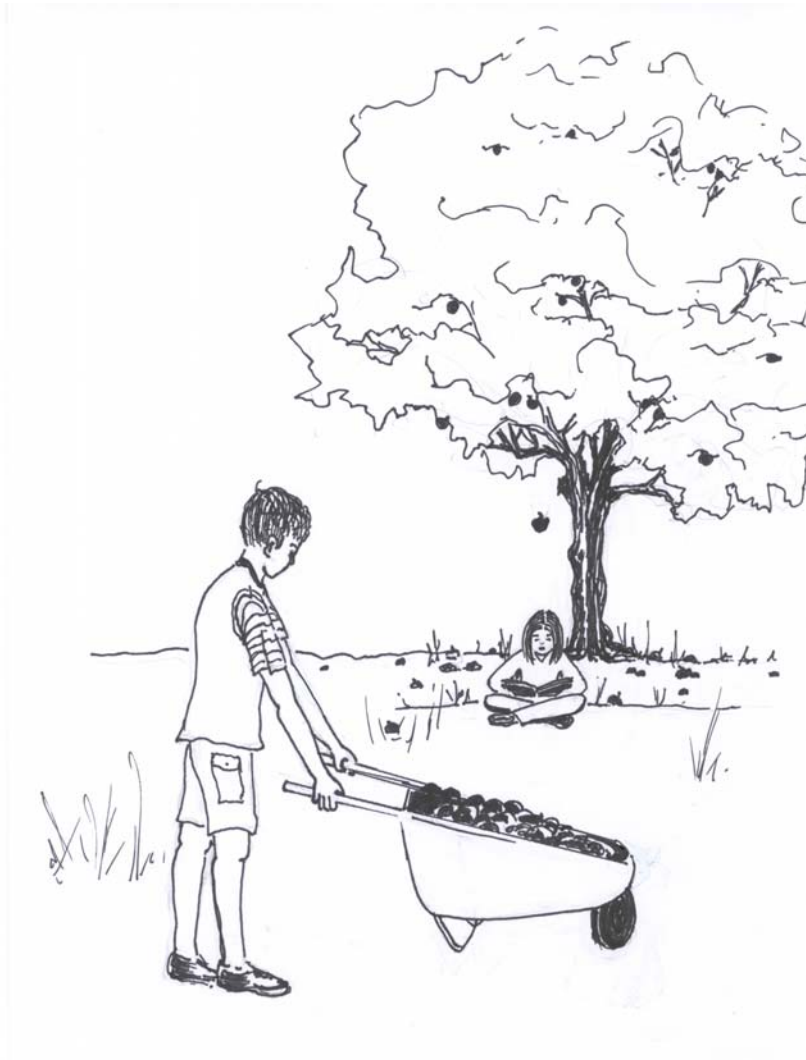


**ELEMENTARY SCIENCE PROGRAM**  
**MATH, SCIENCE & TECHNOLOGY EDUCATION**

A Collection of Learning Experiences  
**NATURES FORCES**  
**SIMPLE MACHINES**



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# NATURE'S FORCES SIMPLE MACHINES

GRADES 5/6

## Unit Overview

A force is a push or a pull. Forces differ in their strength. All motion (change in position or direction) is caused by force. Forces may have different names, for example, friction, gravity, electromagnetic, and centrifugal force.

Simple, compound, or complex machines are devices that help make the work easier by changing the size and/or direction of the force that is applied. There are six simple machines – inclined plane, wedge, screw, lever, pulley, and wheel-and-axle. Simple machines can be combined in all kinds of ways to create the machines we use everyday.

The science skills emphasized in Nature's Forces Simple Machines are collecting data, manipulating, constructing models, observing, and predicting.

## Scheduling

This unit may take from four to six weeks to complete depending upon the goals of the teacher and interests of the students. Use of the section included in this manual called More Ideas may extend the time span of this kit.

### Materials to be

#### obtained locally:

Please make **one** student activity book for **each** student.

scissors	water
pencils	pennies
meter stick	copy paper
tape	crayons or colored pencils

## Caution

Remind students to wash their hands after handling any of the materials in the kit. Small objects should be handled with care.

## About the Format

Each learning experience is numbered and titled. Under each title is the objective for the learning experience.

Each learning experience page has two columns. The column on the left side of the page lists materials, preparations, basic skill processes, evaluation strategy, and vocabulary. The evaluation strategy is for the teacher to use when judging the student's understanding of the learning experience.

The right column begins with a "Focus Question" which is typed in italicized print. The purpose of the "Focus Question" is to guide the teacher's instruction toward the main idea of the learning experience. The "Focus Question" is not to be answered by the students. The learning experience includes direction for students,

illustrations, and discussion questions. These discussion questions can be used as a basis for class interaction.

A **Student Assessment** has been included in the **Teacher's Manual** and the **Student Activity Manual**. If you do not want the students to have the assessment beforehand, remove it from the **Student Activity Manual** before printing a class set of the student manuals.

## **Background Information**

### **Force**

A force must be used any time an object begins moving, changes direction, speeds up, slows down, or stops moving. A force is a push or pull that changes the motion or shape of an object. An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.

Changes in speed or direction of motion are caused by forces. The greater the force, the greater the change in motion. Given the same force, the more massive an object is, the less change in motion will occur.

Whenever an object exerts a force on another object, an equal amount of force is exerted back on it. When an object speeds up, slows down, or changes direction, we know that an unbalanced force acted upon it.

Force is often called "effort" in reference to simple machines.

The international metric unit of force is the Newton (N). The Newton (N) was named after the English scientist Sir Isaac Newton. Force is commonly measured in pounds in the United States. When we get on a bathroom scale we are measuring the force of gravity upon us. The force of gravity from a very large object such as the Earth, acting on an object, is measured in units of weight. Weight is therefore measured in Newtons or pounds.

One Newton is the force needed to cause a one kilogram mass to be accelerated one meter per second each second.

$$F = ma$$

$$F = 1\text{kg} \times 1\text{m/s}^2 = 1\text{N}$$

### **Mass vs Weight**

Mass is defined by physical content, by the number of electrons, protons, molecules, etc. Mass is a measure of the amount of matter in an object. The basic measurement unit for mass is the kilogram. Weight is a measure of the gravitational pull or attractive force of one mass to another mass (generally the Earth). A single ingot of gold would have the same mass wherever it was transported, but the weight of the ingot would be different on Earth than on the Moon or on Mars. An astronaut may be nearly weightless in space but if he were mass-less he would not be there.

Spring scales are used in this learning experience. Using a spring scale to measure mass can confuse students using a spring scale to measure mass because a spring scale is actually measuring the force of gravity on an object. The proper way to measure mass is by using a balance. When a balance is used, the effect of gravity is minimized due to the pull of gravity on each arm of the balance. The mass measurement is constant regardless of gravitational force. If we measured an object's mass with a balance here on Earth and we could measure the object's mass (amount of matter) on the moon, it would not change. But, if we measured our weight (force of gravity acting on an object) here on Earth, and then measured our weight on the moon it would be about 1/5 as heavy, because the force of the moon's gravity is about 1/5 that of the Earth's gravity. The moon is about 1/5 as massive as the Earth.

Weight, in Newtons, can be figured out by using an object's mass multiplied by the acceleration of gravity. Weight (Force) = mass x acceleration of gravity (acceleration of gravity on earth is  $9.8\text{m/s}^2$  or  $32.15\text{ft/s}^2$ ).

For a 1kg mass near the Earth:

$$F = ma$$

$$F = (1\text{kg})(a)$$

$$F = (1\text{kg}) \cdot (9.8\text{m/s}^2)$$

Near Earth

1kg weighs 9.8N

1000g weighs 9.8N

100g weighs .98N

1g weighs .098N

### **Gravity**

Gravity affects everything on Earth. However, gravity is not just the attraction between objects and the Earth. Gravity is a force of attraction that exists between any two masses, any two bodies, and any two particles. Every object exerts gravitational force on every other object. This force depends on how much mass the objects have and on how far apart they are. This force is hard to detect unless at least one of the objects has a lot of mass.

Gravity is the major attractive force on objects by the Earth. This includes bodies of air and water and the things in them. Gravity pulls the air or water and the things in them toward the center of the Earth. Only the solid surface beneath the air or water prevents them from being drawn farther toward the center of the Earth.

Gravity's attractive force can cause objects to roll down an incline or down hill. Gravity is the force that causes an object to be pulled toward the ground when suspended from a rope. When you throw a ball, the force of your muscles places the ball in motion. The force changes the ball's position. Another force also acts on the ball. Gravity causes the ball to fall toward the ground. Gravity is the Earth's attractive force acting on objects. Weight in pounds is a measurement of the force of gravity. In the metric system, the Newton is the standard measurement for force.

Newton discovered that a force is required to change the speed or direction of movement of an object. He realized that the force called "gravity" must make an apple fall from a tree. Furthermore, he deduced that gravity forces exist between all objects. He also found that some objects required more force to move than others. The force needed to push an object at a given acceleration rate was proportional to the object's mass.

