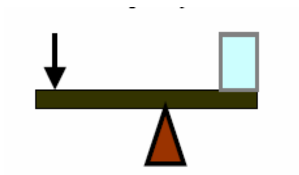
Topic 1 – Levers and Inclined Planes

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

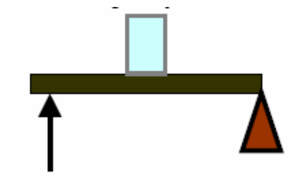
The **fulcrum** supports the load. The force exerted on the lever to make it move is called the **effort force**. The mass of the object lifted by the lever is called the **load**.
There are 3 classes of levers. (a prybar can be all three classes of lever, depending on how it is used.)

Moving heavy loads



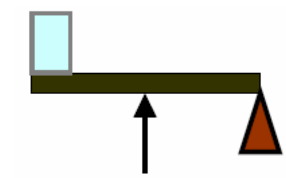
First Class Lever
crowbars and pliers

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.

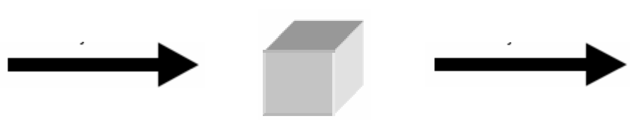
A more complex version – **Canadarm 2** - has been installed on the **International Space Station** – It is the **Mobile Servicing Station** component of the Space Station.

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: $\mathbf{W = F \times d}$

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

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

Work output is the work done by the machine.

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

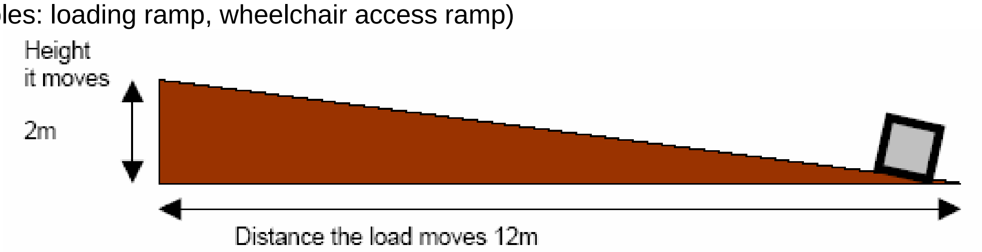
Work and Friction

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.

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

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.

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

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

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.

Change the direction of a force (a pulley on a flagpole)

Multiply force (a screwdriver)

Increasing or decreasing speed (scissors)

Transferring force (removing staples)

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