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FOCUS: Simple Machines

ESSENTIAL QUESTION: Can you describe the six types of simple machines and explain how each makes work easier? Can you calculate the mechanical advantage of each?

Simple & Compound Machines

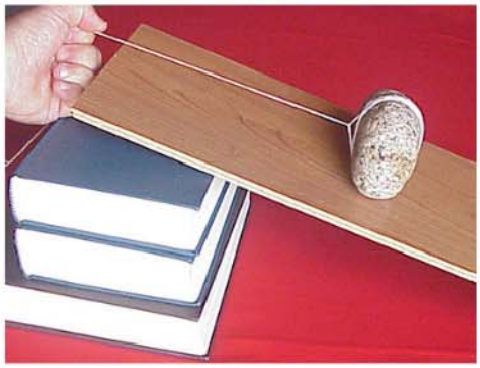
- A *simple machine* is:
- There are SIX TYPES of simple machines. They are:
  -
  -
  -
  -
  -
  -
- A *compound machine* is:
- Each simple machine has a unique way of making work _____, and therefore, each has its own way of calculating _____.

Purpose: In this activity, you will learn what each type of simple machine is, how each makes work easier, and how to calculate the mechanical advantage of each. You will also learn to identify simple machines in the world around you.

Station 1: INCLINED PLANE

1) An inclined plane is...

2) Set up an inclined plane like the one in the picture using the given materials: board and textbooks. Perform the following three experiments (several times, if you want) and make observations.



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Experiment	Observations
Experiment 1: Use the string to lift the load (rock) from the desk to the top of the book pile without using the inclined plane.	Book Height: Other observations:
Experiment 2: Use the string to drag the load (rock) up the inclined plane.	Book Height: Ramp Length: Other observations:
Experiment 3: Place the load (rock) in the back of the truck and use the string to pull the loaded truck up the inclined plane.	Book Height: Ramp Length: Other observations:
Experiment 4: Use more books to build a taller, steeper inclined plane and repeat Experiment #3 on your new inclined plane.	Book Height: Ramp Length: Other observations:

3) Which experiment required **you** to put in the most INPUT FORCE? Which required the least INPUT FORCE?

4) Explain why using the truck would reduce the amount of input force you were required to put in. (***Hint: Use what you know about friction to help you***)

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The formula for the **mechanical advantage** of an inclined plane is:

$$IMA_{inclined\ plane} = \frac{Length\ of\ Ramp}{Height\ of\ Ramp}$$

5) Calculate the mechanical advantage of the inclined plane that you built for Experiments 2-3.

6) Calculate the mechanical advantage of the inclined plane that you built for Experiment 4.

7) An inclined plane makes your work easier or more effective by... (circle as many as apply)

CHANGING THE **AMOUNT OF FORCE** THAT MUST BE APPLIED	CHANGING THE **DISTANCE** OVER WHICH THE FORCE IS APPLIED	CHANGING THE **DIRECTION** IN WHICH THE FORCE IS APPLIED.

*****Please disassemble your inclined plane before you leave the station.*****

HOMEWORK: Find as many examples of inclined planes as you can in the world around you (home, school, stores, in the car, on the road, etc.). List or draw your examples below.

Station 2: WEDGE

1) A wedge is...

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2) Choose a food from the plate in front of you. Try to take a bite and "chew" it up ***without*** using your teeth. Then try to take a bit and chew it up ***using your teeth.*** Make observations.

3) Your front teeth are called incisors and they look like this → → → → → → → How does the shape of incisors make it easier to take a bite of food than if you just had just lips or gums in the front of your mouth?

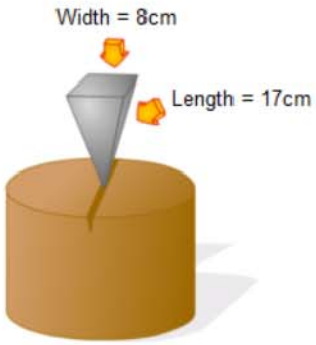
4) Carefully study the nail at the station in front of you. Draw a detailed picture of it below, paying special attention to the end that is driven into the wood.

5) Could a nail be considered a wedge? Why or why not?