### **Friction**

Friction is a force that opposes motion. All moving objects have friction between them when they touch including objects moving through water or air. Rough surfaces have more friction when they rub against other objects than smooth surfaces do. Regardless how it may feel, no surface is perfectly smooth. When two surfaces rub together the roughness (tiny bumps, craters, and splinter-like projections catch on the roughness of the other surface, resulting in friction. Liquid materials such as oils or waxes are often used between surfaces to reduce friction. Friction between objects and air or water is often called drag.

### **Inertia**

Inertia is the tendency of an object to remain at rest, if it is at rest. It is also the tendency to continue moving in the direction it is traveling, if it is moving. An object's inertia is determined by its mass.

### **Momentum**

A property possessed by moving objects that is the product of an object's mass, velocity and direction (or mass x velocity.)

$$\text{Momentum} = \text{mass} \times \text{velocity}$$

### **Impulse**

In a collision in which the time interval is very brief impulse is equal to the change in the momentum of the body. The impulse is the result of the change in velocity times the mass. If the object stops, the impulse equals the momentum.

### **Speed**

Speed is the ratio of the distance traveled divide by time. An example of speed would be km/hr, m/s, ft/s or mi/hr.

## **Velocity**

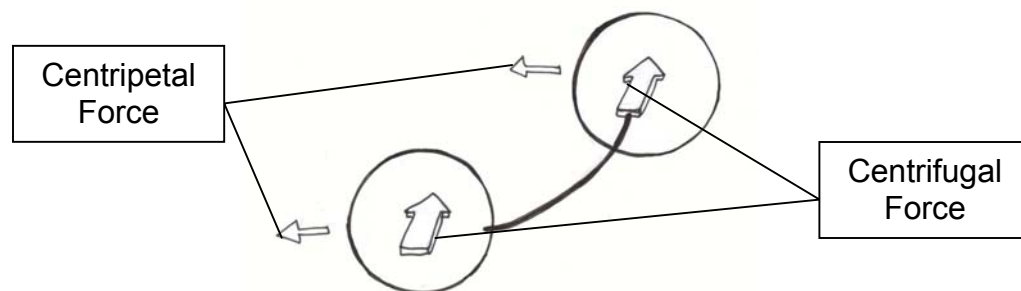
Velocity is the ratio of the distance traveled divide by time elapsed with direction. An example of velocity would be km/hr, m/s, ft/s or mi/hr in the direction north or downward toward the center of the Earth. Velocity is speed with a direction.

## **Centrifugal and Centripetal Force**

An unbalanced force acting on an object changes it speed or path of motion, or both. If the force acts toward a single center, the object's path may curve into an orbit around the center.

A passenger rounding a corner in a car seems to be pushed to the outside of the curve. This force that the passenger is feeling is centrifugal force. The force is not due to something pushing you in that direction, but by your body's inertia trying to keep you moving in a straight line. The car is curving around in front of you and intercepting you in your straight path. The car door pushes you towards the center of the curve and makes you change direction. A similar phenomena occurs with a ball on a string.

The center-directed force that causes an object to follow a circular path is called a centripetal force. When you swing a ball from the end of a piece of string in a circular motion, you must pull on the string to keep it in motion, exerting a centripetal force. When you let go of the string, the ball travels in a straight path. Part of Newton's first law of motion states that an object in motion will move in a straight line unless acted on by an unbalanced force. In the case of the ball on a string, your inward pull on the string is the unbalanced force that keeps the ball traveling in a circle instead of a straight line. Upon release, the ball travels away in a straight line in the exact direction it was traveling at the very moment it was released.



## **Position**

Position is the location of an object. When an object has moved from one position to another, motion has happened.

## **Distance**

Distance is the measurement of separation between two objects.

## **Motion**

Motion is defined as a change in position. The motion of an object can be described by its position, direction of motion, and speed. Motion cannot occur without a force. Force is needed to change the position of all objects. The motion of an object is always judged with respect to some other object or point. A bicycle moves when enough force is applied to the pedals or when the bicycle coasts downhill. An object's motion is the result of the combined effects of all forces acting on the object.

## **Work**

The term "work" has a special definition in science. "Work" happens when a force is used to cause motion. You can push on a desk all day but unless you are able to cause the desk to move, you have not done any work. Work is a product of the force applied to an object and the distance that the object moves as a result of the force. Work is what gets done. Holding something without moving it is not work because the object is not moved. The joule is the unit of work. It is named after an English scientist, James Joule.

Work

Work = Force x distance

$$W = F \times d$$

## **Energy**

Energy, like work, has a very special meaning in science. Energy is the ability to do work. If you have energy, that energy can exert a force to move something a distance and change its position.

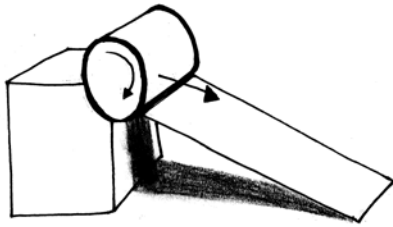
There are two basic states of energy. They are kinetic and potential energy. The energy of an object in motion is kinetic energy. Potential energy of an object is the amount of stored energy. A stretched rubber band is an example of potential energy. When the rubber band is released the stored energy becomes kinetic energy and the rubber band moves.

There are many different types of energy. Different types of energy can be found in the kinetic or potential states. Each type of energy can be used to exert a force to do work. Energy can be transformed from one type to another.

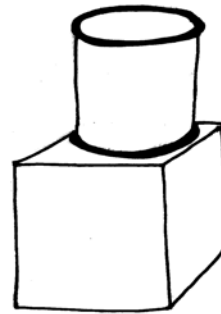
Some types of energy are:

- Heat / Thermal
- Electrical
- Sound
- Chemical
- Light





**Kinetic**



**Potential**

### **Newton's First Law of Motion**

Newton's first law of motion is a *qualitative* one---it tells you that something will accelerate if an unbalance force is applied. Every object in a state of uniform motion tends to remain in that state of motion unless an unbalanced force is applied to it. The first law is often called the "Law of Inertia". The Law of Inertia states that an object at rest will stay at rest unless acted on by an outside force, and an object in motion will stay in motion unless acted on by an outside force. An object's inertia is equal to the object's mass. An illustration of inertia could use a bowling ball and a ping pong ball. The bowling ball has greater inertia because it has more mass and has a greater tendency to stay at rest or in motion. Whereas the ping pong ball can be moved and stopped very easily.

Newton's first law has two parts.

- A. An object at rest will remain at rest unless an unbalanced force causes it to do otherwise.
- B. An object in motion will continue in motion in a straight line with constant speed unless an unbalanced force causes it to do otherwise.

### **Newton's Second Law of Motion**

Any force acting on an object produces acceleration in the direction of the force, directly proportional to the force, and inversely proportional to the mass. This is the foundation for the equation for force as it relates to acceleration.

The relationship between an object's mass ( $m$ ), its acceleration ( $a$ ), and an applied force ( $F$ ) is  $F = ma$ .

We can rewrite this law in the following way  $a = F/m$ . This tells us that the acceleration of a body ( $a$ ) depends upon the unbalanced force ( $F$ ) and the mass ( $m$ ) of the object. What does all this mean? It means that the rate at which an object accelerates depends upon how much force is used and how much mass (inertia) the object has.

For a given amount of force, more massive objects will have a smaller acceleration than less massive objects (a push needed to move a car would send a baseball flying!).

According to Newton an object with a certain velocity maintains that velocity *unless* a force acts on it.

### **Newton's Third Law of Motion**

For every action there is an equal and opposite reaction.

This law is exemplified by what happens if we step off a boat onto the bank of a lake: as we move in the direction of the shore, the boat tends to move in the opposite direction (leaving us facedown in the water, if we are not careful!).

### **Newton's Law of Universal Gravitation**

The force of gravity pulls objects to the Earth. However, the force of gravity is a property not only of the Earth but of all matter. The pull between most objects is small. For example, the force of gravity of a 5000 kg of gold ingot attracts a softball with less force than the weight of a mosquito.

As the distance between two objects increases the force between them decreases.

Every particle of matter attracts every other particle with a force proportional to the product of their masses and inversely proportional to the square of the distance between them.

### **Acceleration Due to Gravity -**

Near the surface of the Earth, the force of gravity causes falling objects to accelerate at 9.8 meters per second squared ( $9.8\text{m/s}^2$ ). Therefore, the downward velocity of the falling object increases 9.8 meters per second for each second that the object falls.

The acceleration of a falling object due to gravity is 9.8 meters per second for each second the object falls. The Changes in Velocity and Distance Traveled due to the Acceleration of Gravity chart on the next page illustrates the effect of gravity on all objects near the earth's surface.

