Electricity

Teaching Notes and Answer Keys

Subject area: Physics

Topic focus: Atoms, Static Electricity, Electric Force and Coulomb's Law, Conductors, Circuits, Batteries, AC/DC

Learning Aims:
- define and understand electrical forces
- work out interactions through Coulomb's Law
- identify systems of units
- identify conductors and insulators
- know the difference between types of circuits
- work out the practical consequences of different circuits
- know how batteries and AC/DC work.

Skills:
Reading: decoding information; scanning for specific information, interpreting visuals
Speaking: defining and describing;
Reasoning Skills: solve problems, interpret, deduct, give reasons, pose questions, predict, test conclusions

Did you know ... ?, p. 23

TR 5 - CLIL_Electricity_1

1 Have the students read and listen to the brief text on the etymology of words beginning with *electr-*. This *cross curricular* approach could be taken further with students who are studying ancient Greek, to reflect on the fact that scientific terms frequently have a Greek root.

Easy experiments, p. 23

2 Have students try out the little experiments on static electricity. These activities are meant to show students the concrete application of abstract concepts.

TR 6 - CLIL_Electricity_3

3 When they have finished the experiments in activity 2, have the students come up with a hypothesis to explain the phenomena observed and complete the text.
Check glossary on p. 63 for challenging words: *rod*, *to rub*, *wire*.

2 A The balloon will stay there by itself.
B They'll move apart.
The completed text for activity 3 provides the answer to the introductory question.
3 1 positively, 2 negatively, 3 no, 4 electrons, 5 charged, 6 atom, 7 atom

Electric force and Coulomb's Law, p. 24

4 Lead in: before you have the students look at the table, ask them if they know what happens when two charged objects are brought together. For example, what is the interaction between two positively charged objects? (*Repulsion*) and between objects where one has a positive and one has a negative charge? (*Attraction*) What about between a positive and a neutral charge? (*No interaction*)
The text on Coulomb's Law will also make clear the concept of *the closer the distance the bigger the force of attraction* (or repulsion) between charges. Then let them analyse the formula.

5 In this activity students apply the formula they have just analysed.
Solution and result:
By substituting the values of k, $|q_1|=|q_2|=1.60\cdot10^{-19}\ \mathrm{C}$ and $r=5.29\cdot10^{-11}\ \mathrm{m}$ in the formula for the interaction force:

$$F=k\frac{|q_1||q_2|}{r^2}$$

we obtain:

$$F=8.99\cdot10^{9}\ \mathrm{Nm^2/C^2}\frac{(1.60\cdot10^{-19}\ \mathrm{C})^2}{(5.29\cdot10^{-11}\ \mathrm{m})^2}=$$

$$=8.99\cdot10^{9}\ \mathrm{N}\frac{\mathrm{m}^2}{\mathrm{C}^2}(3.02\cdot10^{-9})^2\frac{\mathrm{C}^2}{\mathrm{m}^2}=$$

$$=8.22\cdot10^{-8}\ \mathrm{N}$$

$F = 8.22x10^{-8}$ N

Sistem of Units, p. 24

TR 7 - CLIL_Electricity_6

6 Elicit students' knowledge of electricity in everyday life at home, e.g. What does voltage (240V) measure in practice? (*It measures the potential electrical energy available*), What is the real meaning of 'maximum intensity of current' for home appliances? (*It is the amount of electrical energy that the machine absorbs*). What happens when we use more voltage than is allowed? (*The machine can burn up because too much energy is absorbed*).

6 Electromotive Force: *volt*, Intensity of Current: *ampere*, Resistance: *ohm*, Charge: *coulomb*

Conductors, p. 25

TR 8 - CLIL_Electricity_7

7 Elicit students' knowledge of materials and electricity from every day life, e.g. Are plastic, porcelain, rubber, cork or wooden objects insulators or conductors of electricity? (*Insulators*), Are aluminium, copper or iron insulators or conductors? (*Conductors*)

7 (1) metals, (2) conductors, (3) electricity, (4) insulators, (5) insulate

Circuits, p. 25

8+9 In these activities students learn about different types of electrical circuits and practice the skill of interpreting visuals.

Extension
To use this activity to best advantage, the best thing would be to make a circuit in the physics laboratory and show the students what happens with the addition of other bulbs, or the insertion of insulators such as a rubber, etc. Another possibility would be to visit
http://www.thetech.org/exhibits/online/topics/12h_flash.html
where there is a quiz about circuits.

