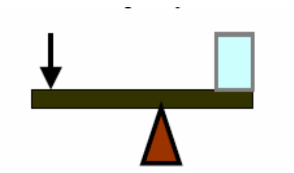
Topic 1 – Levers and Inclined Planes

Lever – is a rigid bar or plank that can rotate around a fixed point called a pivot, or **fulcrum**. Levers are used to reduce the force need to do a particular task. You can move a very large load, but you must move a greater distance than the load moves.
http://207.10.97.102/elscizone/lessons/land/simplmachines/3classes.htm

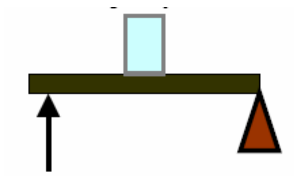
The **fulcrum** supports the load. The force exerted on the lever to make it move is called the **effort force**. The mass of the object lifted by the lever is called the **load**.
There are 3 classes of levers. (a prybar can be all three classes of lever, depending on how it is used.)

Moving heavy loads



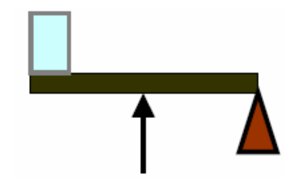
First Class Lever
crowbars and pliers

Lifting heavy loads



Second Class Lever
wheelbarrow

Gaining speed



Third Class Lever
Hammer, your arm

The distance between the fulcrum and the effort force is called the **effort arm**. The distance between the fulcrum and the load is called the **load arm**.

Bones and Muscles: Built-in Levers

Most of the levers in your body are **3rd clad levers**, but there are 1st and 2nd class levers as well. Your bones act as levers with the joints acting as the fulcrum. Tendons exert the effort force on the bone. The load is what is being moved. (**see the examples in SF text p. 274**)

This website gives a detailed description of how the bones and joints act as different types of levers.
http://www.horton.ednet.ns.ca/staff/selig/IDU/jointmachine.htm

An Arm in Space

Since its maiden voyage aboard U.S. Space Shuttle Columbia in 1981, the Shuttle Remote Manipulator System (SRMS), has demonstrated its reliability, usefulness, and versatility and has provided strong, yet precise and delicate handling of its payloads.

Usually called the **Canadarm 1** - the Space Shuttle Remote Manipulator System is an application of levers in space technology. It has been used in different Space Shuttles to help *launch and retrieve satellites* or *repair the Hubble Space Telescope* from the shuttle's cargo bay.

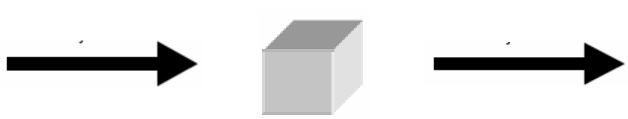
A more complex version – **Canadarm 2** - has been installed on the **International Space Station** – It is the **Mobile Servicing Station** component of the Space Station.

What is Work?

Scientifically, work is done when **a force** acts on an object to make that object **move**.
In order to say that work is being done, there must be movement. If there is no movement, no matter how much force is used, no work is done.

Direction of the force applied to an object

Direction of movement as a result of the force being applied to the object



Object being moved

For example; a worker uses force to move a large carton up a ramp. Energy (pushing) is transferred to the carton from the worker. Thus, we say that the worker did work on the carton as long as the carton moved up the ramp as a result of the worker's pushing action (force).

Calculating Work

The amount of 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 (muscle power – chemical reactions in the body producing energy) or it can be in the form of another energy source, such as gasoline (for a car). A machine transfers energy from its source to the object, causing the object to move. There is a very complicated chain of events that make a car move - beginning with it being fueled up with gasoline - all the way through its many subsystems (each doing work) - to eventually the tires rotating to make the car move forward or backward.

Work and Machines

There are different types of simple machines that can help us do work. 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.

