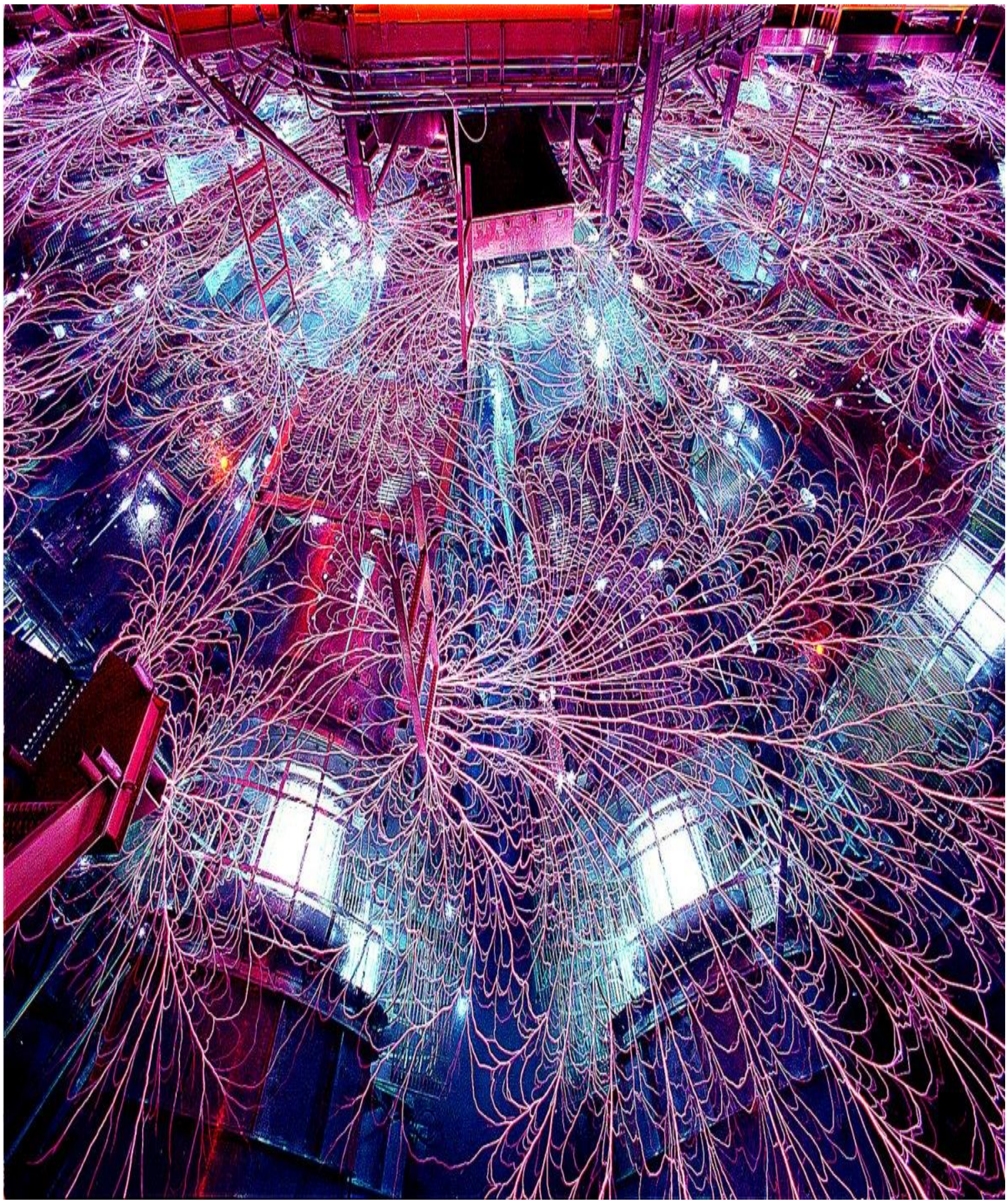
ENERGY (2)



1. ELECTROSTATIC

A.1. Let´s do some experiments about electrification:

a) Electrify a plastic bar with synthetic leather and put it near a cork ball. What happens? Write down carefully the behaviour of the ball before and after touching the electrified bar.

b) A balloon that works as a remote control in the following link.

The phenomena that you have observed are probably familiar to you, but perhaps the repulsion that the cork ball has after touching the electrified bar is not. Why has the ball moved away if it was attracted at first?

