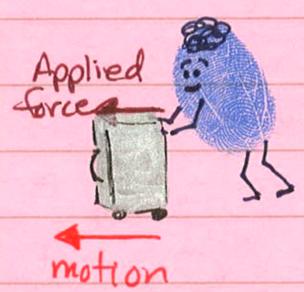
Chapter 9 Work + Simple Machines

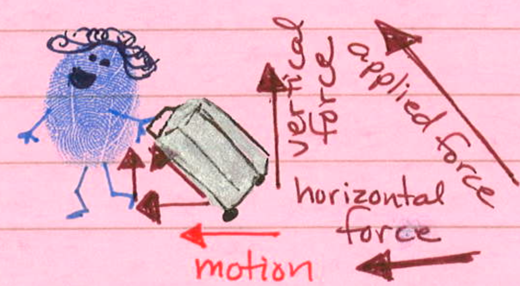
9-1 **Work** is the transfer of energy to an object by a force that makes an object move in the direction of the force.

Work = force x distance

Units: work → Joules
force → Newtons
distance → meters

So... a newton-meter is a Joule

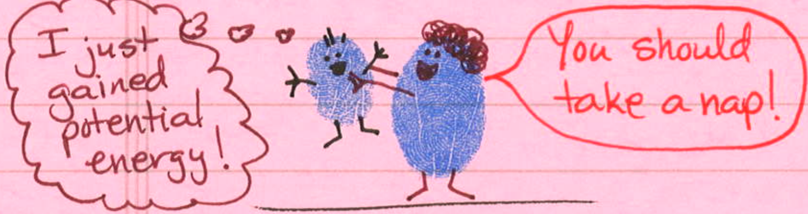




When the force and the motion are in the same direction, just multiply the force by the distance!

The applied force is not in the same direction as the motion. In this picture, only the horizontal part of the force can be used in the equation.

Lifting objects: To lift something, you must pull up with a force equal to or greater than the weight of the object. The work done is equal to the weight of the object times the distance it is lifted.



Doing work on an object transfers energy to the object

Power is the rate at which work is done.

$$\text{Power} = \frac{\text{work}}{\text{time}}$$

Units: Power is in watts
work is in Joules
time is in seconds

Power is the rate at which energy is transferred to an object.

Using Machines

Input force - the force you apply to the machine

Output force - what the machine changes the input force to

A machine can:

- change the size of the force
- change the distance the force acts
- change the direction of the force

Changing the size of a force

Example: crowbar

Output force is > input force

Output force moves a smaller distance

Changing the distance a force acts

Example: rake

Output force moves a greater distance

Input force is > output force

Changing the direction of a force

Example: Pulley

Input force = Output force

Input distance = Output distance

Back of 26

Mechanical Advantage

$$MA = \frac{\text{output force}}{\text{input force}}$$ (Force is in Newtons)

If the MA is...

$>1 \rightarrow$ output force $>$ input force

$<1 \rightarrow$ input force $>$ output force

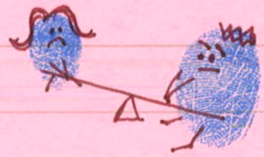
The "ideal" mechanical advantage does not factor in friction. Friction exists, so the IMA is not accurate.

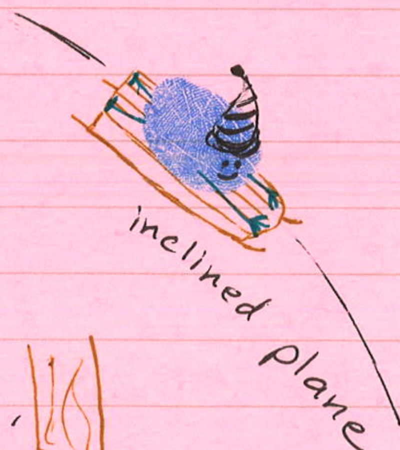
Efficiency

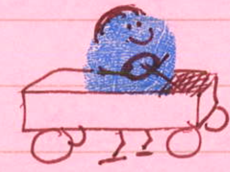
$$\text{Efficiency } (\%) = \frac{\text{output work}}{\text{input work}} \times 100$$

