What Is This Module About?

Imagine what life would be like without the various means of transportation at present. How would you reach far places then? Look at what you are wearing. How is cloth made into the clothes you wear every day? Have you ever wondered how products like shampoos, detergents and so many others that you use at home are produced? What do the producers of these products use to make them in great volumes? How are heavy objects like sacks of rice, cement, etc. transported from one place to another quickly?

This module will tell you all about these and more. It has three lessons. These are:

Lesson 1 – *What Is Work?*

Lesson 2 – *Simple Machines*

Lesson 3 – *How Do Machines Help Us Do Work?*

What Will You Learn From This Module?

After studying this module, you should be able to:

- define what work is in scientific terms;
- identify tools you use at home and in workplaces;
- explain how simple machines help us do work;
- demonstrate how simple machines help make work easier;
- identify the advantages of using machines; and
- determine and evaluate the efficiency of simple machines.

Let's See What You Already Know

Before you continue reading this module, answer first the following questions to determine how much you already know about the topics.

Choose the letter of the best answer:

1. Which of the following is considered work in a scientific sense?
   a. closing the door
   b. lifting an object
   c. climbing up a flight of stairs
   d. all of the above

2. Which of the following is a unit of work?
   a. newton-meter
   b. newton/meter
   c. joule/second
   d. kilowatt

3. How much work is done in raising a 5-kilogram (kg) load to a height of 1 meter (m)?
   a. 0.5 joule
   b. 5 joules
   c. 6 joules
   d. 50 joules

4. Which of the following can a machine not do?
   a. multiply force
   b. multiply speed
   c. transform energy
   d. produce energy

5. Which of the following are the most basic types of machines?
   a. lever and screw
   b. lever and wheel and axle
   c. lever and inclined plane
   d. screw and pulley

6. Which of the following is **not** a wedge?
   a. chisel
   b. jackscrew
   c. nail
   d. knife

7. Which of the following is a lever?
    a. screw
    b. Ferris wheel
    c. ax
    d. tooth
8. The work done by a machine is 80 joules while the work done on the machine is 92 joules. What is the efficiency of the machine?
    a. 72%
    b. 87%
    c. 90%
    d. 111%
9. The work done by a machine is 50 joules while the work done on the machine is 65 joules. What is the efficiency of the machine?
    a. 50%
    b. 65%
    c. 77%
    d. 87%
10. A machine is 90% efficient. The work done by the machine is 83 joules, what is the amount of work done on the machine?
    a. 91 joules
    b. 82 joules
    c. 29 joules
    d. 28 joules

Well, how was it? Do you think you fared well? Compare your answers with those in the *Answer Key* on pages 36 and 37 to find out.

If all your answers are correct, very good! This shows that you already know much about the topics in this module. You may still study the module to review what you already know. Who knows, you might learn a few more new things as well.

If you got a low score, don't feel bad. This means that this module is for you. It will help you understand some important concepts that you can apply in your daily life. If you study this module carefully, you will learn the answers to all the items in the test and a lot more! Are you ready?

You may go now to the next page to begin Leson 1.

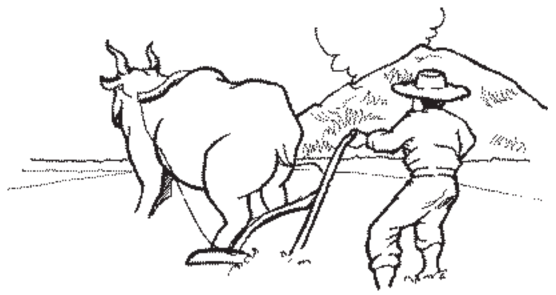
What Is Work?

To many people, the word **work** has several meanings. People consider earning a living as work. But in physics, the word has a specific meaning. It is used to describe what is accomplished by the action of a force when it acts on an object as the object moves through a distance.

In this lesson, you will learn more about the meaning of work as used in physics.

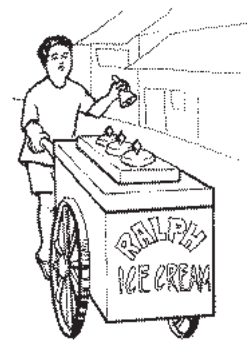
Let's Study and Analyze

Below are pictures of some common jobs in a community. Study them very well then answer the questions that follow.



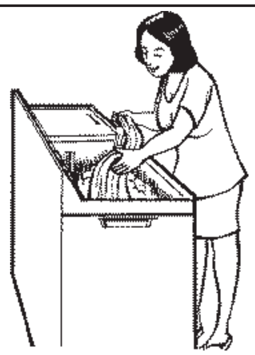
Farmer plowing the field

A



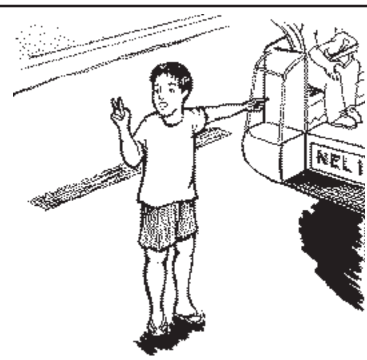
Sorbetero selling ice cream

B



Laundry woman doing the laundry

C



Barker calling out to jeepney passengers

D

Balut vendor selling a basketful of balut

E

Carpenter hammering a nail onto the wall

F

Let’s Review

1. Who among the people in “Let’s Study and Analyze” are doing work?

2. Do your father and mother work? Do you work? Why do you say so?

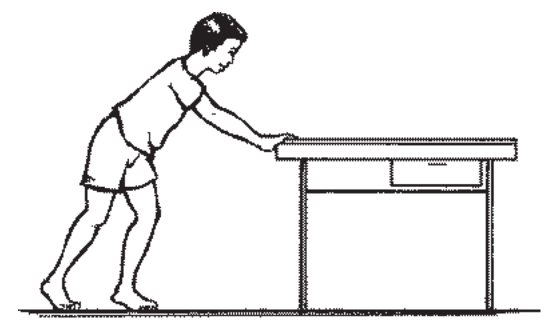
The answers to this activity may vary. Just consult your Instructional Manager or Facilitator if you are not sure of your answers.

Let's Think About This

Everyone in the pictures can be considered working in a general sense. But can their activities actually be considered work as defined in physics?

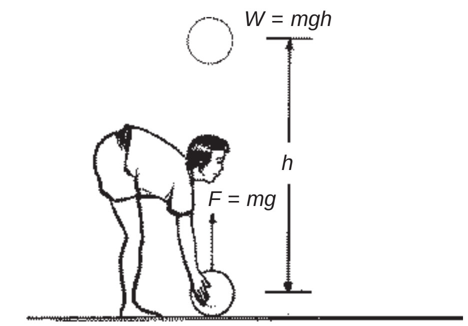
Let's Learn

The balut vendor, sorbetero, farmer, carpenter and laundry woman earn a living from what they do. But not all of them do work as defined in physics. Find out more about what work is in the following situations.



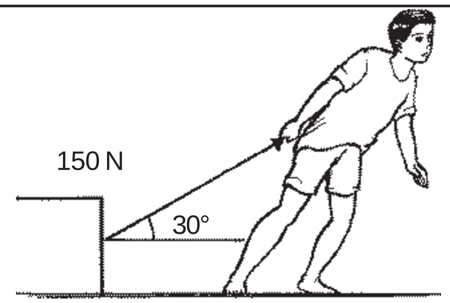
A table is being pushed.

A



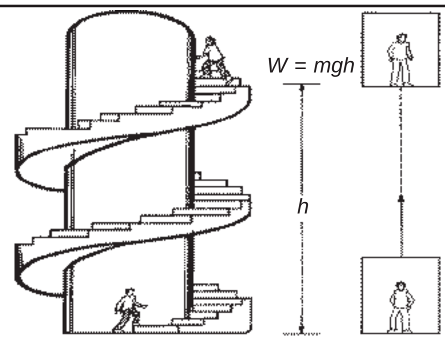
An object is being lifted.

B



A box is being pulled.

C



A man is going up the stairs.

D

Let’s Study and Analyze

A. Study Picture A, then answer the questions that follow.

1. Describe what is being done to the table. Do you think the table is moving?

2. To what direction is the table being moved? How do you compare this to the direction of the push?

3. Is work done on the object?

B. Study Picture B on the previous page, then answer the questions that follow.

1. What is being done to the object?

2. Do you think the object covered a distance? Compare the direction in which the object moved to the direction of the pull.

3. Was work done in the situation? Explain your answer.

C. Study Picture C. Answer the questions that follow.

1. What happened to the box as it was pulled diagonally?

2. Has work been done in this situation?

D. How does Picture differ from Pictures A and B?

____

____

Compare your answers with those in the *Answer Key* on page 37. Did you get all the answers right? If you did, that's very good! If you didn't, don't worry. Just review the parts you made mistakes in before going to the next part of the lesson.

Let's Learn

In physics, **work** is done when a force acts upon an object, causing a displacement. A **displacement** is the shortest straight line from a starting point to the end point. In order for a force to do work on an object, the force must cause the object to move or the object must be displaced. **Work,** then, is defined as the product of the magnitude of the displacement and the component of the force parallel to the displacement. In equation form, work is written as:

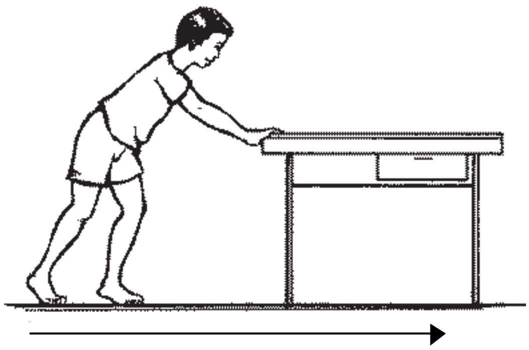
$$W = Fd\cos\theta$$

where F is the magnitude of the constant force

d is the magnitude of the displacement of the object

θ is the angle between the direction of the force and the displacement

Let us study the situation in which the motion and the force are in the same direction. Look at A again below.