### Changes in Velocity and Distance due to Acceleration by Gravity

Time in Seconds	Velocity Downward (m/s)	Velocity Downward (km/hr)	Distance Traveled
0	0.0 m/s	0.0 km/hr	0.0 m
0.05	.49m/s	1.76 km/hr	24.5 cm / .245m
0.1	.98m/s	3.53 km/hr	49 cm / .49m
0.2	1.96m/s	7.06 km/hr	98 cm / .98m
0.4	3.92m/s	14.12km/hr	196cm/1.98m
0.5	4.9m/s	17.64 km/hr	245 cm /2.45m
1	9.8 m/s	35.3 km/hr	4.9 m
2	19.6 m/s	70.6 km/hr	19.6 m
3	29.4 m/s	105.9 km/hr	44.1 m
4	39.2 m/s	141.2 km/hr	78.4 m
5	49.0 m/s	176.5 km/hr	122.5 m

Time in Seconds	Velocity Downward (ft/s)	Velocity Downward (mi/hr)	Distance Traveled
0	0.0 ft/s	0.0 mi/hr	0.0 mi
0.05	1.61 ft/s	1.10 mi/hr	9.7 in / .81 ft
0.1	3.22 ft/s	2.19 mi/hr	19.32 in / 1.61 ft
0.2	6.43 ft/s	4.38 mi/hr	38.6 in / 3.22 ft
0.4	12.88ft/s	8.76mi/hr	77.28 in /6.44 ft
0.5	16.08 ft/s	10.96 mi/hr	96.48 in / 8.04 ft
1	32.15 ft/s	21.92 mi/hr	16.1 ft.
2	64.3 ft/s	43.8 mi/hr	64.3 ft
3	96.45 ft/s	65.76 mi/hr	96.45 ft
4	128.6 ft/s	87.68 mi/hr	128.6 ft
5	160.75 ft/s	109.6 mi/hr	160.75 ft

The acceleration of an object while falling is the same for any object regardless of the objects mass, provided the air resistance is the same. The velocity of the object at impact will be the same. The only difference is the amount of momentum at impact. When a 1kg ball and a 100kg ball are dropped from a tall building, the acceleration is the same for each ball,  $9.8\text{m/s}^2$ . The force attracting the 100kg ball is 100 times greater than the force attracting the 1kg ball due only to the difference in mass. The impact of the object's momentum is called impulse. The 100kg ball will have a much greater impulse.

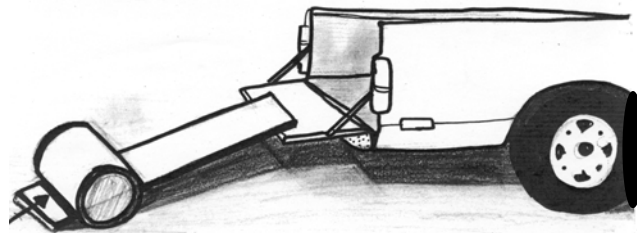
## **Simple Machines**

Simple machines are used to make work easier, faster, or humanly possible, but never give out more work that is put into them. Actually, because of friction, simple machines put out less work than is put into them. There are six simple machines and they are:

### **Inclined plane**

An inclined plane or ramp is a slanted surface that may be used to raise or lower heavy objects from one position to another. The inclined plane is unique, because it is a machine with no moving parts. "Inclined" means slanted and "plane" means flat surface, so an inclined plane is a slanted flat surface. The inclined plane helps decrease the effort needed to get objects up to a higher level. Lifting an object straight up takes more force but the distance is shorter.

A ramp is a common form of an inclined plane. Using the ramp to roll the object up takes less effort but the object must go a longer distance. An inclined plane does not lessen the work done, but it does lessen the force needed by increasing the distance. Some examples of incline planes are stairways, ladders, roads winding up hills, slides, and ramps. Mechanical Advantage = Length of the inclined plane divided by its height.



### **Wedge**

A wedge is a simple machine that is used to spread an object apart or to raise an object. A wedge has a sloping surface like an inclined plane. It is made with two inclined planes placed back to back. A wedge multiplies a force. This force may be used to penetrate very hard objects. Any effort that is applied to the wide end of the wedge is concentrated on the narrow edge making actions like splitting logs or cutting with a knife easier. The tip of a needle, a chisel, the blade on a plow, a knife, an axe, and a paper cutter are all examples of wedges. By decreasing the thickness of the cutting edge, less effort is needed to move through the object being cut. The tip of a wood screw is a wedge and the edge of the thread is also a wedge. Cutting tools generally contain a wedge.



## Screw

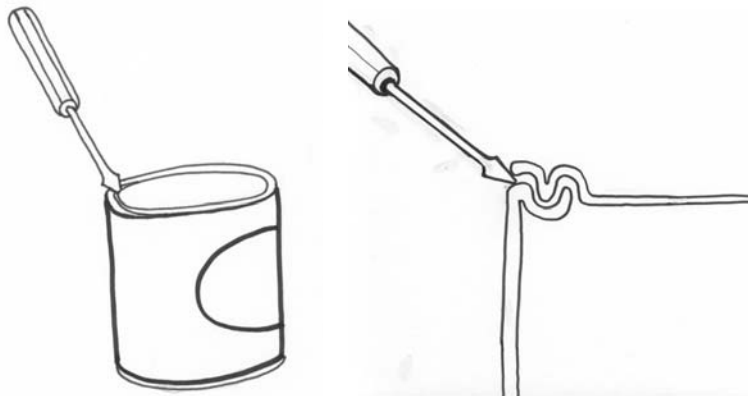
A screw is a simple machine in the form of an inclined plane wrapped around a central shaft. The grooves on a screw are called threads. The wrapped thread is the inclined plane. The distance between the threads is called the pitch. The smaller the pitch, the less force it takes to twist the screw, but the distance the screw must be turned is increased. A screw is one of the strongest means of binding two things together. Screws may be found in light bulbs, bolts, wood screws, drill bits, c-clamps, and twist off caps from bottles. A spiral staircase is a large version of a screw.



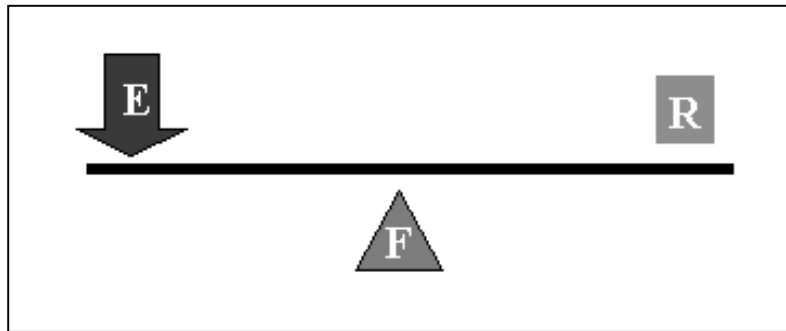
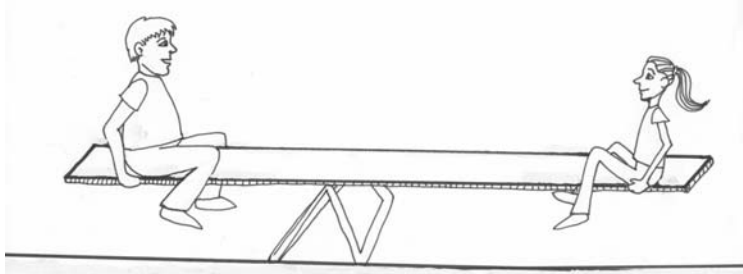
## Lever

A lever is an arm, bar, or rod that is free to move around a fixed position (fulcrum). A fulcrum is the turning point for any lever. Levers consist of four parts: an arm, a fulcrum, a load (object to be moved), and effort (force).

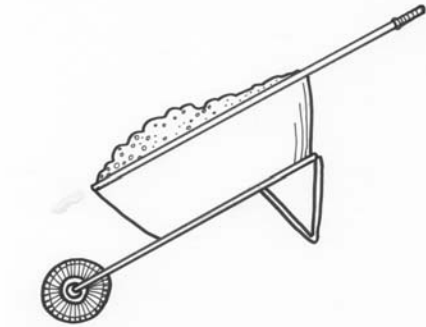
The distance from where the force is applied to the fulcrum is called the effort arm. In the example below of a simple lever machine (a pry bar), the effort from a hand is applied to the effort arm. The lever's shorter distance from the edge of the paint can to the lid is the resistance arm. A closed can of paint is usually difficult to open. With a pry bar, the lid may be easily removed. The pry bar or lever changes the amount and direction of the force needed to remove the lid. Scissors, tin snips, nutcrackers, tongs, a broom, a mop, a baseball bat, and fishing rods are all examples of common levers. Simple levers have one great disadvantage in that the resistance can't be moved very far. Mechanical Advantage = effort arm / resistance arm.



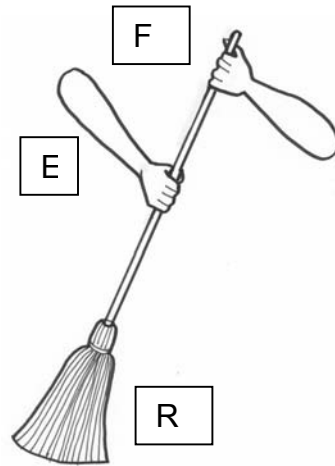
In a first class lever, the fulcrum is located between the force (effort) and the resistance (load). Example: see-saw.



