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Photocopy Master Sheets

Years 7-8

FORCES

Disk filename = “02.Forces”

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Topics Available

Year 7-8 General Science

Disk Filename	Topic Name
01.Energy	Energy
02.Forces	Forces
03.Matter	Solids, Liquids & Gases
04.Mixtures	Separating Mixtures
05.Elements	Elements & Compounds
06.Cells	Living Cells
07.Life	Living Things
08.LifeSystems	Plant & Animal Systems
09.Astronomy	Astronomy
10.Earth	The Earth
11.Ecosystems	Ecosystems

Year 9-10 General Science

Disk Filename	Topic Name
12.Waves	Wave Energy (inc. Light)
13.Motion	Forces & Motion
14.Electricity	Electricity
15.Atoms	Atoms & Elements
16.Reactions	Compounds & Reactions
17.DNA	Cell Division & DNA
18.Evolution	Evolution of Life
19.Health	Health & Reproduction
20.Universe	The Universe
21.EarthScience	Earth Science
22.Resources	Resources & Technology

Year 11-12 Science Courses

Biology

Preliminary Core

Local Ecosystem
Patterns in Nature
Life on Earth
Evolution Aust. Biota

HSC Core

Maintain. a Balance
Blueprint of Life
Search for Better Health

Options

Communication
Genetics:Code Broken?

Chemistry

Preliminary Core

Chemical Earth
Metals
Water
Energy

HSC Core

Production of Materials
Acidic Environment
Chem.Monit.&Mngment

Options

Shipwrecks, Corrosion...
Industrial Chemistry

Earth & Envir. Science

Preliminary Core

Planet Earth...
Local Environment
Water Issues
Dynamic Earth

HSC Core

Tectonic Impacts
Environs thru Time
Caring for the Country

Option

Introduced Species

Physics

Preliminary Core

World Communicates
Electrical Energy...
Moving About
Cosmic Engine

HSC Core

Space
Motors & Generators
Ideas to Implementation

Options

Quanta to Quarks
Astrophysics

All Topics Available as PHOTOCOPY MASTERS and/or KCiC

Photocopy Masters (PDF files)
Black & White, A4 portrait-orientation
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KCiC = Key Concepts in Colour
Full colour, formatted for on-screen study
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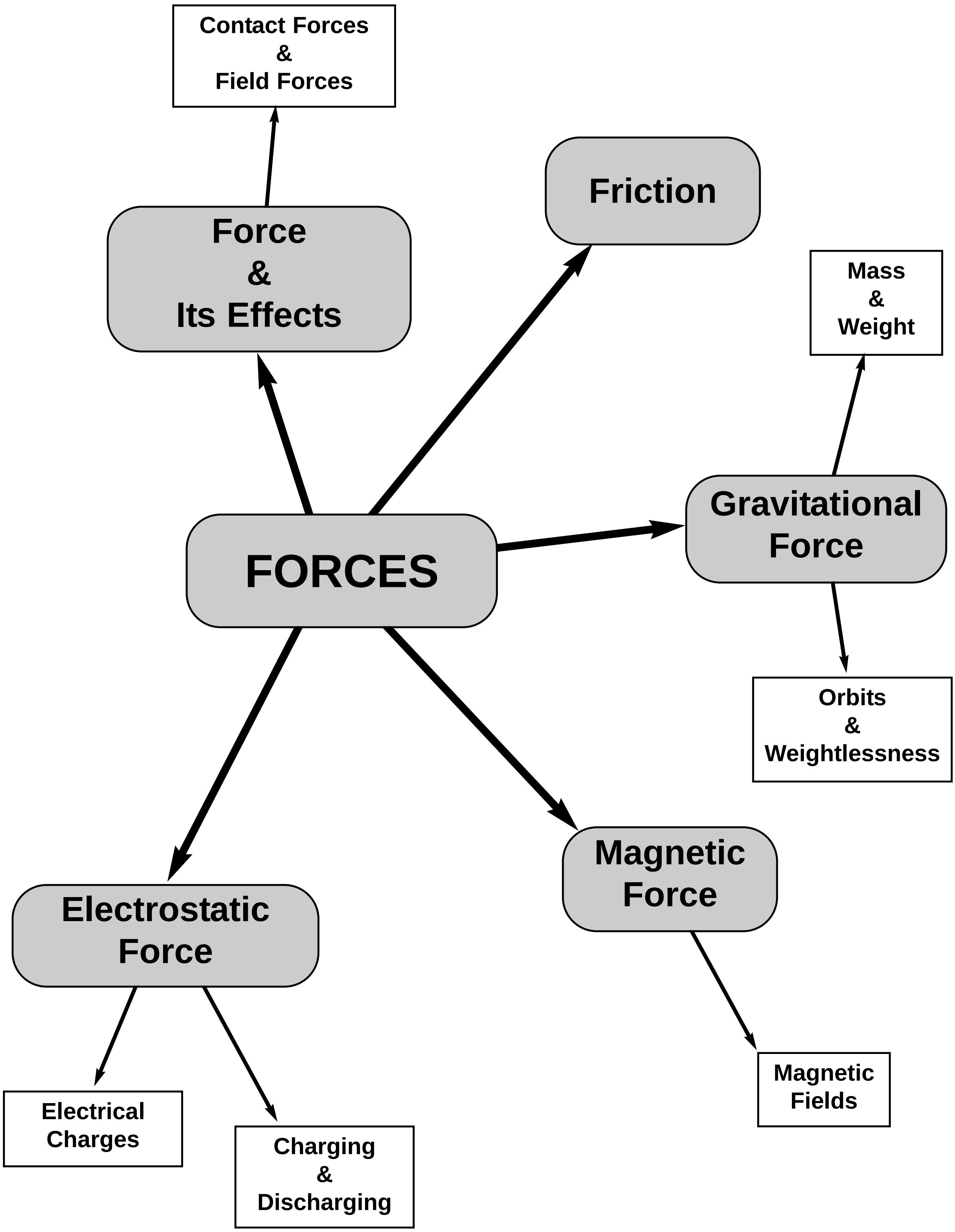
"Mind-Map" Outline of Topic

This topic belongs to the branch of Science called "Physics".
Physics is the study of the physical world of forces, motion & energy.



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Make your own "Mind-Map" TITLE PAGE.
Cut out the boxes. Sort them into an appropriate lay-out on a page of your workbook, then glue them down. Add connecting arrows and colour in.

FORCES

Electrostatic Force

Friction

Force & Its Effects

Magnetic Force

Mass & Weight

Orbits & Weightlessness

Gravitational Force

Contact Forces & Field Forces

Magnetic Fields

Charging & Discharging

Electrical Charges

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FORCES

Electrostatic Force

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Force & Its Effects

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Mass & Weight

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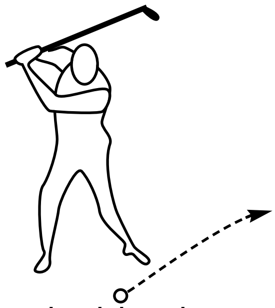
Magnetic Fields

Charging & Discharging

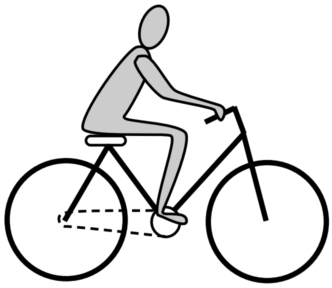
Electrical Charges

What is a FORCE? <u>A force is a PUSH or a PULL.</u>

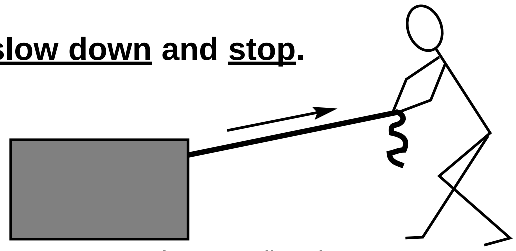
Force is what causes things to <u>begin moving</u>, or <u>slow down</u> and <u>stop</u>.



When the club strikes the ball, a force <u>pushes</u> to make the ball move.

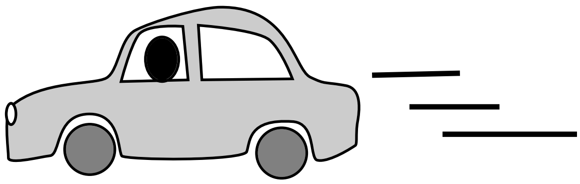


Your legs <u>push</u> on the pedals. Wheels go around and <u>push</u> on the road.



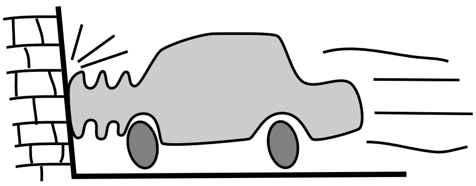
When you <u>pull</u> on the rope, a force is transmitted through the rope to pull on the box and drag it along

If something is already moving, force can make it <u>go faster</u>, or <u>slow down</u> and stop.



Pressing the accelerator makes the engine supply more force to the wheels... the car goes faster. Pressing on the brake pedal causes a force in the wheels to slow the car down.

Force can also cause a <u>change of shape</u>. For example, in a collision, forces can change the shape of the things involved.



Sometimes, forces can change the <u>temperature</u>.

In the car above, the brakes become very hot when force is used to slow the car down.

Contact Forces and Field Forces

All the forces described above are "<u>Contact Forces</u>" because they act only if the force is in contact with something.

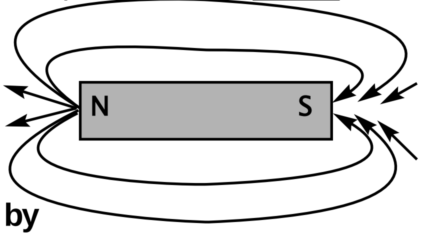
For example, if the golf club swings and misses the ball, no force would act on the ball and it would not move.

There are also some forces which can act on things without touching them.

Gravity
Electrical Force
Magnetic Force

How can gravity, electrical and magnetic forces reach out through space and apply a force to things without touching them?

To understand this, we use the "<u>model</u>" of a "<u>force field</u>".



