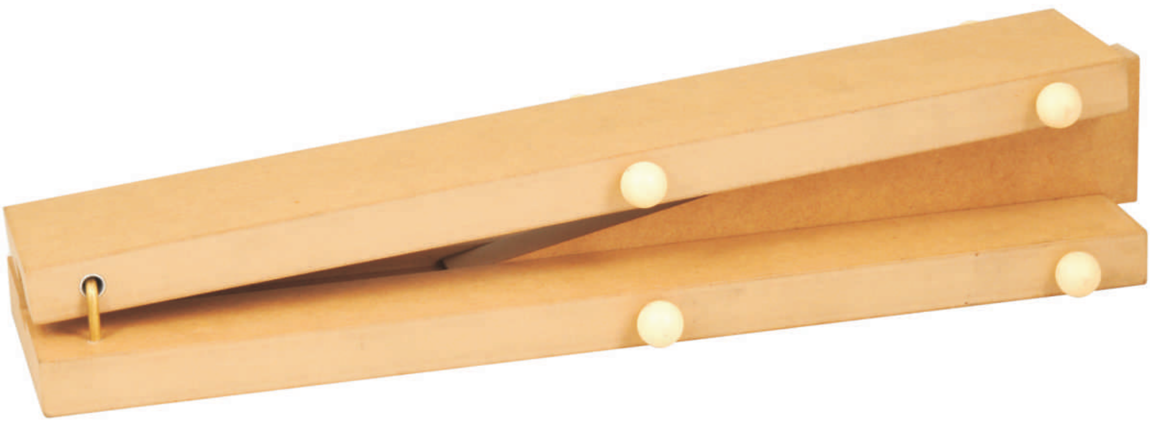
SIMPLE MACHINES : THE WEDGE

CAT NO. WDMS14



Experiment Guide

GENERAL BACKGROUND OR THEORY ON THE EXPERIMENT:

There are six simple machines that all other machines are made out of. Even complex machines like an automobile really consist of simple machines that all convert energy in order to do work. Machines are used to make work easier. Here work is defined as a force applied over a given distance. The force applied and the distance traveled must be in the same direction.

Simple machines can either change the direction the force is applied, or increase the mechanical advantage by doing the same amount of work over a longer distance and therefore decreasing the amount of force needed.

Mechanical advantage is a way of measuring how much easier it is to do work or how much less force is required. Written as a formula:

$$\text{Mechanical Advantage} = \frac{\text{Output force (load)}}{\text{Input force (effort)}}$$

The load is the amount of force or weight that is being lifted
The effort is the amount of force or weight being applied to the rope in order to move the load.

The six simple machines are pulleys, levers, wedges, inclined planes, screws and wheels & axles. Compound machines have two or more simple machines that when used together make work easier.

A pulley is a variation of a wheel and axel in which a rope or cord is stretched over a wheel to make it rotate as the rope is pulled. Pulleys are used to raise and lower flags, on oil derricks, to raise lower and adjust sails on a sailboat and to pull open or close curtains. A single pulley can change the direction that a force is needed to be applied in order to make doing work more convenient. A combination of several pulleys can make it easier to do work, by applying a smaller force over a larger distance mechanical advantage is gained.

Levers are when a long stiff object, like a post or board rests on a fulcrum. The lever lifts a load by applying an effort force. The arrangement of the effort, load and fulcrum determines the "class" of levers. There are three classes of levers.

Class one levers have the effort and the load on opposite sides of the fulcrum as shown in diagram 1.

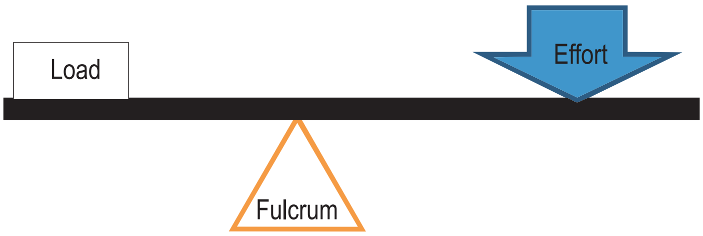


Diagram 1

Examples of class one levers are a teeter totter or see-saw, a catapult, scissors, or a crowbar.

Class two levers have the load in the middle and the fulcrum on the end and effort is applied on the opposite side of the fulcrum as shown in diagram 2.

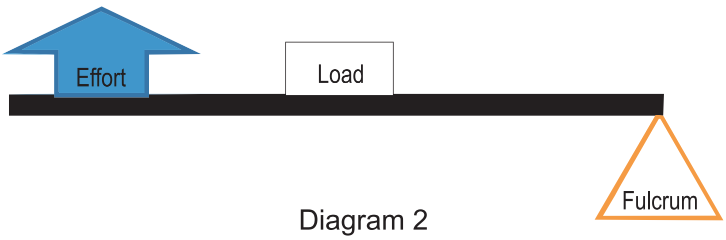


Diagram 2

Examples of class two levers are wheel barrows, shovels and nutcrackers.

