Simple Machines

Definition

Work: is done when a force, which is pushing or pulling on an object, makes it move a certain distance.

Examples

1. Riding a bike - you apply a force on the wheels through the pedals and chain that moves you across the ground.
2. Lifting a box - you are applying a force to overcome gravity and move the box through a height.

Simple machines make work easier or allow it to be done in a better way.

Definition

Simple machine: allows energy to be transferred from one place to another, and allows work to be done more easily or in a more convenient way.

There are only a few kinds of simple machines - the lever, wheel and axle, inclined plane, gears, pulleys and hydraulic equipment.

(Each of these will be looked at separately in notes.)

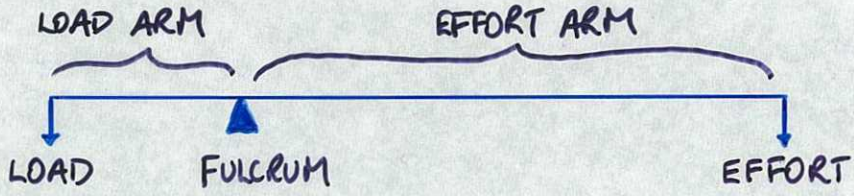
Machines can do the following.

1. Allow energy to be transferred from one place to another where it will be used.
2. They change the size and direction of a force.
   Some machines allow us to exert a very large force on something by exerting a small force - this is a <u>force advantage</u>.
3. They can change the distance and speed with which something is moving.
   In this case, a force applied can make something move a large distance or faster - this is a <u>distance</u> or <u>speed advantage</u>.

LEVERS

A lever is a rigid bar, and all levers have the following parts.

1. FULCRUM - fixed point around which the lever turns
2. EFFORT (FORCE) - force applied to the lever.
3. EFFORT ARM - distance from the fulcrum to the point where the effort is applied.
4. LOAD (FORCE) - force moving the load.
5. LOAD ARM - distance from the fulcrum to the position of the load.



There are 3 classes of levers.

1ST CLASS

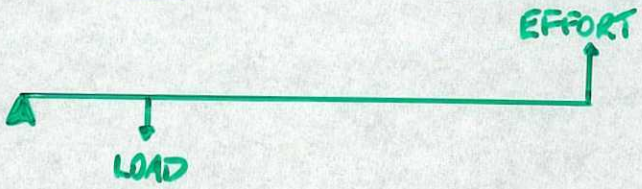
e.g. crowbar

Effort arm is much longer than the load arm.

Has a force advantage but a distance disadvantage.

i.e. small effort shifts a large load, but has to move through a large distance for the load to move a small distance.

2nd CLASS



e.g. wheelbarrow

Same characteristics as 1ST class, except that the load and effort are on the same side of the fulcrum

3rd CLASS

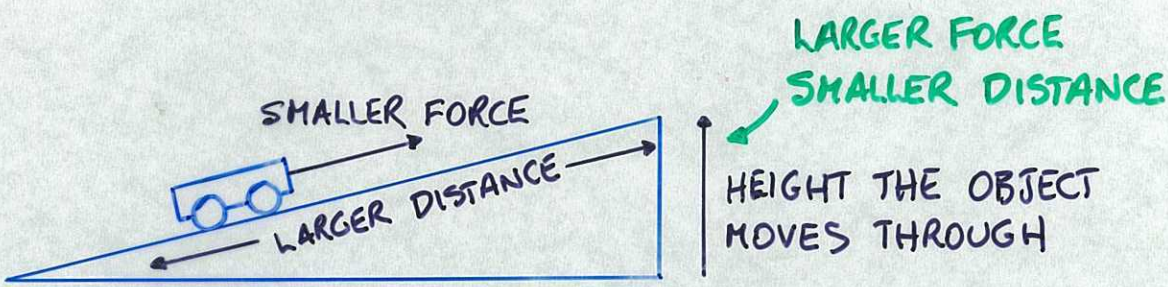
e.g. fishing rod.

Shorter effort arm than load arm.

Force disadvantage but a distance advantage.

INCLINED PLANE

This makes it easy to move an object through a height. The force required is smaller, but the same amount of work is done when compared to moving the object vertically.



NOTICE THE RELATIONSHIP BETWEEN FORCE AND DISTANCE. A FORCE ADVANTAGE GIVES A DISTANCE DISADVANTAGE.

EXAMPLES.

1. RAMP - as seen above, a smaller force is required to shift a heavy object to a height. ie. the force is less than the weight of the object.
2. AXE - has a simple wedge shape that exerts a large splitting force for a small effort force.
3. SCREW - the thread acts as an incline plane. A small turning force on the head

exerts a large force that holds things together.

4. NUT ON A BOLT - same as the screw.
5. CAR JACK / BENCH VICE - screw thread makes it easy to exert a large lifting or gripping force.

