

Mechanical Advantage of Simple Machines

NAME: KEY

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:

$$MA_{\text{lever}} = \frac{F_{\text{output force}}}{F_{\text{input force}}}$$

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

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

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

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?

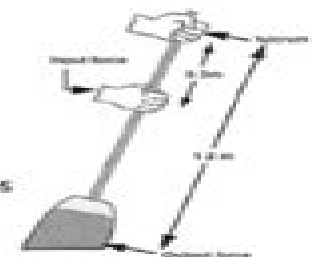
$$MA = \frac{3 \text{ meters}}{0.75 \text{ meters}} = 4$$



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:

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

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.



1. A lever used to lift a heavy box has an input arm of 4 meters and an output arm of 0.8 meters. What is the mechanical advantage of the lever?

$$MA = \frac{4 \text{ m}}{0.8 \text{ m}} = 5$$

2. What is the mechanical advantage of a lever that has an input arm of 3 meters and an output arm of 2 meters?

$$MA = \frac{3 \text{ m}}{2 \text{ m}} = 1.5$$

3. A rake is held so that its input arm is 0.4 meters and its output arm is 1.0 meters. What is the mechanical advantage of the rake?

$$MA = \frac{0.4 \text{ m}}{1.0 \text{ m}} = 0.4$$

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