All Work and no Play

Work, work, work. You might head off to your job one day, sit at a computer, and type away at the keys.

Is that work?

To a physicist, only parts of it are.

Work is done when a **force** that is applied to an object **<u>moves</u>** that object.

Answer #2 on your notes before moving on!

Sitting and looking at a computer screen is NOT WORK because nothing is moving.

Tapping on the keyboard and making the keys move is work. Your fingers are applying a force and moving the keys.

Sitting in the car on the way to school is NOT WORK.

…but the energy your car engine uses to move the car does work.

You have to exert a <u>force</u> AND <u>move</u> something in the <u>same</u> direction as the force to qualify as doing <u>work</u>.

The work is calculated by multiplying the force by the amount of movement of an object. The formula is:

(Work = Force x Distance)

The unit for work is the joule (J).

For example:

With the **work** formula, you can compare the amount of work you do to lift some trees you are planting. To lift one tree that has a weight of 100 Newtons, you would have to exert a force over **100 Newtons**. If you were to raise the tree **1 meter**, you would do:

W = F x D

100 N x 1 m =

100 Joules (of work)

To lift a tree that has twice as much weight, you would have to exert a force over **200 Newtons**. If you were to raise the tree **1 meter**, you would do:

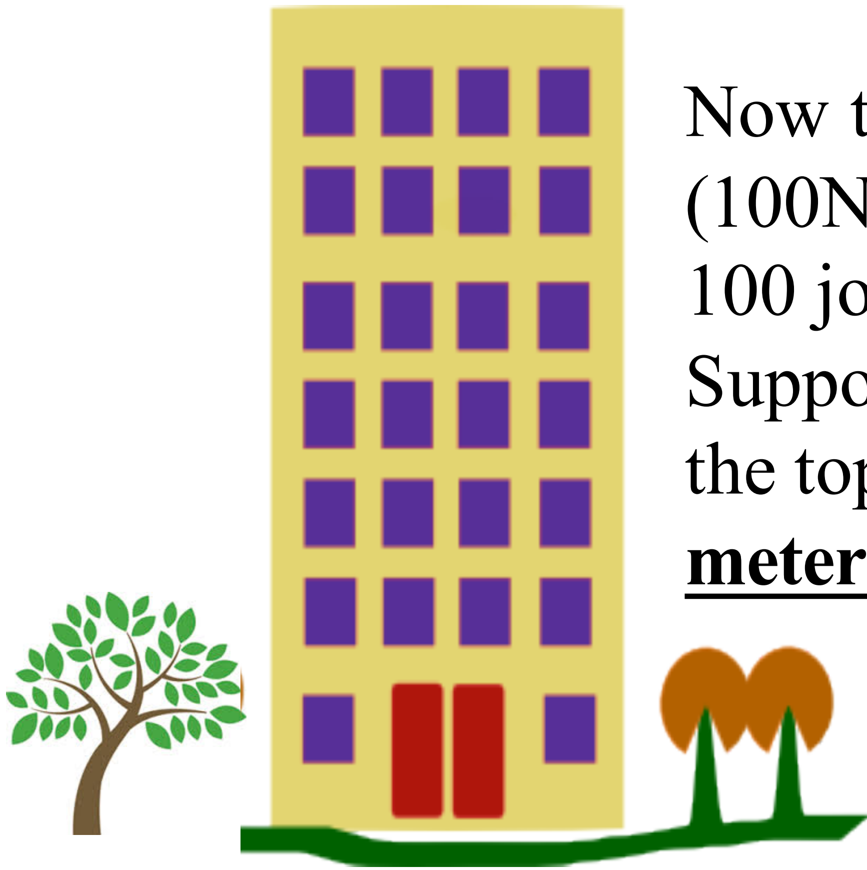
W = F x D

200 N x 1 m =

200 Joules (of work)

Therefore, the <u>heavier</u> the object, the more work needed to move the object the same distance!

Another example:



Now think about lifting the first tree (100N) up a longer distance. You did 100 joules of work lifting it 1 meter. Suppose you needed to lift the tree to the top floor of a building that is **<u>40 meters tall</u>**.

