SIMPLE MACHINE AND MECHANISMS

Mechanisms and simple machine are devices that are used to reduce the amount of effort needed to complete a number of different actions or to transmit and/or transform motion.
Humans have used them since ancient times, and they include everything from simple machines to extremely sophisticated designs of today.

SIMPLE MACHINES
They are used to reduce the amount of effort needed. They are:

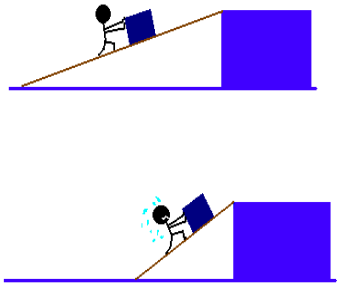
1. The wheel
2. The inclined plane
3. The wedge
4. The roller
5. The screw
6. The pulley
7. The lever

1. THE WHEEL - LA RUEDA

The wheel is probably the most important mechanical invention of all time. Nearly every machine built since the beginning of the Industrial Revolution involves a single, basic principle embodied in one of mankind's truly significant inventions.
The wheel is very important for its simplicity. Furthermore, the wheel allows you to very significantly reduce friction and allows you to move heavy objects from one place to another more easily.

2. THE INCLINED PLANE - EL PLANO INCLINADO

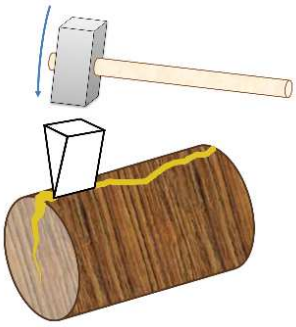
The inclined plane is simply a flat surface raised at an angle, like a ramp. It is a way of lifting a load that would be too heavy to lift straight up.
The angle (the steepness of the inclined plane) determines how much effort is needed to raise the weight. The steeper the ramp, the more effort is required. The ramp makes life easier not by altering the amount of work that is needed, but by altering the way in which the work is done. Work has two aspects to it: the effort that you put in, and the distance over which you maintain the effort. If the effort increases, the distance must decrease, and vice versa. This is easiest to understand by looking at two extremes. Climbing a hill by the steepest route requires the most effort, but the distance that you have to cover is shorter.



Climbing up the gentlest slope requires the least effort, but the distance is greater. This is a basic rule that is obeyed by many mechanical devices, and it is the reason why the inclined plane ramp works: it reduces the effort needed to raise an object by increasing the distance that it moves.

3. THE WEDGE - LA CUÑA

A wedge is a simple machine made up of two inclined planes put together. These 2 planes meet and form a sharp edge.
Wedges are used to push two objects apart, or cut an object into pieces.
A wedge gets inbetween objects and splits it apart.



4. THE ROLLER - EL RODILLO

The first rollers were simple wooden cylinders, such as tree trunks, which were used to move heavy objects.

5. THE SCREW - EL TORNILLO

A screw is a simple machine made up of other simple machines. It is an inclined plane wrapped around a cylinder.
The screw has 2 parts.
The inclined plane is the thread that wraps around the screw.
The cylinder is the long rod.
Screws hold down objects and hold them together.
They can be used for many things, e.g., to press objects or to move water, as you can see in the picture (Archimedes' screw).

6. THE PULLEY - LA POLEA

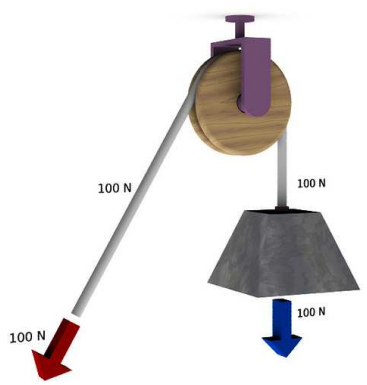
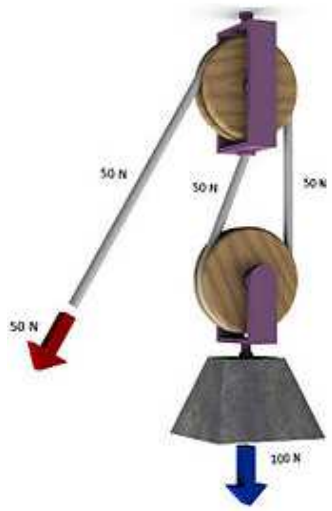
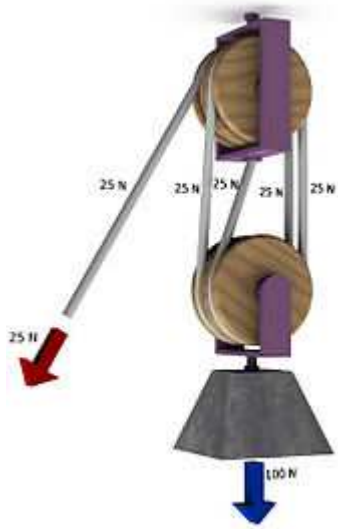
A pulley is a wheel with a groove all around its perimeter that allows us to place a rope/belt around it. This wheel can turn around its center (axle) because of the rope motion. We often use pulleys to lift weights easier.
The pulley makes it easier to lift a weight because you can use the weight of your body