Model of electric charge

One thing is to describe the phenomenon but a different one is to understand it. Science describes reality with the single aim of understanding it. We use some ideas to understand something (a theoretical model to be accurate). Let´s sum up the ideas you will need to understand the previous phenomena:

- Matter has got one property called electric charge that is responsible for the electric attraction and repulsion phenomena that we have observed.
- There are two types of electric charges called positive and negative.
- Non electrified ordinary objects are called neutral and they are so called because they have as many positive charges as negative ones.
- An object is charged when it shows more charges of one kind than of the other one. An object that is considered as a whole will have a positive charge if it has more positive charges than negative ones and vice versa.
- Two objects with the same type of charge are repelled from each other, but if the charges are different they are attracted.
- The total charge is constant so that if an object gives some charge to another, the amount of charge lost by the first one is the same as the amount obtained by the second one.
- An object can give or take electric charge from another by rubbing.
- Two objects that come into contact can share their charges. So a fully charged object can electrify a neutral one by means of contact.
- A fully charged object can attract another neutral one by means of a phenomenon known as charge induction. When the charged object gets nearer the neutral one, the charges are organized and produce a charges separation that can electrify for a moment.

A.2. Use the new concepts and draw simple pictures that represent the objects carrying some positive and negative charges (in fact the number of charges in any object is around a quadrillion):

a) Explain the full behavior observed in the first experiment.

b) How is it possible that the charged balloon attracts a can that is electrically neutral in the second experiment?

A.3. Relate the studied phenomena to all you know about the structure of matter and how the atoms and the different particles are organized (review the Rutherford atomic model here) answering these questions:

a) Why exactly does a positive charge neutralize a negative charge?

b) Why do the electrons move but the positive charges don´t in the video?

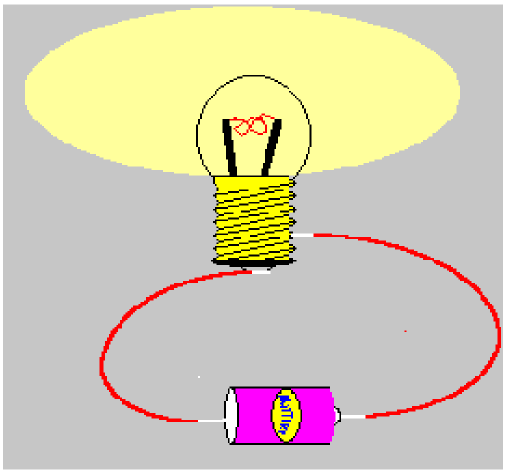
c) Why are the negative charges exchanged when objects make contact?

2. ELECTRIC CURRENT

In all the previous phenomena the electrons have been passing from one object to another without control. Could it be possible that the circulation of the electrons could be better controlled and obtain beneficial effects? We are talking about electric current that has changed our lives completely. Use your imagination and ask yourself this question: what would happen in a big city like Malaga if we did not have electricity , for example, for one month?

A.4. What do you think electric current consists of?

A.5. What do you have to do with a battery and a bulb to produce electric current? How many wires do you need?

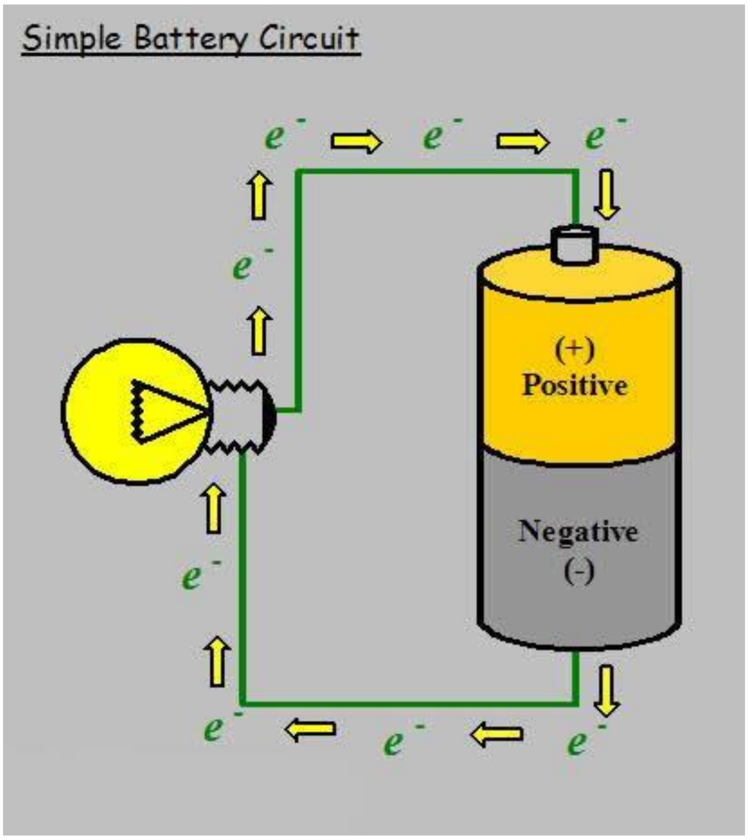


A.6. Look at the picture above:

a) Which side has more electrons in the wire: the right or the left? Explain your answer.

b) Draw lines indicating the way you think the electrons current flows in each branch of the circuit.

