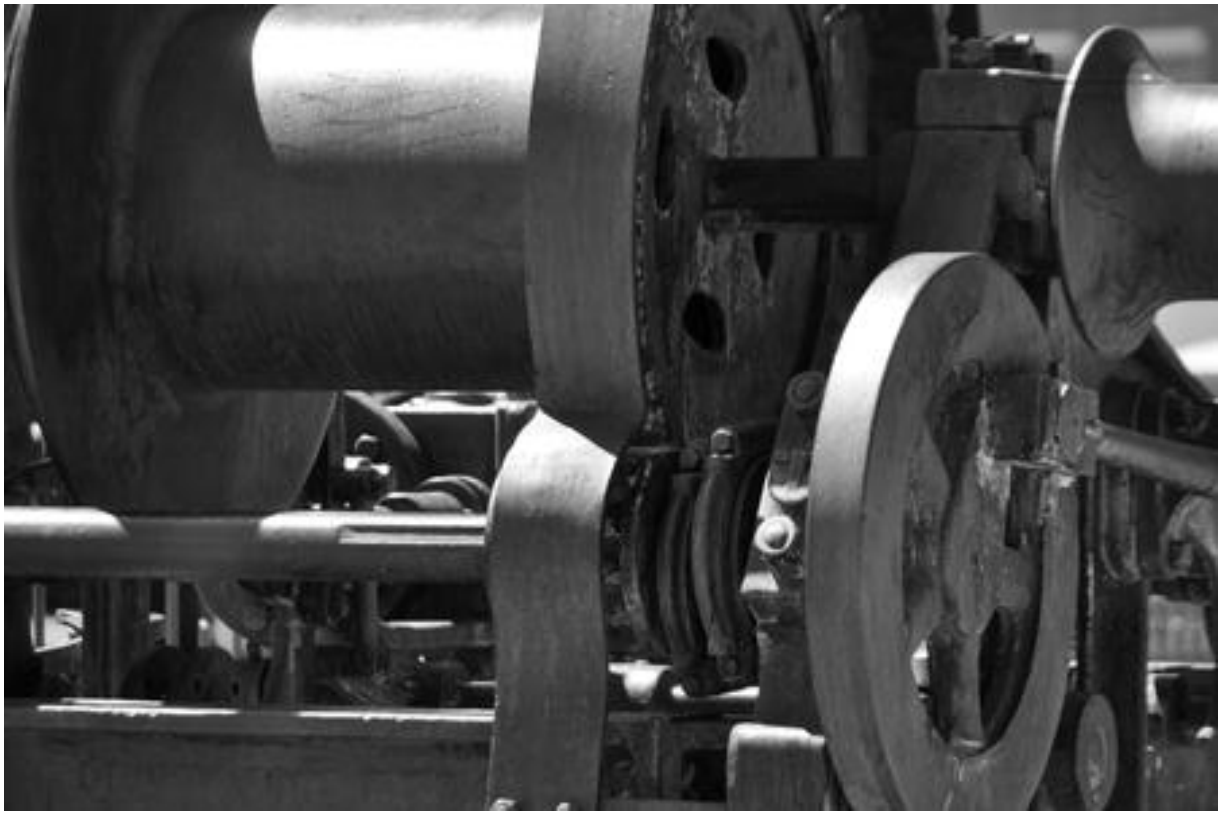
11.5
Machines



Machines

Machine:

A mechanical device used to make work easier to accomplish.

(It does not save work, just makes it easier)

Ways Machines do work:

1.) Transform Energy (Heat and Electric Motors)

2.) Transfer Energy (Multiply force, speed/distance)

Machines

Ways Machines do work:

1.) Transform Energy
- Heat Engines: Chemical Energy to Mechanical Energy
- Electric Motors: Electrical Energy to Mechanical Energy

2.) Transfer Energy
- Multiply Force
- Multiply Speed / Distance
- Change Direction of Force

Machines

Transform Energy

1.) Transforming Chemical Energy to Mechanical Energy

Heat Engines

Examples of everyday heat engines include the steam engine, the diesel engine, and the gasoline engine in an automobile.

Machines

Transform Energy

2.) Transforming electrical energy to mechanical energy

Electric Motors

Electric motors are found in applications such as industrial fans, blowers and pumps, machine tools, household appliances, power tools, and disk drives.