A table is being pushed.

Since the force and the motion are in the same direction, $\theta = 0$ and $\cos\theta = 1$. The equation for work is:

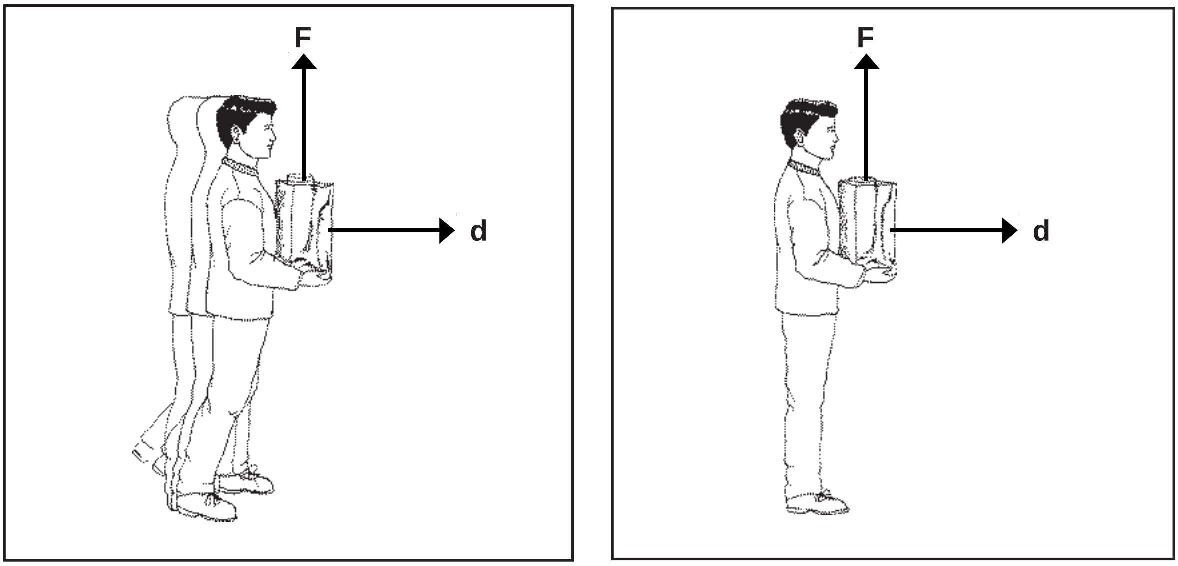
$$\begin{aligned} W &= F \times d \times \cos\theta, \text{ but } \cos\theta = 1 \\ \text{so } W &= F \times d \times 1 \\ &= F \times d \end{aligned}$$

To illustrate, the table in Picture A was pushed at a distance of 0.5 m by a force of 30 N exerted by the man. The work done on the table is 30 N × 0.5 = 15 newton-meters.

Work is measured in newton-meters. A special name is given to this unit, the joule (J).

1 joule = 1 newton-meter

A force can be exerted on an object, yet it cannot be defined as work. An example is when you carry a bag of groceries in your hands which are at rest (see Picture B below). A force is exerted, but the displacement is 0, so no work is done. You also do not do work on the bag of groceries as you carry it even if you walk horizontally across the floor at a constant velocity (see Picture A below).



A B

In Picture A, no horizontal force is required to move the package at a constant velocity. However, you do exert an upward force F on the package equal to its weight. But this upward force is perpendicular to the horizontal motion of the package and therefore has nothing to do with that motion. Hence, the upward force is doing no work.

Applying the equation of work, which is

$$\begin{aligned} W &= F \times d \times \cos\theta \\ &= 0, \text{ since } \theta = 90° \text{ and } \cos 90° = 0 \\ \text{so } W &= F \times d \times 0 = 0 \end{aligned}$$

This means that when a particular force is perpendicular to the motion, no work is done by that force.

Let’s Review

Read the following statements and determine whether or not they represent examples of work. Check those that are considered work and cross out those that are not. Give explanations for your answers.

Statement	Answer With Explanation
A teacher applies a force to a wall and becomes exhausted.	
A book falls off a table and falls to the ground.	
A waiter carries a tray full of food above his head with one arm while moving across the room.	
A rocket accelerates through space.	

Compare your answers with those in the *Answer Key* on pages 37 and 38. Did you get all the answers right? If you did, that’s very good! If you didn’t, don’t worry. Just review the parts you made mistakes in before going to the next part of the lesson.

Let’s Learn

Now that you have learned what work is, you can now study how to compute for the amount of work done by a person.

Recall the formula given earlier for work:

$W = F \times d \times \cos\theta$

Solve for the amount of work done in the following problems.

EXAMPLE 1

An object was pushed with a constant force of 500 N and moved a distance of 2 m. How much work was done in moving the object?

Given: F = 500 N

d = 2 m

θ = 0° (because the force vector and the displacement vector were in the same direction)

Unknown: $W = ?$

Solution:

$$W = F \times d \times \cos \theta$$
$$W = 500 \text{ N} \times 2 \text{ m} \times \cos 0°$$
$$W = 1000 \text{ N}\cdot\text{m} \times 1$$
$$W = 1000 \text{ N}\cdot\text{m or } 1000 \text{ J}$$

Final Answer: $W = 1000$ J

Note: In problems such as this wherein the force vector and the displacement vector are in the same direction, you can just use the following formula: $W = F \times d$ since cos 0° is always equal to 1 and any number multiplied by 1 will always be equal to itself.

EXAMPLE 2

A 2-kg object is lifted to a height of 1.5 m. How much work was done in lifting the object?

Given:

$m = 2$ kg (mass of the object)
$d = 1.5$ m

Unknown:

$F = ?$
$W = ?$

Note: In solving for F in problems such as this one, you should always remember that **weight** is equal to **force.** And that weight or $w = m \times 9.8$ meters per second squared (m/s^2), wherein 9.8 m/s^2 is a constant denoting the **acceleration due to gravity** or the acceleration that acts on all objects that fall within the earth's gravitational field. As an object falls, gravity pulls it to the earth at a rate of 9.8 m/s^2. That is, for every second that an object falls, its speed increases by 9.8 m/s^2.

Solution:

$$w = m \times 9.8 \text{ m/s}^2$$
$$w = 2 \text{ kg} \times 9.8 \text{ m/s}^2$$
$$w = 19.6 \text{ kg}\cdot\text{m/s}^2 \text{ or } 19.6 \text{ N}$$

$$F = w$$
$$F = 19.6 \text{ N}$$

$$W = F \times d$$
$$W = 19.6 \text{ N} \times 1.5 \text{ m}$$
$$W = 29.4 \text{ N}\cdot\text{m or } 29.4 \text{ J}$$

Final Answer: $W = 29.4$ J

Let’s Try This

Answer the word problems below following the same procedure we used in the examples earlier.

1. How much work is actually done in pushing a box through a distance of 1.2 m along the floor with a force of 200 N?

   Given:

   Unknown:

   Solution:

   Final Answer:

2. If your father raises a hammer that has a mass of 2 kg at a distance of 0.5 m to push a nail onto a piece of wood, how much work does he actually do each time in lifting the hammer?

   Given:

   Unknown:

   Solution:

   Final Answer:

Compare your answers with those in the *Answer Key* on page 38. Did you get all the answers right? If you did, that's very good! If you didn't, don't worry. Just review the parts you made mistakes in before going to the next part of the lesson.

Let's See What You Have Learned

A. Write **T** if the statement is true and **F** if it is false.

_____ 1. Work is done on an object whenever it is pulled or pushed.

_____ 2. Work as in "performing one's job" is the same as work as defined in physics.

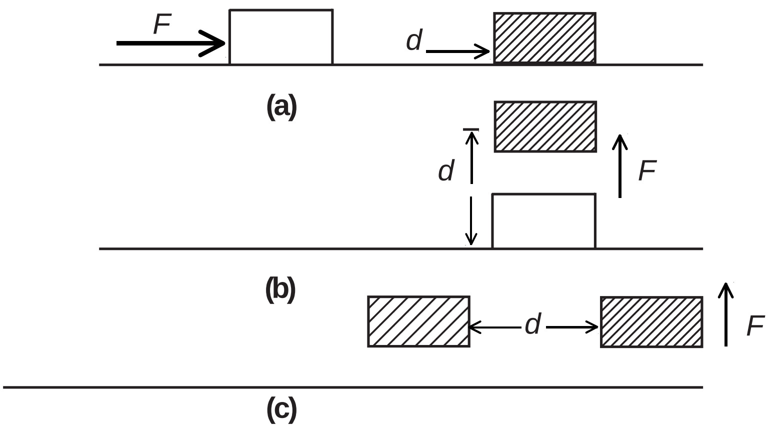
_____ 3. Work is done when pushing a wall.

_____ 4. Work is done if a person lifts a book from a table onto a shelf.

_____ 5. Work is done on a body only if a pull or push moves it through a distance along the direction of the pull or push.

B. Read the given problem and study the diagrams, then answer the questions that follow.

A box weighing 10 N is pushed along the floor with a force of 200 N moving it a distance of 0.5 m. Then it is lifted up a distance of 0.3 m from the floor. The box is then carried across to a distance of 2 m.