Check glossary on p. 63 for challenging words: *to split up*, *dim*.

8 1 bulb, 2 switch, 3 wire, 4 battery
9 1 F, 2 T, 3 F, 4 T, 5 T

Frequently Asked Questions, p. 26

10 In this activity students practice Reasoning Skills and make hypotheses to answer the questions. Write each question on the board and let the students work on different questions in small groups. After 10/15 minutes give them a copy of the worksheet so they can check their answers.

Extension

You can find loads of ideas for more FAQs about electricity in the following link: http://amasci.com/elect/elefaq.html
Make a list and have your students formulate hypotheses. Then have them go to the Web in order to find the answers.

Check your Knowledge, p. 27

A The Electricity Test
1 Friction causes the separation of charges in a formerly neutral molecule. Rubbing a plastic rod with wool or a glass rod with silk produces such charge separation effects.
2 Electrons can be made to move from one atom to another. When those electrons move in a "flow" between the atoms, a current of electricity is created.
3 Conducts electricity: Metal spoon, Copper penny; Doesn't conduct electricity: plastic comb, wooden spoon, rock;
4 See picture of parallel and series circuit on p. 24.
5 Inside a battery there is an electrolyte that has charged particles. If you attach a wire to the top and bottom of the battery a flow of electrons is provoked, which creates an electric current.
6 The direction of the charges is not constant; it reverses at equal intervals of time, i.e. with a specific frequency.
7 Dimmer
8 Since the rubber is an insulator, the circuit is broken and the current doesn't flow.
9 The intensity of the electric current.

B Multiple Choice Test
1 B, 2 B, 3 A, 4 B, 5 C, 6 A, 7 A, 8 B, 9 C, 10 C

Did you know... ?

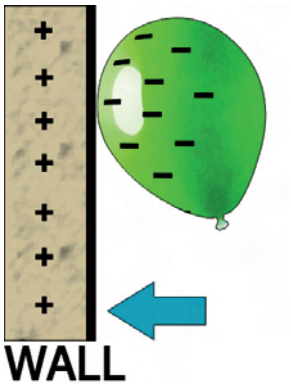
1 TR 5 - CLIL_Electricity_1 **Listen and read.**

Electrons, *electricity*, *electronic* and other words that begin with *electr-* all originate from the Greek word *elektron*, meaning "beaming sun". In Greek, *elektron* is also the word for "amber". *Amber* is a goldish brown stone that is actually fossilized tree sap! Ancient Greeks discovered that amber behaved oddly – like attracting feathers – when rubbed by fur or other objects. They didn't know what it was that caused this phenomenon, but the Greeks had discovered one of the first examples of static electricity.

Easy experiments

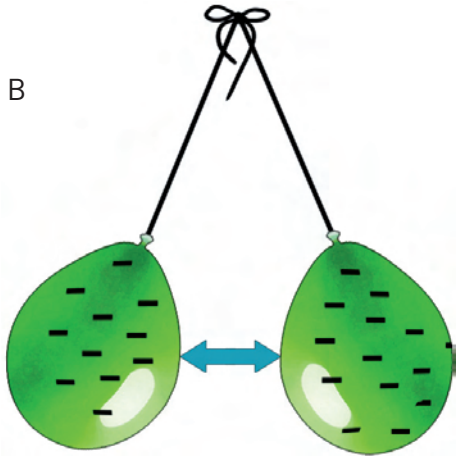
2 **Try them out! What happens? Can you explain why?**

A



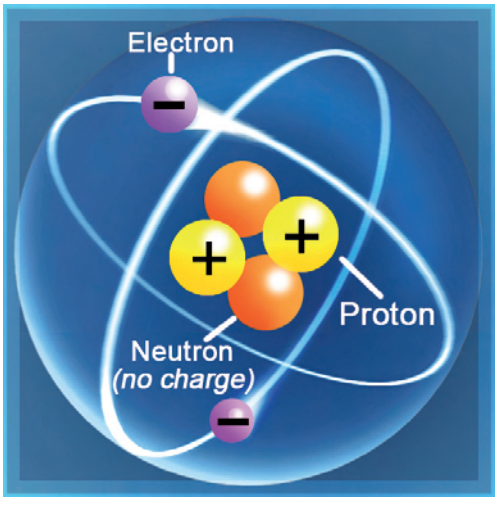
Rub a balloon filled with air on a wool sweater or on your hair. Then hold it up to a wall. What happens?