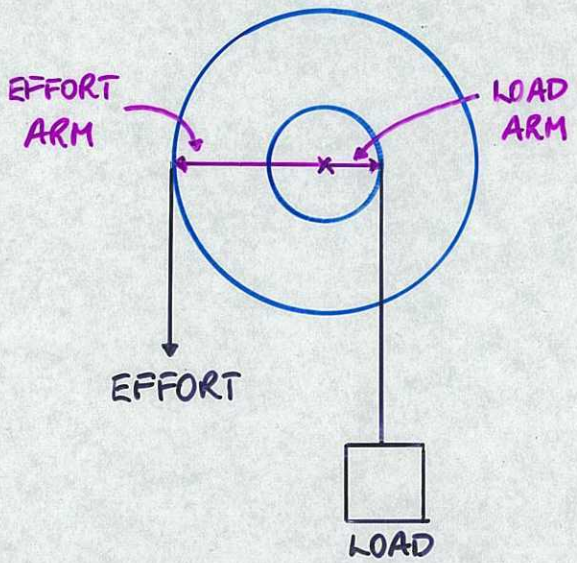
WHEEL AND AXLE

The wheel and axle is made up of two "wheels" which are joined. They can act like turning levers.

The wheel and axle can be used to gain a force advantage or a distance (speed) advantage.

To gain a force advantage, the effort is applied to the edge of the larger wheel.

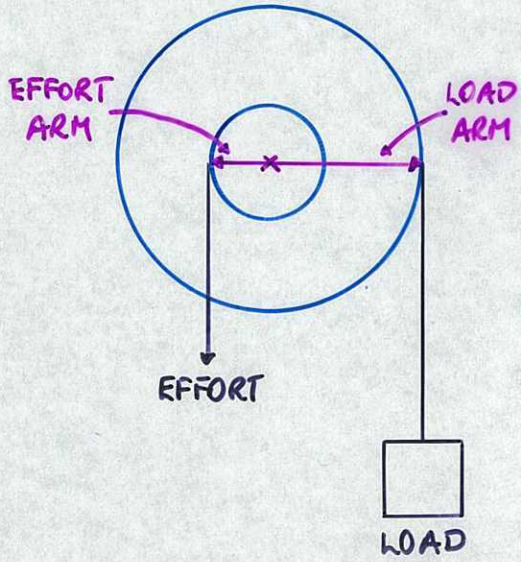
If the effort is placed on the smaller wheel or axle, a distance or speed advantage is gained.



EFFORT ARM > LOAD ARM

∴ FORCE ADVANTAGE

DISTANCE DISADVANTAGE



EFFORT ARM < LOAD ARM

∴ FORCE DISADVANTAGE

DISTANCE ADVANTAGE

EXAMPLES

Door knob - outside turns in a large circle while the axle moves in a much smaller circle.

∴ force advantage.

All of the following a similar in that a force advantage is obtained.

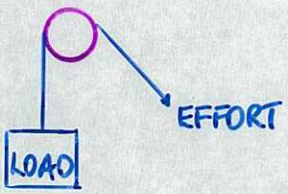
steering wheel on a car, handlebars on a bike,

a spanner turning a nut, pedals on a bike.

PULLEYS

These are useful for lifting loads vertically. They work by changing the direction of the force.

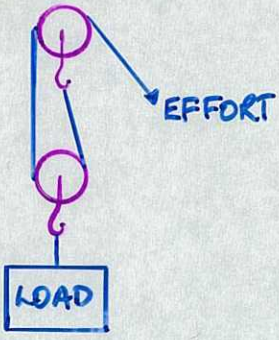
ONE PULLEY



The load will move the same distance as the effort.

∴ there is no force advantage

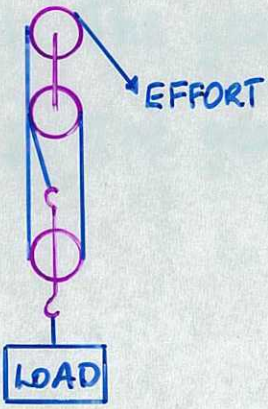
TWO PULLEYS



Since the load is held by two ropes, the distance moved by the effort will be twice that of the load.

∴ have a distance disadvantage but a force advantage.

THREE PULLEYS

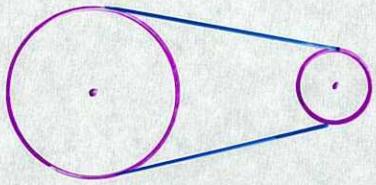


Three ropes are supporting the load.

∴ effort moves three times the distance of the load.

⇒ distance disadvantage but a force advantage.

Pulleys can be set up to gain a distance advantage - the driving pulley is large while the second pulley is small. Both are connected by a belt of some type.



This gives a distance advantage but a force disadvantage.

e.g. used in wood/metal lathes to turn pieces at a high speed.

NOTE. A small driving wheel will give a force advantage and a distance disadvantage.

e.g. motor on a concrete mixer.

GEARS

Gears are similar to belts and pulleys but have two major differences.

1. The gears interlock or mesh together.
2. The gear wheels in contact move in opposite directions.

As with pulleys, a large driving cog gives a distance advantage and a force disadvantage. (The opposite is true for a small driving cog.)