1. How much work is done in pushing the box on the floor?

____

____

2. How much work is done in lifting the box to a height of 0.3 m?

____

____

3. How much work is done in carrying the box through a distance of 2 m?

____

____

Compare your answers with those in the *Answer Key* on pages 38 and 39. Did you get all the answers right? If you did, that's very good! If you didn't, don't worry. Just review the parts you made mistakes in before going to the next lesson.

Let's Remember

- Work is defined as the product of the magnitude of the displacement and the component of the force parallel to the displacement. In equation, it is written as:

$$W = Fd \cos \theta$$

where F is the magnitude of the constant force

d is the magnitude of the displacement of the object

θ is the angle between the directions of the force and the displacement

- Work is measured in newton-meters and is given a special name, joule (J). 1 joule = 1 newton-meter.
- The acceleration due to gravity is the acceleration that acts on all objects that fall within the earth's gravitational field. It is equal to 9.8 m/s^2.
- The force acting on a free-falling object is always equal to the mass of the object multiplied by acceleration due to gravity.

$$\text{weight} = m \times 9.8 \text{ m/s}^2$$

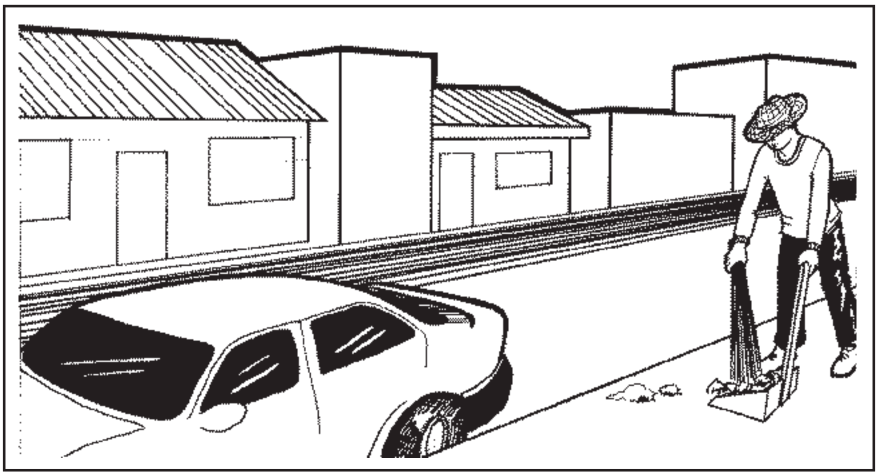
LESSON 2

Simple Machines

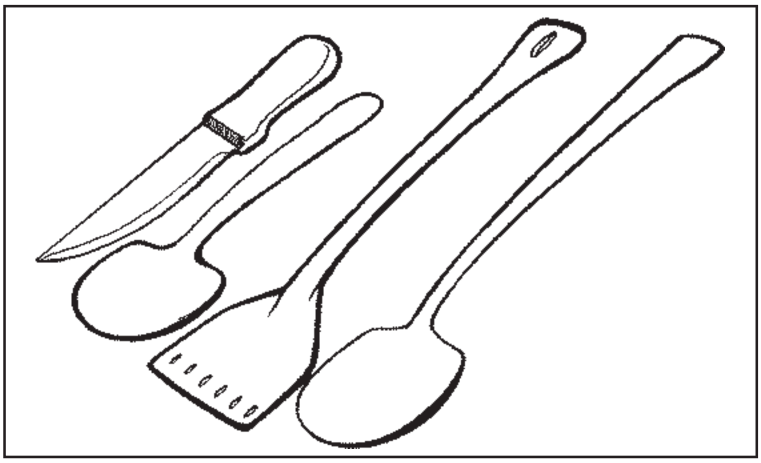
At present, many things help us do things more easily. The tools we use at home, in the workplace, on the farm and in so many other places help us do our work. This lesson will help you learn about some of these tools or machines. It will also tell you how these machines make your work easy. Finally, it will also teach you how to make simple tools to help you with your work.

Let's Study and Analyze

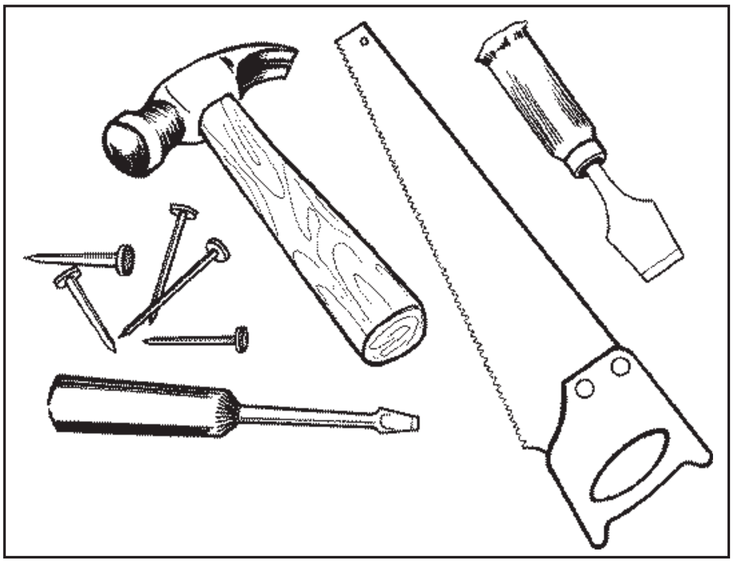
Are you familiar with the objects in the illustrations below?



A metro aide sweeps streets using a broom and a dustpan.



Mother uses these tools when she works in the kitchen.



A carpenter uses tools like hammers, nails, screws, saws and chisels.

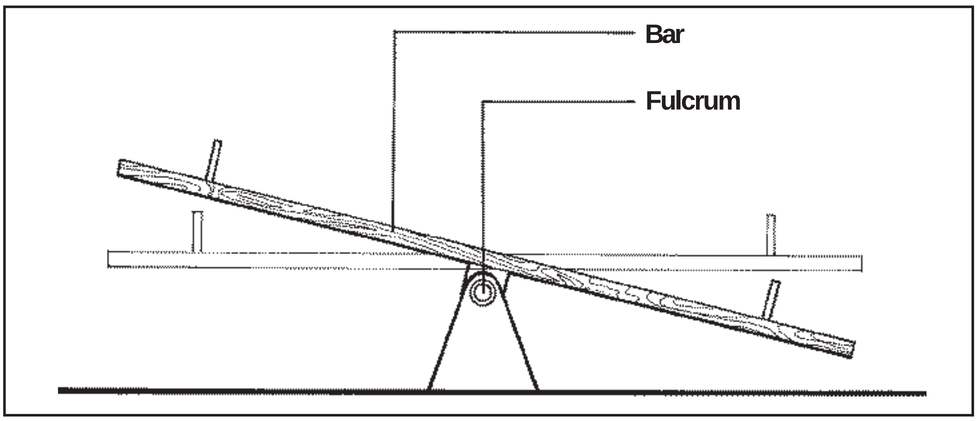
By what other name can you call the tools just mentioned? They can be called **machines. Machines** are devices with some power source used to accomplish some task or work. They allow us to reduce the human effort it takes to move, lift or change something.

Let's Learn

The machines that we often use at home, in the workplace and in other places are called **simple machines.** Simple because they are easy to use. There are six different types of simple machines, namely: levers, inclined planes, wheels and axles, pulleys, wedges and screws. Each of these types will be discussed in detail in this lesson.

Have you ever ridden on a seesaw? How does it work?

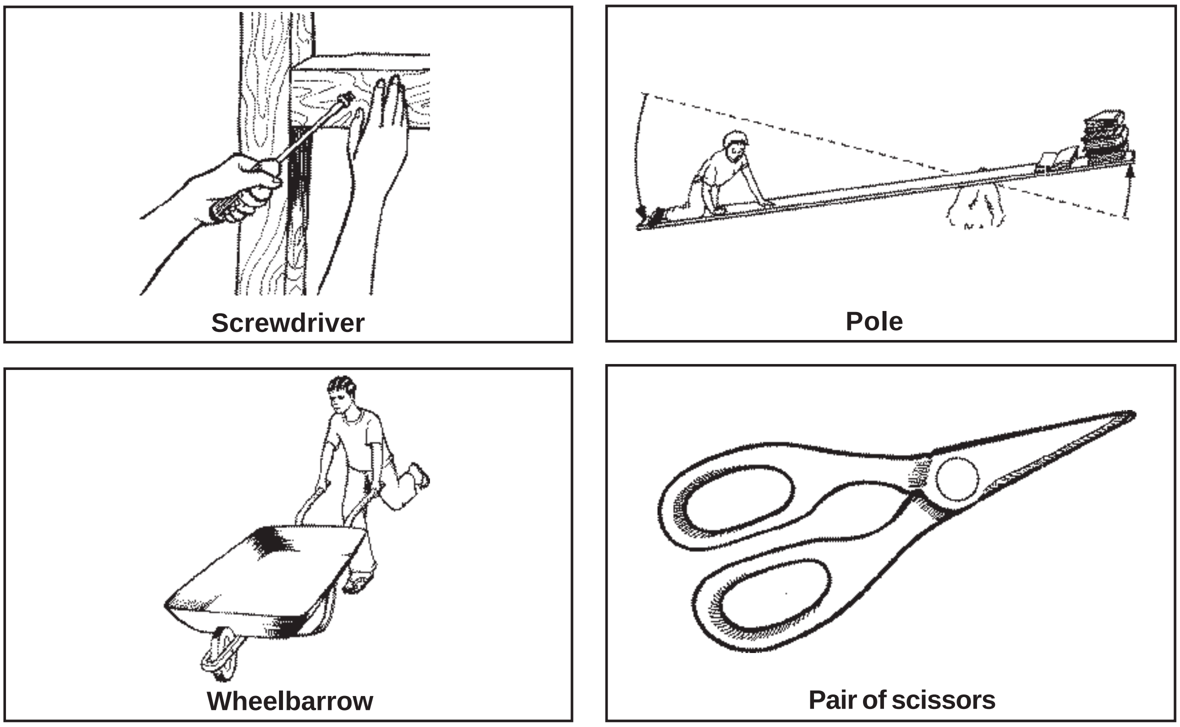
Look at the illustration of a seesaw below.