For example, we imagine that a magnet is surrounded by an invisible web of forces. If certain things come within this "field", a magnetic force will push or pull on them.

"<u>Field Forces</u>" will be studied in more detail later in this topic.

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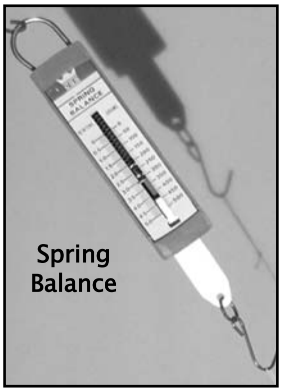
Measuring Forces

Force is measured in units called "<u>newtons</u>", abbreviated "N".

A simple way to measure some forces in the laboratory is to use a spring balance.

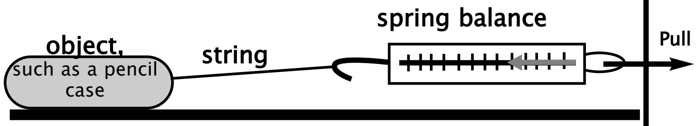
> The newton unit is named after <u>Sir Isaac Newton</u>, an English scientist who lived about 300 years ago. He discovered many basic ideas about forces.



There are various models, but they all work by a spring being stretched when a force pulls on the mechanism. (They cannot measure pushes... only pulls.)

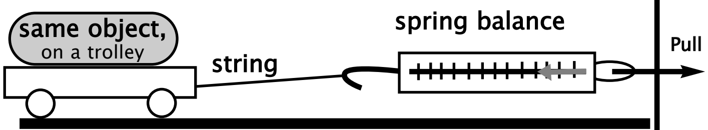
A number scale allows you to read the size of the force in newtons. Be aware that spring balances are not totally accurate or reliable.

To start getting an idea of how to measure forces, and some idea of how much 1N of force is, you might use a spring balance to drag various objects across the bench and measure the force required to move them.



You should read the balance scale while the object is moving along steadily.

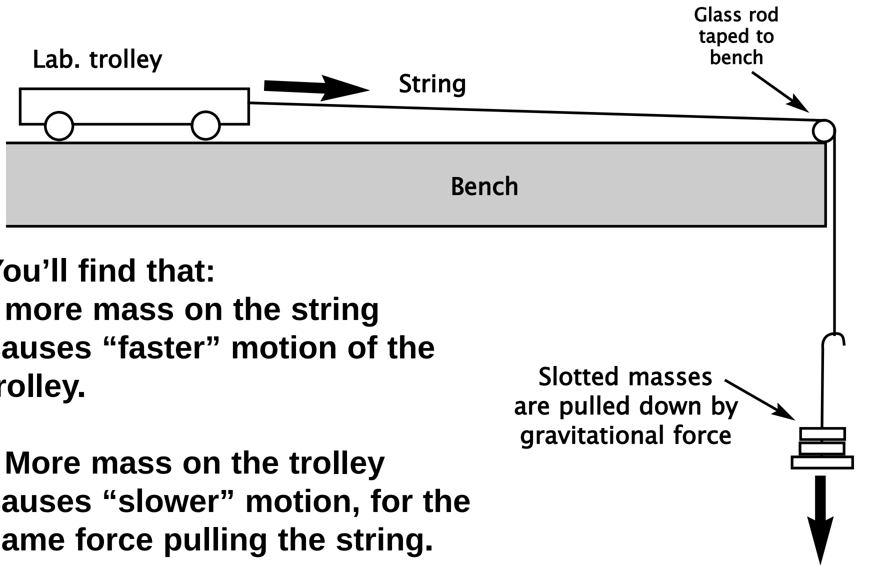
If you measure for the same object loaded onto a laboratory trolley, you may find it requires <u>less force</u> to move it when on wheels.



You'll find out why, soon!

Forces Cause Movement

Here's a simple experiment you might do, or see demonstrated in class.



You'll find that:
- **more mass on the string causes "faster" motion of the trolley.**
- **More mass on the trolley causes "slower" motion, for the same force pulling the string.**

You can experiment by:

- **Adding more hanging masses. This increases the gravitational force pulling on the string.**
  How does this change the movement?

- **Adding a large mass to the trolley to make it "heavier", but leave the same amount of mass hanging on the string.**
  How does this change the movement?

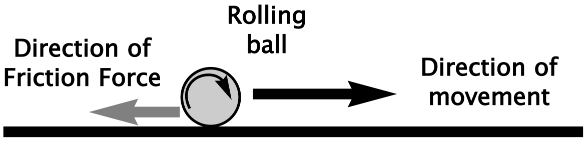
Later, you'll learn what is really meant by "mass" & "weight", and how the speed and acceleration of moving objects can be measured. For now, simply judge things "by eye".

The Force of Friction A vital contact force.

Sometimes it helps us, sometimes it hinders, but it's always there.

If you roll a ball across a flat smooth surface, such as playing field, it may travel a long way, but gradually it slows down and stops.

Why? It's because of "Friction".

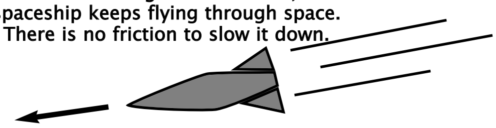


Friction is a contact force which always pushes in the opposite direction to the way an object is moving.

If a moving object is touching anything, (the ground, the air, anything) there will be friction.

However, in outer space there is no air, so no friction. A moving meteor, or spaceship, will keep coasting along without slowing down.

Even with its engines turned off, the spaceship keeps flying through space. There is no friction to slow it down.

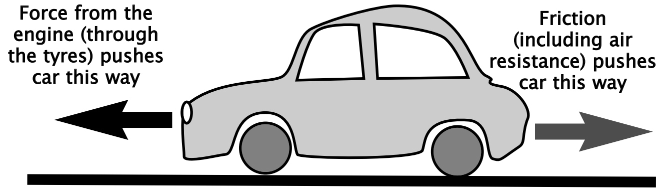


Since friction always pushes against the motion, friction always:

- **slows down a moving object, and**
- **tries to stop any object moving any faster.**

Friction is why a car's engine must keep supplying a force (through the tyres pushing on the road) just to keep going at a steady speed.

If the engine force (pushing the car forward) is the same strength as friction (pushing backwards) then the forces "cancel out" and the car travels at a constant speed.



To go faster, the driver must increase the engine thrust force so it is bigger than the friction force.

To stop, the driver increases the friction force by pressing the brakes, and also lets the engine force die down to nothing.

A Little History

Until about 300 years ago, the concept of "force" had not been thought of in a scientific way. It seemed "natural" that an apple from a tree would fall down. People thought that down-on-the-ground was the "natural place" for all things. Things fell down because they were trying to get to their "natural place".

Similarly, it was considered "natural" for a moving object to slow down and stop. No reason for this... it was just "natural".

These ideas were overturned by Sir Isaac Newton (1642-1727). He figured out that all these things were due to forces. A moving object will keep moving unless a force acts on it. In everyday situations, things slow down and stop because friction force stops them. Apples fall down because of gravitational force.

You will learn more about these things, and Sir Isaac Newton, in future studies.

Examples of Situations Involving Friction

(or lack of friction!)

Accelerating, Stopping or Turning a Corner

If it wasn't for friction no vehicle could ever get moving, and if it did, it could never turn a corner or stop again.

Friction between the tyres and the road gives the "grip" which allows the tyres to push against the road. Without that grip it would be impossible to:

- get a stationary vehicle moving, or
- turn a corner, or
- slow down and stop.

Think about what happens when roads are wet or icy. Cars skid sideways, or can't stop and have "rear-end" collisions. Wet or icy conditions reduce friction and make driving much more hazardous.

Wheels and Wheel Bearings

It's good to have friction "grip" between tyres and road, but while you're cruising along it's better to have no friction to slow you down.

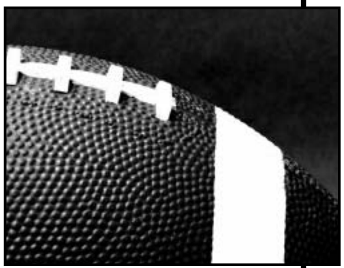
The rolling action of a wheel has much less friction than dragging a wheel-less vehicle over the ground.

A "bearing" is a low-friction device which joins a wheel to its axle. This rotates freely and keeps friction to a minimum, especially if it is lubricated with grease or oil.

Dimples on a Footy Ball

Traditionally, the ball for Rugby, or League or Aussie Rules was made from leather. When wet, these could be slippery and cause a lot of mistakes in the game.

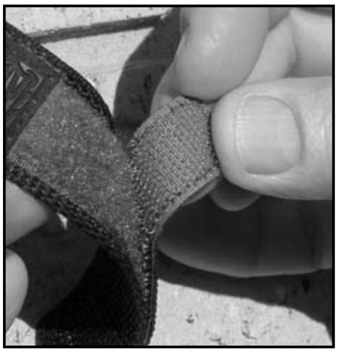
Modern balls are often made of a plastic with small dimples all over them.



This increases the friction between ball and hand or boot so there are less handling errors, even in wet weather.

Velcro

Perhaps the ultimate in friction! It's just 2 different pads of nylon material, but once they are pressed together, friction holds them so that they keep your sneakers on, or your pants up.



Notice that it's easy to pull them apart by lifting one side up from the other.

However, it is very difficult to pull them apart sideways.

Cold Hands? Friction Can Help

On a cold day people rub their hands together to warm them up.

Remember that forces can change the movement of an object, or its shape, or even its <u>temperature</u>.

Friction forces often result in an increase in temperature. Rubbing your hands together creates friction, which causes a rise in temperature, so your hands get warmer.

Worksheet 1
Forces

Fill in the blank spaces

Student Name..

A force is a a).................... or a b)................ Force is what causes things to begin to c)......................, or to d).............................. and stop. Force can change the e)............. of something, such as in a collision. Force can also change the f)..............................., such as when the g)...................... of a car get hot.

Many forces are known as "h)..................... forces" because they only act when things touch. There are also some forces which push or pull without touching. These are called "i)....................... forces". Examples are j)............................, electrical force and k).......................... force.

Force is measured in units called l)................................, abbreviated m)........

A simple way to measure forces in the laboratory is to use a n)................................ ....