B



Tie strings to the ends of two balloons. Now rub each of the two balloons, separately, on some wool. Hold them up by the strings and put them next to each other. What happens?

3 TR 6 - CLIL_Electricity_3 **Look at the picture and complete the text. Then listen and check.**



The nucleus of an atom is made up of (1) _____ charged **protons**, (2) _____ charged **electrons** and **neutrons** with (3) _____ charge at all. Friction can result in a separation of charges in a formerly neutral molecule. Rubbing a plastic rod with wool or a glass rod with silk produces such charge separation effects. An atom can gain or lose electrons. If it gains (4) _____ , it becomes negatively charged, if it loses electrons it becomes positively (5) _____ . A "charged" atom is called an "ion." Electrons can be made to move from one atom to another. When those electrons move in a "flow" between the atoms, a current of electricity is created as one electron is attached and another electron is lost. When electrons move among the atoms of matter, a current of electricity is created. This is what happens in a piece of wire. The electrons are passed from (6) _____ to (7) _____ , creating an electrical current from one end to the other.

Electric Force and Coulomb's Law

4 **What do you know about the interaction between two charges? Look at the chart and read the text below.**

Charge 1	Charge 2	Electric force between them
Positive	Positive	**Repulsion**
Positive	Negative	**Attraction**
Positive	Uncharged	**No interaction**
Negative	Positive	**Attraction**
Negative	Negative	**Repulsion**
Negative	Uncharged	**No interaction**

In 1785, the French physicist Charles Coulomb formulated a law regarding interactions between charges. That law is now called *Coulomb's Law*.
Electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The force of mutual interaction between electric charges is directly proportional to the product of the charges and – as with gravitation – inversely proportional to the square of the distance between them.

$$F = k\frac{|q_1||q_2|}{r^2}$$

Where
F = electrostatic force
k = constant ($8.99 \cdot 10^9$ Nm²/C²) - coefficient of proportionality
$q1$ $q2$ = charges
r = distance between the charges

5 **Let's apply the formula!**

In a hydrogen atom, the electron ($q = -1.60 \cdot 10^{-19}$ C) is $5.29 \cdot 10^{-11}$ m away from the proton of equal charge magnitude (but opposite sign). Find the electrical force of attraction.

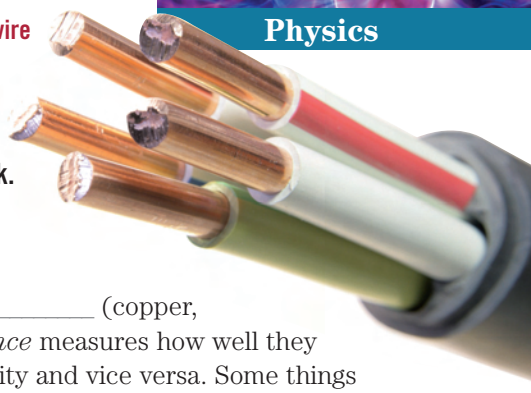
System of Units

6 TR 7 - CLIL_Electricity_6 **Match the unit to the quantity it measures. Then listen and check.**

There exists a basic system of measurement units (called: *volt*, *ampere*, *ohm*, *coulomb*) that are used to quantify electricity in terms of:

- **Electromotive Force**, which is something that moves electricity in a circuit.
- **Electric current**, which is the flow of electric charges.
- **Resistance**, which is the degree to which an object opposes an electric current running through it.
- **Charge**, which is a definite quantity of electricity, identified as positive, negative or neutral.

