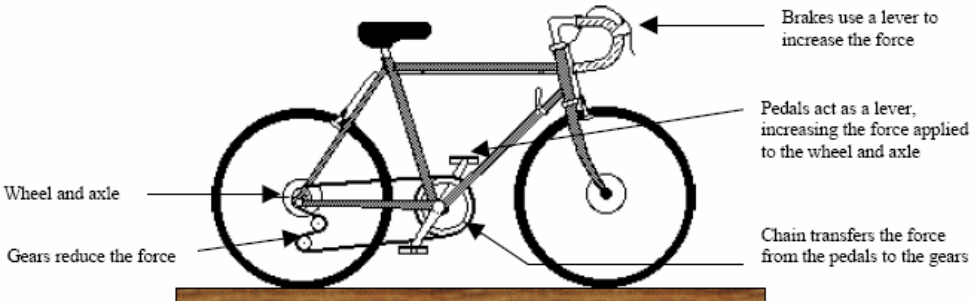
Topic 2 – The Wheel and Axle, Gears and Pulleys

A Lever That keeps on Lifting

A **winch** consists of a small cylinder that has a **crank** or handle. The axle of the winch acts like the fulcrum, the handle is the effort arm. By exerting a force on the handle to turn the wheel the cable is retracting the load. Because the handle is longer than the radius of the wheel, the effort force is smaller than the load – making it act like a small lever over and over again.

The **Wheel and Axle** is a combination of two wheels of different diameters that turn together - a lever that rotates in a circle around a center point or fulcrum.
A longer motion on the wheel produces a more powerful motion on the axle, thus giving it a **mechanical advantage** (steering wheel in a car).
Several simple machines all working together in a system are called **complex machines**. A **system** is a group of parts that work together to perform a function. A wheel and axle can be also be used to increase the speed (bicycle wheels) for a **speed advantage**.

The **bicycle** is a good example of a complex machine because it is a system for moving a person from one place to another. Within the bicycle are groups of parts that perform specific functions, such as braking or steering. These groups of parts are called **subsystems**. Each subsystem in a complex machine contains a simple machine and usually has just one function.



The subsystems of a bicycle are:

- Wheel and axle
- Drivers & Gears
- Frames & Materials
- Brakes & Steering
- Aerodynamic design

Explore the Science of Cycling at this website:
http://www.exploratorium.edu/cycling/index.html
Build your Dream Bicycle:
http://www.thetech.org/exhibits/online/topics/54j.html

The subsystems in a mechanical device that produce motion, such as in a bicycle, play a role in how energy is transferred within the system. The subsystems are called **linkages** and **transmissions**.

Linkages

The linkage is the part of the subsystem that transfers your energy from the pedals to the back wheel. In the bicycle, the chain is the linkage. In a car, the fan belt is the linkage from the engine to the cooling fan – to prevent the engine from overheating. Chains or belts form a direct link between two wheels – one that drives the motion and the other will follow in the same direction.

Transmissions

Machines that are more complex than a bicycle move much larger loads. A special type of linkage is needed. It is called a transmission. It transfers energy from the engine to the wheels. A transmission contains a number of different gears. This enables the operator to move the object slowly with a large force, or quickly with a smaller force

Gears

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

This website has just a few: http://www.fi.edu/time/Journey/Time/Escapements/geartypes.html

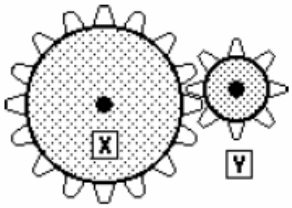
Gears can also be used to change the direction of motion in a mechanical device, such as in an ***eggbeater.***

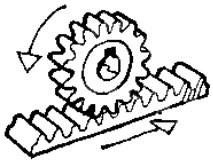
Gears can be used to increase or decrease force or speed

Gearing Up

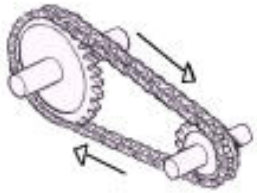
Gears transfer energy in a mechanical system. Gear wheels – which are wheels with precisely manufactured, identical teeth around its edge - work together in gear trains of two or more wheels transferring rotary motion and force from one part of a complex machine to another part. A smaller gear (Y) is 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).

Going The Distance





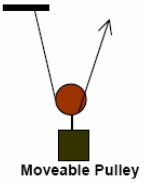
Rack and Pinion Gear



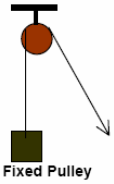
Chain and Sprocket

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**.
The relationship between the speed of rotations of a smaller gear and a larger gear is called **speed ratio**. It can be calculated by dividing the number of driver gear teeth by the number of follower gear teeth.

A **Pulley** consists of a wire, rope, or cable moving on a grooved wheel. One or more combinations of wheels and ropes can be fixed in place or moveable.
Pulleys help you lift larger loads.



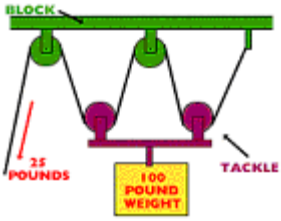
Moveable Pulley



Fixed Pulley

Supercharging Pulleys

A very complex combination of pulleys, including fixed and movable is called a **block and tackle**.



Depending on the number of pulleys used, a block and tackle can have a large mechanical advantage.