MECHANISMS

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1 INTRODUCTION

In technology, when we are designing a machine, the most common is that it is moved by a motor, which has a circular motion, but sometimes that is not the kind of movement we need. In that case you have to put something that changes the type of movement.

For example in a crane, our intention is usually to lift (with a linear movement) a weight, for which we have a motor with circular movement. We can not directly attach the weight to the engine, because then it would turn instead of lifting. But we can wind the cable of the crane in a drum moved by the engine. That element will be one of those that we will study in this subject.

At other times we find that we have to increase the strength of the machine to perform its function correctly. For example, in the case of the crane we are interested in lifting as much weight as possible. In this case we will also have to put something that increases the force, such as a reduction system using gears. In this topic we will also study several operators capable of solving this problem.

We have used the word "operator". In technology we use it to refer to a technological solution that solves an elemental problem. When trying to solve a complex problem it is good to divide it into simpler problems. Solutions to simpler problems we call operators. Very different problems can have similar parts that are solved with the same type of operator. You will notice that in the machines you construct in the subject of technology, although their function is very different, it is frequent that there are similar parts, the operators, that solve a similar part within the problem.

The present unit deals with the mechanisms of transformation of movements, which are the operators capable of changing the types of movement and the forces inside the machines.

- **Force Transformations**

The mechanisms have an input and an output. A movement and a force are applied to the entrance and others are obtained at the exit. When on one side we have a lot of movement and on the other we have very little, the forces are transformed. We will always find that in the part of the mechanism that there is more movement there will be less force and where there is less movement there is more force.

When we value a mechanism, one of the things we are going to ask is whether or not it increases the force. To know, we have to see if the input is the same as the output. In the case that it is different, there will be more force in the part that is moving less.

Even calculations can be made, because there is a general law that relates movement to force in mechanisms:

Motion x force (at the input) = motion x force (at the output)

This general law sometimes takes one form or another depending on the mechanism in question.

- **Reversibility of mechanisms**

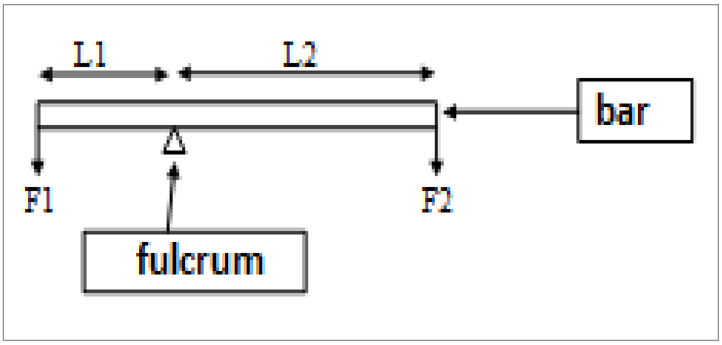
Another concept that we will consider in all mechanisms is their reversibility. The mechanisms may be reversible or irreversible. In the reversible we can exchange input and output, that is, apply force and motion in what was the output and obtain the result in what was the input. In irreversible this is not possible.

Let's look at the different types of mechanisms we are going to study one by one.

2 LEVER

A lever with a bar and a fulcrum. This transforms one movement of a bow into another.

The point of support divides the bar into two sections called arms (L1 and L2 in the drawing). When these two arms are not equal, the movements in the entrance and the exit are not equal, therefore, it is a mechanism that transforms forces. In fact, that is their main utility. In the small arm (Ll in the drawing) there is less movement, so there is more force (F1 will be greater than F2).



The general equation of mechanics in the case of the lever takes the following form because it is easier to measure the length of the arms than the arcs that describe the ends of the lever.

$$F1 \times L1 = F2 \times L2$$

Where F1 and F2 are the forces applied to the lever and L1 and L2 are the arms of the lever. This equation is called the **lever law**.There are levers in well-known gadgets, for example: in a clamp, in a pliers or in a wheelbarrow.

3 PULLEYS

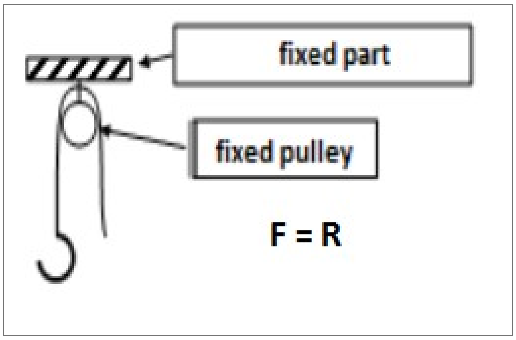
Pulleys are grooved wheels. We can imagine them as a bicycle wheel in which we have removed the rubber. The size can vary, but they may be larger than the bicycle wheel, but they are usually much smaller.