Seesaw

A seesaw is an example of a lever. A **lever** is a simple machine used for lifting and moving heavy loads. It is made up of a rigid bar supported by and pivoting about a fulcrum at some point along its length so that an effort applied at one point can be used to move the load at another point. When a person sits on one end of the seesaw, for example, he/she represents the load along with his/her partner. The **fulcrum** is the point on which a lever turns. It also gives support or balance.

Look at more examples of levers below.



Levers

Let's Study and Analyze

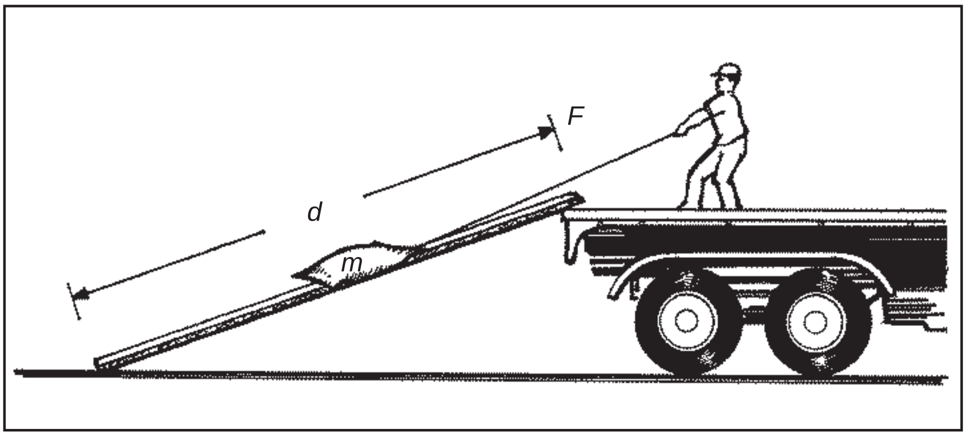
Get a pair of scissors. Observe it. Notice its two blades and how it works. Locate its fulcrum.

A pair of scissors has two blades between which the object to be cut is inserted. When you press on its handles, the blades move together and cut the object. In doing this, you actually push the handles toward each other to create a force that enables you to cut the object. The point where the blades meet together is the fulcrum. The force you exert on the pair of scissors is the **effort** or the **input force.** The object you want to cut is the **resistance** or the **output force.**

Let's Learn

The second kind of simple machine is the inclined plane. An **inclined plane** has a plane surface at an angle to a horizontal surface used especially as a device for lessening the force needed to raise or lower heavy objects.

Observe how an inclined plane is used in the following illustration.

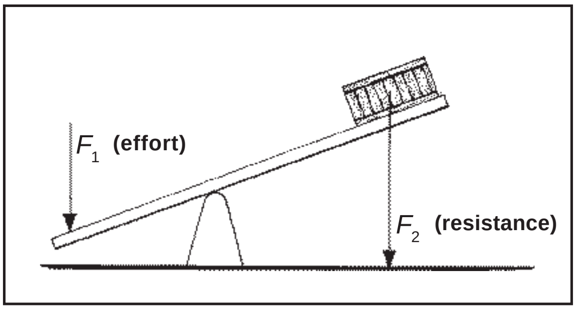


A man pulling a load using an inclined plane

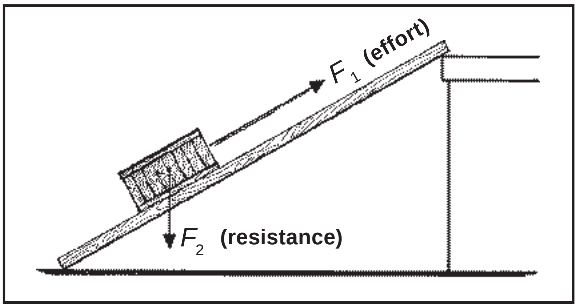
How different is using a lever from using an inclined plane? From the illustration above, you will see that no fulcrum is involved when you are using an inclined plane compared to when you use a lever.

Have you ever lifted a heavy load this way? Was it easier doing the work using the inclined plane than by just using your bare hands? In what other situations can you use an inclined plane to make your work easier?

The lever and inclined plane are the two most basic types of simple machines. The other kinds are just modifications of these two.



Lever

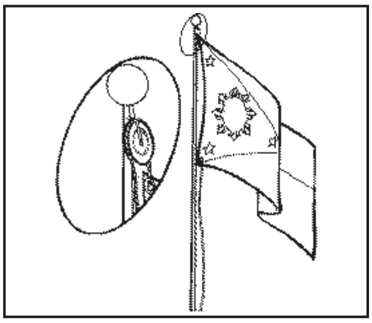


Inclined plane

Let’s Think About This

Remember your younger days when you used to attend the flag-raising ceremony every morning? Do you know how the flagpole works? How are the flag raisers able to raise the flag without actually going up the pole themselves?

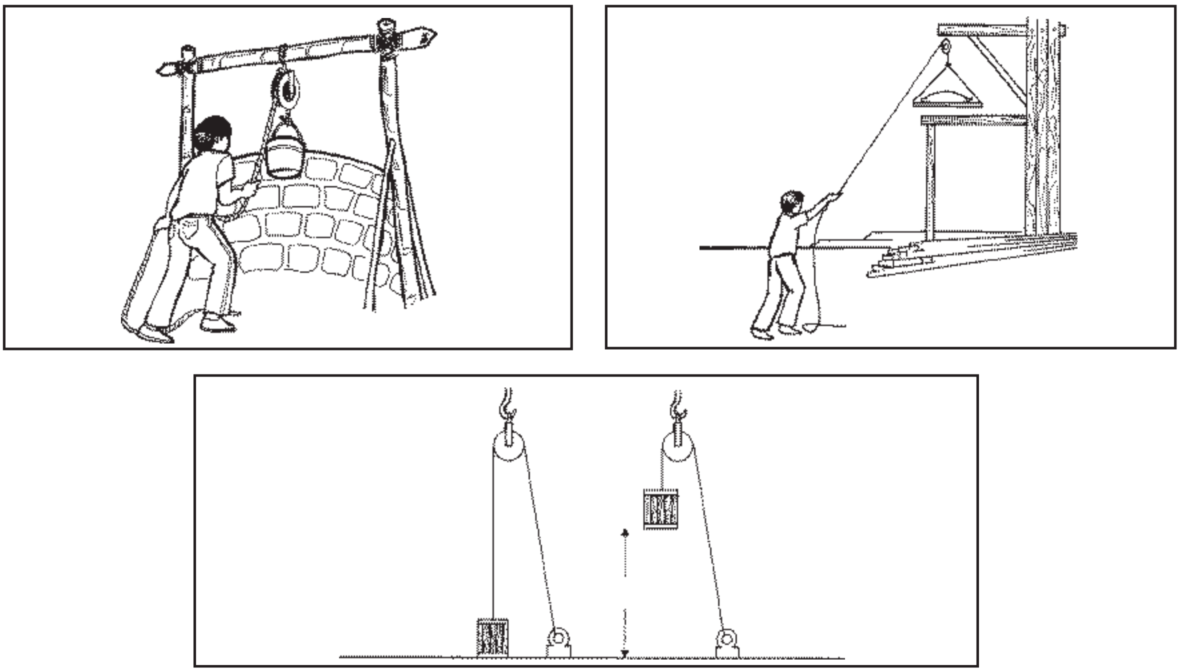
Look at the illustration below.



A single fixed pulley on the flagpole: a modified lever

Let’s Learn

The third kind of simple machine is the pulley. A **pulley** is a simple machine used for lifting and lowering weights. This consists of a wheel with a grooved rim over which a rope or belt runs. It works in such a way that a load tied at one end goes up when a person pulls on the other end of the rope. This way, the load becomes not only easier to get from one place to another, it also becomes easier to carry. Look at some more examples of pulleys below that help us in our everyday lives.



Pulleys that we use in our everyday lives

Let’s Try This

Get a partner, preferably someone of the same build as you are. Prepare two things of the same weight. Put one of these things in a box and the other in a wheelbarrow. Draw two lines on the floor to mark your starting and finish lines. Put the objects on the starting line. Count to three then you and your partner may start pushing each of the objects toward the finish line.

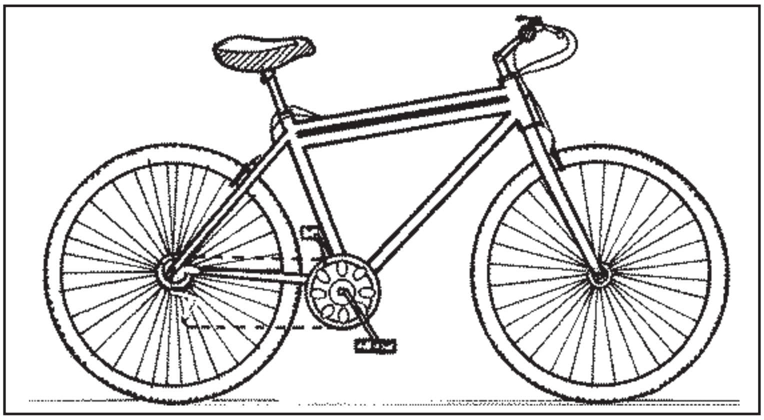
Who was able to reach the finish line first? What does this tell you?