Quantities	**Electromotive Force**	**Intensity of Current**	**Resistance**	**Charge**
Standard Units				


Electric wire

Conductors

7 TR 8 - CLIL_Electricity_7 **Read and complete the text. Then listen and check.**

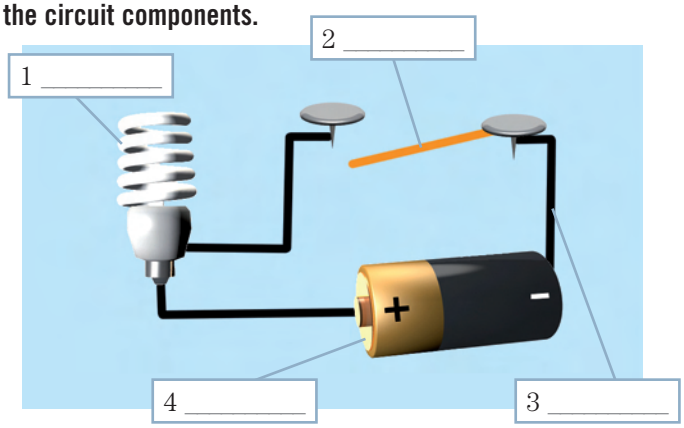
conductors	electricity	insulate	insulators	metals

Electricity flows more easily through particular materials like (1) _____ (copper, aluminium and steel), which are called (2) _____ . The *resistance* measures how well they can conduct (3) _____ . A low resistance means high conductivity and vice versa. Some things hold their electrons very tightly, so electricity does not move through them very well. For example, rubber, plastic, cloth, glass and dry air are called (4) _____ and have a very high resistance. We can safely handle electric wires because, even if they are made of copper, they are covered by a protective plastic sleeve to (5) _____ them.

Circuits

8 **Read the text, and label the picture with the names of the circuit components.**

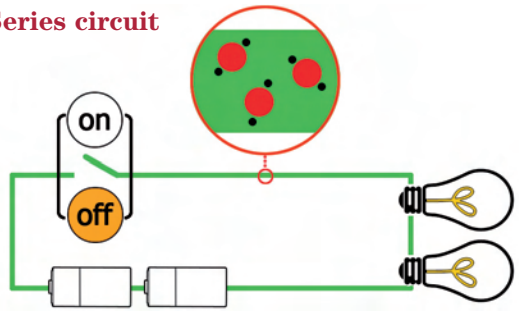
An electric current flows through a pathway called a *circuit*. It consists of a power source (e.g. a **battery**) joined to an unbroken conductor (e.g. a loop of copper **wire**) that connects the two ends of the power source with opposite charges called poles or terminals. An electrical device (e.g. a light **bulb**) can be added to the circuit so that the electromotive force in the circuit is transformed into other forms of energy such as light and heat. A **switch** can be inserted to turn the current flow off and on.



9 **Look at the diagrams and read the text. Then tick T (true) or F (false).**

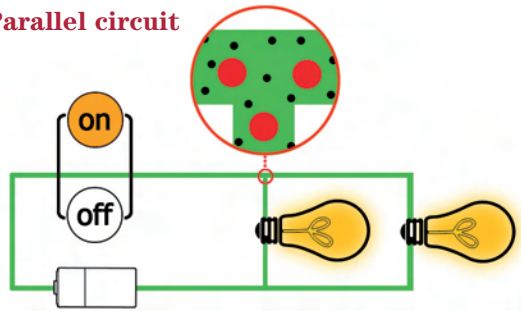
The components of a circuit can be arranged in two ways:

A **Series circuit**



In this circuit all the items are arranged in a row, one after the other, so the electrons follow one single path. You can put together two or more power supplies to increase the amount of power sent to an electrical device. You can also connect two or more electrical devices to share a power supply.

B **Parallel circuit**



Here, there's one power source and two or more electrical devices. Conductor wires connect the battery to each electrical device independently. Some electricity flows to each bulb, distributing the power equally to both. So parallel circuits have more than one path for electricity to follow!

NB: Circuit A is shown as "off" with the switch open: electrons don't jump to the next nucleus down the line, so electricity can't flow. Circuit B is shown as "on" with all parts of the circuit connected: electrons jump from atom to atom, so electrical current can flow and the bulbs light up.

		T	F
1	In a series circuit there is more than one path for the electricity to flow through.	☐	☐
2	In a parallel circuit the current can flow through more than one route.	☐	☐
3	Bulbs connected in parallel are brighter than if they were on their own.	☐	☐
4	In a parallel circuit the current splits up and goes through all possible routes.	☐	☐
5	Bulbs connected in series are dimmer than one bulb on its own.	☐	☐

Frequently Asked Questions

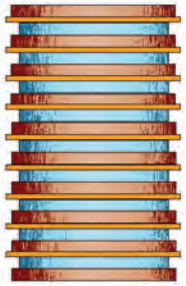
10 **Work in small groups. First read the questions and try to answer them by making a hypothesis. Then check the answers below.**

1 How come a bird sitting on a wire doesn't get an electrical shock?
2 What's inside a battery?
3 AC/DC is not only a hard rock band. What are AC (Alternating Current) and DC (Direct Current)?