In a second class lever, the resistance (load) is located between the force (effort) and the fulcrum. Example: wheelbarrow or a nutcracker.

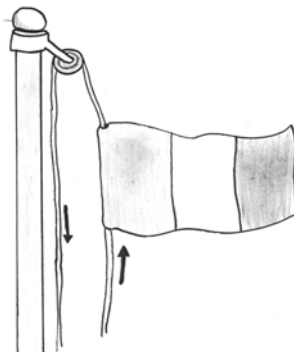


In a third class lever, the force (effort) is located between the fulcrum and the resistance (load). Example: sweeping broom or ice tongs.



### **Pulley**

A pulley is another kind of simple machine. It is simply a wheel with a rope, belt or chain around it. It is used to change the direction of movement or the amount of force. Fixed pulleys only change the direction that something moves. Moveable pulleys move with the resistance forces (load) and are able to multiply the effort force we put in. Because the pulley moves too, it is able to multiply our effort and increase force. What you gain in force you lose in the distance you pull the rope. A block and tackle is a combination of fixed and moveable pulleys. It changes the direction of movement and also multiplies the effect of the effort. That is why it is used to lift heavy loads. Pulleys are used in most cranes, elevators, and exercise equipment.



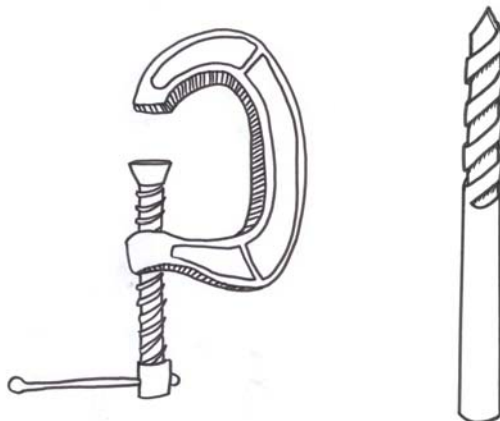
## Wheel & Axle

A wheel and axle machine results when a spinning lever rotates around a center fulcrum. The wheel is a continuous lever. The wheel is always rigidly attached to the axle. The wheel and axle is often confused with the wheels on vehicles, which is a pair of wheels and axles. In the wheel and axle machine, an effort is applied to the wheel. An attached axle turns as a result. The effort at the wheel is multiplied at the axle. The force applied at a doorknob turns around the fulcrum at the axle. The effort is multiplied at the resistance, which is the bolt and the lock. A screwdriver is also a wheel and axle machine. The handle is the wheel and the metal shaft is the axle. The head of the screw is a wheel and the shaft is an axle. Examine the mechanical pencil sharpener in your classroom. The crank handle is attached to an axle that turns a wheel geared to roller blades that sharpen the pencil. The larger the handle or wheel, the easier it is to turn the axle.



## Compound Machines

Compound machines (complex machines) are a combination of two or more simple machines put together in ways to do different kinds of work. Most of the machines used today are actually compound machines. Scissors are a compound machine, comprised of double levers, with double inclined planes on the blades. Our gyms house many compound machines made of levers, inclined planes, wheels and axles, pulleys, wedges and screws. A C-clamp and a drill bit are examples of compound machines.





# Learning Experience 1: Measuring Mass

**Objective:** Students will develop their understandings of the property of mass and that matter is anything that takes up space and has mass.

## **Materials:**

**For each group of 3 students:**

3 Nature's Forces Simple Machines

Student Activity Books

Balance base

Balance arm

Balance pole

2 baskets for balance

Pin for balance

Jar gram centimeter cubes

2 paper clips

Modeling clay

**For the class:**

Container talcum powder

## **Preparation:**

Read background information on pages 3-5. The teacher will prepare to demonstrate the assembly of the double pan balance. Demonstrate calibration of the double pan balance. Prepare two quantities of clay each with a mass of 25 grams and two quantities of clay each with a mass of 50 grams. A very small quantity of talcum powder may be used to reduce the stickiness of the clay ball. Each piece of clay should be rolled as round as possible.

## **Basic Skill Development:**

Generalizing

Inferring

Recording Data

Observing

Following Directions

Measuring

Identifying Variables

## **Evaluation Strategy:**

Students will accurately prepare a variety of clay balls of specified mass on demand.

## **Vocabulary:**

mass                      double pan balance

gram centimeter cube

*How might we use the double pan balance to measure mass and create our own measured masses?*

Student groups will begin this learning experience by discussing what they understand about mass. Take this opportunity to discuss that mass is the measure of the amount of matter in an object and that matter is anything that takes up space and has mass. The measurement of mass of an object is unaffected by gravity. Students should assemble and calibrate the double pan balance. Each basket and objects in each basket are pulled by the force of gravity. When the balance is in balance, the affect of gravity on each basket is equalized. By using known units of mass (gram centimeter cubes), an object's mass (amount of matter) may be measured. The standard unit of measure of mass is the gram or kilogram. Each group of three students should measure clay into four ball-like shapes. Students will make measured masses from clay. Two balls should have a mass of 25 grams and two a mass of 50 grams. Students should compare the two 50 gram balls with the balance. Students should compare the two 25 gram balls with one 50 gram ball. Observations should be recorded on the activity sheet for Learning Experience #1 in the Nature's Forces Simple Machines Student Activity Book. Save the clay balls from this learning experience for use in later learning experiences.

# Learning Experience 1 continued

## Page 2

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### **Discussion Questions:**

Why is it important to calibrate the double pan balance?

How did your 50 gram masses compare?

How did your 25 gram masses compare?

How did your two 25 gram masses compare with the 50 gram masses?

What do you think would happen if you compared your 50 gram mass with those from other groups of students?

Mass is a measure of what property?

## Learning Experience 2: Measuring Weight

**Objective:** Students will develop their understandings of the weight.  
Weight is a measurement of force and that weight is measured in Newtons in the metric system.

### **Materials:**

#### **For each group of 3 students:**

3 Nature's Forces Simple Machines

Student Activity Books

Spring scale

2 200 gram masses

Friction box

Double sheave pulley

Friction block

### **Preparation:**

Read background information on pages 3-5. The teacher will prepare to demonstrate the use of the spring scale to measure force.

### **Basic Skill Development:**

Generalizing

Inferring

Recording Data

Observing

Following Directions

Measuring

Identifying Variables

### **Evaluation Strategy:**

Students will measure the mass of selected objects in Newtons.

### **Vocabulary:**

mass

gravity

weight

force

spring scale

Newton

*How might we use the spring scale to measure weight?*

Student groups will begin this learning experience by discussing what they understand about mass vs. weight. Take this opportunity to discuss that weight is a measure of the gravitational pull or attractive force of one mass to another mass (generally the Earth). Weight is a measure of the force (pull) of gravity on an object. Weight is measured with a spring scale. It is a measurement of the force of gravity acting on the object and stretching the scale's spring. Direct the students to observe that the spring scale has both a Newton scale (N) and a gram (g) scale.

The spring scale is designed primarily to measure force (F). The gram scale is only an approximation of the mass of an object and is not a proper or accurate method to measure mass. Mass is generally measured with a double pan balance and utilizes measured masses for comparison.

Direct the students to measure the force acting on the objects listed on the activity sheet for Learning Experience #2 in the Nature's Forces Simple Machines Student Activity Book.

### **Discussion Questions:**

What force is stretching the spring when you weigh an object with a spring scale? If the force of gravity increased would the weight of an object increase or decrease? Why?

If the force of gravity decreased would the weight of an object increase or decrease? Why?

What is the metric unit used for force?

## Learning Experience 3: Measuring Forces

**Objective:** Students will develop their understandings of the measurement of force and that force is measured in Newtons in the metric system.

### **Materials:**

**For each group of 3 students:**

3 Nature's Forces Simple Machines

Student Activity Books

Spring scale

2 200 gram masses

Friction box

Double sheave pulley

Friction block

### **Preparation:**

Read background information on pages 3-5. The teacher will prepare to demonstrate the use of the spring scale to measure force.

### **Basic Skill Development:**

Generalizing

Inferring

Recording Data

Observing

Following Directions

Measuring

Identifying Variables

### **Evaluation Strategy:**

Students will measure the weight of selected objects in Newtons.

### **Vocabulary:**

mass

gravity

weight

force

newtons

spring scale

*How might we use the spring scale to measure force?*

Student groups will begin this unit by discussing what they understand about mass vs. weight. Take this opportunity to discuss that weight is a measure of the gravitational pull or attractive force of one mass to another mass (generally the Earth). Weight may be thought of as a measure of the force (pull) of gravity on an object. Weight is measured with a spring scale. It is a measurement of the force of gravity acting on the object and stretching the scale's spring. Direct the students to observe that the spring scale has both a Newton scale (N) and a gram (g) scale. The spring scale is designed primarily to measure force (F). The gram scale is only an approximation of the mass of an object and is not a proper or accurate method to measure mass. Mass is generally measured with a double pan balance and utilizes measured masses for comparison. Direct the students to measure the force in Newtons acting on the activity sheet for Learning Experience #3 in the Nature's Forces Simple Machines Student Activity Book.