W = F x D

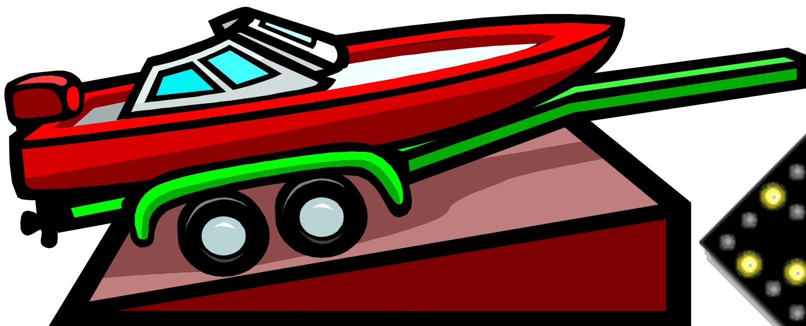
100 N x 40 m =

4,000 Joules (of work)

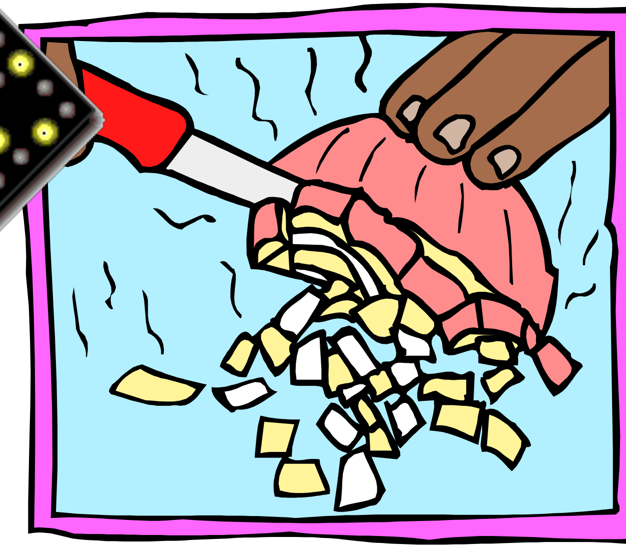
(40 times as much work as you did lifting it 1-meter!)

Therefore, if you try to move the same object a longer distance, more <u>work</u> is needed!

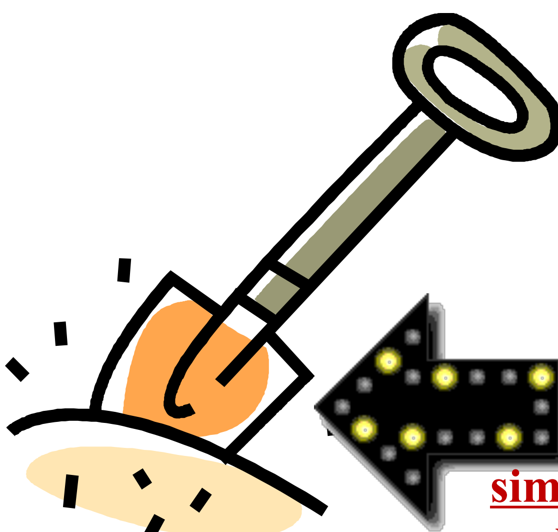
A **simple machine** is a device that has one or two parts which you can use to make work **easier** or more effective.