Work input is the work needed to use, or operate the machine

$$Work_{input} = Force_{input} \times d_{input}$$

Work output is the work done by the machine.

$$Work_{output} = Force_{output} \times d_{output}$$

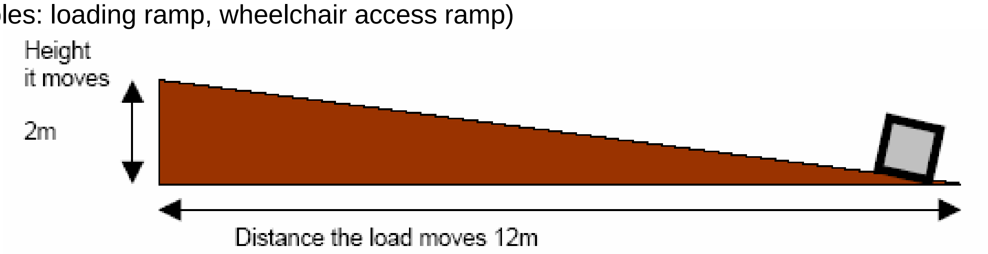
Work and Friction

Friction is the reason that work input does not equal work output in real situations. Friction affects the machine's efficiency. **Efficiency** can be calculated using work input and work output.

$$\textbf{Efficiency} = \frac{Work_{output}}{Work_{in}} \times 100$$

Inclined plane

Or ramp, makes it easier to move a load higher than it is, but, it has to be moved over a much longer distance. An inclined plane makes it possible to lift heavy objects using a smaller force (examples: loading ramp, wheelchair access ramp)



Mechanical Advantage

Mechanical Advantage is the comparison of the *force produced by a machine* to the *force applied to the machine*. (the size of the load vs the size of the force needed to move the load)

$$\textbf{Mechanical Advantage (MA)} = \frac{\textbf{Load Force}_{(FL)}}{\textbf{Effort Force}_{(FE)}}$$

There are *examples* in the textbook to help you practice this calculation (**SF p. 278-279**)

Another Way to Calculate Mechanical Advantage

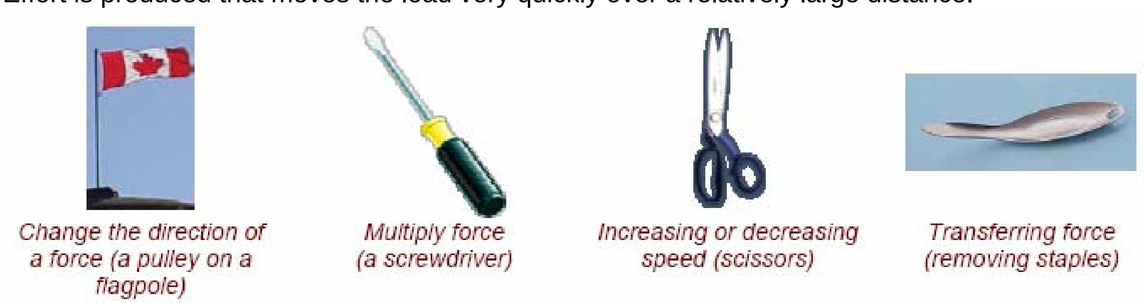
The concepts of mechanical advantage and work can be linked.

$$\text{Mechanical Advantage (MA)} = \frac{\text{Load Force}_{(FL)}}{\text{Effort Force}_{(FE)}} = \frac{\text{Effort Arm}}{\text{Load Arm}}$$

$$\text{(MA)} = \frac{\text{Effort Arm}}{\text{Load Arm}}$$

Speedy Levers

Speed is the rate of motion that an object changes position. *Class 3 levers* are not very useful for decreasing the effort force, but rather they are useful because they provide a speed advantage. Effort is produced that moves the load very quickly over a relatively large distance.



See also the review notes here: http://www.connect.ab.ca/~lburns/students_eightunit2notes.html

Machines Made to Measure

Body weight, height, size, age and gender are factors taken into account when designing products for use by the consumer. The science of designing machines to suit people is called ***'ergonomics'***. Ergonomics is especially important in the design of work environments where occupational safety is an issue. *Carpal tunnel syndrome* causes numbness and pain in the thumb and first three fingers, caused by the continuous repetitive movements of the fingers on the computer keyboard.