### **Discussion Questions:**

What force is stretching the spring when you pulled objects with a spring scale?

If the force of gravity increased, would the pull needed to move the objects increase or decrease? Why?

If the force of gravity decreased, would the pull need to move the objects increase or decrease? Why?

What is the metric unit for force? Mass?

## Learning Experience 4: Force, Weight, and Mass

**Objective:** Students will explore basic units of measurement and refine their understandings force, weight, and mass.

### **Materials:**

#### **For each group of 3 students:**

3 Nature's Forces Simple Machines Student Activity Books

Spring scale  
Balance base  
Balance arm  
Balance pole  
2 baskets for balance  
Pin for balance  
Modeling clay  
2 paperclips  
2 200 gram masses  
Spring scale  
Double sheave pulley  
25 and 50 gram clay balls  
Jar gram centimeter cubes

### **Preparation:**

Read background information on pages 3-5.

### **Basic Skill Development:**

Generalizing  
Inferring  
Recording Data  
Observing  
Following Directions  
Identifying Variables

### **Evaluation Strategy:**

Students will correctly identify the appropriate units for mass, force or weight.

### **Vocabulary:**

weight  
force  
mass  
gravity  
Newtons  
pounds

*How might spring scales and the double pan balance be used to help understand force, weight, and mass?*

### **Session 1:**

Student groups will begin this learning experience by discussing what they understand about mass and weight. Take this opportunity to emphasize that mass is a measure of the amount of matter in an object and that weight is a measure of an effect of gravity on that object's matter. The measurement of mass of an object is unaffected by gravity. However, weight is directly affected. Mass is generally measured in grams or kilograms. Weight is measured in Newtons or pounds. Direct the students to inspect the spring scale and assemble and calibrate the double pan balance. Observations should be recorded on the activity sheet for Learning Experience #4 in the Nature's Forces Simple Machines Student Activity Book.

### **Discussion Questions:**

What is the difference between mass and force?  
What devices should be used to measure mass?  
What devices should be used to measure weight?  
What metric units should be used to measure mass?  
What metric units should be used to measure force (weight)?

## Learning Experience 5: Gravity – Gravity Everywhere

**Objective:** Students will explore effects of the law of gravity on the motion of falling objects.

### **Materials:**

#### **For each group of 3 students:**

3 Nature's Forces Simple Machines

Student Activity Books

Jar gram centimeter cubes

25 and 50 gram clay balls

2 paperclips

200 cm string cut from a ball of string

Balance base

Balance arm

Balance pole

2 baskets for balance

Modeling clay

Pin for balance

Flexible centimeter ruler

#### **For the class:**

Ball of string

Jar of talcum powder

### **Preparation:**

Read the background information on pages 9 and 10. The teacher will need to prepare to demonstrate to the students the assembly of the double pan balance, the zeroing or calibrating of the double pan balance, measuring mass of small quantities (25 and 50 grams) of clay with the gram centimeter cubes and rolling the measured clay into symmetrical ball. A very small quantity of talcum powder may be used to reduce the stickiness of the clay ball. Demonstrate the dropping of a clay ball from one meter in height using a measured string, how to measure the diameter of the impact mark on each ball and determine the average size of the impact to the nearest mm.

*How does gravity effect falling objects?*

After the teacher demonstration, student groups should be directed to follow the demonstrated procedures accurately. Each group of students will assemble and calibrate a double pan balance. Each group will measure out two pieces of clay, one 25 gram and one 50 gram. Each piece of clay should be rolled into a very round ball. A small amount of talcum powder may be used to reduce stickiness of each clay ball and aid rounding. The balls of clay will be dropped from various heights and the diameter of the impact mark on the clay ball recorded. The measurement of the diameter of the impact should be taken at 90 degrees to each other and the average calculated. The ball will need to be re-rounded after each trial.

Each ball will need to be dropped from the following heights- 25cm, 50 cm, 75 cm, 100 cm and 200 cm.

Note: An optional drop heights may also be used. 500 cm is suggested.

Observations should be recorded on the activity sheet for Learning Experience #5 in the Nature's Forces Simple Machines Student Activity Book.

### **Discussion Questions:**

What did your data show for the 25 gram ball?

What did your data show for the 50 gram ball?

Is there any friction acting on the ball at any time?

# Learning Experience 5 continued

## Page 2

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Momentum is the product of an objects velocity and mass.

Momentum = mass x velocity.

Each ball will experience acceleration due to gravity. Each ball will accelerate at the rate shown on the Velocity and Distance due to Acceleration by Gravity chart. Acceleration due to gravity does not depend on the mass of the object. The difference in mass of the balls of clay doe effect the acceleration of the balls

### **Basic Skill Development:**

Generalizing

Inferring

Recording Data

Observing

Following Directions

Identifying Variables

### **Evaluation Strategy:**

Students will use the Velocity and Distance due to Acceleration by Gravity chart to determine how far objects will fall in a given time or how speed of object after they have fallen, given specific times or distances.

### **Vocabulary:**

force

motion

gravity

momentum

friction

speed

velocity

impulse

What other forces might be acting on the ball?

Which ball had the greatest momentum?

What might happen to a clay ball if its mass was increased but dropped from the same height as a smaller ball?

How might a change in mass effect an object's momentum?

## Learning Experience: 6 Unseen Forces

**Objective:** Students will explore effects of some unseen forces and develop their understandings of the interactions of gravity, motion, friction, and inertia.

### **Materials:**

#### **For each group of 3 students:**

3 Nature's Forces Simple Machines

Student Activity Books

9 oz. plastic tumbler

Jar gram centimeter cubes

2 3 x 5 index cards

Index card sized 80 grit abrasive paper

Flexible centimeter ruler

Small butterfly paper binder clip

#### **For the class:**

4 pennies\*

Scissors\*

\*provided by the teacher

### **Preparation:**

Read background information on pages 3-5.

### **Session 1:**

The teacher will need to collect four pennies for each student group. Demonstrate to the student groups the following procedures. Place 30 gram centimeter cubes in a 9 oz. plastic tumbler. Place an index card on top of the tumbler with a penny placed in the center of the card. A quick flick of a finger should move the card forward leaving the penny to drop into the tumbler. Students should repeat the procedure while using one, two, three, and four pennies. Students should repeat the procedure while using the sandpaper-sized index card and one, two, three, and four pennies.

*How might gravity, motion, friction and inertia interact?*

### **Session 1:**

Student groups will begin this learning experience by discussing what they understand about gravity, motion, friction, and inertia. Gravity should be described as a force of attraction between two objects. Motion is defined as a change in position. Friction is a force that opposes motion. Inertia is the tendency of an object to remain at rest, if it is at rest. It is also the tendency to continue moving in the direction it is traveling, if it is moving.

Direct the students to follow the instruction and record their observations on the activity sheet for Learning Experience #6 in the Nature's Forces Simple Machines Student Activity Book for Session 1.

### **Discussion Questions:**

What did you observe when you used the index card and pennies?

What is your explanation for the action of the pennies in each case?

What hidden forces are at having an effect on the pennies?

### **Session 2:**

Direct the student to follow the directions in the Nature's Forces Simple Machines Student Activity Book for Session 2.

Observations should be recorded on the activity sheet for Learning Experience #6 in the Nature's Forces Simple Machines Student Activity Book.



# Learning Experience 6 continued

## Page 2

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### **Session 2:**

The teacher will need to make the penny launcher describe in the Natures' Forces Simple Machines Student Activity Book for Session 2. Demonstrate the launching of two pennies with the launcher.

### **Basic Skill Development:**

Generalizing  
Inferring  
Recording Data  
Observing  
Following Directions  
Identifying Variables

### **Evaluation Strategy:**

Students will correctly identify some of the forces that are interacting in Session 1 and Session 2.

### **Vocabulary:**

gravity  
motion  
friction  
inertia  
momentum

### **Discussion Questions:**

What did you observe when you used the penny launcher and pennies?  
What is your explanation for the action of each of the pennies?  
What hidden forces are at having an effect on the pennies?

# Learning Experience: 7 Inclined Plane

**Objective:** Students will explore principles and practical uses of inclined planes and describe factors that effect its use.

## **Materials:**

### **For each group of 3 students:**

3 Nature's Forces Simple Machines

Student Activity Books

4 plastic jars

Spring scale

String with 2 s-hooks

Double sheave pulley

Friction box

Friction block

2 5 x 8 index cards

2 200 gram masses

Incline plane with pulley

Offset base

Pole

Pole clamp

Protractor

2 #82 rubberbands

2 baskets for balance

Pin for balance

Balance arm

Modeling clay

Jar gram centimeter cubes

### **For the class:**

Box rice

String

Container salt

Meter stick\*

Water\*

\* provided by teacher

### **Preparation:**

Read background information on page 11. Assemble the pole clamp, pole, and offset base as shown in the student manual. You may want to place a book on the bottom of the offset base to prevent movement. Save the plastic jars with the items for Learning Experience #10.