The person pushing the objects on a wheelbarrow will surely finish faster than the other pushing the object inside a box. The wheelbarrow is an example of a machine using the wheel and axle.

Let’s Learn

A **wheel and axle** is one of the simple machines made up of a cylindrical axle on which a wheel, concentric with the axle, is firmly fastened. To make it work, effort should be applied to the wheel and the weight should be attached to the axle.

Look at the illustration below.

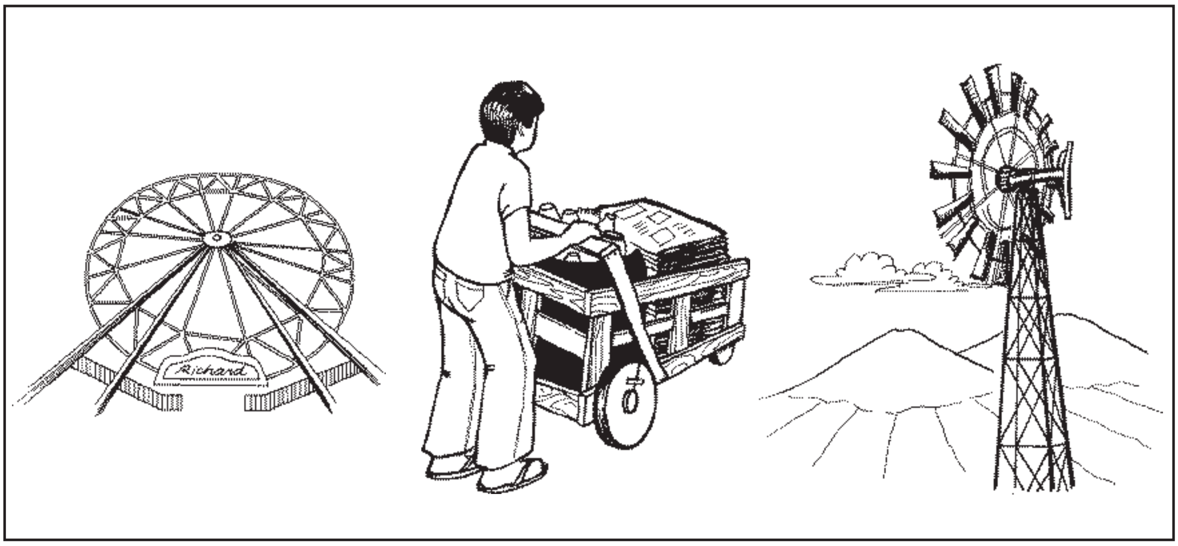


A wheel and axle allows a bicycle to move.

A bicycle is an example of a simple machine that makes use of a wheel and axle to make it work. How does the wheel and axle help the bike move?

The pedals of the bicycle are attached to the front sprocket wheel. The front sprocket wheel serves as the axle attached to the wheels of the bike which move together to enable the bike to move forward when a force is applied to the pedals.

Look at the picture on the next page for more examples of simple machines that make use of wheels and axles.



Other machines that make use of wheels and axles

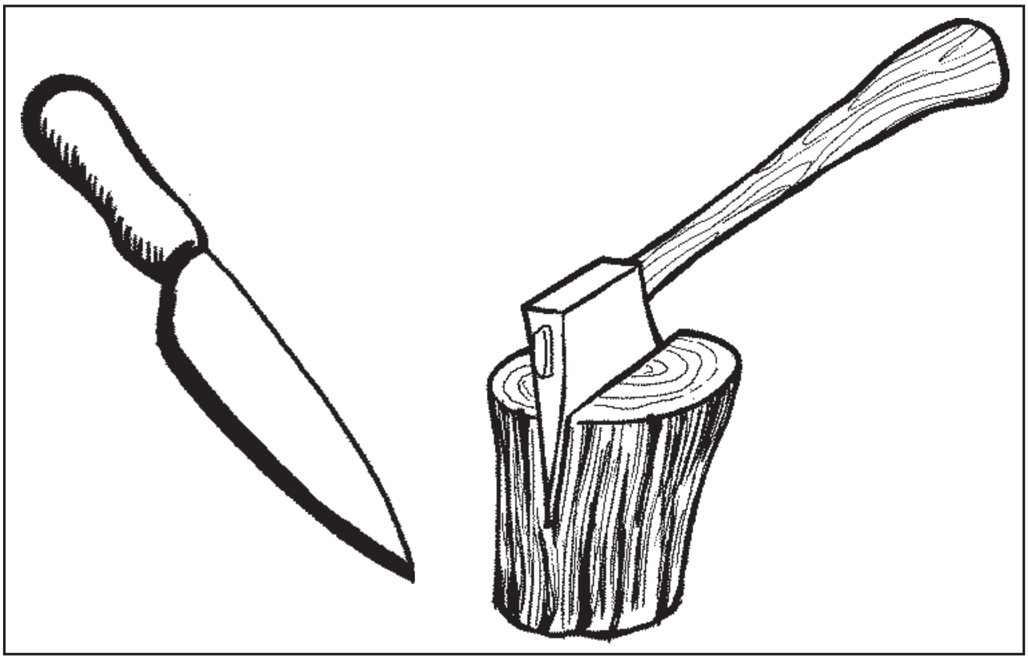
How do you think these machines work? Can you identify where their wheels and axles can be found?

 Let’s Think About This

Are you familiar with the following tools? Have you ever used any one of them? How did it/they help you with your work?

Knives, axes and other tools used to cut things to smaller pieces are examples of wedges. Do you know what wedges are?

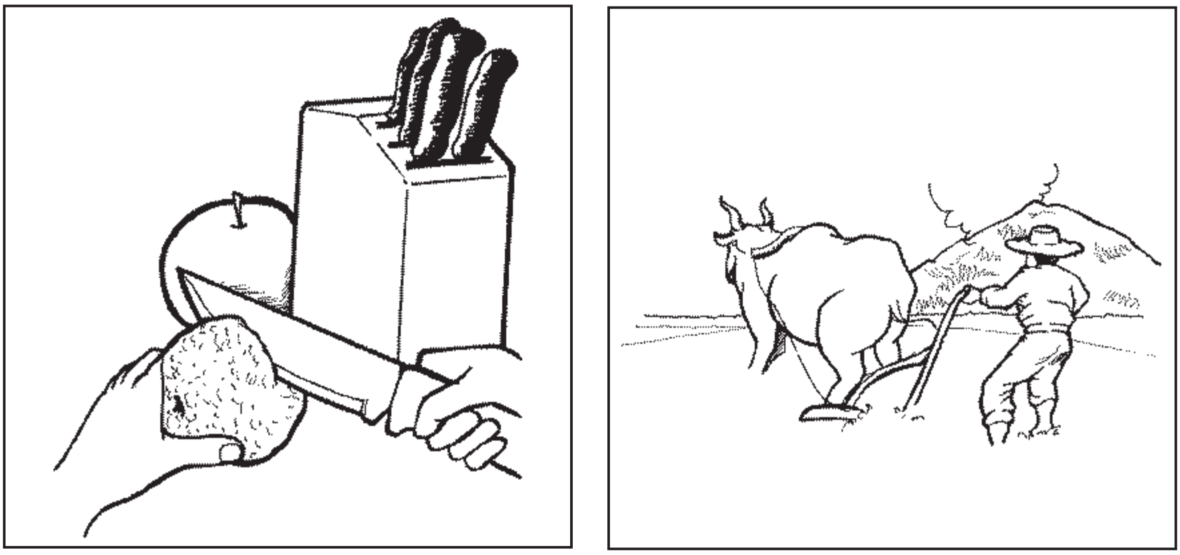
Look at the illustration below to find out.



Wedges

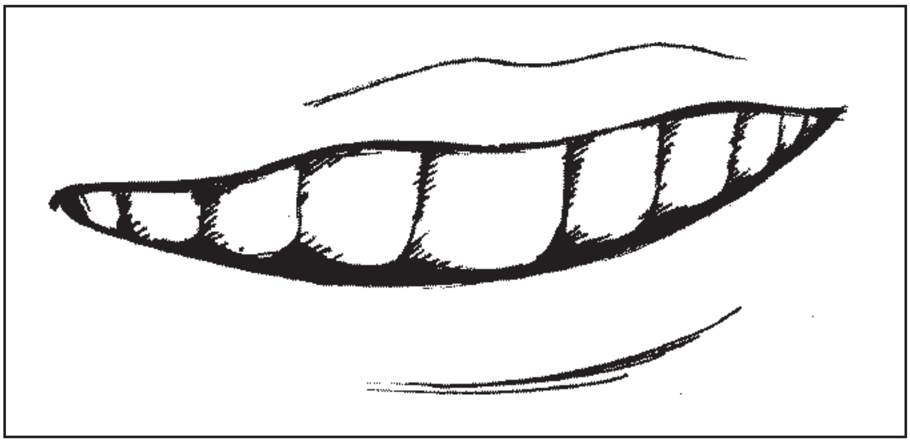
Let’s Learn

A **wedge** is a piece of solid wood, metal or other material, tapering to a thin edge, that is driven into wood to split it, pushed into a narrow gap between moving parts to immobilize them or used to hold a door open, etc. Other examples of this are your teeth, the farmers’ plows, etc.