We can find three kinds of pulleys

1. **Fixed pulley**
   The pulley is fixed to the ceiling, like the first picture in the table.

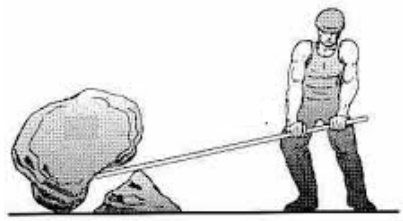
2. **Moveable pulley**
   It has two pulleys, one is fixed and the other can move. In this pulley we have to move double the amount of rope, but we managed to carry half weight.

3. **Compound pulley (block and tackle) - Polipasto**
   It has more than two pulleys. The pulleys are assembled together to form blocks and then blocks are paired so that one is fixed and one moves with the load. The rope is driven, through the pulleys to provide mechanical advantage that amplifies that force applied to the rope. The more rope you move, the less force you have to apply.

Fixed pulley	Moveable pulley	Block and tackle
		

7. THE LEVER - LA PALANCA

A lever is a simple machine consisting of a beam or a rigid rod pivoted at a fixed point called a fulcrum.



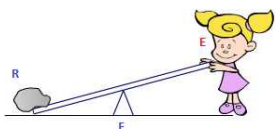
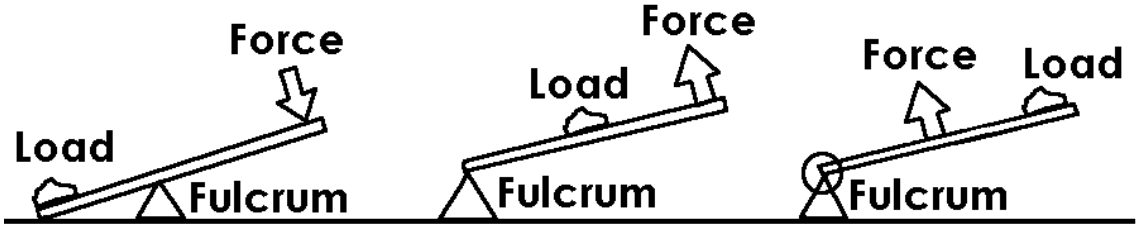
The ideal lever does not bend. In this case, the power in the lever (Effort) equals the power out (Resistance or Load), and the ratio of output to input force is given by the ratio of the distances from the fulcrum to the points of application of these forces. This is known as the ***ruler of the lever.***

The mechanical advantage of a lever can be determined by the ruler of the lever:

E x D = R x d

When: E = Effort you have to do
D = Distance from the effort to the fulcrum
R = Resistance you want to move.
d = Distance from the resistance to the fulcrum

There are three types of levers, according to the position of the resistance, effort and the fulcrum.

Class 1	**Class 2**	**Class 3**
Fulcrum in the middle: the effort is applied on one side of the fulcrum and the resistance (or load) on the other side. Mechanical advantage is important (E<<R).	Resistance (or load) in the middle: the effort is applied on one side of the resistance and the fulcrum is located on the other side. Mechanical advantage is important (E<<R).	Effort in the middle: the resistance (or load) is on one side of the effort and the fulcrum is located on the other side. Mechanical advantage doesn't exist (E>>R).
		
		

MECHANISMS

The purpose of mechanisms is to transmit and/or transform motion. This transmission may (or not) include:

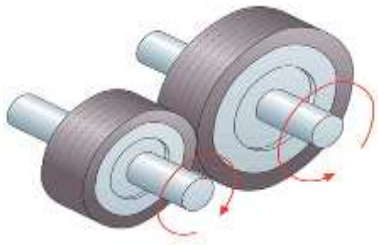
- Increasing or reducing speed.
- Varying the axis angle or the direction of spin.
- Changing direction
- Varying the type of motion.