*How might an inclined plane be used to make moving a heavy object easier?*

### **Session 1:**

Direct the student groups to assemble the offset base, pole, and pole clamp. Assemble the inclined plane as shown on the activity sheet for Learning Experience #7 in the Nature's Forces Simple Machines Student Activity Book. Set height of the ramp by adjusting the pole clamp. Set the angle of the ramp with the angle drawn on the index card.

Place the friction box at the base of the incline. Hook the s-hook of the spring scale to the end of the string with 2 s-hooks. Place the arrangement as shown on the activity sheet for Learning Experience #7 in the Nature's Forces Simple Machines Student Activity Book.

Record the data on the activity sheet for Learning Experience #7 in the Nature's Forces Simple Machines Student Activity Book.

### **Session 2:**

This session will use four plastic jars. Gram centimeter cubes, water, rice, and salt will need to be placed in each jar. Assemble the included plane as shown on the activity sheet for Learning Experience #7 in the Nature's Forces Simple Machines Student Activity Book.

### **Discussion Question:**

Did the data from your trials all agree? What might account for any differences?

# Learning Experience 7 continued

## Page 2

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Demonstrate the use of the protractor. Each group should draw a 10 degree angle. Use the angle drawn on the index card to set the angle of the incline plane. Repeat for 20 and 30 degrees ramp will be set at 10, 20, and 30 degrees for Session 2. Ramp will be set at 20 degrees for Session 3.

**Basic Skill Development:**

Generalizing  
Inferring  
Recording Data  
Observing  
Following Directions  
Identifying Variables

**Evaluation Strategy:**

Students will correctly identify some of the forces that are interacting in Session 1 and Session 2.

**Vocabulary:**

inclined plane  
ramp  
slope  
steep  
friction  
force  
angle

Did your trials agree with the other groups? Why or why not?  
What effect did the angle of the inclined plane have on the amount of effort needed to move the friction box and the friction block?

## Learning Experience 8: Wedge

**Objective:** Students will explore principle and practical uses of wedges, and describe factors that effect its use.

### **Materials:**

**For each group of 3 students:**  
3 Nature's Forces Simple Machines Student Activity Books

### **For the class:**

Offset base  
Pole  
Pole clamp  
Wedge handle  
3 wedges  
Modeling clay

### **Preparation:**

Read background information on page 11. A wedge is a simple machine that is used to spread an object apart or to raise an object. Cutting tools generally contain a wedge. This learning experience begins with a demonstration. Set the pole clamp at the height of 8 cm to the center of the pole rod. Place the handle on the rod. Place the sharpest wedge on the handle. Role a piece of clay about 2 cm in diameter and about 10 cm long. Place a handle on the pole rod. Align the handle and wedge with the clay cylinder. Lift the handle vertical and let go of the handle.

### **Basic Skill Development:**

Generalizing  
Inferring  
Recording Data  
Observing  
Following Directions  
Identifying Variables

### **Evaluation Strategy:**

The student should draw three simple machines that uses a wedge.

### **Vocabulary:**

wedge  
inclined plane  
friction

*How might a wedge be used to make work easier? How does a wedge decrease the amount of force needed to penetrate a substance?*

### **Session 1:**

After the teacher demonstration, student groups should take turns in repeating the demonstration. Observations should be recorded on the activity sheet for Learning Experience #8 in the Nature's Forces Simple Machines Student Activity Book.

### **Discussion Questions:**

Which wooden block is easier to push into the sand?  
Why do you think that is so?  
How is a wedge like an inclined plane?  
What are some tools that use a wedge?  
How are tools used that have a wedge?  
How might friction affect a wedge?  
How could a wedge be changed to make it easier to use?

# Learning Experience 9: Screws

**Objective:** Students will develop an understanding of the screw as an inclined plane.

## **Materials:**

### **For each group of 3 students:**

3 Nature's Forces Simple Machines

Student Activity Books

Machine screw

Wood screw

Flexible centimeter ruler

Scissors\*

Tape\*

Crayons or colored pencils\*

Copy paper\*

Pencils\*

### **For the class:**

Course machine bolt

Fine machine bolt

\*provided by teacher

## **Preparation:**

Read background information on page 12. Students will need instructions in making the triangles required for this learning experience. Depending on your groups, you may want to precut 5 x 10 cm and 5 x 20 cm paper strips, one strip for each student.

## **Basic Skill Development:**

Generalizing

Inferring

Observing

Following Directions

Measuring

## **Evaluation Strategy:**

The students should compare the machine screws and the wood screws. Compare the threads with the fine screw and course screw.

## **Vocabulary:**

inclined plane

thread

pitch

slope

steep

diagonal

coarse

fine

friction

*How is a screw like an inclined plane?*

## **Session 1:**

Provide each group of students with a wood screw and a machine screw that have different pitches. Direct the students to observe the characteristics of each screw. Students should find the similarities and differences between each screw.

## **Discussion Questions:**

How is each screw similar?

How is each screw different?

How might each screw be used?

Provide each group of students access to copy paper. Instruct each group to measure a rectangle 5 x 10 cm. Draw a slanted diagonal line that forms two identical triangles on the 5 x 10 cm rectangle. Color both the edges of the diagonal line. The colored edge is also the edge of an inclined plane. Follow the pictures in the activity sheet for Learning Experience #9 in the Nature's Forces Simple Machines Student Activity Book. Cut and wrap the triangle around a pencil. Carefully tape the rolled up triangle and remove the pencil. Instruct each group to measure a rectangle 5 x 20 cm and repeat the process. Compare the two circular inclined planes.

## **Discussion Questions:**

What does the colored edge represent?

Which distance is greater, the height of your circular inclined plane or the spiraled distance around the rolled paper?

# Learning Experience 9: continued

## Page 2

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### **Session 2:**

Show the students the large bolts and nuts provided in the kit. Explain that they have a different number of threads and therefore a different pitch. Explain that these two bolts have different advantages. They will investigate to find out more about them.

Direct the students to cut five strips of copy paper 2 cm wide. Join two strips with tape end to end. Join the three other strips end to end. The distance around the bolts is 6 cm. The number of times the thread wraps around the coarse bolt is eight times. Mark off 8 – 6 cm distances of the shorter strip of paper. Draw the diagonal line as shown on the activity sheet for Learning Experience #9 in the Nature's Forces Simple Machines Student Activity Book. Cut on the diagonal line as done in Session 1.

Repeat the process in reference to the fine thread bolt. The number of times the thread wraps around the fine threaded bolt is thirteen times. Mark off 13-6 cm distances on the long strip of paper. Draw the diagonal line and cut on the diagonal line. Compare a strip from the first sample (coarse thread) with the second (fine thread).

### **Discussion Questions:**

Which strip of cut paper is longer?

Which bolt does it represent?

Which strip has the longest incline?

Which bolt must be turned more times to tighten it?

Which bolt should require less force to move it?

Which bolt could be tightened with the fewest number of turns?

How, when and why would a screw be preferred to a nail?

# Learning Experience 10: Levers

**Objective:** Students will explore principle and practical uses of levers, and describe factors that effect its use.

**Materials:**

**For each group of 3 students:**

3 Nature's Forces Simple Machines

Student Activity Books

Wood lever

Wood fulcrum

4 plastic jars w/items

Modeling clay

**Preparation:**

Read background information on pages 12-14. Review that a first class lever can consist of a rigid bar resting on a fixed pivot point (fulcrum) and makes work easier.

The teacher will demonstrate the use of a first class lever. Set up the wooden lever with the fulcrum at the mid-point. Calibrate the lever to balance as close as possible with clay. Ask the students to record all their observations on the activity sheet for Learning Experience #10 in the Nature's Forces Simple Machines Student Activity Book.

**Basic Skill Development:**

Generalizing

Inferring

Recording Data

Observing

Following Directions

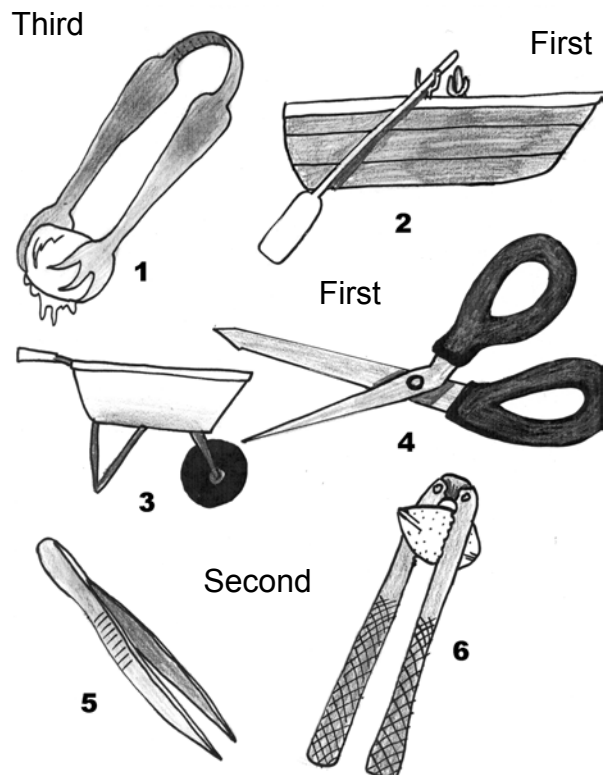
Identifying Variables

*How might levers be used to make work easier?*

Student groups should observe the movement of the load and force applied to the lever. Observations should be recorded on the activity sheet for Learning Experience #10 in the Nature's Forces Simple Machines Student Activity Book.

