GEARS

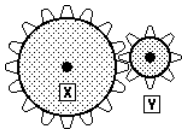
Gears are essential components of most mechanical systems. They consist of a pair of wheels that have teeth that interlink. As they rotate together, one gearwheel transfers turning motion and force to the other.

Gears can be used to change the direction of motion in a mechanical device, or to increase or decrease force or speed.

Gear wheels – which are wheels with precisely manufactured, identical teeth around its edge - work together transferring rotary motion and force from one part of a complex machine to another part in gear trains of two or more wheels.

A smaller gear (Y) is called a **pinion**. The gear that supplies the energy is called the **driving gear** (X). The gear to which the force is directed is called the **driven gear** (Y).

TYPES of GEARS



A ***large gear (X) driving a smaller gear (Y)*** decreases torque and **increases speed** in the driven gear. Gears such as these are called **multiplying gears**.

A ***small gear (Y) driving a larger gear (X)*** increases torque and **reduces speed** in the driven gear. Gears like these are called **reducing gears**. When the driving gear has fewer teeth than the driven gear, the driven gear then rotates more slowly than the driving gear. A car or bicycle in low gear uses reducing gears.

When the driving and the driven gears are the same size they are known as **parallel gears**.

MECHANICAL ADVANTAGE

A machine makes work easier for you by increasing the amount of force that you exert on an object. This produces a **mechanical advantage**, which is the amount of force that is multiplied by the machine. The force applied to the machine (by you) is the ***input force***. The force that is applied to the object (by the machine) is the ***output force***.

Mechanical Advantage is calculated as follows:

$$MA = \frac{\text{Output Force}}{\text{Input Force}}$$

Mechanical advantage is *force ratio*

$$MA = \frac{F_{Out}}{F_{In}}$$

The more a machine multiplies the force, the greater is the mechanical advantage of the machine

SPEED RATIO

Speed measures the distance an object travels in a given amount of time. The measure of how a machine affects speed is called the **speed ratio**. It is calculated by dividing the ***input distance*** by the ***output distance***.

$$SR = \frac{\text{Input distance}}{\text{Output distance}}$$

Speed Ratio formula:

$$SR = \frac{d_{in}}{d_{out}}$$

In a machine when you gain something, you also lose something. If you gain Force or Speed, you lose Distance. If you gain Distance, you lose Force or Speed.

FORCE of FRICTION

The difference between the calculated value and the real (actual) value of mechanical advantage is friction, which is **a force that opposes motion**. Friction is caused by the roughness of materials. Because friction is a force in any device, additional force must be applied to overcome the force of friction. The mechanical advantage of the device will be less because of this added force that must be overcome. The speed ratio will not be affected. In fact, the speed ratio represents the *ideal mechanical advantage* of a machine – as if friction didn't exist. Friction in a system also causes heat, which can cause additional concerns.

When people calculate mechanical advantage and speed ratio they may find that they are the same. In real situations however, when they are calculated, they are very different because of the force of friction.

EFFICIENCY

Efficiency is a measure of how well a machine or a device uses energy. The more energy that is lost, the less efficient a machine is. Efficiency is represented in %.

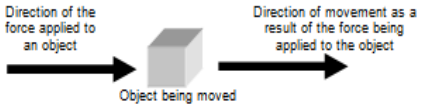
$$\text{EFFICIENCY} = \frac{\text{Mechanical Advantage}}{\text{Speed Ratio}}$$

In complex machines, there are many subsystems that are affected by friction and other factors. Because of this, most complex machines are not very efficient.

NO MACHINE CAN EVER BE 100% EFFICIENT

WORK

Scientifically, work is done when **a force** acts on an object to make that object **move**.



For work to be done there must be movement. If there is no movement, no matter how much force is used, no work is done.

Calculating Work

Work is calculated by multiplying the force times the distance the object moves. The formula looks like this:

$$W = F \times d$$

Force is measured in Newtons and distance is measured in meters. The resulting work unit is called a **joule**, named after the English scientist **James Joule.**

ENERGY and WORK

Energy and work are closely related, because without energy there would be no work. Work is done when there is a transfer of energy and movement occurs. Energy provides the force needed to make an object move. The energy can be in the form of human energy or it can be in the form of another energy source. A machine transfers energy from its source to the object, causing the object to move.

The work done with a machine is the same as the work done without it. This can be shown by calculating work input and work output.

$$\text{Work}_{input} = \text{Force}_{input} \times d_{input}$$

$$\text{Work}_{output} = \text{Force}_{output} \times d_{output}$$

The efficiency of the machine can then be calculated using this formula:

$$\text{Efficiency} = \frac{\text{Work}_{output} \times 100}{\text{Work}_{input}}$$

HYDRAULICS

Most machines that move very large, very heavy objects use a **hydraulic system** that applies force to levers, gears or pulleys. A hydraulic system uses a liquid under pressure to move loads. It is able to increase the mechanical advantage of the levers in the machine. Blaise Pascal discovered that pressure applied to an enclosed fluid is transmitted equally in all directions throughout the fluid, known as **Pascal's Law** making **hydraulic** (liquid) and **pneumatic** (air) systems possible.

Pressure is a measure of the amount of force applied to a given area.

$$p = F / A$$

p is pressure **F** is Force and **A** is Area

The unit of measurement for pressure is a Pascal (Pa), 1 **Pa**scal is equal to the force of 1 **N**ewton over an area of 1 $\mathbf{m^2}$