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Class three levers have the load on one end of the post, the fulcrum on the opposite end, and the effort is applied to the middle as shown in diagram 3.

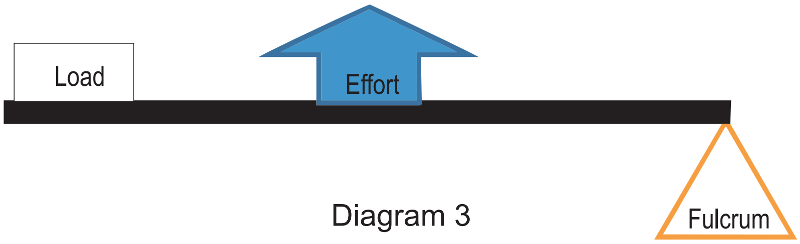

Diagram 3

A fishing pole, your forearm, and tweezers are good examples of class three levers.

A wedge is a simple machine that changes the direction of a force. The force applied is usually perpendicular to the force acting on the object. Examples of wedges are door stops, nails, axes, teeth (incisors, not molars), pins, and a chisel.

Wheels and axles increase mechanical advantage by covering a longer distance using less force. The larger the wheel, the greater the mechanical advantage. As a wheel turns the distance traveled by the one rotation of the wheel is directly proportional to the diameter of the wheel. For the penny farthing bike one rotation of the pedal equals one rotation of the bike's wheel. However, the distance covered by the person's foot is much smaller than the distance covered by the bikes wheel. Examples of wheels and axles include bike tires, car tires, wind mills, and steering wheels.

Inclined planes also increase mechanical advantage by increasing the distance traveled and decreasing the amount of force applied. Examples of inclined planes include ramps, hills, ladders, stairs, and the backs of dump trucks.

Screws are really just inclined planes wrapped around a post as shown in diagram 4. Examples of common screws are screw top jar lids, drill bits, meat grinders, corkscrews, swivel stools, and of course, screws.

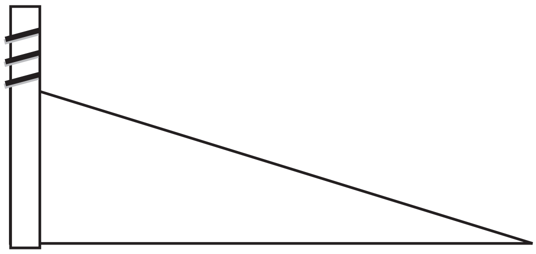

Diagram 4

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Wedge	1
Boards connected by metal hinge	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Hammer	1
Nails	1 per student
Bolt	1 per student
Block of wood	1
Rubber bands	several

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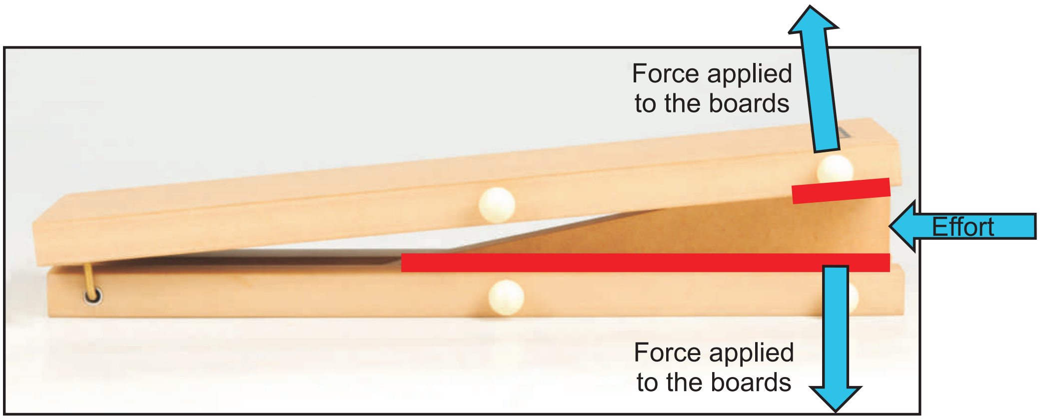
ACTIVITY 1: CHANGING THE DIRECTION OF THE FORCE (TEACHER ANSWERS)

The wedge is a fairly simple device. This wedge clearly demonstrates that as a force is applied to the wedge parallel to the table, but the wedge is being driven perpendicular to the surface of the wedge. When using a wedge, there is a lot of friction. In the diagram below, draw the direction of the effort and the direction the force acts on the two boards. Draw a red line where you think friction may act.