**Discussion Questions:**

What did you observe about how far the load moved on the resistance arm?  
What did you observe about how far the force moved the effort arm?  
Why did the load move in this manner?



Third

Second

# Learning Experience 10 continued

## Page 2

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**Evaluation Strategy:**

The students should answer the questions to each session and identify the class of levers shown in the drawing on page 6 in the Nature's Forces Simple Machines Student Activity Book.

**Vocabulary:**

lever  
effort  
resistance arm  
fulcrum  
load  
effort arm  
resistance arm  
mechanical advantage



# Learning Experience 11: Pulleys

**Objective:** Students will explore principles and practical uses of pulleys and a block and tackle, and describe factors that effect their use.

## **Materials:**

**For each group of 3 students:**

3 Nature's Forces Simple Machines

Student Activity Books

2 200 gram masses

Double sheave pulley

Triple sheave pulley

2 meter ribbon

Pole

Pole clamp

Offset base

Small butterfly paper binder clip

Spring scale

2 s hooks

## **Preparation:**

Read background information on page 14.

The teacher will need to arrange the ribbon on the pulley system as illustrated

on the activity sheet for Learning

Experience #11 in the Nature's Forces

Simple Machines Student Activity Book.

## **Vocabulary:**

block and tackle

double sheave pulley

triple sheave pulley

mechanical advantage

*How might pulleys or a block and tackle be used to make work easier?*

## **Session 1:**

The teacher will demonstrate the pulley system setup. Demonstrate the setup of the pole clamp, pole, and offset base. A book should be placed on the offset base to stabilize it. Observations should be recorded on the activity sheet for Learning Experience #11 in the Nature's Forces Simple Machines Student Activity Book.

## **Discussion Questions:**

Was there a difference in the force needed to move the 200 gram mass when using the pulley system?

Was there a difference in the speed that the 200 gram mass traveled when comparing the effort and the resistance?

Was there a difference in the distance that the 200 gram mass traveled when comparing the effort and the resistance?

## Learning Experience 12: Wheel & Axle

**Objective:** Students will explore principles and practical uses of wheel and axle, and describe factors that effect its use.

### **Materials:**

#### **For each group of 3 students:**

3 Nature's Forces Simple Machines

Student Activity Books

Flexible centimeter ruler

Scissors\*

Copy paper\*

#### **For the class:**

Course machine bolt

Fine machine bolt

\*provided by teacher

### **Preparation:**

Read background information on page 15. Depending on your groups, you may want to precut 1 x 25 cm paper strips, one strip for each student.

A wheel and axle machine results when a spinning lever (a wheel) rotates around a center fulcrum. This movement forms a continuous lever. The wheel is always rigidly attached to the axle. This learning experience begins with a teacher demonstration. Demonstrate by turning the head of the large coarse or fine machine bolt used in Learning Experience #12. Have a student resist the motion by having a student hold the body of the bolt (axle) tightly. The teacher then turns the bolt head (wheel). The large coarse or fine machine bolt should be passed to each group and students should repeat the demonstration themselves.

### **Basic Skill Development:**

Following Directions

Measuring

Comparing

Generalizing

Decision Making

*How might a wheel and axle be used to make work easier?*

Direct the students to observe illustrations of wheel and axle machines on their activity sheets for Learning Experience #12 in the Nature's Forces Simple Machines Student Activity Book.

Provide the students with the paper strips to determine the distance that the bolt head (wheel) or the bolt (axle) moves in one rotation.

Provide each group of students access to copy paper. Direct the student to cut 1 x 30 cm strips for each student. Wrap a strip around the axle and cut the paper to that distance. Wrap a strip around the wheel and cut the paper to that distance. Measure the two strips and record the data on the activity sheet for Learning Experience #12 in the Nature's Forces Simple Machines Student Activity Book.

### **Discussion Questions:**

How did the two paper strips compare?  
What do the two paper strips represent?  
How is a wheel and axle like a lever?  
What are some tools that use a wheel and axle?

# Learning Experience 12 continued

## Page 2

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**Evaluation Strategy:**

The student should list three examples of wheel and axle machines, identify the wheel and the axle in each case and describe how the system works.

**Vocabulary:**

wheel  
axle  
lever

How are tools used that have a wheel and axle?

How could a wheel and axle be changed to make it easier to use?

Name: \_\_\_\_\_

Date: \_\_\_\_\_

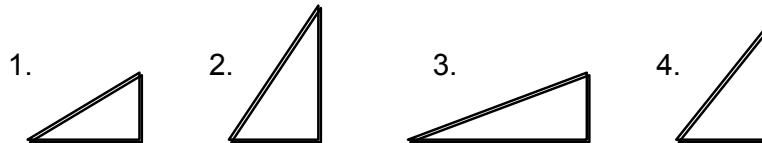
**Natures Forces Simple Machines Student Assessment**

Directions: Read the question carefully and answer based on your knowledge about natures forces simple machines. Place the correct number in the space provided.

\_\_\_\_\_ 1. What is the force of attraction between any 2 objects?  
1. Friction                      2. Inertia                      3. Gravity                      4. Motion

\_\_\_\_\_ 2. An object that is sitting there (at rest) stays there. This is called  
1. Friction                      2. Inertia                      3. Gravity                      4. Motion

\_\_\_\_\_ 3. Which inclined plane would need more force to pull an object up?



\_\_\_\_\_ 4. A doorknob is what kind of simple machine?  
1. lever                      2. pulley                      3. wedge                      4. wheel & axle

\_\_\_\_\_ 5. Which of the following simple machines is a lever?  
1. wheel barrow                      2. Scissors                      3. Hammer                      4. All of these

\_\_\_\_\_ 6. Look at the picture of the see saw below. It is a first class lever.

What is the part called that the arrow is pointing to?



1. The resistance                      2. The effort                      3. The fulcrum

\_\_\_\_\_ 7. What unit do we measure metric mass in?  
1. meter                      2. liter                      3. degree                      4. gram

\_\_\_\_\_ 8. If you were to go into space, which of the following would not change?  
1. mass                      2. weight                      3. gravity                      4. friction

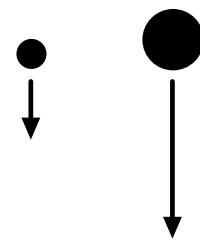
\_\_\_\_\_ 9. When you stand on the scales, what force affects your weight?  
1. Friction                      2. Inertia                      3. Gravity                      4. Motion

- \_\_\_\_\_ 10. If you push on a wall and you and the wall isn't moving, which statement is true?
1. The wall is pushing with more force than you
  2. The wall is pushing with less force than you
  3. The wall is pushing with the same force as you
  4. The wall doesn't push at all

11-12. Here is a drawing of 2 objects. The more mass the object has, the greater the attraction of gravity.

10                      100

11. Which object would weigh the most?  
Explain your answer using the word gravity.



12. If there is less gravity would you need more or less force to lift it? Explain your answer.

Use the following drawings to answer the next 2 questions. The drawings represent a box sitting on a table.

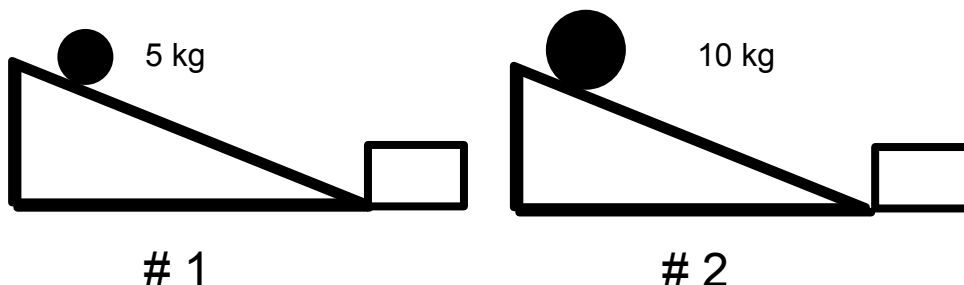


13. Which of the boxes would have the greatest friction? Explain your answer.

14. What would happen to the friction if you put wheels on the boxes?

Use the following drawings for the next 2 questions.

The following experiment has the same inclined plane, a ball going down it and a box at the bottom that the ball hits and moves.



15. Which ball will move the box farthest? Why?

16. Which ball will have the most momentum? Why?

17. You have learned about Gravity and Friction. Think about riding your bicycle. Write a sentence that tells how gravity and friction help make your bike work?

18. Which would have momentum, a school bus or a car if both are going the same speed? Explain your answer!

19. This is a hard question... think about it!

If there were no wind pushing up, which object would fall the fastest if dropped....

