Name: _____ Date: _____

PRACTICE 112m / 4 sec = 10.1

Mechanical Advantage of Simple Machines

READ CPO Science

We use simple machines to make tasks easier. While the output work of a simple machine can never be greater than the input work, a simple machine can multiply input forces OR multiply input distances (but never both at the same time). You can use this skill sheet to practice calculating mechanical advantage (MA) for two common simple machines: levers and ramps.

The general formula for the mechanical advantage (MA) of levers:

$$MA_{lever} = \frac{F_o \text{ (output force)}}{F_i \text{ (input force)}}$$

Or you can use the ratio of the input arm length to the output arm length:

$$MA_{lever} = \frac{L_i \text{ (length of input arm)}}{L_o \text{ (length of output arm)}}$$

Most of the time, levers are used to multiply force to lift heavy objects.

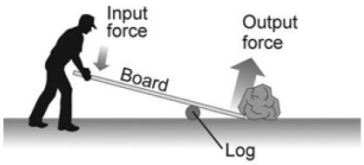
The general formula for the mechanical advantage (MA) of ramps:

$$MA_{ramp} = \frac{\text{ramp length}}{\text{ramp height}}$$

A ramp makes it possible to move a heavy load to a new height using less force (but over a longer distance). The mechanical advantage of a ramp can be found using this formula:

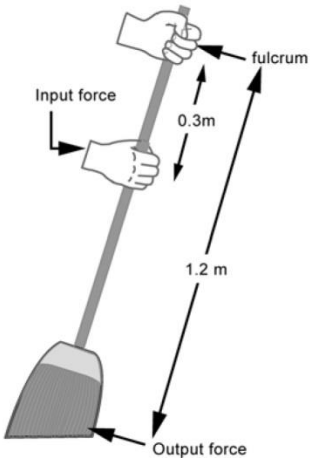
EXAMPLES

Example 1: A construction worker uses a board and log as a lever to lift a heavy rock. If the input arm is 3 meters long and the output arm is 0.75 meters long, what is the mechanical advantage of the lever?



$$MA = \frac{3 \text{ meters}}{0.75 \text{ meter}} = 4$$

Example 2: Sometimes levers are used to multiply distance. For a broom, your upper hand is the fulcrum and your lower hand provides the input force: Notice the input arm is shorter than the output arm. The mechanical advantage of this broom is:



$$MA = \frac{0.3 \text{ meter}}{1.2 \text{ meters}} = 0.25$$

A mechanical advantage less than one doesn't mean a machine isn't useful. It just means that instead of multiplying force, the machine multiplies distance. A broom doesn't push the dust with as much force as you use to push the broom, but a small movement of your arm pushes the dust a large distance.

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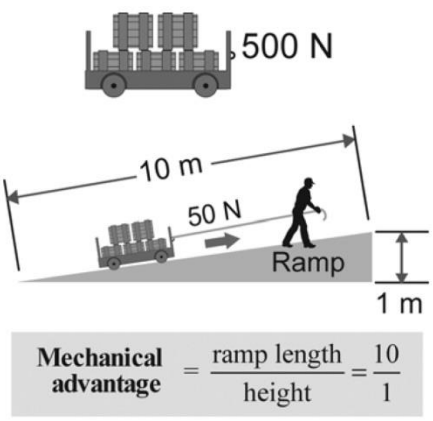
Example 3: A 500-newton cart is lifted to a height of 1 meter using a 10-meter long ramp. You can see that the worker only has to use 50 newtons of force to pull the cart. You can figure the mechanical advantage in either of these two ways:

$$MA_{ramp} = \frac{\text{ramp length}}{\text{ramp height}} = \frac{\text{10 meters}}{\text{1 meter}} = 10$$

Or using the standard formula for mechanical advantage:

$$MA = \frac{\text{output force}}{\text{input force}} = \frac{\text{500 newtons}}{\text{50 newtons}} = 10$$



Mechanical advantage $= \frac{\text{ramp length}}{\text{height}} = \frac{10}{1}$

Type of machine	Mechanical Advantage
Lever	$\frac{Length\ of\ Input\ Arm}{Length\ of Output\ Arm}$
Pulley	$\frac{1}{\#\ pulleys}$
Wheel and Axle	$\frac{radius1\ (of\ axle)}{radius2\ (of\ wheel)}$
Inclined plane (ramp)	$\frac{Ramp\ length}{Ramp\ height}$