When a pulley rotates freely on its axis, it is called the idle pulley. When it rotates together, it is called the solidary pulley. If we attach the shaft of an idler pulley, the pulley can rotate. However, if we grasp the shaft of a solid sheave, the sheave does not rotate because they are attached.

An axis is a bar allows elements to rotate. A shaft is a rod that holds rotating elements in a solid manner. An axis can not transmit motion, a shaft does. Solid pulleys do not have an axle, they have a shaft

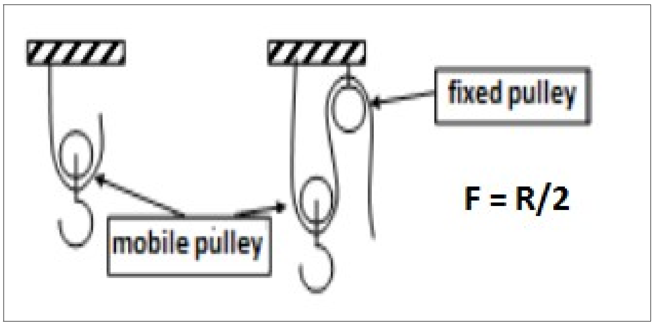
- **Fixed Pulley:**

A pulley that is attached to a fixed element. Can roll, but does not move.
It transforms a linear motion into another linear motion of different directions. It does not transform forces, it only serves to change the direction of a rope. It is reversible because if I pull the hook up the rope rises.



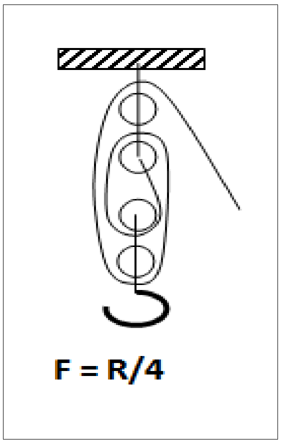
- **Mobile Pulley:**

The rope is attached to a fixed element, but the pulley cannot move sideways. Both at the entrance and at the exit we have linear movements. Multiply the strength by two. It is reversible, if you pull the hook moves the end of the rope can move freely.



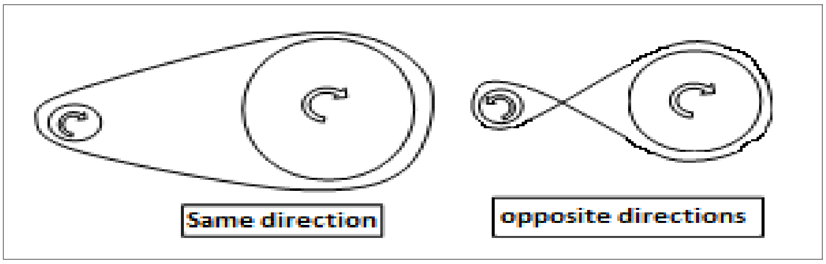
- **Hoists**

They are several fixed pulleys and several mobile ones.
Example: a crane.



4 BELT AND PULLEY SYSTEM

It transforms a circular movement into another circular movement in the same direction or opposite direction depending on how the belt is placed. The small pulley goes faster, so there is less movement. It is a reversible mechanism.



The **transmission ratio (i)** is equal to

- the speed of the first pulley divided by the speed of the second pulley. **ω** : speed (unit: rpm , revolutions per minute)
- or, the diameter of the first pulley divided by the diameter of the second pulley. **d**: diameter (unit: cm)

$$i = \omega_1 \times d_1 = \omega_2 \times d_2$$

Examples: tthe belt of the alternator or the water pump of the car, the transmission of some motorcycles.

5 GEARS

A gear is a wheel with teeth. If the teeth are weighted (for example on the cymbal plate) it is called a crown. If the gear is small it is called a sprocket.

It transforms one circular movement into another in the opposite direction. The small gear goes faster than the big gear and therefore has less force. It is reversible because we can apply the motion on either of the two gears.