Ergonomically designed products include:


Spacesuit


Infant Car Seat


Assembly Line

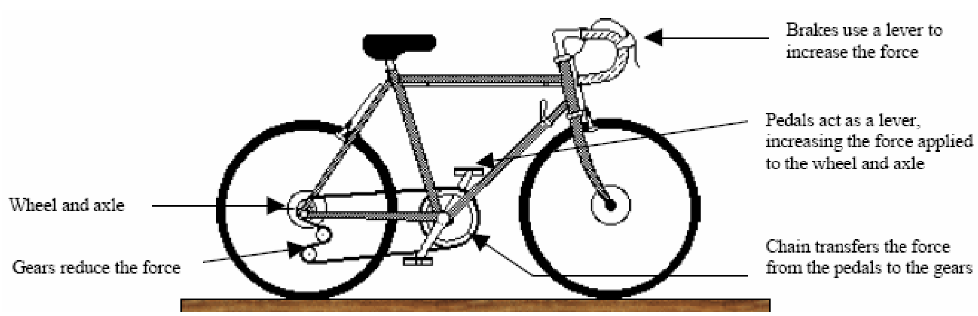
Topic 2 – The Wheel and Axle, Gears and Pulleys

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

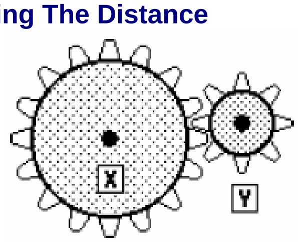
Gears can also be used to change the direction of motion in a mechanical device, such as in an ***eggbeater.***

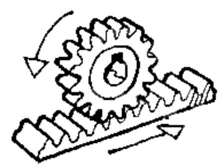
Gears can be used to increase or decrease force or speed

Gearing Up

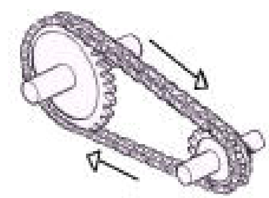
Gears transfer energy in a mechanical system. Gear wheels – which are wheels with precisely manufactured, identical teeth around its edge - work together in gear trains of two or more wheels transferring rotary motion and force from one part of a complex machine to another part. A smaller gear (Y) is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





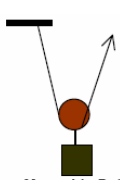
Rack and Pinion Gear



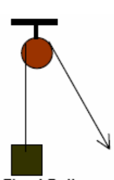
Chain and Sprocket

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.



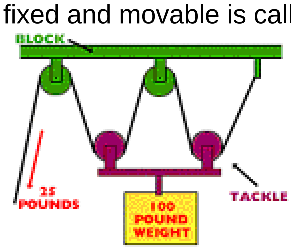
Moveable Pulley



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.

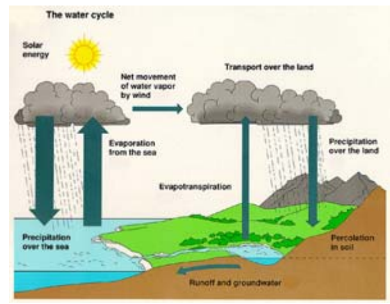
Topic 3 – Energy, Friction, and Efficiency

Work and Energy

Machines help people do things that they normally couldn't do on their own.
Work is a transfer of energy. In the example of the bicycle – your energy (chemical energy from your food) is transferred to the pedals giving them **kinetic energy**, or energy of motion. The pedals transfer this energy to the sprockets and chain, and then to the wheels.

Stored Energy

Stored energy is called **potential energy**. Much of the energy for machines is stored as chemical potential energy. Gravitational potential energy is transferred to kinetic energy in machines in a dam to generate electrical energy.



Another example of **potential gravitational energy** is the water cycle.

Energy Transmitters

In energy **transmission**, the energy is transferred from one place to another, and no energy is changed or converted.

Energy cannot be created nor destroyed – It is only transformed or transferred

No Machine is 100% Efficient

An ideal machine would transfer all the energy it received to a load or to another machine. However there are no ideal machines. Real machines lose energy. The work output of a real machine is always less than the work input. ***NO MACHINE IS 100% EFFICIENT***. The *efficiency* of a machine tells you how much of the energy you gave to the machine is actually transferred to the load. **Efficiency** is a comparison of the useful work provided ***by*** a machine or a system with the work supplied ***to*** the machine or system.

$$\text{Efficiency} = \frac{\text{Work done by machine}}{\text{Work done to make the machine operate}} \times 100\%$$

The higher the efficiency, the better the machine is transferring energy. The reason that machines are never 100% efficient is because of the energy that is lost by a machine to **friction**.

Boosting Efficiency

Since some of the effort force put into a machine is used to overcome the frictional force of the machine, there are ways to boost the efficiency of a machine. Lubricants, reducing the surface area interaction where parts rub together and good maintenance of the machine will help to reduce friction and increase efficiency.