Answer 1
Actually, when a bird sits on a wire (that is not insulated), electrical current can, in fact, go through its body. Its resistance, however, is very high if compared to that of the segment of wire between the bird's feet and one of the laws of electricity states that electrical current will prefer to pass through those objects offering the least resistance. So, only an infinitesimal amount of electricity passes through the bird, not enough to give it an electrical shock.

Answer 2
A battery is a store of chemical energy that can be turned into electrical energy. The most common type is a *dry cell* battery containing a paste, called an electrolyte, that has charged particles. Alessandro Volta discovered this device and named it Voltaic Pile. He stacked alternating layers of zinc, cardboard soaked in salt water and silver.
If you attach a wire to the top and bottom of the pile, you create an electric current because of the flow of electrons. Adding another layer will increase the amount of electricity produced by the pile.

The Voltaic Pile looked like this:



Answer 3
With DC electricity, connecting a wire from the negative (–) terminal of a battery to the positive (+) terminal will cause the negatively charged electrons to rush through the wire to the positively charged side. A battery is a typical example of DC. With an AC generator, a slightly different configuration alternates the push and pull of each generator terminal. Thus, the electricity in the wire moves in one direction for a short while and then reverses its direction at equal intervals of time, i.e. with a specific frequency.

Check your knowledge

A The Electricity Test.

1 A plastic rod will pick up small pieces of paper when it has been rubbed with a cloth. Why?
2 What's electric current?
3 Fill in the table:

Name of object	Conducts electricity	Doesn't conduct electricity
Plastic comb		
Wooden spoon		
Metal spoon		
Copper penny		
Rock		

4 Describe the two different ways of arranging a circuit. Draw two diagrams.
5 What happens inside a battery (or a dry cell)?
6 How do electrons move with an AC generator?
7 If you added another bulb in line with the first bulb in a series circuit, how would these light bulbs compare in brightness to one bulb on its own?
8 What happens when you connect a rubber to an electrical circuit?
9 What do amperes measure?

B Multiple Choice Test. Choose the single best answer to the following questions.

1 Two like charges
- ☐ A attract each other.
- ☐ B repel each other.
- ☐ C neutralize each other.

2 Protons and electrons
- ☐ A repel each other.
- ☐ B attract each other.
- ☐ C do not interact.

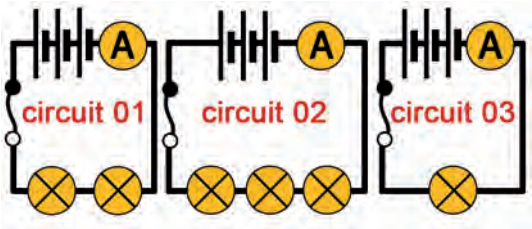
3 The electrical force between charges is strongest when the charges are
- ☐ A close together.
- ☐ B far apart.
- ☐ C the electric force is constant everywhere.

4 If you comb your hair and the comb becomes positively charged, then your hair becomes
- ☐ A positively charged.
- ☐ B negatively charged.
- ☐ C uncharged.

5 A conductor differs from an insulator because a conductor
- ☐ A has more electrons than protons.
- ☐ B has more protons than electrons.
- ☐ C none of these.

6 Which one of the following represents a unit of intensity of current?
- ☐ A ampere
- ☐ B ohm
- ☐ C joule

7 In the three circuits shown, which bulb or bulbs will be the dimmest? Note that the type of bulbs and batteries is identical in all three circuits.



- ☐ A circuit 02
- ☐ B circuit 03
- ☐ C circuit 01

8 How could you turn off a parallel circuit?
- ☐ A You can't turn off a parallel circuit.
- ☐ B Put a switch before the parallel configuration, like near the battery.
- ☐ C Unscrew one light bulb.

9 Which of the following materials is an insulator?
- ☐ A Aluminium
- ☐ B Gold
- ☐ C Rubber

10 Why is electrical wiring usually covered with a plastic sleeve?
- ☐ A To make it look pretty
- ☐ B To help electricity flow along the wire
- ☐ C To make it safe