Machines

Transfer Energy

1.) Multiply Force

- Using a car jack
- Pulling on a nail with a hammer

2.) Multiply Speed /Distance

- Riding Bike
- Using a broom

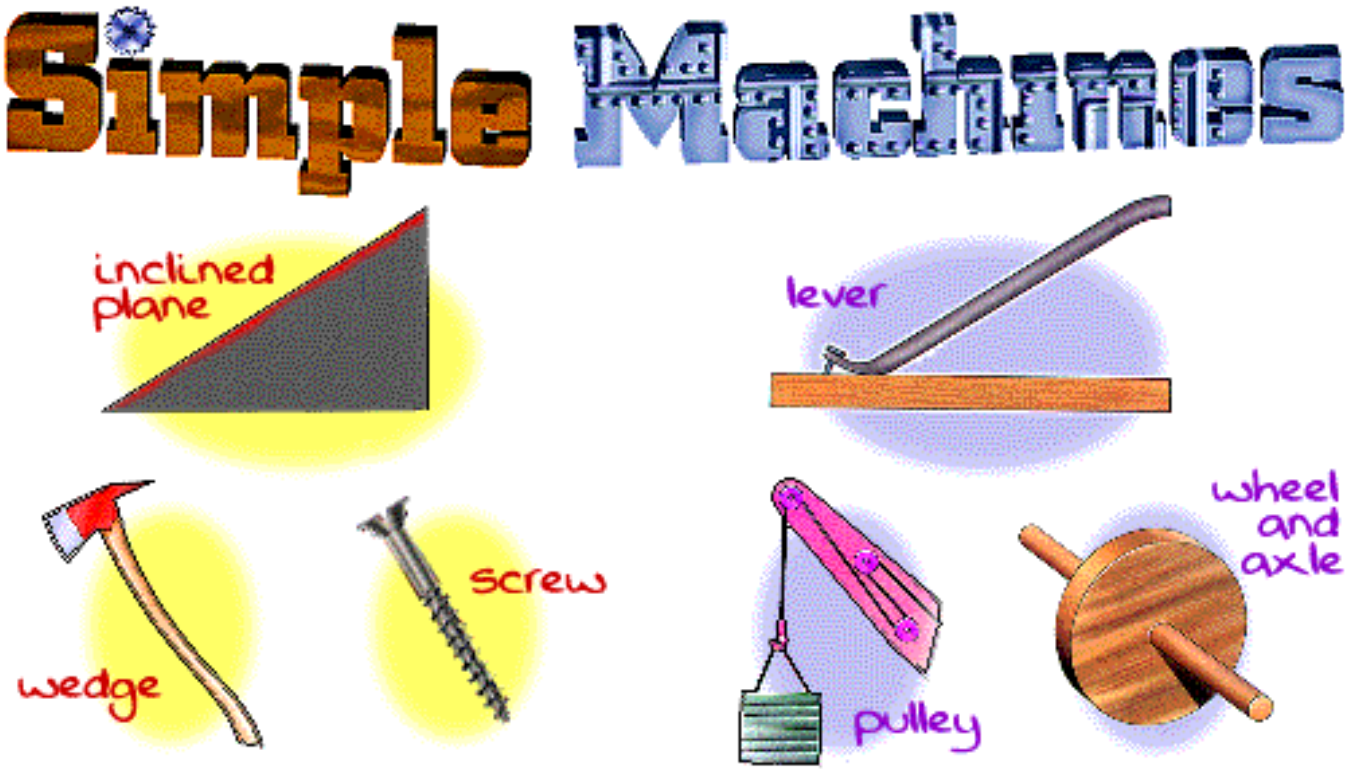
Machines

Transfer Energy

3.) Changing a direction of Force

- Pulley on a flagpole
- Pry-Bar

Simple Machines



Simple Machines

- A simple machine is a machine with only one movement.
- They are the simplest form of tools.
- A simple machine has few or no moving parts.

Simple Machines

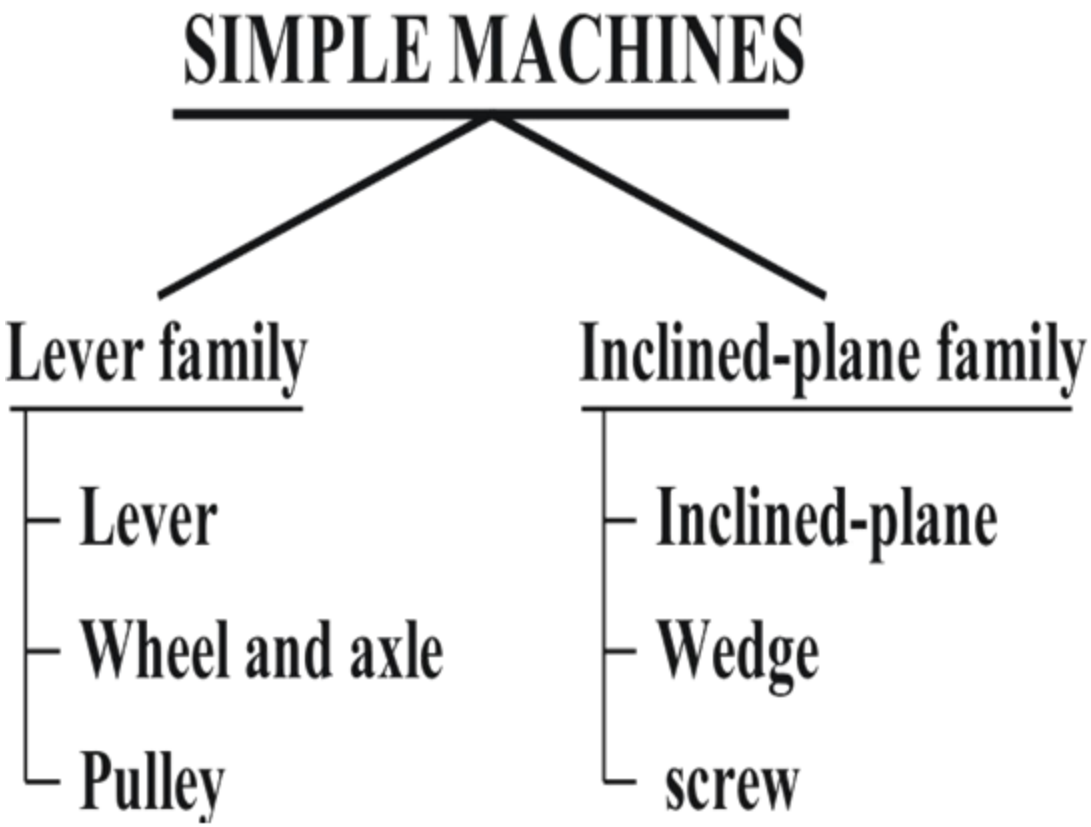
- All simple machines change the way work is done.
- They do not make less work.
- The work done by using the simple machine to do a job will be at least equal to the work done if the machine had not been used and likely will be more because of friction.