Match the Lists

For each definition, write the letter of the matching List Item.

Definitions	**matches with**
1. Type of force which acts when things push or pull when touching.	....
2. Units of force.	....
3. A type of "field force".	....
4. A change that forces can cause.	....
5. Equipment to measure force.	....

List Items (not all will be used)

A. spring balance
B. gravity
C. change of speed
D. volt
E. contact
F. newton
G. light

Worksheet 2
Friction

Fill in the blank spaces

Student Name..

Friction is a a)............................ force (contact/field) which always pushes in the b).......................... direction to the way anything is moving. This means that friction always causes moving things on Earth to c)........................ and eventually d).............

However, in outer space there is no e)...................... and no friction. A space craft with its f)......................... turned off, will coast along at the g)...................... speed.

In a car on Earth, the only way to travel at a constant h)....................... is to constantly provide a i)......................... from the car's j)............................ to overcome the k)............................... force.

To go faster the engine must provide a force l)........................... (larger /equal/smaller) than friction.

If the engine's force is less than friction, the car will m)....................................

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Earlier you learned that there are certain forces that act on things without touching them. These are the "Field Forces" of Gravity, Electricity and Magnetism. The rest of this topic is all about these.

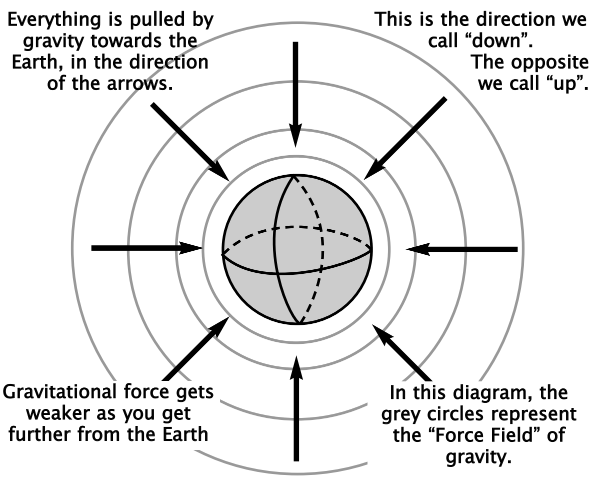
Gravitational Force

What Goes Up, Must Come Down

If you throw a ball vertically upwards it goes up, and then falls vertically down again. If you throw it upwards at an angle it follows an arc and curves back down to the ground.

The ball, and every other object on or near the Earth is being pulled toward the Earth by the force of gravity.

Gravity reaches out and pulls on things without touching them. It's as if the Earth is surrounded by an invisible "field" of force which attracts all objects.



How Does Gravity Work?

We still don't fully understand what causes gravity, but we do know that:

Gravitational Force attracts every object in the Universe to every other object in the Universe

Gravity holds the planets in orbit around the Sun, and holds entire galaxies together. More on this in a later topic!

Mass and Weight

Gravity pulls on all objects because of their "mass". Mass is a measure of how much matter, or how much "substance", an object contains.

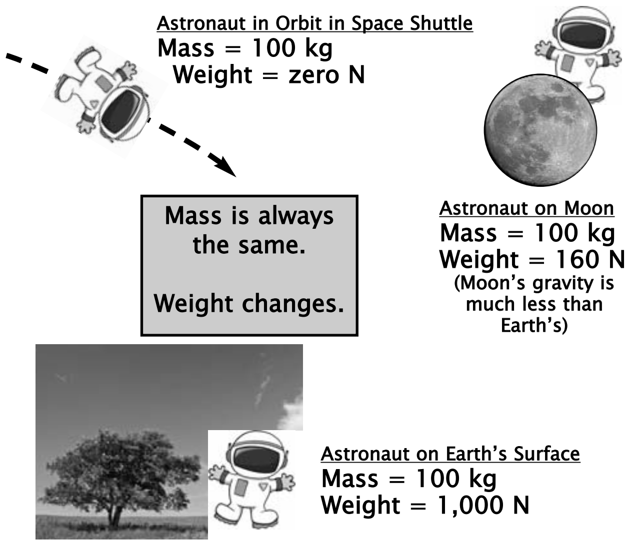
Mass is measured in kilograms (kg).

Unfortunately, in everyday life there is confusion about "mass" and "weight".

When a person says "I weigh 65 kg" they really should say "My mass is 65 kg... my weight depends on where I am".

Weight is the force of gravity acting on your mass. Since weight is a force it is measured in newtons (N).

The strength of this force depends on where you are within a gravitational field, so the same object can have different weights in different places.

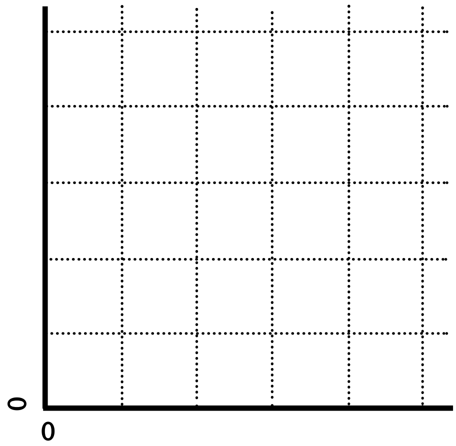


You might do an experiment in class to learn about the relationship between mass and weight here on the surface of the Earth (next page).

Worksheet 3 An Experiment to Investigate Mass & Weight

You need:
spring balance 0-5 N
slotted 50g masses & mass carrier

Procedure: simple!
1. Start with (say) 100g mass. Record this **mass** in both grams (**g**) and in kilograms (**kg**) in a table.
2. Hang the mass on the spring balance and record its **weight** in newtons (**N**).
3. Add another 50g or 100g and repeat these measurements.



Data Table

Mass (g)	Mass (kg)	Weight (N)
100	0.1	

Analysis:
Construct a **Line Graph** of Mass (kg) (horizontal) against Weight (N)(vertical).

You'll need to work out a suitable number scale on each axis first.

Don't forget to write a "Title", and to label the axes.

For Discussion:
1. You may have found that the points on the graph lie almost in a perfect straight line. Why are some of them not quite perfectly lined up?

2. Can you determine a mathematical way to calculate the weight (on the Earth's surface) of any given mass?

3. The ratio between Weight (N) and Mass (kg) gives a special number we call "g". On the Earth's surface g = 10. The value of "g" is different in different places. (example: on the Moon, g = 1.6)
Can you find out the values for "g" on different planets of our Solar System?

All Objects Fall at the Same Rate

Try This:
Drop a heavy object (e.g. a brick) and a light-weight object (e.g. a sheet of paper) from the same height at the same time. Watch carefully to see which hits the ground first.

The brick wins! Heavy things fall faster!

Wrong!

The paper was slowed down by air resistance, so your test wasn't fair.

Scrunch the paper into a ball (this reduces air resistance) and try the test again.

Without air resistance, all objects fall at the same rate due to gravity

Orbits & Being Weightless

Most people know that when the astronauts are up in orbit in the Space Shuttle (or other spacecraft) they are weightless.

Many think that this is because there is no gravity up there in space. WRONG!

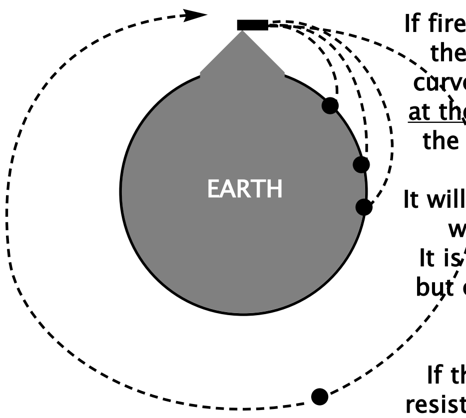
Without gravity, they would not even be able to stay in orbit and would fly off into deep space.

Gravity & Orbiting

It was Sir Isaac Newton (again!) who first figured out how orbiting is possible.

He imagined a cannon on a very high mountain, firing cannon balls horizontally.

When fired, a cannon ball curves downwards until it hits the surface. If fired faster, it goes further before hitting the ground.



If fired fast enough, the cannon ball curves downwards at the same rate as the Earth curves.

It will now circle the whole Earth! It is falling down, but cannot hit the surface.

If there is no air resistance (no air in space!) it can orbit around and around the Earth, always falling due to gravity.

Orbital Speed needed to orbit the Earth varies with height, but is about 25,000 km/hr

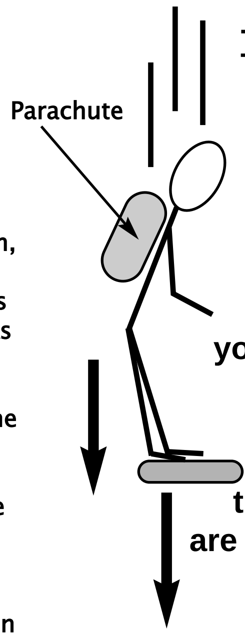
This is how satellites are put in orbit, but using rockets, not cannons. They are not fired straight up, but up at an angle to eventually get them flying parallel to the ground at orbital speed.

Then, turn off the engines and let them fall... gravity holds them in orbit.

Weightless in Free Fall

Your weight is the force pulling you downwards due to gravity. To measure your weight you allow your weight-force to push against the springs in (say) a set of bathroom scales.

What if you stood on these scales in an aircraft, then jumped out feet-first with the scales glued to the soles of your feet? Falling feet-first with the scales still in position, you read your weight.



The scales read zero! Why?

Simple! You and the scales are both falling at the same rate due to gravity.

Since you and the scales are falling at the same rate, you are not pressing on them at all, so they read zero.

The same thing happens to the astronauts in orbit. They are in a free-fall orbit and while falling they are weightless.

They still have their mass, and gravity is still pulling on them, but there is no weight force.

You can get small changes in your weight by standing on scales in a lift. As the lift first begins to move down, your weight becomes slightly less. As the lift first moves upwards your weight becomes a little more.

If you can't arrange to have scales with you in a lift, just feel the weight changes... they really happen.

Worksheet 4
Gravity

Fill in the blank spaces.

Student Name...

Gravity is a “a)............................ force” which acts on objects without b).............................. them. Gravitational force c)........................ (attracts/repels) every object in the Universe.