Think about things you do every day, when do you use wedges to make your work easier? *(Cutting food with a fork or knife, a door stop, hammering a nail into a board, using a pin in a bulletin board, etc.)*

ACTIVITY2 : PRACTICAL EXPERIENCE

Have students try to hammer a bolt and then a nail into a board. The bolt will not hammer into the board, but the nail will because it is shaped like a wedge.

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ACTIVITY 1: CHANGING THE DIRECTION OF THE FORCE:

1. In the diagram below, draw the direction of the effort force and label this effort.
2. Draw the direction of the force applied to the two boards, and label these forces as force applied to the boards.
3. With a red marker or colored pencil, draw a line where friction would be acting on this machine as the wedge is pushed into the two boards.

4. Think about things you do every day, when do you use wedges to make your work easier?

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OPTIONAL ACTIVITY 2:

1. What was easier to drive into the board, the bolt or the nail?

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2. Which object had a wedge shape? The bolt or the nail? Did this shape make it easier to do work? In other words, was there less force needed to do work?

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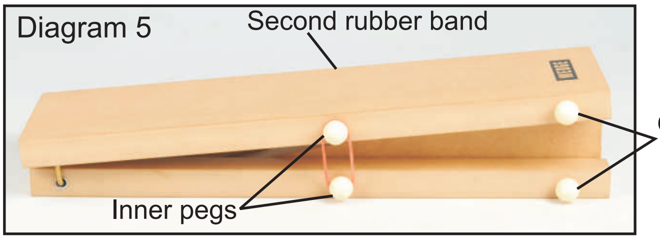
ACTIVITY 3: INCREASING THE FORCE (TEACHER ANSWERS)

1. Place a rubber band on the two pegs as shown in diagram 5. Note that there should be one rubber band on each side of the apparatus to keep the tension even. .



2. Observe what happens to the rubber band as the wedge is pushed into the apparatus. Record your observations in the space provided below.
   (The rubber band stretches and may break the further the wedge is pushed into the boards)

3. Which distance is greater? The distance the rubber band stretches or the distance the wedge moves? *(The distance the wedge moves.)*

4. Assume that the work done by pushing the wedge is equal to the work done lifting the top board. If the top board moves a smaller distance than the wedge, then what can we conclude about the force applied to push the wedge versus the force applied to lift the board?
   (Since the board is moving a smaller distance the force applied to the board by the wedge must be greater than the force applied to the wedge.)

5. Lift the boards apart without the wedge and then lift the boards apart by pushing the wedge in. Which is easier (requires less force)?
   (It requires less force to push the boards apart with the wedge.)

6. If we move the rubber bands to the outer pegs, predict what will happen to the force needed to push the boards apart with the wedge. Will it increase, decrease or remain the same?
   (Any answer is ok here.)

7. Which is easier, to push the boards apart with rubber bands on the outer pegs or the inner pegs? Why is it easier?
   (It is easier push the wedge between the boards when the rubber band is on the inner pegs. The top board is acting like a lever. The amount of work a lever is able to do is a product of the force applied times the distance from the fulcrum to the place where the force is applied. If the force is assumed to be the same for the rubber bands, then the greater the distance from the fulcrum to where the rubber bands are, the greater the amount of work the rubber bands are able to do, and the greater the amount of work needs to be done by the wedge to separate the boards.)

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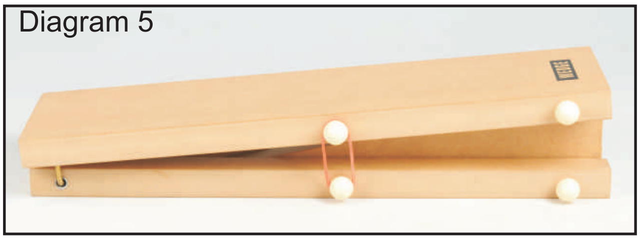
Diagram 5

2. Observe what happens to the rubber band as the wedge is pushed into the apparatus. Record your observations in the space provided below.

3. Which distance is greater? The distance the rubber band stretches or the distance the wedge moves?

4. Assume that the work done by pushing the wedge is equal to the work done lifting the top board. If the top board moves a smaller distance than the wedge, then what can we conclude about the force applied to push the wedge versus the force applied to lift the board?

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5. Lift the boards apart without the wedge and then lift the boards apart by pushing the wedge in. Which is easier (requires less force)?

6. If we move the rubber bands to the outer pegs, predict what will happen to the force needed to push the boards apart with the wedge. Will it increase, decrease or remain the same?

7. Which is easier, to push the boards apart with rubber bands on the outer pegs or the inner pegs? Why is it easier?

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