The different kinds of mechanism are:

MECHANISMS WHICH TRANSMIT MOTION

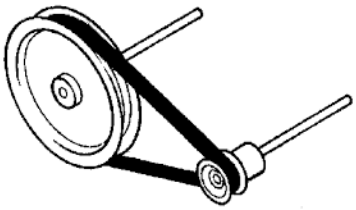
1) FRICTION WHEEL - RUEDAS DE FRICCIÓN

The friction wheels of friction drives are wheels joined though friction. The driver wheel transmits motion to the driven wheel by rolling, but both wheels turn in opposite direction.



2) PULLEYS AND BELTS - POLEAS CON CORREAS

A pulley system consists of two pulley wheels each on a shaft, connected by a belt. This transmits rotary motion and force from the input, or driver shaft, to the output, or driven shaft.
If the pulley wheels are different sizes, the smaller one will spin faster than the larger one.
The main feature of a pulley is its diameter (D)



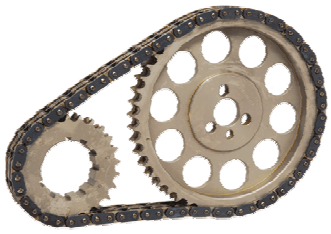
3) GEARS OR COGWHEELS - ENGRANAJES O RUEDAS DENTADAS

3.1-STRAIGHT SPUR GEAR - ENGRANAJES RECTOS

Spur gears are the most common type of gears. They have straight teeth, and are mounted on parallel shafts.
The movement is transmitted tooth by tooth.
The main feature of a gear is its number of teeth (Z).

3.2-CHAIN GEAR - ENGRANAJES UNIDOS POR CADENAS

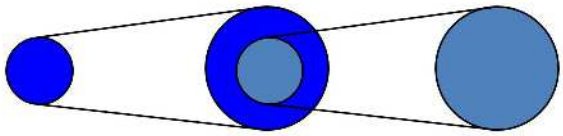
The chain drive is a way to transmit mechanical power from one place to another. It is often used to transmit power to the wheels of a vehicle, including bicycles and motorcycles. It is also used in a wide variety of machines, besides vehicles.
The movement is transmitted by a chain with hollow links, known as the transmission chain.
Each gear tooth mesh with the holes in the chain links.



4) TRAINS - TRENES

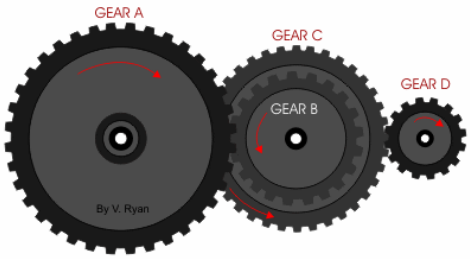
4.1-PULLEY TRAINS - TRENES DE POLEAS

A pulleys train is a combination of more than two pulleys. They are used to reduce or increase the speed considerably.



4.2-GEAR TRAINS - TRENES DE ENGRANAJES

A gears train is a combination of more than two gears.
They are used to reduce or increase the speed considerably.



5) HOW THESE MECHANISMS TRANSMIT MOTION

The motion is transmitted from the motor pulley to the conducted pulley. The relationship between theses two pulleys is very simple.

$$V_m \times D_m = V_c \times D_c$$

where:

V_m is the speed of the motor pulley (in revolutions per minute - rpm)
D_m is the diameter of the motor pulley
V_c is the speed of the conducted pulley (in revolutions per minute)
D_c is the diameter of the conducted pulley

If we have gears instead of pulleys, the way to calculate the speed is similar:

$$V_m \times Z_m = V_c \times Z_c$$

where:

V_m is the speed of the motor pulley (in revolutions per minute - rpm)
Z_m is the number of teeth of the motor pulley
V_c is the speed of the conducted pulley (in revolutions per minute)
Z_c is the number of teeth of the conducted pulley

If we have trains (of pulley or gears), we have to calculate the speed two by two, I mean, we have to calculate the speed of pulley two (pair one-two), after this we have to calculate the speed of pulley three (pair two-three), after the speed of pulley four (pair three-four) and so on. For gears is exactly the same.

It is important to notice that two pulleys of gears collocated ON THE SAME SHAFT have the same speed.

6) TRANSMISION RATIO - RELACIÓN DE TRANSMISIÓN

The transmission ratio is the relationship between the speed of the motor pulley or gear and the speed of the conducted pulley or gear.

$$I = V_m / V_c$$

It gives us an idea of the acceleration or deceleration of our system. If we have a train of pulleys or gears, the transmission ratio uses to be calculated between the first and the last mechanism.

$$I = V_m / V_{final}$$

The transmission ratio can be:

- $I = 1$. When $V_m = V_c$
- $I > 1$ When $V_m > V_c$ It means deceleration. If e.g. I=3, the second pulley rotates three times lowlier than the first.
- $I < 1$ When $V_c > V_m$ It means acceleration. If e.g. I=1/3, the second pulley rotates three times faster than the first.