Gravity is what makes everything near the Earth d)................................. Gravity holds the Earth in orbit around the e)................ and holds all the stars together in a f)..................................

Gravity pulls on everything which has g)...................... This is the amount matter in an object, measured in units of h)................

Your weight is the i).......................... due to j)......................... pulling on your mass. The k)...................... of any object stays the same, but its l)........................... changes depending on where it is.

For example, an object on Earth has a certain mass and weight. If the same object was taken to the Moon, its mass would be m)................................, but its weight would be n)................................

All objects fall o)....................................... under gravity, so long as p)....................... has no effect.

A satellite in q)..................... around the Earth is actually r)........................ under gravity. However, because of its “sideways” speed it curves downwards at the same rate as the s)................................ of the Earth, so it never reaches the surface. So long as there is no friction with the t).................. (there is none in space) it continues to u)..................... around the Earth without falling down.

Anything orbit or in free-fall has no v).......................... The object still has its w)......................., but is weightless.

Worksheet 5
Skills Exercise on Gravity

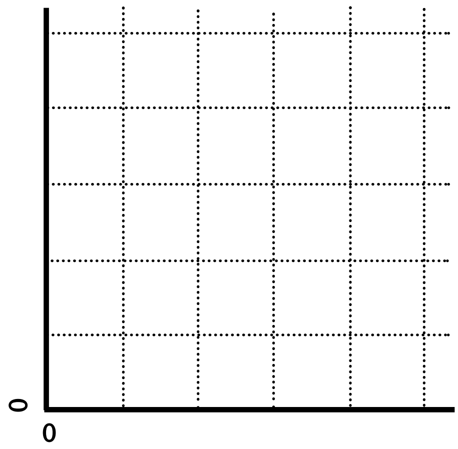
Student Name...

Did you do the experiment and complete Worksheet 3?

An astronaut who landed on a planet of our Solar System did exactly the same experiment. Here are her results:

Mass (g)	Mass (kg)	Weight (N)
	0.1	0.4
	0.2	0.8
	0.25	1.0
	0.4	1.6
	0.5	2.0

1. Fill in the first column of the table above.
2. Graph the Mass(kg) against Weight(N).
(also label the axes, work out number scales, and write a Title)



3. Your points should lie in a straight line. Find the gradient (slope) of this line.
(gradient = vertical rise / horiz. run)
4. What is the value of “g” on this planet?
5. Which planet of our Solar System is the astronaut most likely visiting?

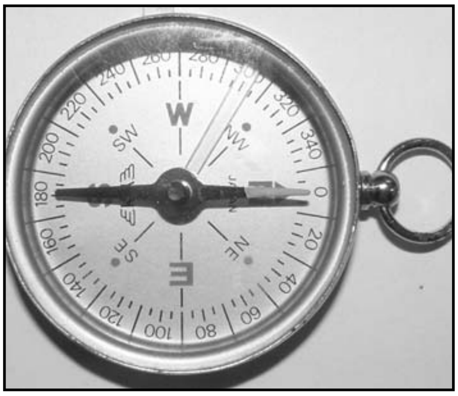
keep it simple science

Magnetic Forces

Magnets are surrounded by an invisible force field which acts on some substances. If certain types of materials come within the field they will be attracted, and pulled by a force.

Magnets can also repel, or push another magnet away.

Magnetism can be created from electricity, and we know that all magnetism is actually due to electricity.



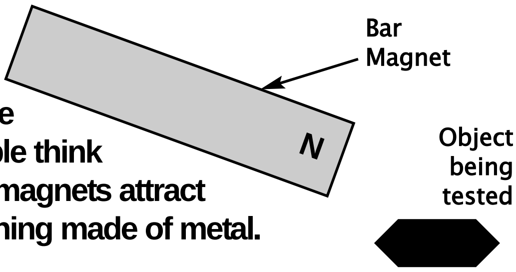
The Earth also has some magnetism. The Earth's magnetic field is why a compass can tell us directions.

The magnetic field of the Earth is also important in protecting us from dangerous radiations from the Sun, and produces the beautiful and eerie "aurora" which can be seen in the sky from places near the North Pole or near the South Pole.

There are many ways to investigate magnetism. You may do some as class experiments and/or your teacher may demonstrate.

What Can Magnets Attract?

You might carry out a simple investigation with a bar magnet to find out what substances are attracted to magnets.



Some people think that magnets attract anything made of metal.

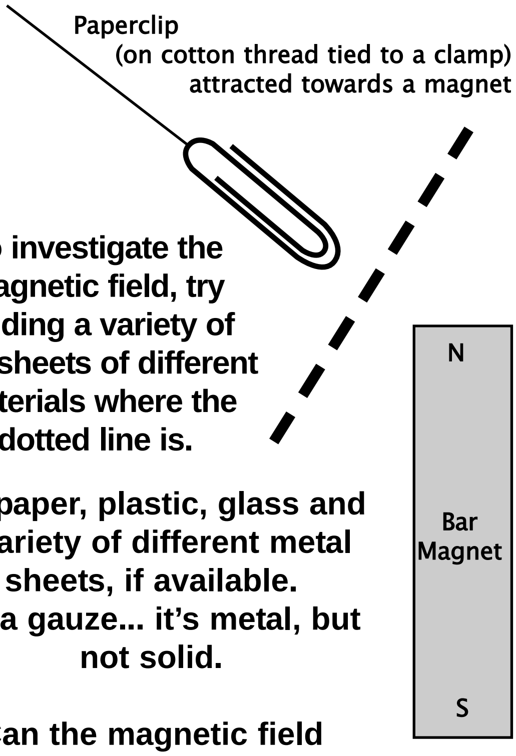
If you test some different metals, you will quickly find out that magnets only attract "ferrous metals". ("Ferrous" = iron)

These are metals containing iron, and include many "steels" (e.g. stainless steel).
"Steel" is a metal made of iron mixed with some carbon and may include a variety of other metals mixed in.

It's the iron that a magnet attracts.

Investigating the Magnetic Field

Here's another simple investigation you might do.



To investigate the magnetic field, try holding a variety of thin sheets of different materials where the dotted line is.

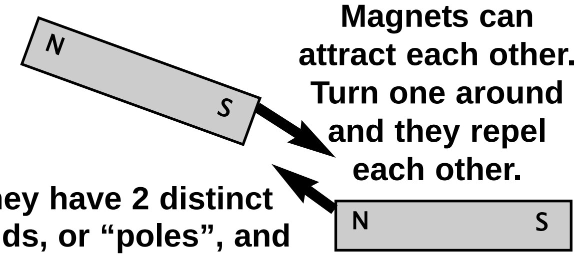
Try paper, plastic, glass and a variety of different metal sheets, if available.
Try a gauze... it's metal, but not solid.

Can the magnetic field attract the paperclip through solid substances?

Which substances can block the magnetic field?

How Magnets Affect Each Other

If you place a bar magnet on the bench and slowly bring another bar magnet towards it you'll quickly find out several things:

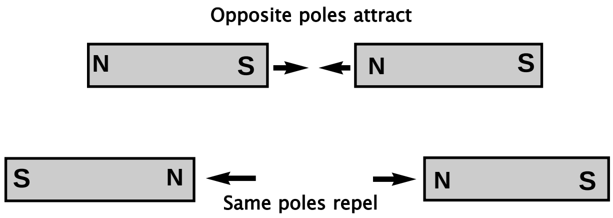


Magnets can attract each other. Turn one around and they repel each other.

They have 2 distinct ends, or "poles", and the magnetic force is concentrated at the poles.

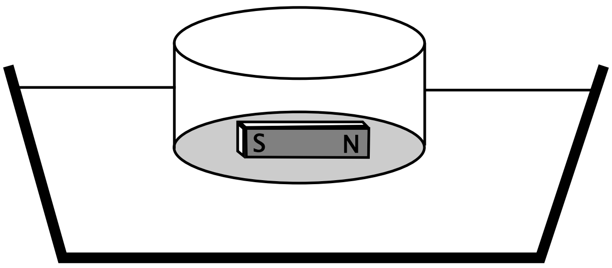
This is often summarised as follows:

**Opposite poles attract.
Like poles repel.**



Finding Directions with a Compass

Place a bar magnet in a small plastic container and float it in a tub of water. You'll see that the magnet and floating container will swing arround to always point in a particular direction.



The end of the magnet marked "N" always points in the direction of north.

The "N" end of the magnet is called the "north-seeking pole" of the magnet, because it seeks out and points to the Earth's magnetic north pole.

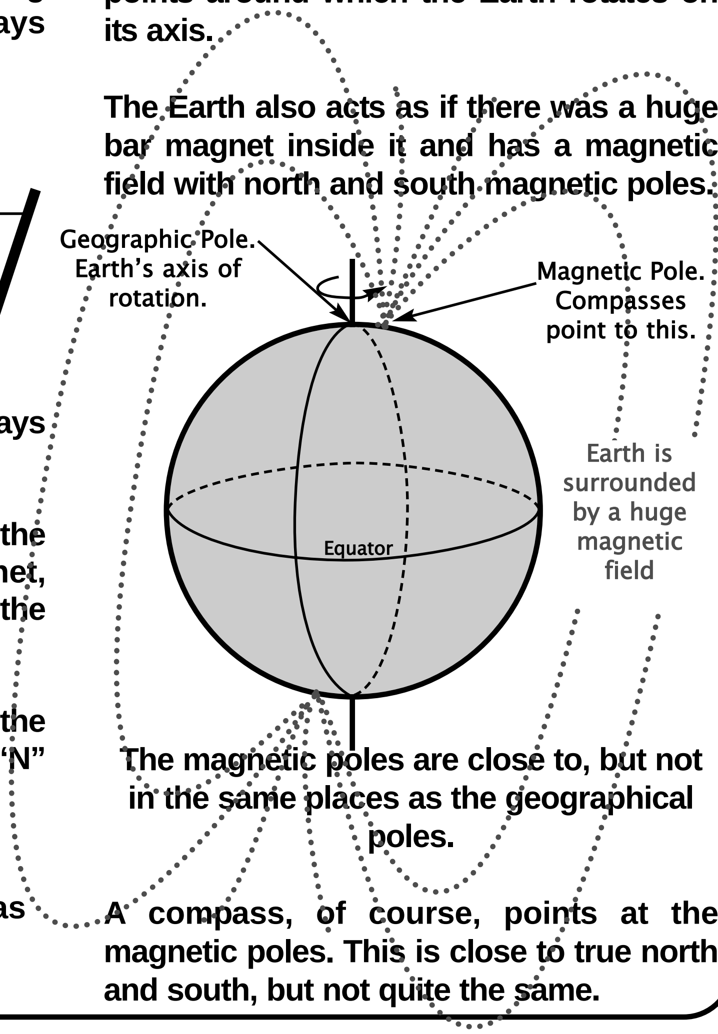
Since the "N" end is attracted towards the Earth's north pole, it follows that the "N" end is actually a magnetic south pole.