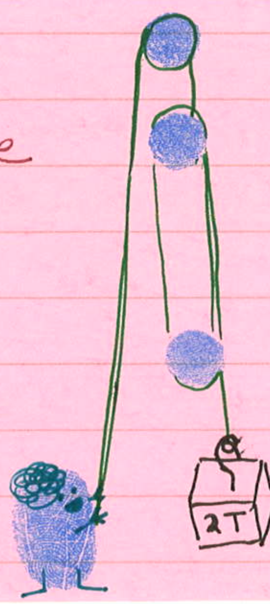
9-3 Simple Machines

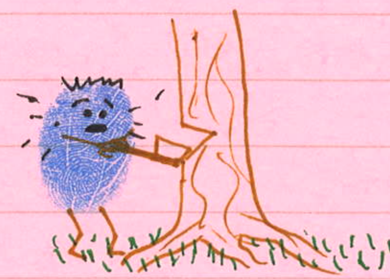
There are 6: Lever





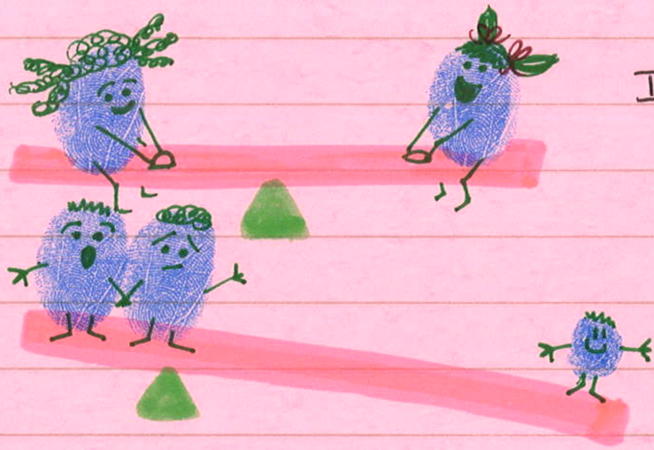






3 Types of Levers

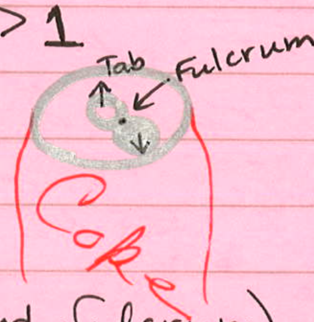
1st class (fulcrum is between input + output)



Input arm = Output arm
MA = 1

Input arm > Output arm
Output force > Input force
MA > 1

Examples: hammer pulling out a nail
opening a can of Coke

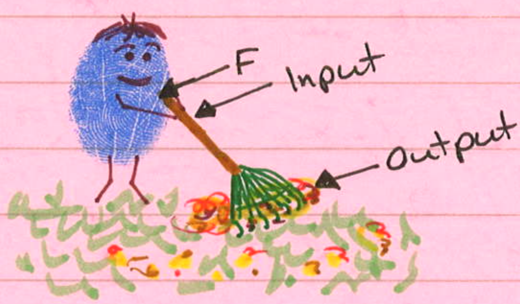


2nd class (Output is between input and fulcrum)

Input arm > Output arm
Output force > Input force
MA > 1

Examples: wheelbarrow, nutcracker, your foot

3rd class (Input is between the output and fulcrum)



Input arm < Output arm
Output force < Input force
MA < 1

Examples: Tweezers, rake, broom

Back of 27

Ideal Mechanical Advantage = $\frac{\text{Length of input arm (m)}}{\text{Length of output arm (m)}}$

Levers in your body:

Neck: 1st class

Foot: 2nd class

Arm: 3rd class

Wheel & Axle

Ideal M.A. = $\frac{\text{Radius of wheel (m)}}{\text{Radius of axle (m)}}$

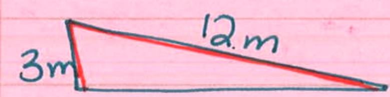
Radius of wheel > Radius of axle

MA > 1

Examples: steering wheel of a car, screwdriver

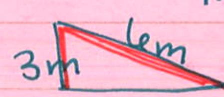
Inclined Plane (ramp)

Ideal M.A. = $\frac{\text{length of inclined plane (m)}}{\text{height of inclined plane (m)}}$



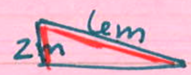
$IMA = \frac{12}{3}$

$= 4$



$IMA = \frac{6}{3}$

$= 2$



$IMA = \frac{6}{2}$

$= 3$

* increasing the length or decreasing the height of the inclined plane increases the mechanical advantage

Wedge (inclined plane with 2 sloping sides)

Examples: axe, knife, front teeth, (doorstop)