Useful Friction

There are reasons why we need friction in a machine for it to perform properly. Slipping and sliding would occur and proper gripping would be impossible without friction. There are many places where friction is useful, including:

- Bicycle – tires create friction with the road surface to give you grip
- Baseball – ***rosin*** is used to form a stronger grip with the bat
- Gymnasts – also use ***rosin*** to provide grip on slippery metal surfaces (like rings or bars)
- Curlers – sweep the ice in front of the rock to decrease friction with the ice surface

Topic 4 – Force, Pressure, and Area

Calculating Pressure

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), named after Blaise Pascal who did important research on fluids.

1 **Pa**scal is equal to the force of 1 **N**ewton over an area of 1 $\mathbf{m^2}$

1 **K**ilo**pa**scal is equal to 1000 **pa**scals

Equipped Against Pressure

Safety equipment is need in many situations in order to protect our body from injury or accident. Most of the safety equipment is designed *to spread the force over a larger area*.

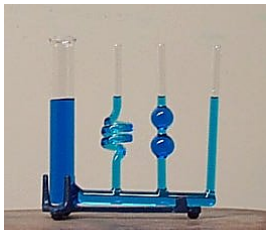
Pascal's Law

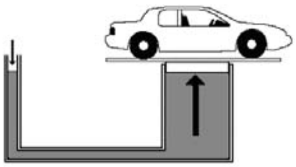
Blaise Pascal (1623-1662) discovered that …

Pressure applied to an enclosed fluid is transmitted undiminished in all directions throughout the fluid and perpendicular to the walls of the container.

This is known as **Pascal's Law** and it makes **hydraulic** (liquid) and **pneumatic** (air) systems possible.

He was the first to notice that the shape of the container had no effect on the pressure at any given depth as illustrated here.





A common application of Pascal's law is the *hydraulic lift.*

It is a mechanical system that raises heavy objects, using a fluid under pressure in a *closed system* (self-contained collection of parts).

Pascal's Law and Mechanical Advantage

$$\text{Mechanical Advantage} = \frac{\text{Load Force}}{\text{Effort Force}}$$

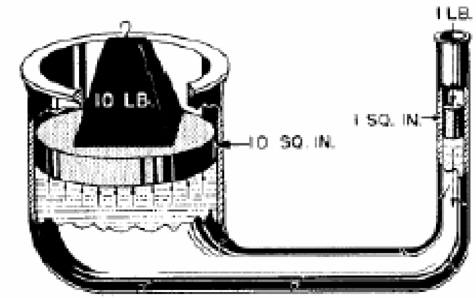
In hydraulic systems, the pressure is created using a piston. Pistons can be different sizes and hydraulic devices use pistons that are different sizes attached to each other with a flexible pipe. The **Input piston** is used to apply force to the fluid, which creates pressure in the fluid. The fluid transfers this pressure to the **output piston**. This pressure exerts a force on the output piston and the result is a mechanical advantage that makes the hydraulic system very useful.

The mechanical advantage in a hydraulic system comes from the fluid pressure in the system.

Calculating the input force and the output force will give you the Mechanical advantage of the system.

MA = Output force / Input force

MA = $F_o xd_o$ / $F_i xd_i$ MA = 10 / 1 = 10



This hydraulic system has a mechanical advantage of 10

Mechanical advantages in hydraulic systems are usually quite high, showing how useful they are.

Pressure and Mechanical Advantage

The reason for the large mechanical advantage in a hydraulic system is the ability of the fluid to transmit pressure equally. It allows you to use a small force on the small piston to produce a larger force on the large piston.

$$p = F / A$$

From Pascal's law, we know that the pressure the small piston creates is the same everywhere in the fluid. So the large piston has a larger area and is able to multiply the pressure because of its larger area. The force and area at each piston act as ratios that have to be equal.

$$\frac{\text{Force of the small piston}}{\text{Area of the small piston}} = \frac{\text{Force of the large piston}}{\text{Area of the large piston}}$$

$$\frac{F_{small}}{A_{small}} = \frac{F_{large}}{A_{large}}$$

By solving this ratio you will find that the forces created within a hydraulic system provides very large mechanical advantages - making them useful in many applications.

Larger Force – Greater Distance To Move

Mechanical advantage in hydraulic systems has a cost. That cost is the increased distance the smaller force must go through to make the large force move a small distance.

To increase the force on the output piston ,
the input piston must move through a greater distance.