The formula for the **mechanical advantage** of a wedge is:

$$IMA_{wedge} = \frac{Length\ of\ Wedge}{Width\ of\ Wedge}$$

6) Calculate the mechanical advantage of the ax-head pictured here:



7) A wedge makes your work easier or more effective by... (circle as many as apply)

CHANGING THE **AMOUNT OF FORCE** THAT MUST BE APPLIED	CHANGING THE **DISTANCE** OVER WHICH THE FORCE IS APPLIED	CHANGING THE **DIRECTION** IN WHICH THE FORCE IS APPLIED.

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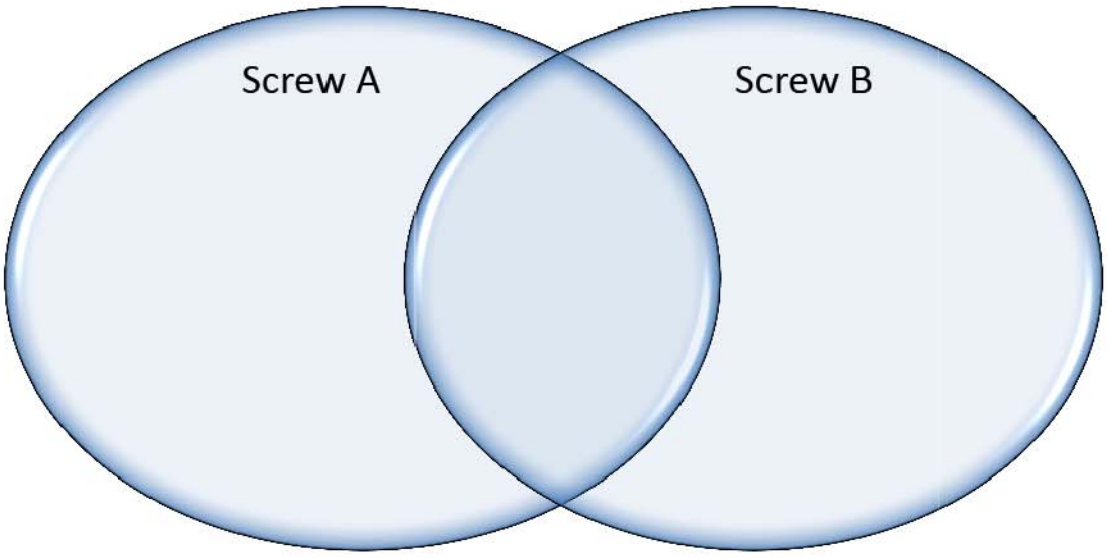
HOMEWORK: Find as many examples of wedges as you can in the world around you (home, school, stores, in the car, on the road, etc.). List or draw your examples below.

Station 3: SCREW

1) A screw is...

2) Study the two screws in front of you carefully. Compare and contrast Screw A and Screw B below.



3) Use the screwdriver to try to screw each one into the board placed between two desks. Add any observations to the Venn diagram above.

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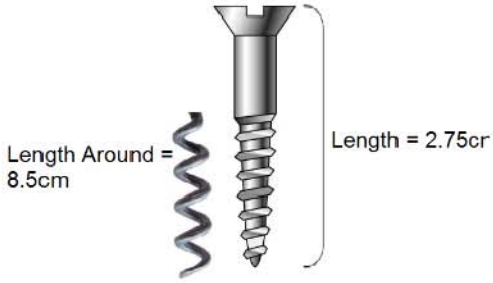
The formula for the **mechanical advantage** of a screw is:

$$IMA_{screw} = \frac{Distance\ around\ threads}{Length\ of\ screw}$$

4) Calculate the mechanical advantage of the screw pictured here:



5) A screw makes your work easier or more effective by... (circle as many as apply)

CHANGING THE **AMOUNT OF FORCE** THAT MUST BE APPLIED	CHANGING THE **DISTANCE** OVER WHICH THE FORCE IS APPLIED	CHANGING THE **DIRECTION** IN WHICH THE FORCE IS APPLIED.

HOMEWORK: Find as many examples of screws as you can in the world around you (home, school, stores, in the car, on the road, etc.). List or draw your examples below.

Station 4: WHEEL & AXLE

1) A wheel & axle is...