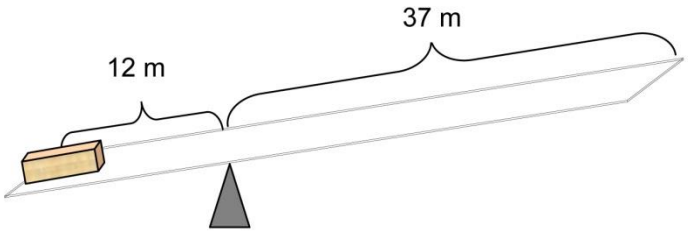
Mechanical Advantage Worksheet

Directions
Using the notes from class, and from the previous page, calculate the following. Remember; show your formulas, work, and units of measure (if any)!

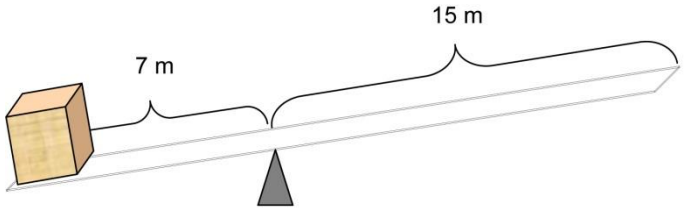
Levers

1. Assume that the length of the output arm of a lever is 5.5 m, and the length of the input arm is 2.25 m, what would be the mechanical advantage of the lever? Show your work.

2. What is the mechanical advantage of the following lever? Show your work.



3. What is the mechanical advantage of the following lever? Show your work.



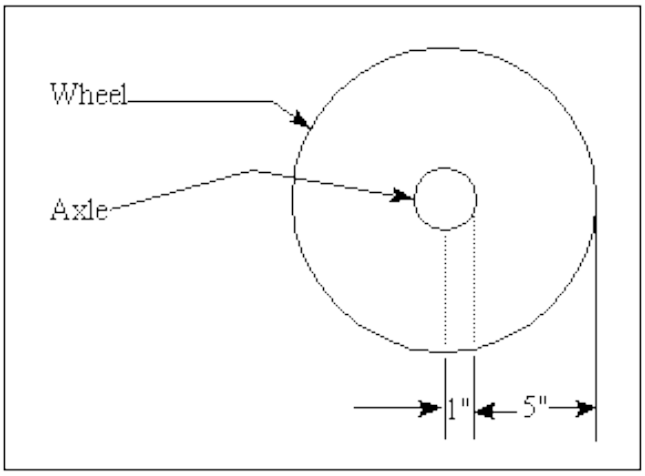
Pulleys

4. If a simple machine has four pulleys, what is its mechanical advantage? Show your work.

Wheel and Axle

5. If a wheel has a radius of 3 feet, and the axle has a radius of 0.5 feet, what is the mechanical advantage of this wheel and axle? Show your work.

6. What is the mechanical advantage of the following wheel and axel? Show your work.

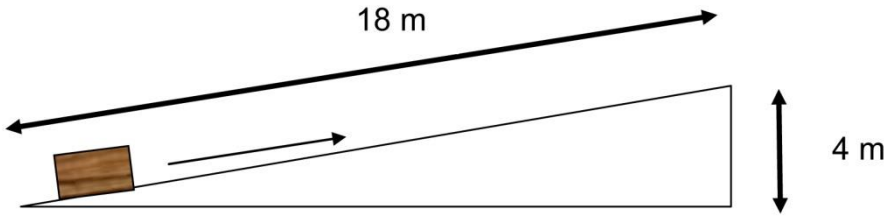


7. If a wheel has a radius of 2 cm and the axle has as radius of 1 cm, what is the mechanical advantage of the wheel and axle? Show your work.

Inclined plane

8. If an inclined plane is 7 feet high and 21 feet long, what is its mechanical advantage? Show your work.

9. What is the mechanical advantage of the following inclined plane? Show your work.



10. What is the mechanical advantage of the following inclined plane? Show your work.