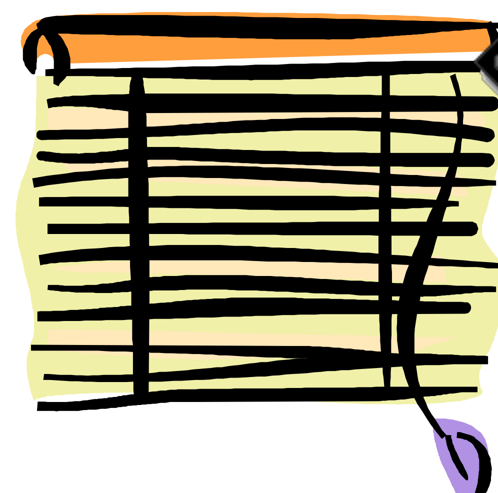
simple machine



simple machine



simple machine



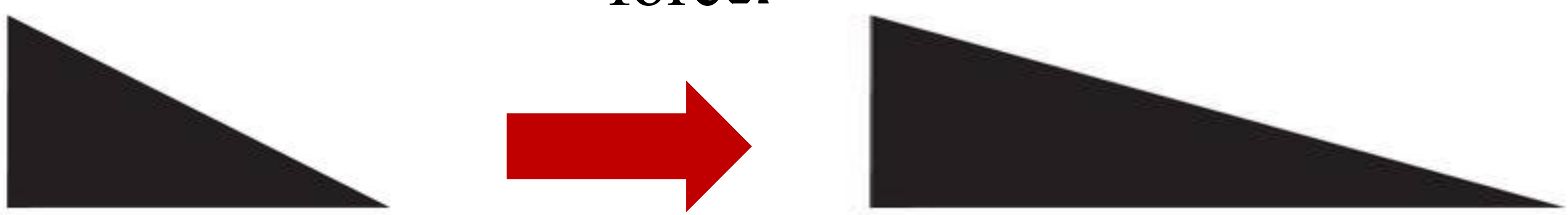
simple machine

A **machine** does **NOT decrease** the amount of **work** that is done, but it makes the work **easier** by:

-Increasing the amount of **FORCE** exerted to

move the object

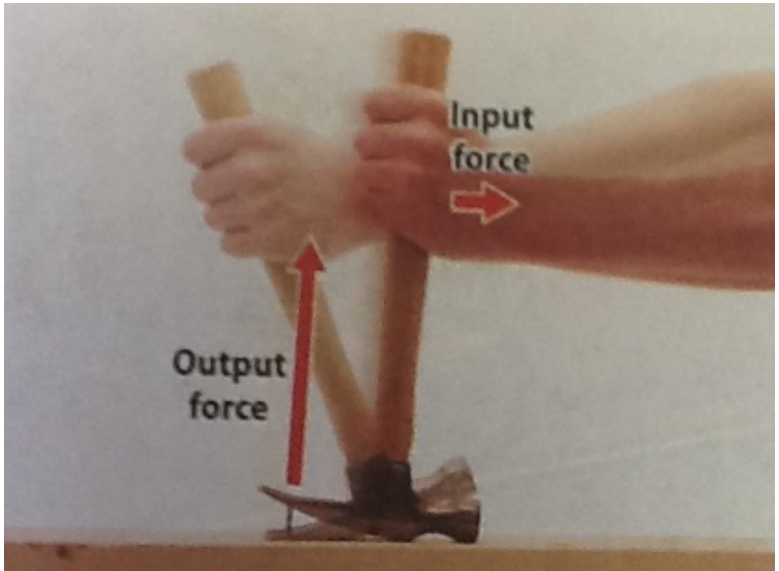
-Increasing the **DISTANCE** over which you exert the force.



-**CHANGING** the **DIRECTION** in which you exert your force.

The force you apply to the simple machine is called the **INPUT force**.

The machine does work by exerting a force on the object over a distance. The force exerted by the machine on the object to be moved is the **OUTPUT force**.



MECHANICAL ADVANTAGE

A machine's mechanical advantage is a ratio of the output force to the input force. It indicates how much the simple machine changes the input force (the force you apply to it.)

$$\text{Mechanical Advantage} = \frac{\text{Output Force}}{\text{Input Force}}$$

Mechanical Advantage of Increasing Force

The output force (the force the machine exerts) is GREATER than the input force (the force you put on the machine.)