**Confusing?
That's why it should be referred to as the "north-seeking pole".**

Earth's Magnetic Field

The Earth's geographical poles are the points around which the Earth rotates on its axis.

The Earth also acts as if there was a huge bar magnet inside it and has a magnetic field with north and south magnetic poles.



The magnetic poles are close to, but not in the same places as the geographical poles.

A compass, of course, points at the magnetic poles. This is close to true north and south, but not quite the same.

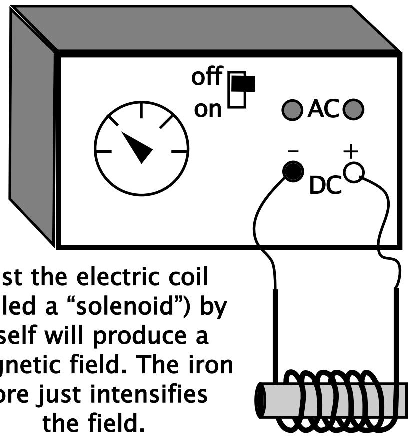
Electromagnets

Magnetism can be made from electricity.

Wrap insulated wire around a bar of soft iron. (a large bolt will do) Connect to a power pack and turn on an electric current.

The iron bar becomes instantly magnetic, which you can prove by using it to attract paper clips or similar.

Turn it off, and most of the magnetism instantly stops. (Some may linger for a while.)



Just the electric coil (called a "solenoid") by itself will produce a magnetic field. The iron core just intensifies the field.

Uses of Electromagnets

The electromagnet is one the most useful devices ever invented. Electromagnets are the basis of the electric generators which we use to make all our electricity in power stations.

Electromagnets are also the main part of all electric motors which we use in power tools , machinery, and many household appliances.

Electromagnets are also the main part of speakers in radios, TVs, public address systems, etc. The electromagnets in a speaker are able to convert electrical signals into sound by causing the speaker to vibrate and create sound waves in the air.

Technology Makes Life Easier

Electromagnets are the basis of some of the of most important technologies our society depends on... electrical motors and generators.

These technologies make our life and work easier and more convenient.

In the Home	Factories & Workshops
washing machine	power tools
vacuum cleaner	machinery
refrigerator	conveyors
fans & hair driers	pumps & compressors

Each of these devices works because of an electric motor, which runs on electricity produced by a generator (at a power station).

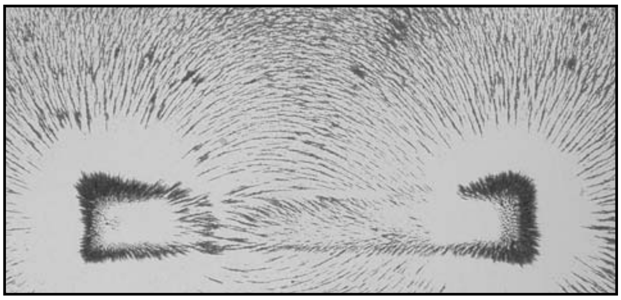
Think about how each device makes life or work easier and more convenient.

The Magnetic Field

We can easily see the effects of a magnetic field, but we can never actually see the field... or can we?

Firstly, place a bar magnet inside a plastic bag or wrap it in cling film.

Then place a sheet of stiff paper over it. Sprinkle the paper with powdered iron granules. Now gently tap the paper and watch the pattern develop.



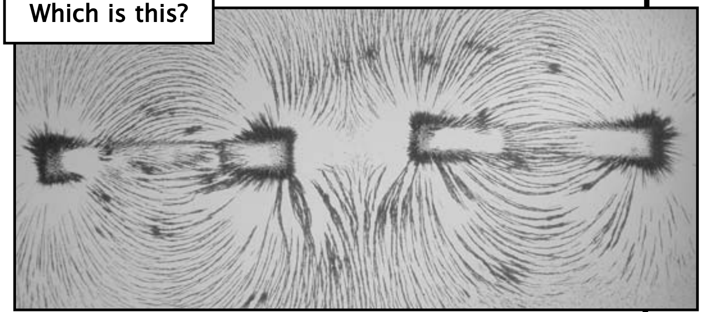
The small particles of iron line up with the shape of the magnetic field and allow you to “see” it.

Instead of using paper, your teacher might demonstrate this using a clear plastic sheet on an overhead projector.

As well as a single magnet, try using 2 magnets which are attracting each other,

or 2 magnets repelling each other.

Which is this?



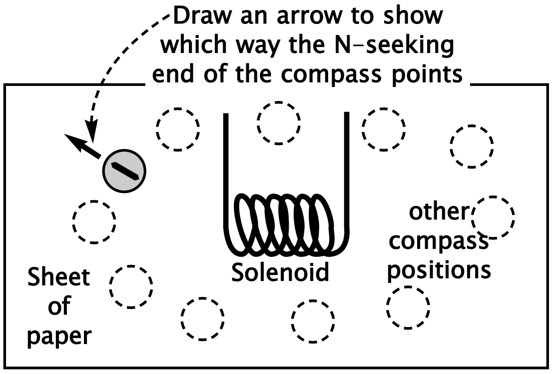
Mapping a Magnetic Field with a Compass

Another way to understand and to “see” a magnetic field is to map it using a compass to find the direction of the “magnetic field lines” at various points.

Place a solenoid coil on a blank piece of paper and connect to a power pack on low voltage. Now place a compass on the paper and see which direction it points.

Draw an arrow on the paper to show which way the north-seeking end of the compass points.

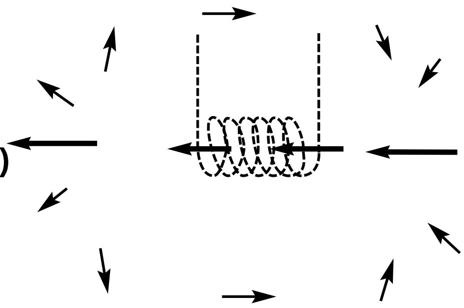
Now move the compass to a variety of other places on the paper and repeat the “mapping”. You might even be able to place the compass inside the coil.



You may end up with a pattern similar to this sketch.

Can you see from this pattern that the magnetic field produced by an electrical coil (and an electromagnet) is more or less the same shape as the field of a bar magnet?

Can you tell which end of the coil was the N-pole?



Worksheet 6
Magnetism

Fill in the blank spaces

Student Name..

Magnetism is a a)........................... force (contact/field) which can both b)................. (pull towards) or c)..................... (push away).

The Earth has a magnetic d)................... That is why a freely-rotating magnetic needle (called a e)”..............................”) always points in the f).............. - .... direction. The Earth’s magnetic field also acts as a shield against dangerous g)............................... from the Sun.

A magnet will attract any metal containing h)............. The magnetic field can penetrate through substances such as i)...................., but is blocked by any j)......................

Every magnet has two ends, or k)”.....................” called north & south

Two magnets affect each other as follows: Opposite poles l)................................ while m).................... poles n)..............................

An electromagnet can be made by wrapping o)........................... around an p).......................... bar and connecting it in an q).......................... circuit. The magnetism can be turned on and off with the r)...................................... This makes electromagnets very useful in electric motors, s).............................. and ....

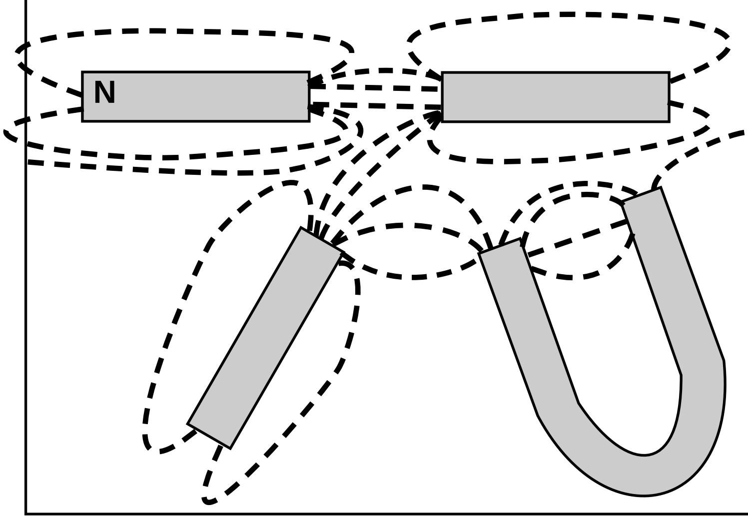
Worksheet 7
Magnetism

Student Name..

Each set of diagrams shows a number of magnets with the “field lines” made visible using iron dust.

Only one pole of one magnet is known. Identify <u>all</u> the magetic poles (write “N” or “S” on the diagrams).

1.