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2) A doorknob is a good example of a wheel and axle. The knob acts as the wheel and the shaft that goes through the door acts as the axle. Use our classroom doorknob for the following investigation:

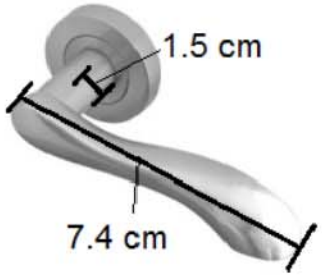
Experiment	Observations
Experiment 1: Place your hand as far to the outside edge of the door handle as you can and open the door.	
Experiment 2: Place your hand as close to the center shaft of the door handle as you can and open the door.	
Experiment 3: Place your hand in the middle of the doorknob handle and open the door.	

3) Your great aunt suffers from weakness in her hands and can't apply a large force using just her hands. Based on your observations above, if she were to replace all the average size doorknobs in her house, should it be with smaller knobs or larger knobs? Explain.

The formula for the **mechanical advantage** of a wheel & axle is:

$$IMA_{W\&A} = \frac{Radius\ of\ Wheel}{Radius\ of\ Axle}$$

4) Calculate the mechanical advantage of the doorknob pictured here:



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5) A wheel & axle makes your work easier or more effective by... (circle as many as apply)

CHANGING THE **AMOUNT OF FORCE** THAT MUST BE APPLIED	CHANGING THE **DISTANCE** OVER WHICH THE FORCE IS APPLIED	CHANGING THE **DIRECTION** IN WHICH THE FORCE IS APPLIED.

HOMEWORK: Find as many examples of wheel & axles as you can in the world around you (home, school, stores, in the car, on the road, etc.). List or draw your examples below.

Station 5: LEVER

1) A lever is...

- Levers have three important components:
  a. EFFORT: Input force provided by the person using the lever.
  b. FULCRUM: The pivot point or axis on which the rod of the lever rests.
  c. LOAD: The mass that needs to be lifted. The output force is what moves the load.
- There are 3 classes of levers, each with a different arrangement of these three components.

The formula for the **mechanical advantage** of a lever is:

$$IMA_{lever} = \frac{Distance\ from\ fulcrum\ to\ input\ force}{Distance\ from\ fulcrum\ to\ output\ force} = \frac{Length\ of\ input\ arm}{Length\ of\ output\ arm} = \frac{L_i}{L_o}$$

****Use this formula to help you solve the problems found in Stations 5A, 5B, and 5C.**

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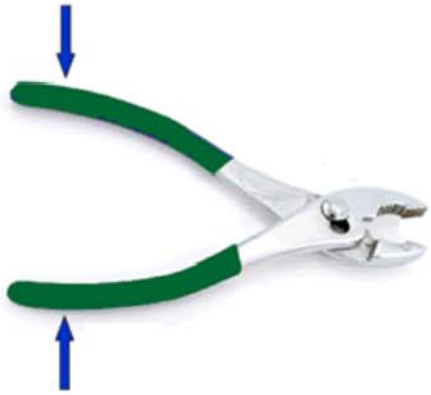
Station 5A: 1ST CLASS LEVER



1) Pliers are an example of a first class lever. Use the pliers to move a few of the nuts from the container to the cart. Label the picture with the words EFFORT, FULCRUM, LOAD.

2) Use the formula given above to find the mechanical advantage of the pliers. Please use the centimeter ruler provided.

A 1st class lever makes your work easier or more effective by... (circle as many as apply)

CHANGING THE **AMOUNT OF FORCE** THAT MUST BE APPLIED	CHANGING THE **DISTANCE** OVER WHICH THE FORCE IS APPLIED	CHANGING THE **DIRECTION** IN WHICH THE FORCE IS APPLIED.

HOMEWORK: Find as many examples of 1st class levers as you can in the world around you (home, school, stores, in the car, on the road, etc.). List or draw your examples below.

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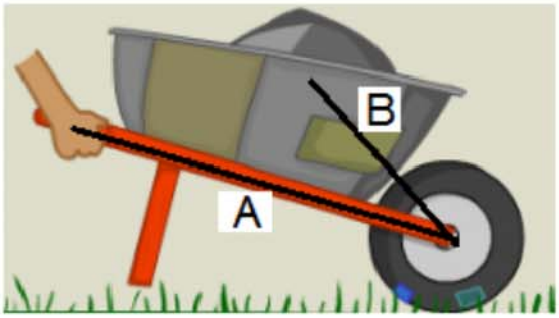
Station 5B: 2ND CLASS LEVER

1) Wheelbarrows and carts are examples of 2nd class levers. Pull the cart around a bit and then label the picture with the words EFFORT, FULCRUM, LOAD.