For Example: If you exert a force of 20 Newtons on a can opener, and the opener exerts a force of 60 Newtons on the can, the mechanical advantage is:

$$\frac{\text{Output Force}}{\text{Input Force}} = \frac{60 \text{ Newtons}}{20 \text{ Newtons}} = \mathbf{3}$$

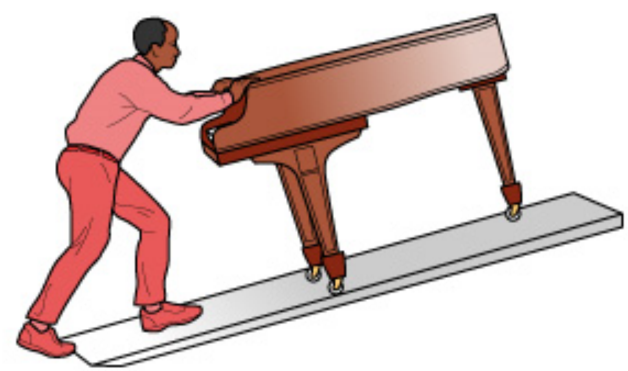
The can opener **TRIPLED** your force!

Mechanical Advantage of Increasing Distance

For a machine that increases distance, a **lesser force is exerted but over a longer distance.**

For Example: If you exert a force of 10 Newtons pushing a piano up a ramp and the height of the ramp compared to the distance you have to move the piano exerts an output force of 20 Newtons, the mechanical advantage is:

$$\frac{\text{Output Force}}{\text{Input Force}} = \frac{20 \text{ Newtons}}{10 \text{ Newtons}} = \mathbf{2}$$



The longer ramp (distance) **DOUBLED** your force!

Mechanical Advantage of Changing Direction

If only the direction changes, the input force will be the **SAME** as the output force. This means the mechanical advantage is **one**. You still exert a force, but because it is in a different direction, it is easier to do.

For example:

A sailor pulls on a rope to raise the sail and exerts an input force of 10 N. The sail has an output force of 10 N. The mechanical advantage is:

$$\frac{\text{Output Force}}{\text{Input Force}} = \frac{10 \text{ Newtons}}{10 \text{ Newtons}} = \mathbf{1}$$

Even though changing direction kept the mechanical advantage the same, changing the direction you pulled on the sail and working **WITH** gravity made the work seem **EASIER!**

So, some machines allow you to:

-use **<u>more</u>** force over a **<u>shorter</u>** distance (can opener)

-**<u>less</u>** force over a **<u>longer</u>** distance (piano up ramp)

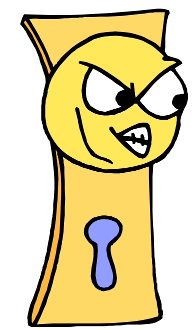
-or the **<u>same</u>** force in a **<u>different</u>** direction (raising sail.)

In the end, you do the **<u>same</u>** amount of **<u>work</u>** with the machine as you do without the machine, but the work is **<u>easier</u>**.

There are SIX types of machines which make work easier.

They are called simple machines!

The **Wedge**

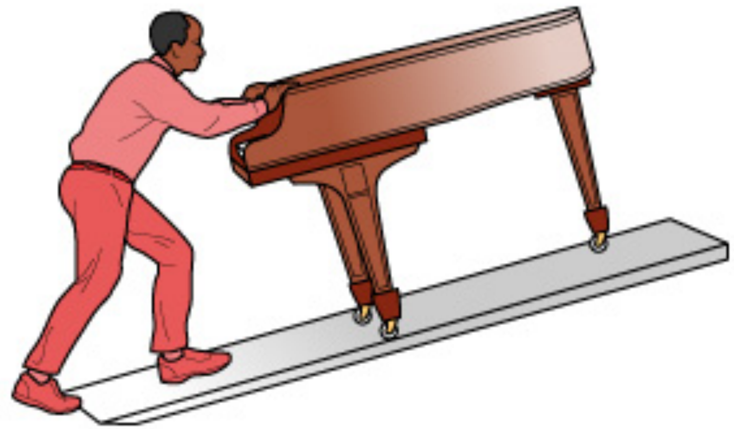


The **Wheel & Axle**

The Screw

The Lever

And the two we will focus on this year:



The Inclined Plane

The Pulley