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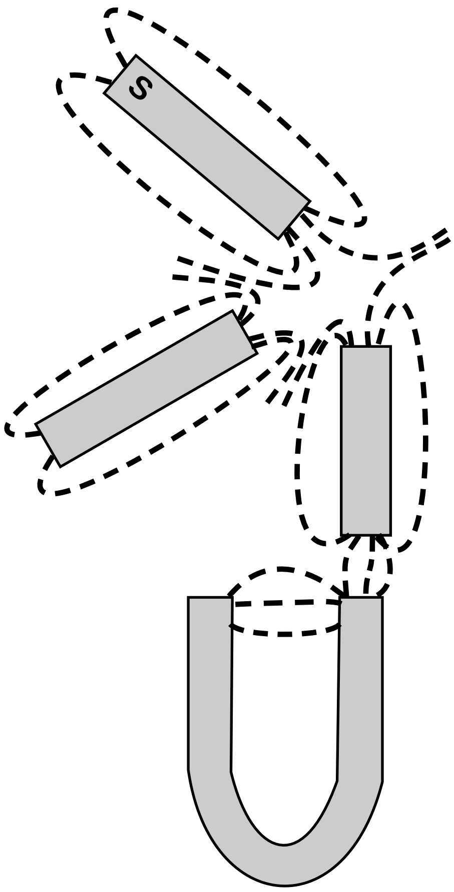


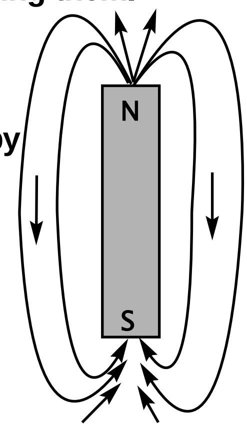
How Scientific "Models" and Theories Help Us to Understand Things

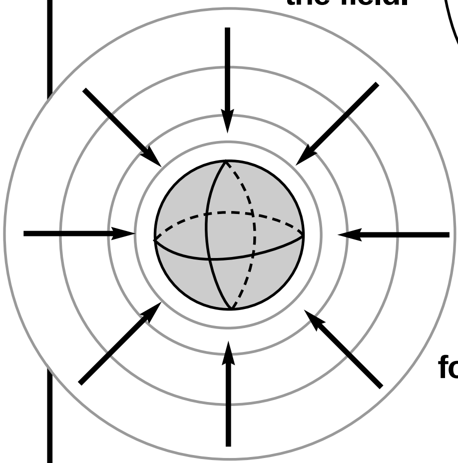
Sometimes it's very difficult to understand strange natural things like gravity, or magnetism.

To help us understand such things we use scientific "<u>models</u>".

For example, the idea of a "<u>Force Field</u>" is a model to explain how some forces can reach out through space and push or pull on things without touching them.

Our explanation of magnetism is that a magnet is surrounded by an invisible field of magnetic forces, and we use diagrams like this to help visualise the field.





We explain gravity by imagining that the Earth is surrounded by an invisible force field which attracts mass.

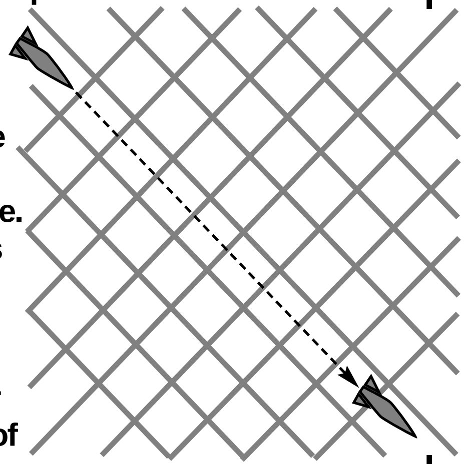
Are these models true and real? Are there really invisible force lines everywhere?

> Even if a model is not the full reality, it is still useful if it helps us understand the facts we observe in the Universe.
>
> The "force-field model" of gravity is ideal to explain the facts of gravity in everyday events here on Earth.
>
> In the wider Universe of massive stars and black holes, Einstein's "warped space model" is necessary to explain what we see.

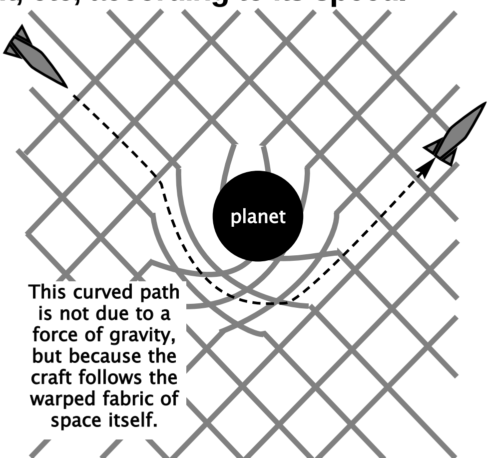
The force-field model is not the only way to explain gravity.

<u>Einstein's "Theory of Relativity"</u> explains gravity in a totally different way. According to this theory, empty space itself has a certain geometry or "shape". We can model this by imagining a grid which represents the "shape" of space itself.

Things coasting through space follow the shape of space. Moving things could include solid objects such as a space craft, or even a beam of light.



Einstein's theory is that mass causes the shape of space to be warped or distorted. Moving things still follow the geometric grid, so near a massive object such as a planet, the space craft follows a curve which may lead it down to the planet's surface, or into orbit, etc, according to its speed.



Einstein's theory is able to explain things that the "force-field model" of gravity cannot, such as the bending of light travelling near stars.

Electrostatic Force

In an electric circuit there is a flow, or current, of electrical charges moving through a conductor.

Materials which are electrical insulators (e.g. plastic) will not allow a current to flow, but they can develop an electrostatic charge. ("static" = not moving)

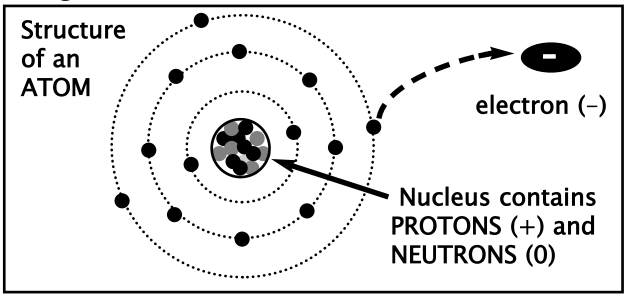
Electrostatic charges can exert a force (push or pull) on each other and cause many strange effects.

Each hair has a static charge and repels every other hair.

Electric Charge

You need to be aware that every substance is made up of tiny units of matter called atoms.

Each atom often acts as if it was a tiny solid ball, but in fact it is composed of smaller particles arranged as in this diagram.



The little electrons are whizzing around the central nucleus, like miniature planets around the Sun.

(Note: this is NOT a gravitational orbit,)

Each electron, and each proton in the nucleus, carries a field-force which we call electric charge.

There are 2 opposite types of electric charge which have been called simply "positive" (+ve) and "negative" (-ve).

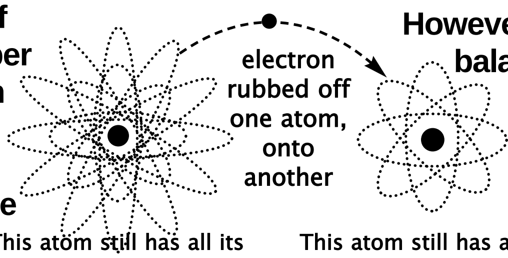
Electrons carry negative electric charge.

Protons carry positive electric charge.

How Things Get an Electrostatic Charge

Normally, the number of electrons and the number of protons in each atom is exactly the same.

The +ve charges and the -ve charges "cancel out" and no electrical effects are apparent.



This atom still has all its (+ve) protons, but has lost a (–ve) electron. Overall, it now has a (+ve) charge.

This atom still has all its (+ve) protons, but has gained a (–ve) electron. Overall, it now has a (–ve) charge.

However, it is very easy to upset this balance by transferring electrons from the atoms of one substance onto the atoms of a different substance.

Gentle friction is enough. Just rubbing 2 different substances together can transfer electrons from one to the other.

If these substances are electrical insulators, the charges cannot flow away, so the substance stays charged, at least for a while.
The charges can push or pull each other (FORCE!) because each has a force-field.

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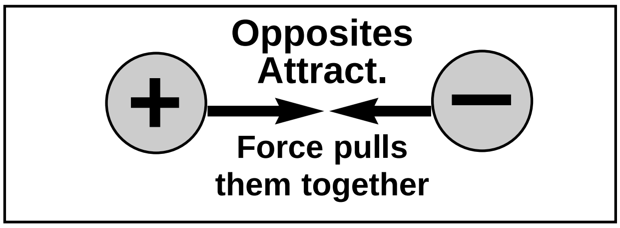
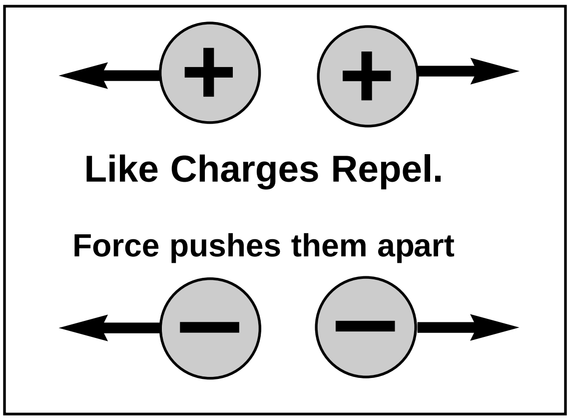
Forces Between Electrostatic Charges

How do electrical charges affect each other?

It turns out to be very similar to the pattern of forces between magnetic poles.



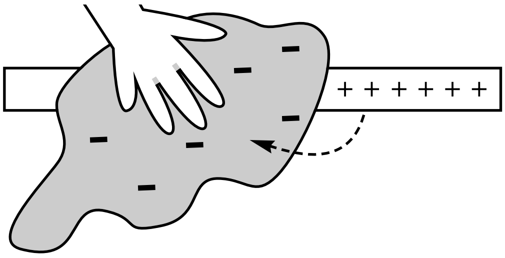


Getting Charged

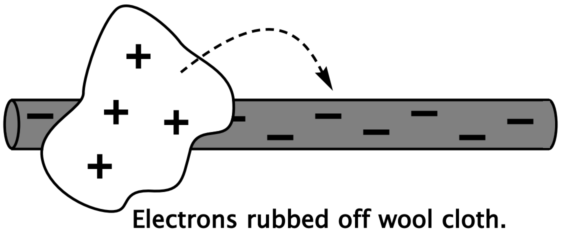
To investigate electrostatic charge you will probably experiment by rubbing different materials together.

One of the best combinations is to rub perspex (a clear plastic) with silk.

Electrons rubbed off perspex rod.
Rod becomes positively charged.



If you rub an ebonite rod (ebonite is a hardened rubber substance) with wool, it becomes negatively charged.