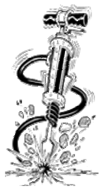
Amusement park rides make extensive use of hydraulic systems

Topic 5 – Hydraulics and Pneumatics

Hydraulic systems use the force of a liquid in a confined space.
Hydraulic systems apply two essential characteristic of fluids – their incompressibility and their ability to transmit pressure.

Pneumatic systems do not seal the gas (usually air) in the same way as hydraulic systems seal in the fluid it uses. The air usually passes through the pneumatic device under high pressure and then escapes outside the device. The high pressure air is used to do the work.

Pneumatics at Work



The *jackhammer* is an example of a pneumatic device that is used to do work. The loud noise of the jackhammer is the compressed air at work. Bursts of air, under very high pressure drive the *'chuck'* in and out of the jackhammer at high speeds, which pounds the concrete – breaking it up into small rocks or fragments.

Staple guns and pneumatic nailers use pulses of air pressure to drive staples or nails into solid objects.

Sandblasters do exactly what the name implies. High pressure air blasts tiny sand particles out of a nozzle to remove dirt and paint from stone or rock. Sandblasting an old building made of stone or brick can make it look almost like new. Sandblasting is also used to roughen surfaces to improve traction, by increasing friction. Medical engineers have developed a type of cast filled with pressurized air, which makes it fit snugly and securely.

Riding on Air

Hovercrafts are used by the Canadian Coast Guard in search and rescue missions. They are also used commercially, to transport people, cars and equipment over long distances on land or water. The hovercraft has a pump that draws air from outside and pumps it out through small holes in the bottom of the hovercraft. A skirt around the bottom holds enough air to support the weight of the craft above the water or land. Propellers on the back of the craft drive the hovercraft forward, and rudders are used to steer it.

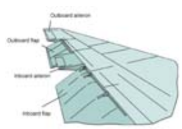
Hydraulics at Work

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. Modern construction projects use hydraulic equipment because the work can be done quicker and safer. There are many practical applications of hydraulic systems that perform tasks, making work much easier.

Earthmovers use hydraulics to move large amounts of dirt from place to place.

The *cherrypicker* is an example of a hydraulic device that is used to do raise workers to high places to repair or do work at heights that normally could not be reached safely.

Hydraulics in Flight



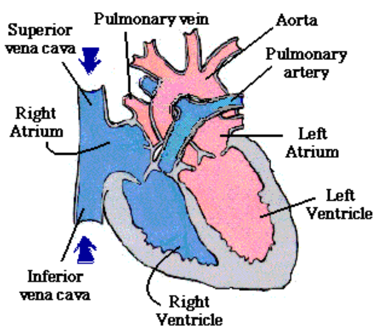
The various parts of an airplane wing are raised and lowered hydraulically. Hydraulics are also responsible for tail adjustments to enable the pilot to turn the plane in the air. Wheels are raised and lowered using a hydraulic system as well. There are different hydraulic systems in different aircraft, but all the systems work together in much the same way to provide reliable and safe adjustments when the plane is taking off, airborne and landing.

Hydraulics and Pneumatics in Your Body

Life depends on a pneumatic system in your body – namely the respiratory system. The lungs that allow air to enter and leave the body as they contract and expand. Breathing depends on changes in air pressure. You breathe in and out about 12 times a minute, exchanging about 500ml of air each time.

Your body also depends on a complex hydraulic system – the circulatory system. The heart (your hydraulic device) pumps the blood (fluid) around your body carrying food and nutrients to all cells in your body. A review of this body system (Unit 2 – Topic 6 – Cells and Systems) will help you understand the details.

Valves and Pumps



A valve is used to control the flow of a fluid. It is a moveable part that controls the flow by opening or closing. Many pumps use automatic valves controlled by pressure to move fluids in specific directions. Pressure on one side opens the valve and closes when the pressure on the other side is greater.

