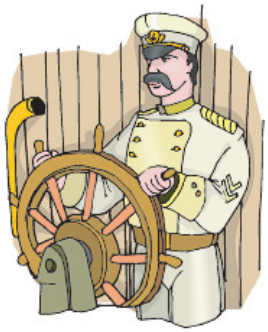
Name: _____ Date: _____

Student Exploration: Wheel and Axle

Vocabulary: effort, force, load, mechanical advantage, radius, wheel and axle

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)



1. A ship captain uses a steering wheel (called a “helm”) to turn the rudder of a sailing ship. Do you think it would be easier for him to turn a large wheel or a small wheel? Explain why you think so.

   _____

   _____

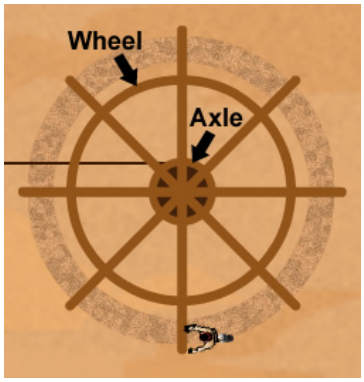
2. Which screwdriver do you think would turn a screw most easily? Circle your choice and explain why you picked the one you did.

   _____

   _____

Gizmo Warm-up: Dragging rocks

The *Wheel and Axle* Gizmo™ shows a simple machine called a **wheel and axle**. In this machine, turning the outer wheel will also turn the inner axle. The axle is connected to a rope that pulls a **load** of rocks.



1. Drag a **barbarian** to the wheel and press **Play** ( ). The barbarian pushes on the wheel with a certain **force**. Is the barbarian strong enough to move the wheel?

   _____

2. Click **Reset** ( ). Drag more **barbarians** to the wheel. The total force that the barbarians exert on the wheel is called the **effort**.

   How many barbarians does it take to move the load of rocks? _____

Activity A: **Wheel radius**	Get the Gizmo ready: • Click **Reset**. • Remove all barbarians from the wheel.	

Question: How does the Wheel radius affect the force needed to turn the wheel?

1. Observe: The **radius** of the wheel is the distance from the center of the wheel to the edge. Use the Gizmo to explore the question given above. (You can tell how much force is needed to turn the wheel by checking the smallest number of barbarians it takes to move it.)

2. Hypothesis: How does the wheel radius affect the effort needed to turn the wheel?

   _____

   _____

3. Collect data: Find the *smallest* number of barbarians needed to turn the wheel for each combination listed below. Click **Reset** between each trial.

Wheel radius	Axle radius	Smallest number of barbarians needed
6 m	4 m	
8 m	4 m	
10 m	4 m	
12 m	4 m	

4. Analyze: How did the effort needed to turn the wheel change as the wheel radius increased?

   _____

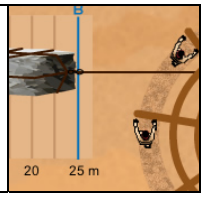
   _____

5. Draw conclusions: How is a wheel and axle useful? _____

   _____

   _____

   _____

Activity B: **Axle radius**	Get the Gizmo ready: • Click **Reset**. • Remove all barbarians from the wheel. • Set the **Wheel radius** to 12 meters.	

Question: How does the Axle radius affect the force needed to turn the wheel?

1. Observe: Use the Gizmo to explore the question given above.

2. Hypothesis: How do you think the axle radius will affect the effort needed to turn the wheel?

   _____

   _____

3. Collect data: First predict the *smallest* number of barbarians that will be needed to turn the wheel for each case listed below. Then use the Gizmo to test your predictions. Also fill in how far the barbarians had to walk to pull the rocks from point **A** to point **B**.

Wheel radius	Axle radius	Predicted number of barbarians needed	Actual number of barbarians needed	Distance barbarians walked
12 m	8 m			
12 m	6 m			
12 m	4 m			
12 m	2 m			

4. Analyze: Look at your data table to answer these questions.

   A. How did the effort needed to turn the wheel change as the axle radius decreased?

      _____

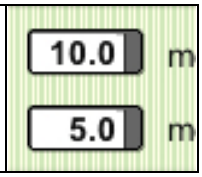
   B. How did the distance the barbarians walked change as the axle radius decreased?

      _____

5. Extend your thinking: The wheel and axle is helpful because it reduces the effort needed to move a load. What is the "price" you have to pay for this help?

   _____

   _____

Activity C: **Mechanical advantage**	Get the Gizmo ready: • Click **Reset**. • Set the **Wheel radius** to 10 meters. • Set the **Axle radius** to 5 meters.	

Question: How does a wheel and axle multiply force?

1. Collect data: For each case, use the Gizmo to determine the *smallest* number of barbarians needed to turn the wheel and the distance they walked. Click **Reset** between each trial.

Wheel radius	Axle radius	Smallest number of barbarians needed	Distance barbarians walked
10 m	5 m		
14 m	7 m		
6 m	3 m		

2. Analyze: What do you notice? _____

   _____

3. Calculate: The **mechanical advantage** (MA) is a number indicating how much a simple machine reduces the effort needed to move a load. The mechanical advantage of a wheel and axle is roughly equal to the **Wheel radius** divided by the **Axle radius**.

   What is the MA when the wheel radius is 8 m and the axle radius is 2 m? _____

4. Collect data: For each setup below, calculate the mechanical advantage and record the *smallest* number of barbarians it takes to move the wheel.

Wheel radius	Axle radius	Mech. advantage	Smallest # of barbarians needed
12 m	3 m		
6 m	1 m		
15 m	5 m		

5. Analyze: In each example, multiply the mechanical advantage by the number of barbarians.

   A. What pattern do you notice? _____

   B. Challenge: How many barbarians would it take to move the load if there were no wheel and axle? (Hint: MA = 1.) _____