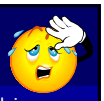
Work, Power & Simple Machines

(Making work easier…phew!)

What is WORK?



- If you put a lot of effort into doing something and are worn out at the end, you think you've done a lot of **WORK**, right?

  Not necessarily….
- If you haven't exerted a force AND moved an object some distance, you haven't done any WORK at all!

What is WORK?

- In scientific terms, you do **WORK** when you exert a **FORCE** that causes an object to move some **DISTANCE** in the **SAME DIRECTION** of the force.
- Examples:
  - Pushing a lawn mower
  - Lifting books out of your bag
  - Pulling a suitcase on wheels

What 2 things <u>must happen</u> for WORK to be done?

- **MOTION** – The object must move.

  If the object doesn't move, there is no work done.

- **FORCE & MOTION IN THE <u>SAME</u> DIRECTION**
- Movement must be in the same direction as force.

  If the motion is in a different direction than the force, there is no work.

Is WORK being done?

- Pushing a car that's stuck in snow.

NO! (No work because the car doesn't move).

- Lifting a baby out of his stroller.

YES! (Baby moves in same direction as you lift)

- Carrying your bookbag to class.

NO! (Force is pulling up, but motion is sideways)

- Pushing a lawn mower.

YES! (Mower goes in same direction as you push)

Calculating WORK

WORK = FORCE x DISTANCE

The <u>greater the distance</u>, the <u>more you work</u>.

Eg. Pushing a car 100 m vs.
Pushing a car 200 m (more work!)

The <u>greater the force</u>, the <u>more you work</u>.

Eg. Lifting 1 book onto a table vs.
Lifting 10 books onto a table (more work!)

Calculating WORK

- You carry a baby that weighs 30 N upstairs to his room (3 meters above you). How much work is done?

  WORK = FORCE X DISTANCE

  WORK = 30 N x 3 meters

  WORK = 90 N·m (90 J)

Work is measured in Joules (J)

1 Joule = 1 N·m

What is POWER?

- Power is the <u>rate</u> at which work is being done (or how much work is being done in a unit of time).
- POWER = WORK ÷ TIME
- More power means <u>less time to do the same work</u> OR <u>more work done in the same amount of time</u>.
- Power is measured in Watts (W).

POWER

- Think about 2 cars – one with a 200 horsepower engine, and one with a 500 horsepower engine.
- Which one has the more <u>powerful</u> engine?
- Which one will go further in 10 minutes?
- Which one will go 10 miles in the shortest amount of time?

Calculating POWER

- A motor exerts a force of 2,000 N to lift an elevator 8.0 m in 4.0 seconds. What is the power of the motor?

Power = $\frac{\text{Work}}{\text{Time}} = \frac{\text{Force x Distance}}{\text{Time}}$

Power = $\frac{2{,}000\text{N x 8 m}}{4\text{ s}} = \frac{16{,}000\text{ J}}{4\text{ s}}$

Power = 4,000 J/s (4,000 Watts)

What are MACHINES?

- Most people think of complex, automated, technical, or electronic gadgets with motors…, but machines can be much simpler.
- A machine is any device that lets you do **WORK** in an ***easier*** or ***more effective*** way.

How do Machines do work?

- Machines make work easier by changing 3 things about the FORCE you exert to do work:
  - **AMOUNT** of force you exert
  - **DISTANCE** over which you exert force
  - **DIRECTION** in which you exert force

How do Machines work?

- In other words, a machine changes the ***strength***, ***distance***, ***direction*** of your push or pull.

What is the *mechanical advantage* of a machine?

- A machine's mechanical advantage is the number of times a machine increases a force exerted on it.
- Mechanical Advantage = $\frac{\text{Output Force}}{\text{Input Force}}$

What is the *mechanical advantage* of a machine?

- You exert 10 N of force on a can opener. The can opener exerts 30 N of force on the can. What is the mechanical advantage?
- Mechanical Advantage = $\frac{\text{Output Force}}{\text{Input Force}} = \frac{30\text{ N}}{10\text{ N}}$
- Mechanical Advantage = 3

What are SIMPLE MACHINES?