Wedges help us with our work.

How can these materials help people with their work? How can they make your work easier and faster to do?



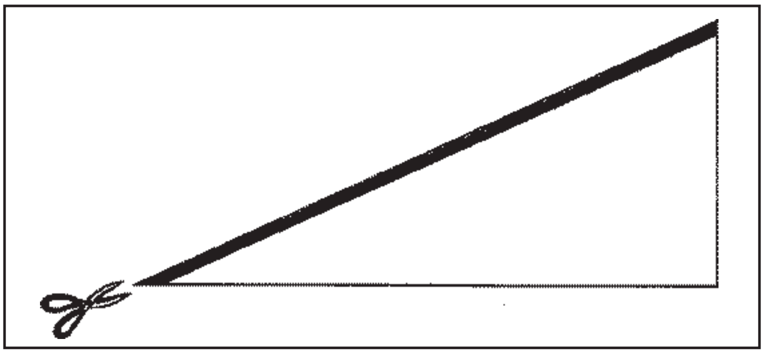
Your teeth are wedges, too.

Let's Try This

Prepare the following materials for the activity below: a pencil or any kind of pen and a triangular piece of paper.

Follow the procedure given below.

1. Color the edge of the triangular piece of paper as seen in the illustration below.



Model for making a screw

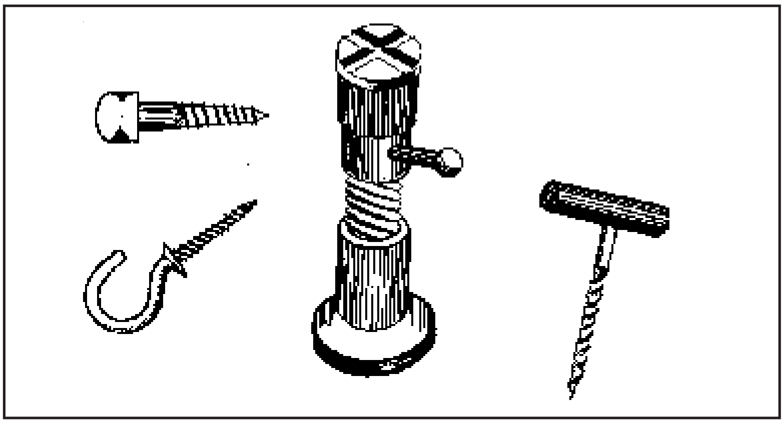
2. Then wrap the piece of paper around the pen.

   What were you able to make? What can it be used for?

Let's Learn

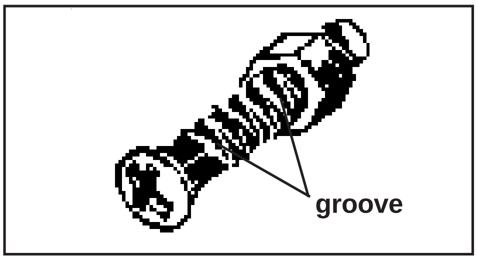
What you made in the preceding activity is a screw. A **screw** is a small, metal cylinder with a spiral ridge or **thread** down the shaft and a slot in its head, driven into position in wood, for example, by rotation using a screwdriver, usually used as a fastening device.

Look at the illustration below to see some examples of screws.



Screws

A screw is a combination of an inclined plane and lever. In the case of the activity you just did, the inclined plane is the triangular piece of paper you wrapped around the pencil or lever. The colored edge of the piece of paper and the white spaces between the **groove** represent the thread of the screw.



Let's See What You Have Learned

A. Match the items in Column A with their descriptions in Column B. Write only the letters of your answers in the blanks before the numbers.

A

_____ 1. Simple machines

_____ 2. Lever

_____ 3. Fulcrum

_____ 4. Effort

_____ 5. Resistance

_____ 6. Inclined plane

_____ 7. Pulley

_____ 8. Wheel and axle

_____ 9. Wedge

_____10. Screw

B

a. A small, metal cylinder used as a fastening device, with a thread down the shaft and a slot in the head, driven into wood, for example, by rotation using a screwdriver

b. A piece of solid wood, metal or other material, tapering to a thin edge, that is driven into wood to split it, pushed into a narrow gap between moving parts to immobilize them or used to hold a door open, etc.

c. A simple machine which is made up of a cylindrical axle on which a wheel, concentric with the axle, is firmly fastened

d. A simple device for lifting and lowering weights, consisting of a wheel with a grooved rim over which a rope or belt runs

e. A plane surface at an angle to a horizontal surface used especially as a device for lessening the force needed to raise or lower heavy objects

f. Output force

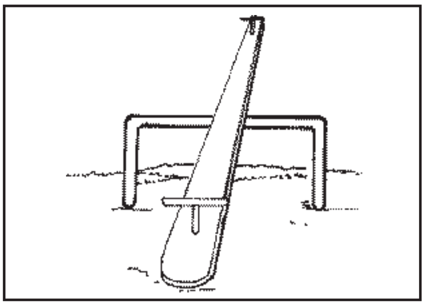
g. Input force

h. The point on which a lever turns, balances or is supported

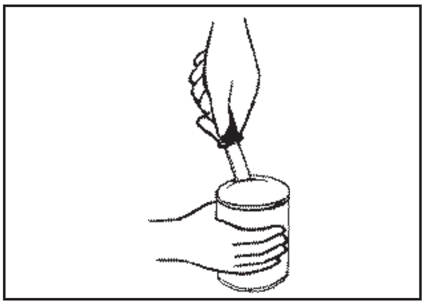
i. Used for lifting and moving heavy loads made up of a rigid bar supported by and pivoting about a fulcrum at some point along its length so that an effort at one point can be used to move the load at another point

j. The machines that we often use at home, in the workplace and in other places

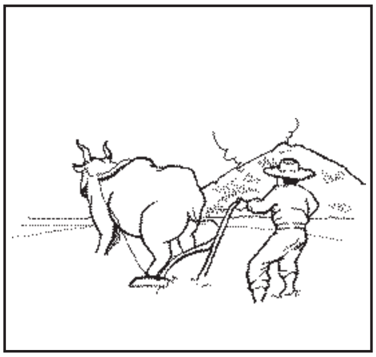
B. Write in the space provided the type of simple machine shown in each picture below.



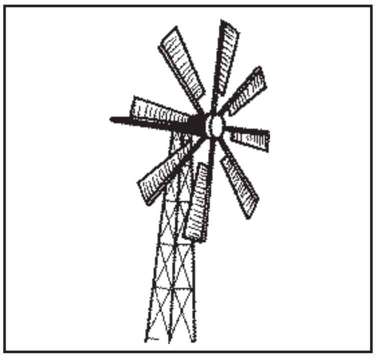
1.________________________



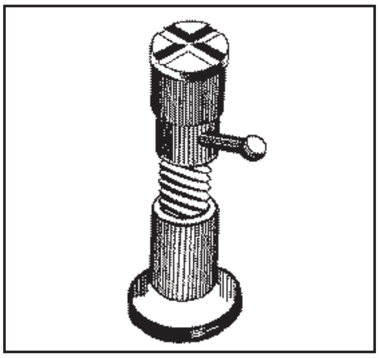
2.________________________



3.____________________



4.____________________



5.____________________

Compare your answers with those in the *Answer Key* on pages 39 and 40. Did you get all the right answers? If you did, that's very good! If you didn't, don't worry. Just review the lesson before going to the next one.

Let's Remember

- **Simple machines** are the machines that we often use at home, in the workplace and in other places.
- There are six types of simple machines, namely:

  1. **lever** — used for lifting and moving heavy loads, made up of a rigid bar supported by and pivoting about a fulcrum at some point along its length so that an effort at one point can be used to move the load at another point;
  2. **inclined plane** — a plane surface at an angle to a horizontal surface used especially as a device for lessening the force needed to raise or lower heavy objects;
  3. **pulley** — a simple device for lifting and lowering weights, consisting of a wheel with a grooved rim over which a rope or belt runs;
  4. **wheel and axle** — made up of a cylindrical axle on which a wheel, concentric with the axle, is firmly fastened;
  5. **wedge** — a piece of solid wood, metal or other material, tapering to a thin edge, that is driven into wood to split it, pushed into a narrow gap between moving parts to immobilize them or used to hold a door open, etc.
  6. **screw** — a small, metal cylinder used as a fastening device, with a thread down the shaft and a slot in the head, driven into wood, for example, by rotation using a screwdriver.

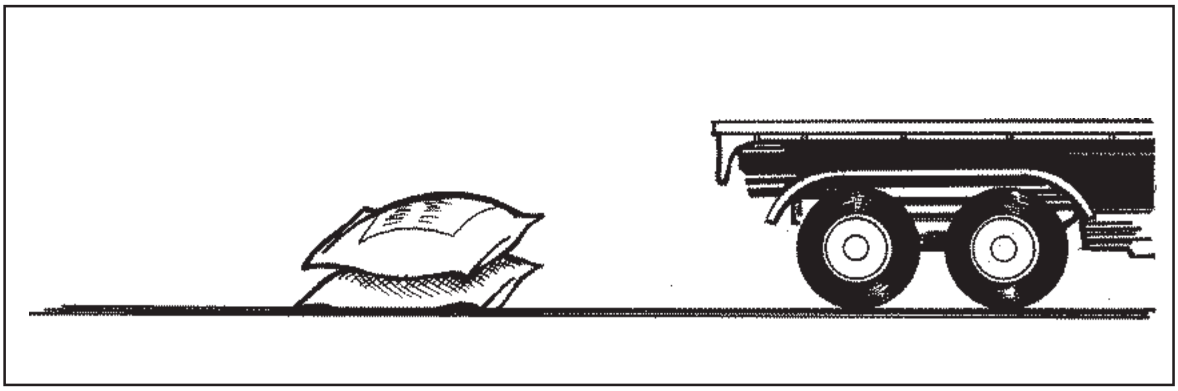
How Do Machines Help Us Do Work?