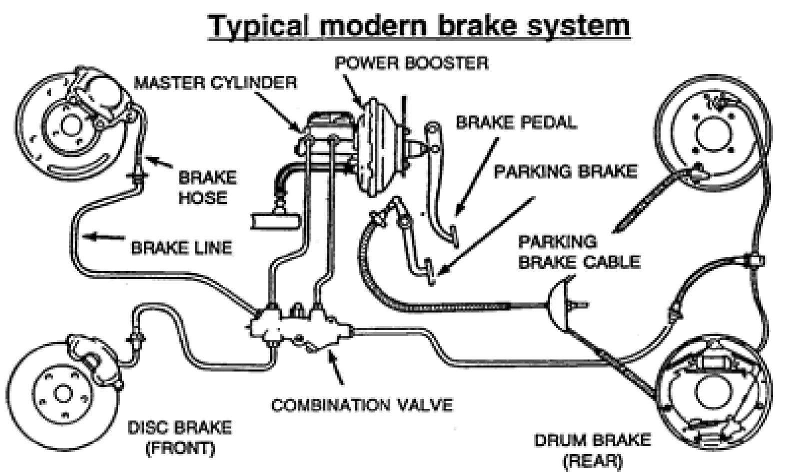
The heart is actually two pumps that circulate your blood throughout the body. Four automatic valves are used to help circulate the blood. Between heartbeats the pressure changes allowing the valves to open and close when they are supposed to.

Topic 6 – Combining Systems

As time passed, people expected more and more difficult tasks to be completed by machines. Machines became more complex. 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. Groups of parts that perform specific functions, in a complex machine, are called **subsystems**. Each subsystem in a complex machine contains a simple machine and usually has just one function.

Subsystems

The different subsystems in a mechanical device can produce a force advantage, such as the **disc brakes** in a car.



The brake fluid transfers the pressure from the brake pedal to the brake pads and the disc, which produces enough force to stop the car.

Another example of a highly efficient combination of levers and hydraulics is the **backhoe**.

The backhoe is a combination of 3 levers, called the *boom (class 3 lever)*, the *dipper (class 1 lever)* and the *bucket (class 1 lever)*.

The assembly of the 3 levers swings around on a gear-like part called the *slew ring*.

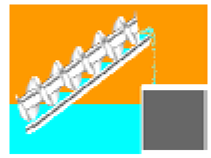
Topic 7 – Machines Throughout History

Machines help people use energy more efficiently. The earliest machines were simple devices to make work easier; like moving a large rock or moving a load up an incline, splitting wood or lifting materials up to a working area above the ground. These simple machines depended on people or animals as their source of energy.

Machines were built to satisfy basic human needs, such as getting water.
Three devices used to get water in earlier times included:

Sakia (or, Persian wheel)

Roman **aquaduct**



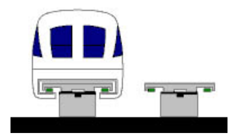
Achimedes screw

The invention of the **steam engine** in the late 18th century was an important achievement. The steam engine moved goods across countries in a very short time, giving people more and better access to food, clothing, tools and raw materials than previously. The standard of living had improved. It led to many changes in transportation technology and in the way we manufacture products. Factories provided jobs for workers and many people moved to the cities. The continual development of new technologies has lead to our virtual dependence on machines.

Different modes of transportation have changed as science and technology have developed.

Steam Engine

Magnetic Levitation Train



Canoe

Motorboat

Dog Sled

Ski Doo

Horse and Cart

Sports Car

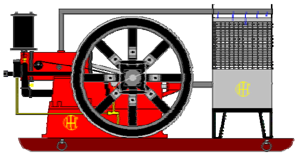
Putting Steam To Work

Heat-operated mechanical devices have been around for a long time. In 150 B.C.E. Hero of Alexandria in Egypt described many of his mechanical devices that used gears, wheels and axles, pulleys, hydraulics and pneumatics.
Thomas Savery developed the first practical steam engine in 1699. He heated water to make steam and then used it to move a piston. When the piston moved, it caused an attached rod (which was connected to a crankshaft) to move as well, making the engine work.

Steamboats

The invention of steam engines, also lead to innovations in water transportation, like the **paddle-wheeled steamboat**.

These steamboats were used extensively during the fur trade, moving furs and goods throughout the country. They also helped supply the pioneers with farming equipment and supplies, during the early settlement of the prairies.



Steam under high pressure operates the pistons to turn the wheel in the engine.

Turning Wheels

Paddle-wheeled riverboats are rarely seen today, but steam still powers many **ocean liners**. Steam turns large *turbines* (rotary engines) which are attached to the propellers, which drive the ocean liner through the water

There are many other uses for turbines, including: toys, jet engines, electricity generators.