Simple Machines

Six Simple Machines

1. Lever
2. Wheel and Axle
3. Pulley
4. Inclined Plane
5. Wedge
6. Screw

Simple Machines - Families



Compound Machine

- Simple Machines can be put together in different ways to make complex machinery.
- Compound Machine: Made up of two or more simple machines.

Examples: Cars, Tractors, Cranes, Bicycles, Tanks, egg beaters, etc…

Mechanical Advantage

A “simple” machine is a single mechanical device used to perform work more conveniently by providing a “mechanical advantage”.

The mechanical advantage of a machine does one of two things:

1. Multiplies force (at the expense of distance/speed)
2. Multiplies distance/speed (at the expense of force)

Mechanical Advantage

The mechanical advantage of a machine is the multiplier of the force or distance/speed. It is a number (without units) that tells us how much a machine helps do work.

Example:

A mechanical advantage of 2 would mean that the simple machine can multiply the force 2 times as much or the speed twice as fast.

Mechanical Advantage

Ideal Mechanical Advantage (IMA)

The ideal mechanical advantage (I.M.A) is the mechanical advantage of an ideal machine. In effect, it is the maximum mechanical advantage that a frictionless machine can deliver.

I.M.A. = d / h

d = distance
h = height

Mechanical Advantage

Actual Mechanical Advantage (AMA)

The actual mechanical advantage (A.M.A) of a machine is the real world mechanical energy of a machine that has friction and thus there is a loss of energy.

The A.M.A. is always less than the I.M.A.

$A.M.A. = F_W / F_A$

F_W = Weight of object
F_A = Applied Force

Mechanical Advantage

If system is frictionless: I.M.A = A.M.A

If I.M.A = 1: Provides no help to the system
If I.M.A < 1: Machine multiples distance or speed
If I.M.A > 1: Machine multiples the force

Efficiency

The efficiency of a machine tells us what percentage of the input energy is "lost" to friction.

Since an ideal machine has no friction (no energy loss), an ideal machine is 100% efficient.

Work Input

Work Input (W_{IN}) : $W_{IN} = F_A \times D$

W_{IN} = the amount of work YOU put into moving an object.

F_A = The effort distance is the distance through which the effort or applied force acts.

D = The effort distance is the distance through which the effort or applied force acts.

Work Output

Work Output (W_{OUT}): $W_{OUT} = F_W \times h$

W_{OUT} = the amount of work you actually GET from moving the object.

F_W = The resistance force of the output force

h = The resistance distance is the distance through which the resistance force acts.

Work - Friction

Work Friction (W_F) : $W_F = W_{IN} - W_{OUT}$

W_F = the amount of work lost to friction

Efficiency

Efficiency

The ratio of useful work output to the total work input as a percentage.

All real world machines have an efficiency of less than 100%.

Efficiency Formulas:

$Eff = (W_{OUT} / W_{IN}) \times 100\%$

$Eff = (A.M.A. / I.M.A.) \times 100\%$

Terminology

Terminology:

F_A: The effort or input force that is applied.

F_W: The resistance force is the output force.

D: The effort distance is the distance through which the effort or applied force acts.

h: The resistance distance is the distance through which the resistance force acts.

Example Problem

Example

A man slid a 75 kg crate up an incline onto a 1.5 m high dock. He slid the crate 6 m with a force of 320 N.

Find:

a. W_{IN}
b. W_{OUT}
c. W_F
d. I.M.A.
e. A.M.A.
f. Efficiency