Imagine a world without the tools that we now use. How can you raise the flag to the top of the flagpole? How can you travel from one province to another? How can you lift heavy loads? How can you travel to other countries? How can an auto mechanic lift a car's engine to clean and repair it?

This lesson will tell you how machines help us with our work. It will also tell you about the advantages of using a machine in doing your work. Finally, it will teach you to make your own tools using available materials to help you with work.

Let's Think About This

Suppose you were asked to lift a heavy load onto a truck (see the illustration below). How will you be able to do this?



How can you lift the heavy load onto the truck?

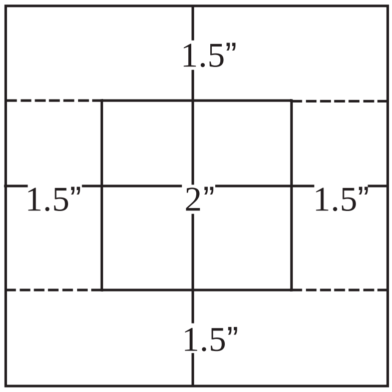
Let's Try This

Do the following activity below to learn about the different variables that affect the amount of work done.

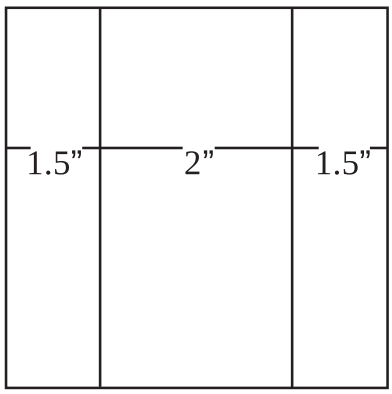
You will need the following materials for this: a meterstick, some discarded shoe boxes, a pencil, paste, a wedge-shaped piece of wood and ten one-peso coins.

Follow the procedure given below.

1. Cut out a 5” by 5” piece of cardboard from a discarded shoe box. Mark it as follows.



2. Fold along the solid lines and cut along the dotted lines. Afterward, paste the overlapping flaps together to form a box.
3. Cut out another 5” by 5” piece of cardboard. Then mark it as follows.



4. Fold along the solid lines. Then paste together the overlapping flaps to make a rider.
5. Paste the box you made on top of the rider and position them on one end of the meterstick. Do this by letting the meterstick pass through the rider with the box on top.
6. Balance the meterstick on top of the wedge-shaped piece of wood.
7. Have a friend put his/her hand at the point at which the meterstick is being balanced to keep the device from falling.
8. Put a one-peso coin in the box. Then using one hand, push the other end of the meterstick and observe how much force you used to balance the two ends.
9. This time, put four more coins in the box. Following the same procedure as above, see how much force you used to balance the two ends of the meterstick again. Was the force you used this time greater than the force you used last time?

10. Finally, put the remaining one-peso coins in the box. Do the same thing and notice how much force you used this time. Make a conclusion about the activity afterward. Write it below.

Conclusion:

____

____

____

Let's Learn

From the previous activity, you will be able to identify the following variables that affect the amount of work done:

1. **effort** — also known as the input force or the force needed to move an object (load or resistance) from one place to another, denoted by F_1; in the activity, this is the force you applied to balance the meterstick while the coins were in the box;
2. **displacement** — the distance of the end of the lever from the surface when a load is placed at the other end of the lever denoted by *d;*
3. **resistance** — also known as the output force or the weight of the load, denoted by F_2, in the activity. This is the weight of the coins in the box.

The amount of work done can be computed by using the following formula:

$$W = F \times d$$

Where W stands for the amount of work done; F for the amount of force applied to accomplish the job; and d for the distance covered by the load when it moved.

Machines help make our work easier. They can also increase our output. The more output a machine can produce, the more efficient it is. But do you know how to compute for this using some given data? The following formula can be used for this purpose:

$$\text{Efficiency} = \frac{\text{Output work}}{\text{Input work}} \times 100\%$$

The higher the machine's efficiency, the better. But it is not possible for any machine to be 100% efficient because of friction. The less friction there is, the more efficient a machine becomes.

So, how can one reduce friction and therefore make machines more efficient?

Let's Try This

After learning about the variables that can affect the amount of work done, let's try solving the following problems.

PROBLEM 1

Lynette pushed horizontally with a 75 N force on a box of pretzels weighing 15 kg. If she pushed it a distance of 20 m, how much work did she do?

Given:	F	=	75 N
	m	=	15 kg
	d	=	20 m
Unknown:	W	=	?
Solution:	W	=	$F \times d$
	W	=	75 N(20 m)
	W	=	1500 N·m or 1500 J
Final Answer:	W	=	1500 J

Now, try solving the next problem on your own. Let the first problem guide you in solving.

PROBLEM 2

Matt is riding on an escalator at the mall. Matt has a mass of 74 kg and the height of the escalator is 30 m. How much work is done in lifting Matt to the top?

Given:

Unknown:

Solution:

Final Answer:

Compare your answers with the following.

Given: $m = 74 \text{ kg}$
$h = 30 \text{ m}$

Unknown: $F = ?$
$W = ?$

Solution: $F = m \times \text{acceleration due to gravity}$
$F = 74 \text{ kg}(9.8 \text{ m/s}^2)$
$F = 725.2 \text{ kg} \cdot \text{m/s}^2 \text{ or } 725.2 \text{ J}$
$W = F \times d$
$W = 725.2 \text{ N}(30 \text{ m})$
$W = 21756 \text{ N} \cdot \text{m or } 21756 \text{ J}$

Final Answer: $W = 21756 \text{ J}$

How well did you do? Were you able to get the same answer? If you did, that's very good! If you didn't, don't worry. Just read the parts of the lesson you didn't understand very well before going to the next part.

Let's See What You Have Learned

A. Complete the following table by computing the work done on the machine, the work done by the machine and the efficiency of the machine.

	Machine 1	Machine 2	Machine 3
Effort (input force)	10 N	4 N	50 N
Distance moved by the effort	100 cm	30 cm	10 cm
Work done on the machine	______	______	______
Load (output force)	45 N	10 N	90 N
Distance moved by the effort	20 cm	10 cm	0.5 cm
Work done by the machine	______	______	______
Efficiency of the machine	______	______	______

B. Solve the given problem below. Encircle the letter of the correct answer.

One end of a lever is pushed downward a distance of 4 m with a force of 500 N. This raises a 900-N load on the other side of the lever a distance of 2 m.

1. How much work was done on the lever?
   a. 500 J
   b. 900 J
   c. 1800 J
   d. 2000 J

2. How much work was done by the lever?
   a. 500 J
   b. 900 J
   c. 1800 J
   d. 2000 J

3. How efficient is the lever?
   a. 45%
   b. 50%
   c. 90%
   d. 100%

Compare your answers with those in the *Answer Key* on page 40. Did you get all the right answers? If you did, that's very good! If you didn't, don't worry. Just review the parts you made mistakes in before going to the next part of the module.

Let's Remember

- The following are some of the variables that can affect the amount of work a person or a machine can do:

  1. **effort** — also known as the input force or the force needed to move an object from one place to another
  2. **displacement** — the distance covered by the load as it moves from one point to another
  3. **resistance** — also known as the output force or the weight of the load

- Work = force × distance or $W = F \times d$

- $\text{Efficiency} = \dfrac{\text{Output work}}{\text{Input work}} \times 100\%$

Well, this is the end of the module. Congratulations for finishing it! Did you like it? Did you learn anything useful from it? A summary of its main points is given on the next page to help you remember them better.

Let's Sum Up

- **Work** is done when a force acts upon an object causing a displacement.

$$W = F \times d \times \cos\theta$$

or simply $$W = F \times d \text{ when } \theta = 0°.$$

- **Joule** denoted by **J** is the standard unit of work.

$$1 \text{ joule} = 1 \text{ newton-meter}$$

or $$1 \text{ J} = 1 \text{ N} \cdot \text{m}$$

- The **acceleration due to gravity** is the acceleration that acts on all objects that fall within the earth's gravitational field. It is always equal to 9.8 m/s^2.

- The **force** acting on a free-falling object is always equal to its weight.

$$w = m \times 9.8 \text{ m/s}^2$$

and $$w = F$$

- **Simple machines** are the machines that we often use at home, in the workplace and in other places.

- There are six types of simple machines, namely:

  1. **lever** — used for lifting and moving heavy loads made up of a rigid bar supported by and pivoting about a fulcrum at some point along its length so that an effort at one point can be used to move the load at another point;
  2. **inclined plane** — a plane surface at an angle to a horizontal surface used especially as a device for lessening the force needed to raise or lower heavy objects;
  3. **pulley** — a simple device for lifting and lowering weights, consisting of a wheel with a grooved rim over which a rope or belt runs;
  4. **wheel and axle** — made up of a cylindrical axle on which a wheel, concentric with the axle, is firmly fastened;
  5. **wedge** — a piece of solid wood, metal or other material, tapering to a thin edge, that is driven into wood to split it, pushed into a narrow gap between moving parts to immobilize them or used to hold a door open, etc.; and
  6. **screw** — a small, metal cylinder used as a fastening device, with a thread down the shaft and a slot in the head, driven into wood, for example, by rotation using a screwdriver.