MECHANISMS WHICH TRANSFORM MOTION

1) BEVEL GEAR - ENGRANAJES CÓNICOS

Bevel gears are useful when the direction of a shaft's rotation needs to be changed. They are usually mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well.

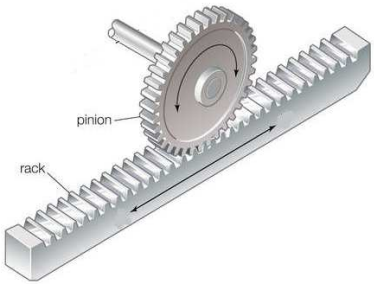
2) WORM GEAR - TORNILLO SIN FIN

Worm gears are used when large gear reductions are needed. It is common for worm gears to have reductions of 20:1, and even up to 300:1 or greater.

Many worm gears have an interesting property that no other gear set has: the worm can easily turn the gear, but the gear cannot turn the worm.

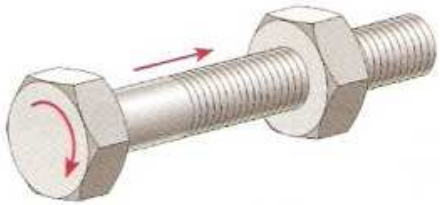
3) RACK AND PINION - SISTEMA PIÑÓN CREMALLERA

A rack and pinion is a type of linear actuator that comprises a pair of gears which convert rotational motion into linear motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack"; rotational motion applied to the pinion causes the rack to move relative to the pinion, thereby translating the rotational motion of the pinion into linear motion.



4) NUT AND BOLT - SISTEMA TUERCA TORNILLO

The screw-nut mechanism is a mechanism to transform circular movement into linear movement comprised of a nut housed in a threaded shaft (screw).
If the screw rotates and the orientation of the nut is fixed, the nut advances straight along the screw.
On the other hand, if the nut is rotated, while keeping the bolt fixed, the nut also advances straight along the screw.



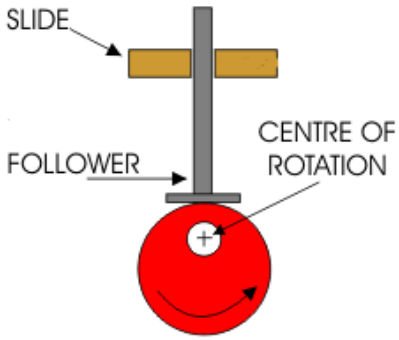
5) CAM - LEVA

A cam is a rotating or sliding piece in a mechanical linkage used especially in transforming rotary motion into linear motion or vice versa. The cam uses to be a simple tooth that produces a smooth reciprocating (back and forth) motion in the follower, which is a kind of lever or dock making contact with the cam.

6) ECCENTRIC CAM - EXCÉNTRICA

An eccentric cam is a disc with its centre of rotation positioned ‘off centre’ (hence the word "eccentric", out of the centre).

Its effect is similar to a cam, because an eccentric cam produces a smooth reciprocating motion too.

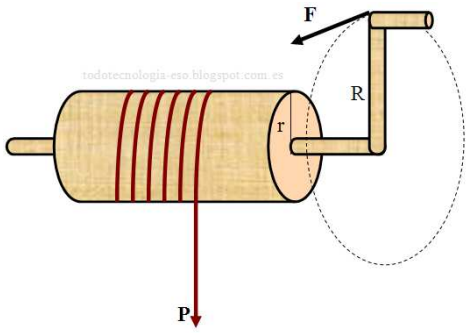


7) WINCH AND CRANK HANDLE - MECANISMO TORNO MANIVELA

A winch is a mechanical device that is used to pull in (wind up) or let out (wind out) a rope tied to a heavy object. In its simplest form it consists of a roller and a attached hand crank.

It translates the rotational motion of the crank handle into linear motion.

The smaller the radius of the roller (r) and handle larger (R), the less force we will have to apply.



8) CRANK LINK SLIDER - MECANISMO BIELA MANIVELA

The crank link slider mechanism is a mechanism that transforms a circular translational movement into a linear back and forth motion or vice versa. The most common current example is in the internal combustion engine of a car, in which the linear movement of the piston caused by the explosion of gas is transmitted to the connecting rod and becomes a circular motion to the crankshaft. It was very common in old trains.