The **transmission ratio (i)** is equal to

- the speed of the first gear divided by the speed of the second gear. **ω** : speed (unit: rpm , revolutions per minute)
- or, the number of teeth of the first gear divided by the number of teeth of the second gear . **z**: number of teeth

$$i = \omega_1 \times z_1 = \omega_2 \times z_2$$

Examples: clocks, watches and many toys.

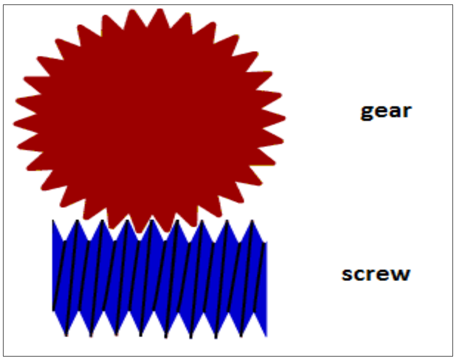
6 GEARS WITH CHAIN

Similar to pulleys with belt, but with gears and chain instead. Therefore, they do not slip. It transforms a circular movement into another of the same direction. The axes can be separate. Otherwise, all of its characteristics are similar to those of the gears.

For example: bicycles.

7 WORM GEAR

It transforms a circular movement of the screw into another perpendicular movement in the gear. The screw goes much faster than the gear. Therefore, there is much more force in the gear.



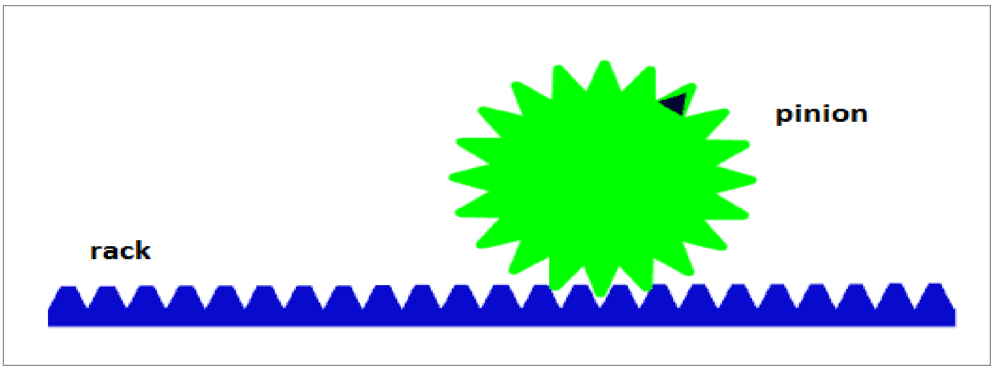
The screw and the gear must have the same module (size of the gap) to fit them together. This is an irreversible mechanism, the screw transmits to the gear, but the gear does not transmit to the screw.
You can observe this type of mechanism in the system of tension on the strings of a guitar.

8 RACK AND PINION

It transforms a circular movement into a linear one or a linear one into a circular one, because it is reversible. The larger the gear the more movement we get with the zipper.

If we are interested in obtaining a linear output motion with force, the gear must be small, but if we are interested in transforming a linear motion into a circular motion and we want it to move with greater force, the gear must be large.

The rack must have the same module (size of the gap) as the gear. This mechanism can be seen on subway doors.

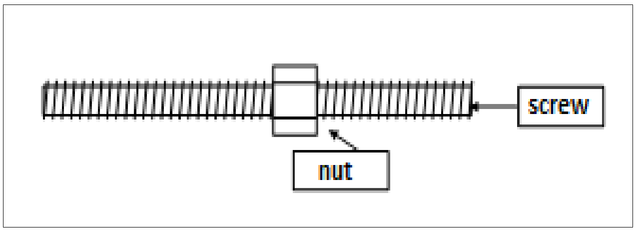


9 SCREW AND NUT

It is a nut that is turned on a long screw. Transforms a circular motion into a linear one. Both the nut and the screw can be turned and the one that does not turn is the one that advances.

It is irreversible, it does not transform linear motion into circular. At each turn the nut (or the screw) moves very little, that is why it greatly amplifies the force.

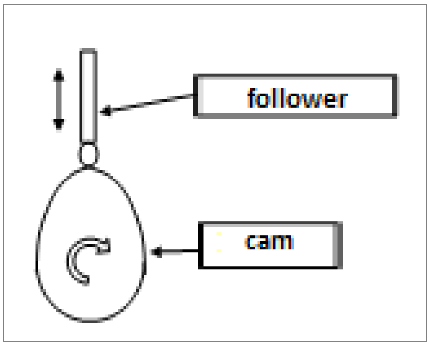
Example: a car jack (to lift the car).