Burning Inside

The desire to improve the steam engine's efficiency led to the development of the **internal combustion engine** in Germany in 1876. The combustion occurs inside the engine. The pistons goes through 4 steps: *Intake stroke* (taking in the fuel), *compression stroke* (compressing the fuel-air mixture), *power stroke* (the fuel-air mixture is ignited), *exhaust stroke* (waste products are released). The crankshaft changes the up-down, or back-forth motion of the pistons to rotary motion, which turns the vehicle's wheels.

Taking Flight

Early internal combustion engines were used in aircraft, because the steam engine was too heavy and cumbersome. New materials and technology, human and environmental needs all contribute to the development of changes to current devices. When failure occurs, modifications must also be made to ensure the device performs its intended function effectively and efficiently. Trail and error also can play a role in technology development.

From Particles To Trains

New technology can also develop from unrelated research. The **MAGLEV** (Magnetic Levitation) trains in Japan operate on super-conductive magnets, powered by electricity. They can travel at speeds over 350 km/h floating on the rails. The technology for the MAGLEV resulted from physics experiments using particle accelerators (huge machines used to break apart atoms and other particles of matter) which use large mounts of electricity to create powerful; magnetic and electric fields.

Changes In Society Result In New Technologies

New technology can also result from changes to human society. Robots were originally popularized in movies and comic books. The word robot comes from the Czech word *'robotnik'*, meaning workers, or slaves. They were thought to be 'human-like' machines that could do the work of humans. It was originally used in a play where millions were manufactured to work as slaves in factories. Most robots today don't really appear to be human-like, but they do the work of many humans, mostly in industry. Robots today weld car bodies together, diffuse bombs, perform surgery, help the handicapped and even explore other planets.

Changes In The Environment Also Result In New Technologies Being Developed

Since the early 1960's the environment has impacted technological development because people wanted to repair the negative impacts they had made on the environment. New technologies (like *recycling*) were needed to prevent more damage. Processing materials over and over or making them *biodegradable* would address some of the issues. Other technologies (like *oil skimmers*) helped make environmental clean-up more effective and prevent further damage.

Topic 8 – People and Machines

Science and technology have given us many different amazing machines that have made our daily tasks easier. The automobile caught on very quickly, but the ideal machine soon demonstrated its greatest flaw. Pollution of the environment was a result of more and more fossil fuels being burned, in larger vehicles. Improving machines brought lots of positives, but there were also some negative side effects (like pollution).

The Industrial Revolution

The invention of the steam engine transformed society. Simple machinery replaced hand labor since 1700. Water-driven spinning machines were used in 1769 and could the work of 12 workers. James Watt's efficient steam engine and Henry Cort's use of coal for fuel (instead of wood) to make iron started the Industrial Revolution.

Mass production industries began and soon small towns became industrialized cities, leading to social change.

People flocked to the cities to get work in the factories – the shift from rural living to urban dwellers began.

Which Came First?

The question of whether technology changes society or society changes technology is still a challenge today. The automobile uses cheap fuel and therefore more vehicles are being used. With cities so large, people need a vehicle to travel from place to place. OR, is the convenience of having a vehicle just societies' reason to have larger cities?
Because of the impact of scientific knowledge on society preferences for styles and sizes of vehicles changed. Larger vehicles polluted more and cost more to operate, so society wanted more compact fuel efficient vehicles. Today alternative fuel sources (solar-powered, electricity, hybrids, propane and hydrogen fuel cells) are being tested and are utilized to a very small extent.

What Is It For?

When a new technology is being designed or an old technology improved upon the starting point must be the function – what is it that you want the technology to do? Scientists often have to ask themselves difficult questions, weighing the positive and negative effects of the technology. The ethical issues must be reviewed and considered in the decision to go ahead. Nuclear power is just one example – clean and efficient power generation VS nuclear accidents can devastate the environment. Consumers must also make smart choices when purchasing goods or services. Certain considerations must be taken into account, including how much energy is needed to make the goods or services available?

Designing for Comfort

How do inventors use their understanding of scientific concepts to design a new device, or modify an old one? Many of the principles of design rely on the physics principles of Force, Area and Pressure (Topic 4).

The Science of Comfort

The science of **ergonomics** was introduced in Topic 1. The testing systems that designers use provide scientific information to researchers, allowing them to decide what type of modification is best for its designed purpose.
C*omfort* is an important criterion that is evaluated.

The wheelchair has gone through many improvements over the years. These changes happened because of the research into ergonomic designs and pressure put on the designers by the consumer.