

5. Simple machines

Everyone uses machines every day. Some are simple tools, such as bottle openers and screwdrivers, while others are complex, such as bicycles and automobiles. Machines, whether powered by engines or people, make tasks easier. A machine eases the load by changing either the magnitude or the direction of a force to match the force to the capability of the machine or the person.

5.1 purpose of machines

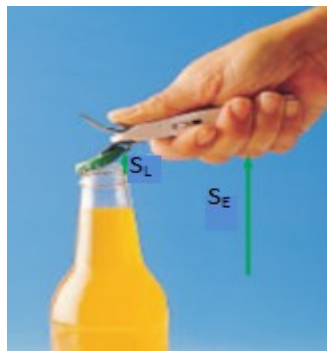
When you use the opener, you lift the handle, thereby doing work on the opener. The opener lifts the cap, doing work on it. The work that you do is called the input work, W_i . The work that the machine does is called the output work, W_o .

Recall that work is the transfer of energy by mechanical means. You put work into a machine, such as the bottle opener. That is, you transfer energy to the opener. The opener, in turn, does work on the cap, thereby transferring energy to it. The opener is not a source of energy, and therefore, the cap cannot receive more energy than the amount of energy that you put into the opener. Thus, the output work can never be greater than the input work. The machine simply aids in the transfer of energy from you to the bottle cap.



Mechanical advantage The force exerted by a person on a machine is called the effort force, E . The force exerted by the machine is called the resistance force, L . As shown in the Figure above. E is the upward force exerted by the person using the bottle opener and F is the upward force exerted by the bottle opener. The ratio of resistance force to effort force, is called the mechanical advantage, MA , of the machine.

$$MA = \frac{L}{E}$$



For an ideal machine, ideal mechanical advantage, IMA , is equal to the displacement of the effort

force, divided by the displacement of the load. The ideal mechanical advantage can be represented by the following equation.

$$\text{IMA} = \frac{S_E}{S_L} = VR$$

A bottle opener is an example of a simple machine. It makes opening a bottle easier, but it does not lessen the work required to do so.

Efficiency In a real machine, not all of the input work is available as output work. Energy removed from the system means that there is less output work from the machine. Consequently, the machine is less efficient at accomplishing the task. The efficiency of a machine, η is defined as the ratio of output work to input work.

$$\eta = \frac{\text{MA}}{\text{VR}} \times 100\%$$

Or,
$$\eta = \frac{W_o}{W_i} \times 100\%$$

Activity 1

1. What is the difference between ideal machine and real machine?
2. Which one of the following is **false** about simple machines? It is a device
 - A. that only requires one or more force to work
 - B. used for doing work that has only one part
 - C. that uses a single effort to do work against a single load force
 - D. used as elementary building block for producing other machines
3. A load of 80 N is placed on a first order lever of length 1m. If an effort of 40 N is applied at a distance 80 cm from the fulcrum, what is the efficiency of the lever? What type of a machine it is?

A. 50 % speed multiplier	B. 50 %, force multiplier
C. 50 % distance multiplier	D. 64 %, distance multiplier