10 CAM

It transforms a circular movement of the cam in a reciprocating motion that depends on the shape of the cam. It does not transform forces.It is irreversible.

The cam transmits to the pivot, but the pivot does not transmit to the cam.
This mechanism opens the valves of the engine of a car.

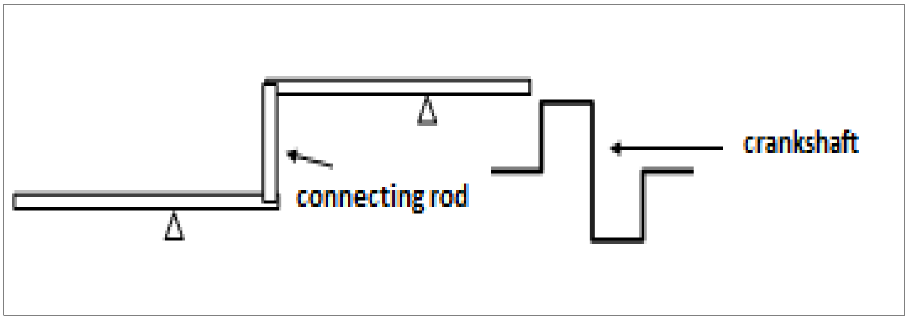


11 ECCENTRIC WHEEL

It is a cam with a circular shape and a deviated center.

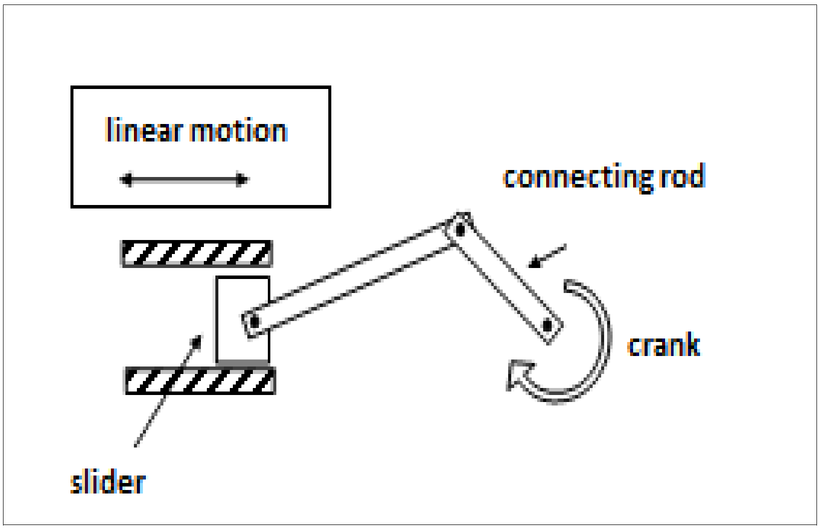
12 CRANK AND SLIDER

A **connecting rod** is a bar with two joints. It is used to couple two movable elements that could not be joined without it. For example, to join two levers. A **crank** is a rod with a shaft at one of its ends. A **crankshaft** is a bent shaft

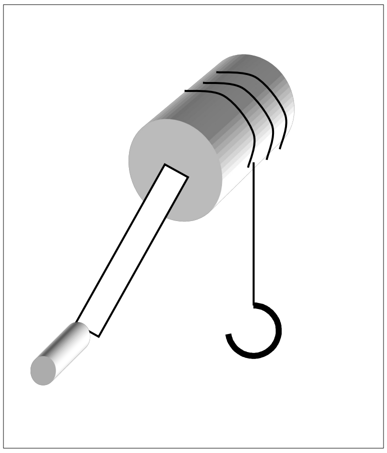


The **crank and slider** system transforms a circular motion into a alternating linear one or viceversa because it is reversible.

Examples: the engines of cars and motorcycles, steam engines.



13 WINCH



It is a cable that is wound onto a drum. It transforms a circular movement into a linear one and viceversa, because it is reversible.
Transforms forces. The longer the crank or the more thin the drum, the more weight can be lifted.

It is a very frequent mechanism in cranes.

14 ACTIVITIES

1. The drawing in figure 1 represents a mechanism.

- What is its name?

- If we hang the rope, as it is seen, 5 kg, how much can we lift?