- The following are some of the variables that can affect the amount of work a person or a machine can do:

    1. **effort** — also known as the input force or the force needed to move an object from one place to another
    2. **displacement** — the distance covered by the load as it moves from one point to another
    3. **resistance** — also known as the output force or the weight of the load

- Work = force × distance or $W = F \times d$

- $\text{Efficiency} = \dfrac{\text{Output work}}{\text{Input work}} \times 100\%$

What Have You Learned?

Answer the following questions briefly.

1. What is work? What is the standard unit of measurement for work?

    ____

    ____

2. Define acceleration due to gravity.

    ____

    ____

3. What are the six types of simple machines? Define each type.

    a. ____

    ____

    b. ____

    ____

    c. ____

    ____

    d. ____

    ____

    e. ____

    ____

f. ____

____

4. What are the variables that affect the amount of work done? Define each variable.

a. ____

____

b. ____

____

c. ____

____

Compare your answers with those in the *Answer Key* on pages 40 and 41. Did you get all the answers right? If you did, that's very good! If you didn't, don't worry. Just review the lessons in this module before studying a new one.

Answer Key

A. Let's See What You Already Know *(pages 2–3)*

1 **(d)** is the correct answer because letters a, b and c all describe work in the scientific sense.

2. **(a)** is the correct answer as work is measured in newton-meters.

3. **(b)** is correct because

$$W = F \times d$$
$$F = 5\text{ kg}$$
$$d = 1\text{ meter}$$
$$\text{so } W = 5 \times 1 = 5\text{ joules (J)}$$

4. **(d)** is the correct answer. A machine cannot produce energy. It can only multiply force, multiply speed and transform energy.

5. **(c)** is the correct answer. The lever and the inclined plane are the two most basic types of machines. The screw, wheel and axle and pulley are variations of the lever and inclined plane.

6. **(b)** is not a wedge. It is a screw.

7. **(a)** is the correct answer. A screw is a lever; a Ferris wheel is a type of wheel and axle.

8. **(b)** is the correct answer. To compute for efficiency we use the formula:

$$\begin{aligned}\text{efficiency} &= \frac{\text{output work}}{\text{input work}} \times 100\% \\ &= \frac{80}{92} \times 100\% \\ &= 87\%\end{aligned}$$

9. **(c)**

$$\begin{aligned}\text{efficiency} &= \frac{\text{output work}}{\text{input work}} \times 100\% \\ &= \frac{50}{65} \times 100\% \\ &= 77\%\end{aligned}$$

10. **(a)** because the formula is $\text{efficiency} = \dfrac{\text{output work}}{\text{input work}}$

Thus we have:

$$\begin{aligned} 90 &= \frac{82}{x} \\ 90x &= 82 \\ x &= \frac{82}{90} \\ &= 91 \text{ joules} \end{aligned}$$

B. Lesson 1

Let's Study and Analyze (pages 7–8)

A. 1. The table is being pushed. Yes, I think so.

2. It is being pushed to the right. The direction in which the table is being pushed and the movement of the table itself are going toward the same direction.

3. Yes.

B. 1. It is being lifted.

2. Yes, it did. They are both going toward the same direction.

3. Yes, because the situation involved a pull toward a certain direction and a displacement.

C. 1. It moved horizontally.

2. Yes.

D. It is different in the sense that it didn't involve moving something else aside from the person himself. The load and the source of the effort were one and the same.

Let's Review (page 10)

Statement	Answer With Explanation
A teacher applies a force to a wall and becomes exhausted.	8 No work was accomplished here since no displacement was involved even if a force was applied.
A book falls off a table and falls to the ground.	8 No work was accomplished here either since no force was applied to cause the displacement of the object.

A waiter carries a tray full of food above his head with one arm while moving across the room.	8 No work was accomplished here too because the force being applied in carrying the tray has nothing to do with the displacement.
A rocket accelerates through space.	4 Work was accomplished here since this situation involved a displacement as a result of force being applied on the rocket.

Let's Try This (pages 12–13)

1. **Given:** $d = 1.2$ m
   $F = 200$ N

   Unknown: $W = ?$

   Solution: $W = F \times d$
   $W = 200$ N (1.2 m)
   $W = 240$ N·m or 240 J

   Final Answer: $W = 240$ J

2. **Given:** $m = 2$ kg
   $d = 0.5$ m

   Unknown: $F = ?$
   $W = ?$

   Solution: $F = m \times 9.8$ m/s^2
   $F = 2$ kg (9.8 m/s^2)
   $F = 19.6$ kg·m/s^2 or 19.6 N

   $W = F \times d$

   $W = 19.6$ N (0.5 m)

   $W = 9.8$ N·m or 9.8 J

   Final Answer: $W = 9.8$ J

Let's See What You Have Learned (pages 13–14)

A. 1. F

2. F

3. F

4. T

5. T

B. 1. **Given:** $F = 200$ N
$d = 0.5$ m

Unknown: $W = ?$

Solution: $W = F \times d$
$W = 200$ N (0.5 m)
$W = 100$ N·m or 100 J

Final Answer: $W = 100$ J

2. **Given:** $w = 10$ N
$d = 0.3$ m

Unknown: $F = ?$
$W = ?$

Solution: $F = w$
$F = 10$ N

$W = F \times d$
$W = 10$ N (0.3 m)
$W = 3$ N·m or 3 J

Final Answer: $W = 3$ J

3. **Given:** $w = 10$ N
$d = 2$ m

Unknown: $F = ?$
$W = ?$

Solution: $F = w$
$F = 10$ N

$W = F \times d$
$W = 10$ N (2 m)
$W = 20$ N·m or 20 J

Final Answer: $W = 20$ J

C. Lesson 2

Let's See What You Have Learned (pages 25–26)

A. 1. j
2. i
3. h
4. g
5. f
6. e
7. d
8. c
9. b
10. a

B. 1. lever
2. wedge
3. wedge
4. wheel and axle
5. screw

D. Lesson 3

Let's See What You Have Learned (pages 31–32)

A.

	Machine 1	Machine 2	Machine 3
Effort (input force)	10 N	4 N	50 N
Distance moved by the effort	100 cm = 1 m	30 cm = 0.3 m	10 cm = 0.1 m
Work done on the machine	10 J	1.2 J	5 J
Load (output force)	45 N	10 N	90 N
Distance moved by the effort	20 cm = 0.2 m	10 cm = 0.1 m	0.5 cm = 0.05 m
Work done by the machine	9 J	1 J	4.5 J
Efficiency of the machine	90%	83.3%	90%

B. 1. d
2. c
3. c

E. What Have You learned? *(pages 34–35)*

A. 1. Work is a force acting upon an object to cause a displacement. The standard unit of measurement used for it is the joule (J).

2. It is the acceleration that acts on all objects that fall within the earth's gravitational field and is always equal to 9.8 m/s^2.

3. a. **lever** — used for lifting and moving heavy loads made up of a rigid bar supported by and pivoting about a fulcrum at some point along its length so that an effort at one point can be used to move the load at another point

b. **inclined plane** — a plane surface at an angle to a horizontal surface used especially as a device for lessening the force needed to raise or lower heavy objects

c. **pulley** — a simple device for lifting and lowering weights, consisting of a wheel with a grooved rim over which a rope or belt runs

d. **wheel and axle** — made up of a cylindrical axle on which a wheel, concentric with the axle, is firmly established

e. **wedge** — a piece of solid wood, metal or other material, tapering to a thin edge, that is driven into wood to split it, pushed into a narrow gap between moving parts to immobilize them or used to hold a door open, etc.

f. **screw** — a small, metal cylinder used as a fastening device, with a thread down the shaft and a slot in the head, driven into wood, for example, by rotation using screwdriver

4. a. **effort** — also known as the input force needed to move an object from one place to another

b. **displacement** — the distance covered by the load as it moves from one point to another

c. **resistance** — also known as the output force or the weight of the load

Glossary

Acceleration due to gravity The acceleration that acts on all objects that fall within the earth's gravitational field.

Displacement The distance covered by the load as it moves.

Effort Also known as the input force or the force needed to move a load from one place to another.

Fulcrum The point on which a lever turns, balances or is supported.

Groove A long, narrow channel, especially one cut with a tool that keeps a screw fastened to a piece of wood, for example.

Inclined plane A plane surface at an angle to a horizontal surface used especially as a device for lessening the force needed to raise or lower heavy objects.

Joule The standard metric unit of work denoted by J, equal to 1 newton (N) of force causing a displacement of 1 meter (m).

Lever A simple machine used for lifting and moving heavy loads, made up of a rigid bar supported by and pivoting about a fulcrum at some point along its length so that an effort applied at one point can be used to move the load at another point.

Pulley A simple device for lifting and lowering weights, consisting of a wheel with a grooved rim over which a rope or belt runs.

Resistance Also known as the output force or the weight of the load.

Screw A small, metal cylinder used as a fastening device, with a thread down the shaft and a slot in its head, driven into position in wood, for example, by rotation using a screwdriver.

Simple machines The machines that we often use at home, in the workplace and in other places.

Thread A spiral ridge down the shaft of a screw.

Wedge A piece of solid wood, metal or other material, tapering to a thin edge, that is driven into wood to split it, pushed into a narrow gap between moving parts to immobilize them or used to hold a door open, etc.

Wheel and axle One of the simple machines made up of a cylindrical axle on which a wheel, concentric with the axle, is firmly fastened.

Work A force acting upon an object to cause a displacement.

References

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