Electrons rubbed off wool cloth.
Rod becomes negatively charged.

Only the (-ve) electrons move. The (+ve) charges (protons) cannot move because they are fixed in the nucleus of the atom.

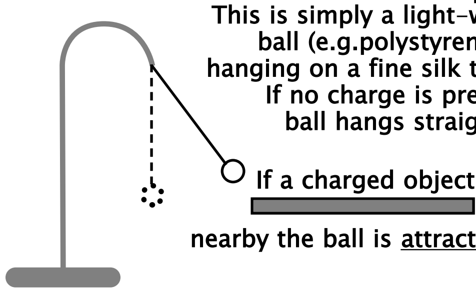
Electroscopes

An electroscope is a device which detects electric charge, and allows you to study it.

There are various types of electroscope you might use, or see demonstrated. The simplest type is shown.

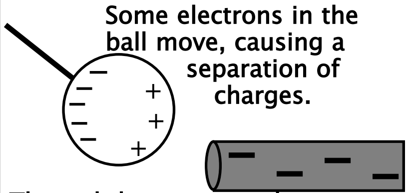
Ball Electroscope

This is simply a light-weight ball (e.g.polystyrene) hanging on a fine silk thread. If no charge is present, the ball hangs straight down.



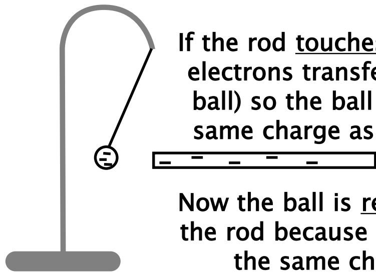
If a charged object is nearby the ball is attracted to it.

Some electrons in the ball move, causing a separation of charges.



The rod then attracts the nearer charges, and the ball is pulled towards the rod.

Why is the ball attracted?



If the rod touches the ball, electrons transfer (rod to ball) so the ball gets the same charge as the rod.

Now the ball is repelled by the rod because they have the same charge.

Static Discharge

Things can get charged up, and they can also lose their charge again.
Often, they lose their charge by a "SPARK" jumping.
A spark occurs when millions of electrons jump through the air.

A spark discharge always involves electrons jumping from a negatively charged object towards a more positively charged object. Remember, only the (-ve) electrons can move.

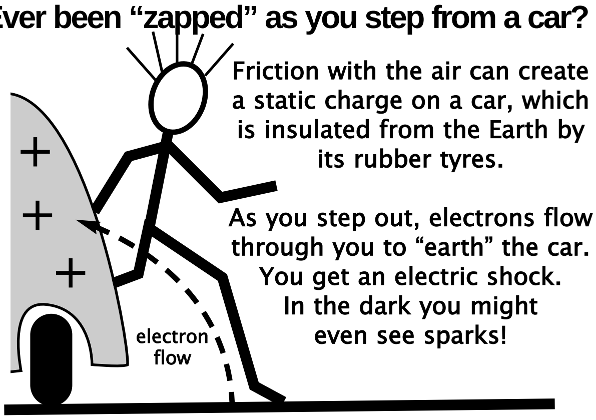
You may have seen a "van der Graaf" generator in action in the laboratory.
It develops strong electrostatic charges which are great for studying the effects of charge, and also great for making discharge sparks!

Earthing a Charge

The Earth itself is such a huge lump of atoms that it can easily supply electrons to, or accept electrons from, a charged object.

So, if electrons can flow between a charged object and the Earth, either by sparking or by flowing through a conductor, they will. The charged object loses its charge. we say it has been "<u>earthed</u>", or "discharged".

Ever been "zapped" as you step from a car?



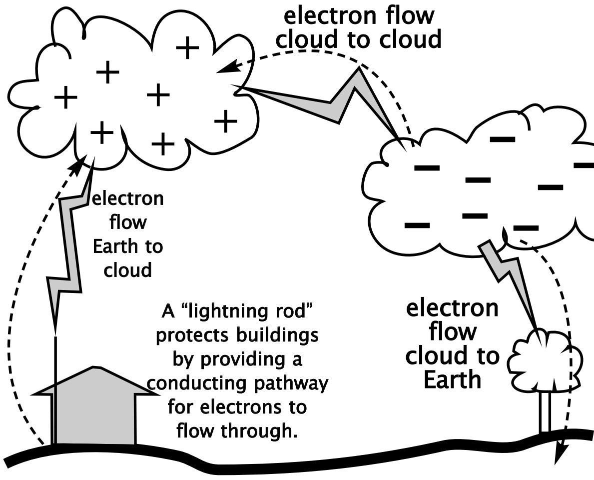
Lightning

The ultimate in an "earth discharge" is lightning.

Violent winds inside a "thunderstorm" system cause static charges to build up in the clouds.

Some clouds become (+ve) and others (-ve).

Eventually, they may discharge by sparking, either from one cloud to another, or by "earthing".



As the electrons force their way through the air, a narrow channel of air is heated to very high temperature and glows briefly.

That is the flash of lightning.

The sudden expansion of air in this "super-heated" channel of air creates a shock wave of sound.

This shock wave is the sound of "thunder".

Worksheet 8
Electrostatic Charge & Force

Fill in the blank spaces.

Student Name..

Electrostatic force is a a)............................ (contact/field) for which acts between things that have an b)........................... charge.

Electric charges are carried by particles within atoms. On the outside of every atom are the c)............................ which carry d)............................ charge. In the e).............................(central part) of each atom are the f)............................. which carry g).......................... charge. (There are also h)............................., which have no charge.)

Normally, the number of electrons and protons are i)............................ and cancel out. However, if two different substances are rubbed together, j).......................... can be rubbed off one type of atom onto the other.

The substance which loses electrons now has a surplus of k)........................ charge. That which gains electrons has an excess of l).............................. charge. If the substance is an electrical m)......................, the charge cannot easily flow away.

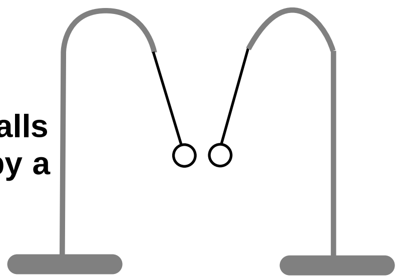
Electric charges exert a force on each other as follows: Opposite charges n)................., while o)...................... charges p)...............

Worksheet 9
Electrostatic Charge & Force

Student Name..

Briefly answer the questions

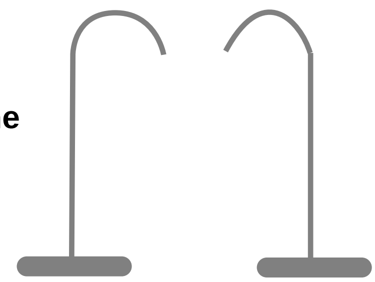
1.
Each of these electroscope balls were touched by a rod which had been rubbed with a cloth.



a) Explain the way they are hanging.

b) Were they both touched by the same rod? Explain.

c) Complete this sketch to show the effect of touching both with the <u>same</u> rod.



2.
This girl was photographed while she was touching a van der Graaf generator.

Photo courtesy of HeyBannerBanner.com

Explain why her hair is standing up.

3.
Fred discovered that if he rubbed his shoes on the nylon carpet, then touched someone who was holding the handrail or a water tap, they got an electric shock. Explain what’s happening.

4.
Why is it NOT wise to shelter under a tree during a thunderstorm?

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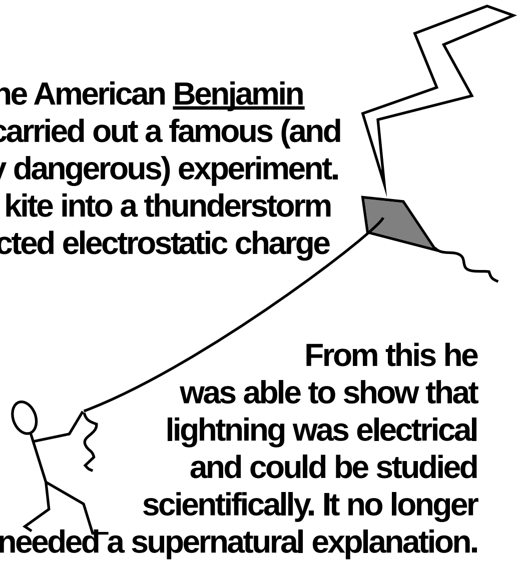
How Scientific Knowledge Has Changed Our Understanding of the World

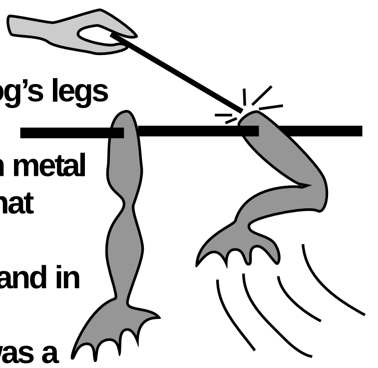
Many ancient people thought that thunder and lightning were caused by angry gods in the sky.

In 1752, the American Benjamin Franklin carried out a famous (and incredibly dangerous) experiment. He flew a kite into a thunderstorm and collected electrostatic charge from the clouds.



From this he was able to show that lightning was electrical and could be studied scientifically. It no longer needed a supernatural explanation.

About 30 years later, 2 Italian scientists studied electricity in a different way. Luigi Galvani discovered that freshly dissected frog's legs would twitch and jump if touched with metal wires. He believed that there was "animal electricity" in them, and in all living things. He thought electricity was a "life force", possibly of supernatural origin.



Alessandro Volta believed the electricity making the frog's legs jump was not some supernatural force, but simple chemistry. He began experiments to prove his ideas.

Over a 20 year period, the experiments and arguments went back-and-forth until eventually Volta was proven correct.

The explanation was that the muscles were still alive and functioning for a while after being cut from the frog. Electricity from a chemical reaction involving the metal wires and the frog's body fluids stimulated the muscles and made them twitch.

Volta went on to invent the first practical electrical battery to make usable amounts of electricity.

This allowed many later scientists to study electricity and gradually gain a full understanding of both static and current electricity. Many inventions followed, leading to light bulbs, electric motors and appliances, etc.

In his honour, we have named the electrical unit, the "volt", after Alessandro Volta.