- There are only 6 basic kinds of simple machines that make work easier.
- These 6 simple machines make up all the other **compound** machines we use everyday.

SIX SIMPLE MACHINES

The six simple machines are:

- Inclined Plane
- Wedge
- Screw
- Lever
- Wheel & Axle
- Pulley

INCLINED PLANE

- An inclined plane is a flat, sloped surface connecting a lower level with a higher level.

INCLINED PLANE

- It lets you use less force over a longer distance to raise a load to a higher level.

INCLINED PLANE: Examples

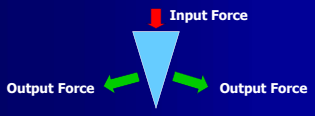
- Ramps (Boat ramps, wheelchair ramps)
- Propeller
- Ladders/Stairs

WEDGE

- A wedge has slanting slides that taper to a thin edge – it splits material apart. *(A moving inclined plane!)*

WEDGE

- It converts motion in one direction, into a splitting motion that acts at right angles to the blade.



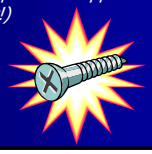
WEDGE: Examples & Uses

- Ax, Knife, etc.
- Zippers

- Used in all cutting machines (to split materials apart)
- Lifting machines may use wedges to slide under loads

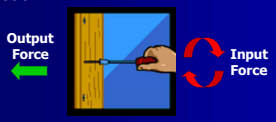
SCREW

- A screw has a "thread" or "groove" wrapped around a central cylinder. *(Another inclined plane - wrapped around a cylinder!)*



SCREW

- While turning, it converts a twisting motion into a forward or backward motion.



SCREW: Examples & Uses

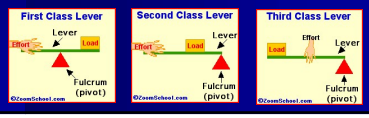
- Screws can holds things together or lift materials.
- Screws
- Screw top lids for jars/bottles
- Light bulb
- Swivel stools/chairs

LEVER

- A lever is rigid bar that pivots/rotates on a fixed point. The fixed point is called the "fulcrum".

LEVER

- Levers may increase the size or distance of force or change direction of the force.
- There are 3 types of levers.



LEVERS: Examples & Uses

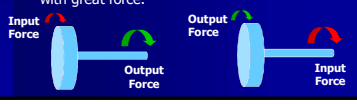
- First Class Levers:
  - Scissors, See-saws, Pliers
- Second Class Levers:
  - Staplers, Nutcrackers, Wheelbarrows
- Third Class Levers
  - Shovels, baseball bats, tweezers

WHEEL & AXLE

- A wheel and axle are 2 circles or cylinders attached together around a common axis.
- The larger circle is the "wheel", the smaller cylinder/rod is called the "axle".

WHEEL & AXLE

- The wheel is locked to the central axle – when one turns, so does the other one.
- A short powerful force at the axle, will move the wheel's edge a long distance.
- A long motion at edge of wheel, moves the axle with great force.



WHEEL & AXLE: Examples & Uses

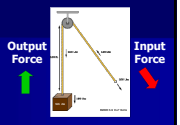
- Screwdriver
- Windmill
- Cars/Bicycles
- Rolling Pin
- Door Knob
- Fan

PULLEY

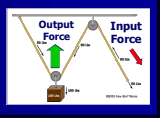
- A pulley is a grooved wheel with a rope, used to raise/lower/move a load.

PULLEY

- A simple fixed pulley only changes the direction of force.

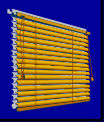


- Pulley systems decreases the input force, allowing you to move heavier loads.



PULLEY: Examples & Uses

- Cranes
- Raising a flag on a pole
- Window Blinds
- Raising a sail on a boat
- Clothesline



COMPOUND MACHINES

- Most machines are **combinations** of 2 or more simple machines.
- For example, a simple can opener is a combination of 3 simple machines:
  - Lever
  - Wheel & axle
  - Wedge