2) If in the picture on the right, Distance A is 1.2 m and Distance B is 0.6 m, what is the mechanical advantage of the wheelbarrow?

A 2nd class lever makes your work easier or more effective by... (circle as many as apply)

CHANGING THE **AMOUNT OF FORCE** THAT MUST BE APPLIED	CHANGING THE **DISTANCE** OVER WHICH THE FORCE IS APPLIED	CHANGING THE **DIRECTION** IN WHICH THE FORCE IS APPLIED.

HOMEWORK: Find as many examples of 2nd class levers as you can in the world around you (home, school, stores, in the car, on the road, etc.). List or draw your examples below.

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Station 5C: 3RD CLASS LEVER

1) Tweezers are an example of a first class lever. Use the tweezers to move the nuts from the cart back to the container. Label the picture with the words EFFORT, FULCRUM, LOAD.

2) Use the formula given above to find the mechanical advantage of the tweezers you used. Please use the centimeter ruler provided.

A 3rd class lever makes your work easier or more effective by... (circle as many as apply)

CHANGING THE **AMOUNT OF FORCE** THAT MUST BE APPLIED	CHANGING THE **DISTANCE** OVER WHICH THE FORCE IS APPLIED	CHANGING THE **DIRECTION** IN WHICH THE FORCE IS APPLIED.

HOMEWORK: Find as many examples of 3rd class levers as you can in the world around you (home, school, stores, in the car, on the road, etc.). List or draw your examples below.

Station 6: PULLEY

1) A pulley is...

2) Visit the following website on the computer provided: http://www.compassproject.net/sims/pulley.html.

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3) Manipulate the controls to test the pulley and complete the data table below.

PULLEY SIMULATION								
Pulley System	**Experiment Setup**				**Controls**	**Measurements**		
	Load	Distance to Lift	Friction	Pulley Diameter	Applied Force	Distance Pulled	I.M.A.	Efficiency
Single Fixed	5N	0.15m	0.2	0.14m				
Single Movable	5N	0.15m	0.2	0.14m				
Single Compound	5N	0.15m	0.2	0.14m				
Double Compound	5N	0.15m	0.2	0.14m				
Triple Compound	5N	0.15m	0.2	0.14m				
Quadruple Compound	5N	0.15m	0.2	0.14m				

4) What is the relationship between the number of pulleys in the system and the input force the user must apply?

As the number of ropes/pulleys in the system _____, the input force the user must apply will _____.

5) What is the relationship between the number of pulleys in the system and the distance the user must pull the input rope?

As the number of ropes/pulleys in the system _____, the distance the user must pull the input rope will _____.

6) What is the relationship between the number of pulleys in the system and the Ideal Mechanical Advantage of the machine?

7) What is the relationship between the number of pulleys in the system and the efficiency of the system? Explain why you think this relationship is this way.

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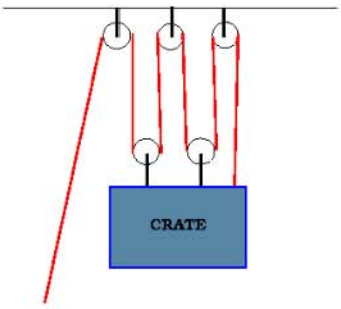
The formula for the **mechanical advantage** of a screw is:

$$IMA_{pulley} = \#\ of\ ropes\ supporting\ the\ load$$

8) What is the mechanical advantage of the pulley pictured here:



9) A pulley makes your work easier or more effective by... (circle as many as apply)

CHANGING THE **AMOUNT OF FORCE** THAT MUST BE APPLIED	CHANGING THE **DISTANCE** OVER WHICH THE FORCE IS APPLIED	CHANGING THE **DIRECTION** IN WHICH THE FORCE IS APPLIED.

HOMEWORK: Find as many examples of pulleys as you can in the world around you (home, school, stores, in the car, on the road, etc.). List or draw your examples below.