A penny or a brick? Explain your answer.

20. You are going to do an experiment to see if friction is greater when you rub a block with sand paper or with a crayon.

What would be your educated guess (hypothesis) about the answer?

What are two steps you could take to find the answer?

## Nature's Forces and Simple Machines Assessment Key

1. gravity (3)
2. inertia (2)
3. 2
4. wheel and axle (4)
5. all of these (4)
6. Fulcrum (3)
7. Gram (4)
8. mass (1)
9. gravity (3)
10. the wall is pushing with the same force as you (3)
11. the ball with a mass of 100 g. The ball with the greater mass has more gravity, so it also has more weight.
12. less gravity means less force is needed
13. 30 kilograms – more force is pushing down
14. there would be less friction
15. #2 – the ball has more mass, therefore more momentum and inertia, and it is harder to stop, so it will go farther
16. #2 – it will have more momentum because it has more mass
17. a variety of answers are possible: for example: friction keeps my tires on the road and gravity holds me down to Earth
18. The truck would have more momentum because of its greater mass
19. Both objects would fall at the same time, because gravity pulls on everything at the same rate.
20. The sand paper would provide more friction  
The steps to find the answer would vary

## MORE IDEAS

### Language Arts

- ◆ Have students pick one of the simple machines and write a Haiku poem about it.
- ◆ Have students write a paragraph about an activity being done from the point of view of one of the simple machines.
- ◆ (Dictionary Activity) – Choose several words from the Glossary. Ask students to locate each of the words in a dictionary. For each word, the students should write the page where they found the word, guide words on that page, write word in syllables, write respelling, write one definition of the word and write an original sentence using the word.
- ◆ After sharing with your class The Best of Rube Goldberg's Inventions, compiled by Charles Keller, have the students invent a wild machine using the Goldberg formula and simple machines.
- ◆ (Sequencing) – Have students list step by step the commands for screwing in a screw. (i.e. Step 1 – take screwdriver in hand. Step 2 – pick up screw, etc.)
- ◆ (Categorizing) Have students cut out and bring in magazine pictures of items made up of simple machines and glue them on a large piece of oak tag under proper column.

### Book Suggestions:

Book suggestions:.. The Simple Facts of Simple Machines by Carol Barkin & Elizabeth James ISBN 0-688-41685-3

Simple Machines and How They Work by Elizabeth N. Sharp

Science For The Elementary School by Edward Victor ISBN 0-02-422861-3

Machines and How They Work by Harvey Weiss

Ardley, N. (1995). How things work. New York: Montreal: Reader's Digest. ISBN 089577-694-4

Baker, W. & H. (1994). Machines: Make it work. New York: Scholastic. ISBN 0-590-20587-0

Butzow, C. & Butzow, J. (1989). Science through children's literature. Colorado: Teacher Ideas Press. ISBN 0-87287667-5

Dunn, A. (1993). How things work: Wheels at work. England: Wayland. ISBN 1-56847-014-2

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Hirsch, E.D. Jr. (1991). What your second grader needs to know. New York: Double Day. ISBN 0-385-41116-2

Horvatic, A. (1989). Simple machines. New York: Dutton. ISBN 0-525-44492-0

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Hutchins, J & Zike, D. (1982). Simple tools and machines: Science pocket. Oak Lawn, IL. Ideal.

Kalman, B. (1992). Historic communities: Tools and gardens. Canada: Crabtree.

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Seller, M. Wheels pulleys and levers. New York: Gloucester. ISBN 0-531-17420-4

Sharp, E. (1959). Simple machines and how they work. New York: Random House.

Skelly, J. R. & Zim, H. S. (1969). Machines tools. New York: Morrow.

VanCleave, J. (1993). Machines mind-boggling experiments you can turn into science fair projects. New York: Wiley. ISBN 0-471-57108-3

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Wiessenthal, E. & Wiessenthal, T. (1969). Let's find out about tools. New York: Franklin.

## **Art**

- ◆ Draw a picture of a simple machine.

## **Social Studies**

- ◆ Describe different simple machines that were used during the construction of the Erie Canal.
- ◆ If any students have old tools, have them bring them in and discuss the simple machines they are made of.

## **Math**

- ◆ Make up word problems involving work.  $Work = Force \times Distance$ .

## **Science**

- ◆ Do experiments in science using simple machines.

## **INQUIRY AND PROCESS SKILLS**

Classifying	Arranging or distributing objects, events, or information in classes according to some method or system.
Communication	Giving oral and written explanations or graphic representations of observations.
Creating Models	Displaying information by means of graphic illustrations or other multi-sensory representations.
Formulating Hypothesis	Constructing a proposition or assumption of what is thought likely to be true based on reasoning, which serves as a tentative testable theory.
Gathering & Organizing	Collecting information about objects and events which show a specific situation.
Generalizing	Drawing general conclusions from information.
Identifying Variables	Recognizing the characteristics of objects or events which are constant or change under different conditions.
Inferring	Making a statement or conclusion based on reasoning or prior experience to explain an observation.
Interpreting Data	Analyzing information that has been collected and organized by describing apparent patterns or relationships in the information.
Making Decisions	Choosing an alternative from among several and basing the judgment on defensible reasons.
Manipulating Materials	Handling or treating materials, equipment or procedures skillfully and effectively.
Measuring	Making quantitative observations by comparing to a standard.
Observing	Becoming aware of an object or even by using any of the senses to identify properties.
Predicting	Making a forecast or estimate of what future events or conditions may occur.

## GLOSSARY

Acceleration	any increase in the speed
Action	an external force (the action) that is applied to a body and that is counteracted by an equal force in the opposite direction (the reaction).
Axle	a rod or shaft on which a wheel turns.
Block and Tackle	a combination of fixed and movable pulleys used together.
Compound Machine	a machine made up of two or more simple machines.
Distance	the space between two objects or a measure of a change in position.
Efficiency	the amount of work done by a machine compared to the amount of work put into it.
Effort Arm	on a lever, the distance from the force to the fulcrum.
Energy	the ability to do work.
Equal	of the same quality, value, degree, or intensity.
Fixed Pulley	a pulley that stays in place as the load moves.
Force	a push or a pull.
Friction	a force that slows the motion of two objects rubbing against each other.
Fulcrum	the turning point of lever.
Gravity	the natural attraction that tends to draw bodies together. Ex. Bodies are drawn toward the center of the earth.
Inclined Plane	a slanted surface that connects one level to a higher level. A simple machine.
Increase	to become greater in amount, size, degree.

Inertia	the property of a material body, due to its mass, by which it resists any change in its motion unless it is overcome by force. Thus if no outside forces are present, a stationary body will remain at rest and a moving body will continue to move in the same direction at the same speed.
Lever	a bar or rod resting on a turning point or fulcrum A simple machine.
Load	object to be moved or lifted by a lever.
Machine	anything that makes work easier.
Magnetism	the properties of attraction possessed by magnets.
Mass	the amount of matter in an object
Mechanical Advantage	the work produced by the machine, divided by the force applied to it.
Movable Pulley	a pulley that moves with the load.
Multiple	having or consisting of many parts.
Pitch	the distance between two threads in a screw.
Position	the location of an object.
Predict	what one believes will happen.
Pulley	(fixed, movable) a wheel with a rope moving around it. A simple machine.
Reaction	an external force (the action) that is applied to a body and that is counteracted by an equal force in the opposite direction (the reaction).
Reduce	to lessen in any way, as in size, weight, amount, value.
Resistance	the opposition of a thing to movement by a force.
Resistance Arm	the distance from the fulcrum to the point where the resistance is exerted or lifted (load arm).

Screw	an inclined plane that winds around a central core or shaft. A simple machine.
Shaft	the rod or axle of the wheel and axle.
Simple Machine	one of six devices used to make work easier, faster or possible with the given force. Simple machines never produce more work than is put into them.
Slope	any inclined line, surface position; slant.
Spiral	circling around a central shaft.
Steep	sharpness of rise or slope.
System	a group of things that act together.
Threads	the spiral ridges of the screw.
Unequal	not the same quality, degree or value.
Wedge	two inclined planes back to back. A simple machine.
Wind	air that is in motion
Wheel and Axle	a machine in which a wheel turns a rod or shaft
Work	what is done when a force moves an object.

## **TEACHER REFERENCES**

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Zubrowski, B. (1986). Wheels at work. N.Y.: William Morrow. A Boston Children's Museum activity book--directions on building simple wheel devices with inexpensive materials.

### **Media Library**

Call the media library to order media materials and to check on new materials that are available. The number to be reached is (716) 376-8212.

**Web Sites**

<http://www.mos.org/sln/Leonardo/LeoHomePage.html> - Leonardo da Vinci

<http://www.ed.uri.edu/SMART96/ELEMSC/SMARTmachines/machine.html>

<http://www.galaxy.net/~k12/machines/index.shtml>

<http://viking.stark.k12.oh.us/~greentown/simpmach.htm>

<http://www.ed.uri.edu/SMART96/ELEMSC/SMARTmachines/machine.html#OVERVIEW>