The work of Ben Franklin and Volta was the start of a series of developments which led directly to our modern electrically-powered world.

However, their work led not only to the new electrical technologies, but helped change the way people understand the natural world.

People gradually began to see that mysterious things like lightning, the Universe, or even life itself, could be understood scientifically without the need for supernatural explanations.

Topic Test - Forces

Answer all questions
in the spaces provided

Student Name...

Score /30

1. (10 marks)
Match each description to an item from the list. To answer, write the letter (A,B,C, etc) of the list item beside the description.

<u>**Description**</u> matches with <u>**List Item**</u>

i) a field force which can attract or repel things. **............**

ii) Unit of force. **............**

iii) Contact force which always opposes the motion of an object. **............**

iv) Unit of mass. **............**

v) Constantly falling down around the Earth, but never reaching the ground. **............**

vi) Coil of wire around an iron bar. **............**

vii) How 2 south poles would affect each other. **............**

viii) Type of electric charge carried by an electron. **............**

ix) Device for detecting electro-static charges. **............**

x) Static discharge from sky to earth. **............**

List Items (not all will be used)

A. repel	**H.** newton
B. electromagnet	**I.** electroscope
C. gravity	**J.** orbit
D. negative	**K.** positive
E. kg	**L.** lightning
F. friction	**M.** neutrons
G. magnetism	

2.
Give a brief explanation of each of the following.

a) On Earth, a moving object (without power) always slows down and stops, but in space things can keep going without power. (2 marks)

b) Rubbing your hands together makes them warmer. (1 mark)

c) A compass needle always points in a north-south direction.(2 marks)

d) Sometimes the more you brush your hair, the more it stands up on end. (2 marks)

3. (4 marks)
True or False? Write "T" or "F" for each

a) Objects in orbit are weightless because there is no gravity up there. ....

b) Frictional force could never make something go faster. ....

c) A magnetic field can be blocked by a sheet of plastic or paper. ....

d) Objects can get a +ve charge by gaining more protons. ....

4. (5 marks)
Fill in the blank spaces in these statements.

a) To measure force in the laboratory you can use a ....

b) Compared to being on Earth, an astronaut on the Moon will have ....mass, but .... weight.
(Choose from "less", "the same" or "more")

c) The common metal that is attracted by all magnets is ....

d) If you rub a balloon on your woollen jumper, the wool loses electrons. This means the balloon gets a .... charge.

5. (4 marks)
Back in the 1970's, an astronaut on the Moon carried out a famous experiment. He dropped a hammer and a feather at the same time.
Both objects fell very slowly, and hit the ground at the same time.

a) Why do you think they both fell very slowly?

b) Why did they hit the ground at the same time?

c) Would they hit the ground at the same time on Earth? Explain your answer.

6. **<u>Skills Question</u>** Your teacher will decide if you are to attempt this question or not. Calculator needed. (8 marks)

This graph shows the <u>weight</u> of different <u>masses</u> on the planet Jupiter.

a) What is the approx weight of a 1 kg mass on Jupiter? ....

b) What is the mass of an 80N weight on Jupiter? ....

c) Calculate the gradient (slope) of the graph. Show working below.

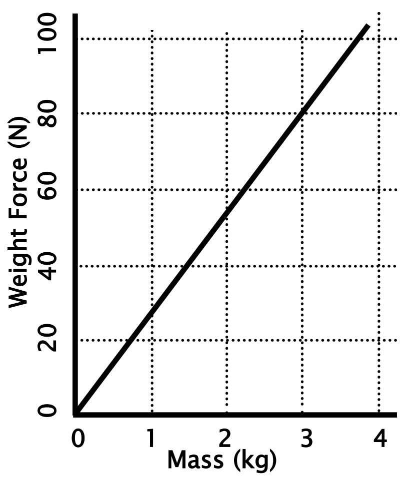
grad. = vert/horiz = .../................= ....

d) What is the value of "g" on Jupiter? ....

e) A 50kg person has a weight force of 500N on Earth.
What is the weight force of the same person on Jupiter? ....

f) What would this same person weigh when in orbit around Jupiter? ....

Mass v Weight on Jupiter



Answer Section

Worksheet 1

a) push b) pull
c) move d) slow down
e) shape f) temperature
g) brakes h) contact
i) field j) gravity
k) electrical (or electrostatic)
l) newtons m) N (capital)
n) spring balance

Match the Lists

1. E 2. F 3. B 4. C 5. A

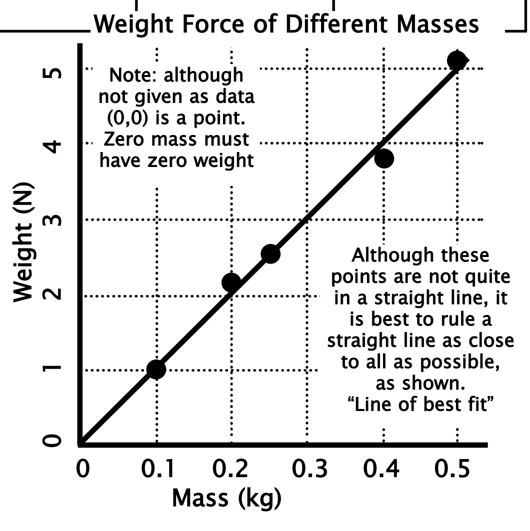
Worksheet 2

a) contact b) opposite
c) slow down d) stop
e) air f) engine
g) same h) speed
i) force j) engine
k) friction l) larger
m) slow down

Worksheet 3

Data Table (Typical results)

Mass (g)	Mass (kg)	Weight (N)
100	0.1	1.0
200	0.2	2.1
250	0.25	2.5
400	0.4	3.9
500	0.5	5.1



Worksheet 3 (cont)

1.
There is some experimental error. Spring balances are often not very accurate or reliable.

2. You can see from the data that the weight force is always about 10 times the mass in kg.

3. examples only: Jupiter g = 27, Mars g = 4

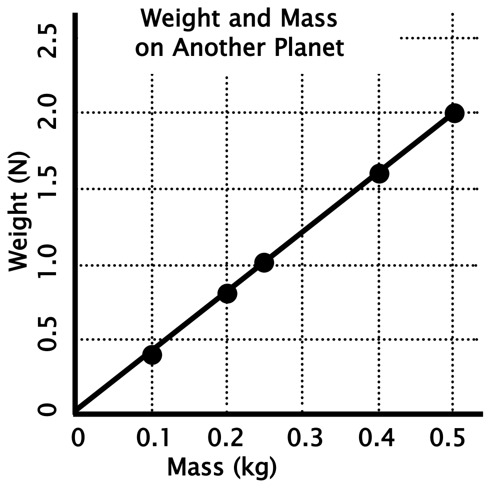
Worksheet 4

a) field b) touching
c) attracts d) fall down
e) Sun f) galaxy
g) mass h) kg
i) force j) gravity
k) mass l) weight
m) the same n) less
o) at the same rate p) air resistance
q) orbit r) falling
s) curvature t) air
u) orbit / fall v) weight
w) mass

Worksheet 5

1. 100, 200,250,400,500

2.



3. grad = vert/horiz = 2.0 / 0.5 = 4

4. g = 4 ("g" is the ratio weight / mass)

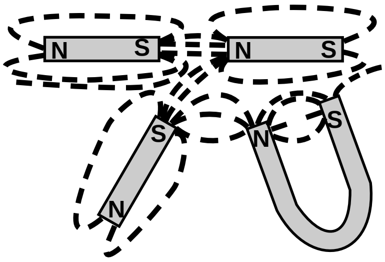
5. If you researched to find the values of g on other planets, you'll know that planet Mars has a g-value close to 4.

Worksheet 6

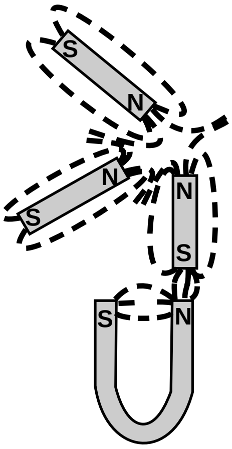
a) field	b) attract
c) repel	d) field
e) compass	f) north-south
g) radiation	h) iron
i) paper / plastic	j) metal
k) poles	l) attract
m) like	n) repel
o) (insulated) wire	p) iron
q) electrical	r) electricity
s) generators and speakers	

Worksheet 7

1.



2.



Worksheet 8

a) field	b) electric
c) electrons	d) negative
e) nucleus	f) protons
g) positive	h) neutrons
i) equal	j) electrons
k) positive	l) negative
m) insulator	n) attract
o) like	p) repel

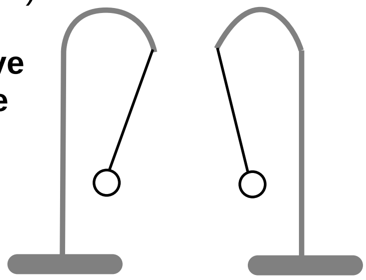
Worksheet 9

1.
They have opposite electric charges and are attracting each other.

2.
No, because they have opposite charges.

Worksheet 9 (cont)

3.
(They would have the same charge and repel each other)



Topic Test

1.

i) G	ii) H	iii) F	iv) E	v) J
vi) B	vii) A	viii) D	ix) I	x) L

2.
a) On Earth there is always some friction.
In space there is no air, and no friction.
b) Friction causes heat and raises the temperature.
c) The compass's magnetic field is attracted/repelled by the Earth's magnetic field, so that the needle points towards the Earth's magnetic poles.
d) The friction of brushing causes each hair to get an electric charge. Since each hair gets the same charge, they all repel each other and stand up to get as far away from each other as they can.

3.a) F b) T c) F d) F

4.
a) spring balance.
b) the same mass, but less weight.
c) iron
d) negative

5.
a) Gravity on the Moon is weaker, so things fall more slowly.
b) All objects fall at the same rate under gravity, so long as there is no air resistance.
c) Unlikely, because air resistance would make the feather flutter and faller slower than the hammer.

6.
a) approx 27 N
b) 3 kg
c) 80 / 3 = 27 (nearest whole number)
d) 27 (g is the ratio of weight / mass)
e) 1350 N (mass x g)
f) zero (weightless in orbit)