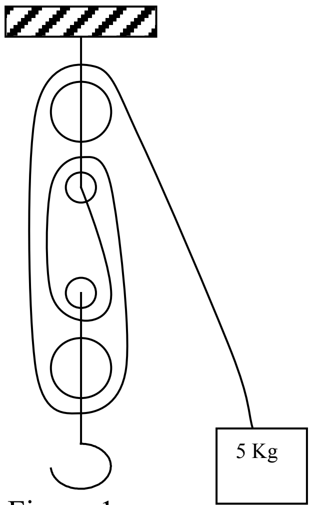


Figura 1

2. The drawing in Figure 2 represents another mechanism.

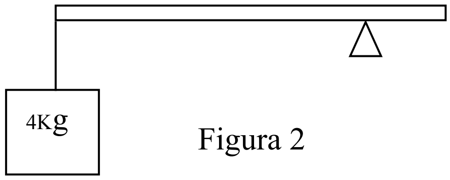


Figura 2

- What is it called? The triangle represents something. What is it called?
- On one side we have hung 4 Kg. How much can we lift on the other side? (must measure with a ruler)
- Where should you place the support to be able to lift 6 kg.

3. Figure 3 represents another mechanism.

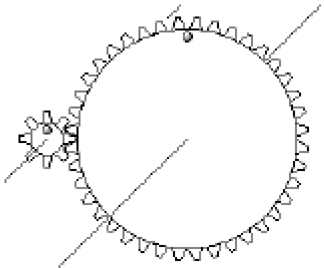
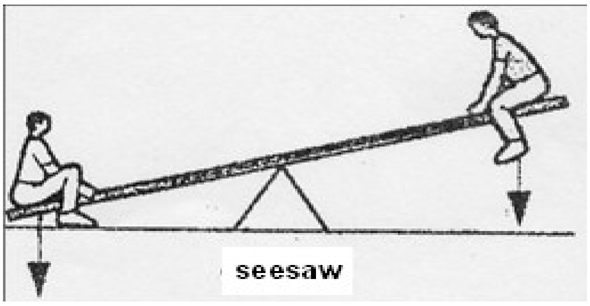


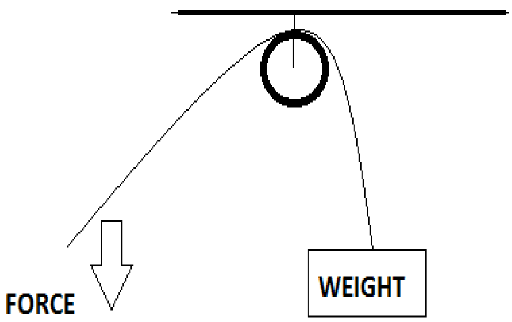
Figura 3

- What is it called?
- The big gear rotates to the right giving 2 turns every second. In what direction does the small gear spin?
- At what speed does the small gear turn? (you will have to count the number of teeth)

4. In the seesaw of a park that measures six meters, It is seated a child (on the right), whose weight is 30 kg, at a distance of 2 m from the fulcrum (point of support). To equilibrate the seesaw we are going to sit a second child (on the left) whose weight is 60 kg. How far from the fulcrum the child of the left will have to sit?



6. In the picture on the right, answer the following questions:



- Which mechanism is being used to lift the weight of the drawing?
- If we know that the weight lifted is 100 kg. How much force we need to do?
- What is the advantage of this mechanism?

7. We have a system of two friction wheels. The first wheel has a diameter of 4 cm and is connected to an engine. The second wheel has a diameter of 8 cm.

- Draw the mechanism. We know that the engine turns in the sense of the clockwise. Write all the data of the problem in the drawing.
- What is the transmission ratio? Write the formula.
- The second wheel rotates with a speed of 1000 rpm What is the speed of the engine?
- Explain the speed variation using the transmission ratio and the drawing.

8. We have a system of two gears. The first gear has 10 teeth and is connected to an engine that turns in the counterclockwise. The second gear has 5 teeth.

- Draw the mechanism. Write all the data of the problem in the drawing.
- What is the transmission ratio? Write the formula.
- The first gear rotates with a speed of 2500 rpm. What is the speed of the second gear?
- Explain the speed variation using the transmission ratio and the drawing.

9. Draw the following examples:

- A belt and pulley mechanism turning in the same direction.
- A belt and pulley mechanism turning in the opposite directions.