Now reconsider the answers in A.6 by looking at the following picture:



A.7. In a simple circuit like the previous one, answer these questions:

a) What do you think is the role of the battery?

b) And of the bulb?

c) And of the wires?

d) Do not take into account the energy lost through the wires and answer these questions: what relationship do you think exists between the energy that the battery produces and the energy that is lost in the bulb? What kind of energetic transformation happens in the circuit?

This video explains electricity as the flow of atomic particles called electrons. Animations demonstrate electron flow. Batteries are described as chemical devices designed to create electron flow and produce energy to ensure their motion.

The general conclusion is that in order to have an electric current it is necessary to have a generator that keeps the electrons moving and a closed circuit where they can circulate. There will not be a current if the circuit is open.

To properly understand every previous concept, **let´s sum up all the ideas that we have been using:**

- The battery makes the electrons move: the same number of electrons that come out of the negative pole go into the positive one. The total number of electrons in the battery and in the circuit is constant so the battery does not add electrons.
- The battery gives energy to the electrons by means of a chemical reaction and then we say that the battery moves the electrons thanks to its internal energy.
- The electrons do not decrease in number in the different elements of the circuit, as for example in a bulb, but they do lose energy.
- The energy lost in a bulb turns into internal energy (heat) and irradiation energy (light).
- The wires are the means of transport for the electrons and they are the ones that move. The metal atoms´ nucleuses with a positive charge do not move.
- All the elements have to have a closed circuit so that there is a current.
- The type of electrical current that we have studied is called continuous current because it circulates in the same direction. The current we have at home is called an alternating current because the electrons change their direction many times per second.
- If a material like copper in the wires lets the electrons circulate, we will say that it is a current conducting material. In the opposite case we will say that it is an insulator.

The following flash animation compares a simple continuous current circuit with a water circuit. The energy gain in water is represented by an elevation in the water level (water gains potential energy) and the waste of this energy in water moves a turbine that would represent the role of a bulb, the element that consumes energy in the circuit. The animation lets you observe the effect of an increase in voltage in a battery that would be similar to throwing water from a high place. The following video compares electric current with a flow of marbles; although the main ideas are the same, they are independent of the analogy we use to understand this phenomenon.

The following link presents a complete list of symbols used in circuits. At first you only have to learn the following ones: wires; wires, connected, crossing; wires, not connected, crossing; switch; battery; ground; resistor; fuse; voltmeter and ammeter. The symbol for a light bulb is:

A.8. Complete a table with all the symbols you need to learn.

In general terms, it will be easier and more useful to draw the representation with symbols than draw a pictorial representation of a circuit:

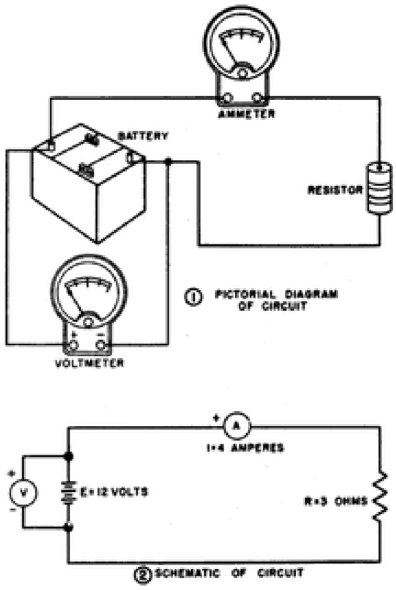


Figure 48. Diagram of a basic circuit.

3. MAGNITUDES THAT CHARACTERIZE THE ELECTRIC CURRENT

3.1. Voltage

We have just learnt that the battery gives energy that is later transformed in different ways in the different elements of a circuit or in an electric installation: bulbs, heaters, HI-FIs, computers,etc. The electric charge unit in the Units International System is the Coulomb (C), which is equivalent to the electric charge that a huge number of electrons transport: $6.\,25 \cdot 10^{25}$ electrons.

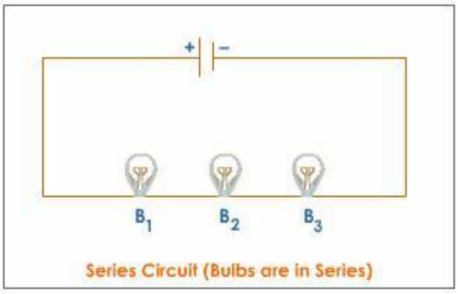
We will say that there is 1 **Volt** between the connections in a battery if this one gives 1 joule of energy to every coulomb of charge that passes by it. We will say that between the connections in a bulb there is 1 volt if in the bulb 1 joule of energy is consumed (in other words, it is transformed into heat and light) for every coulomb of charge that passes through the bulb.

A.9. Look at the battery in the picture:

a) What does the voltage 4.5 V mean?

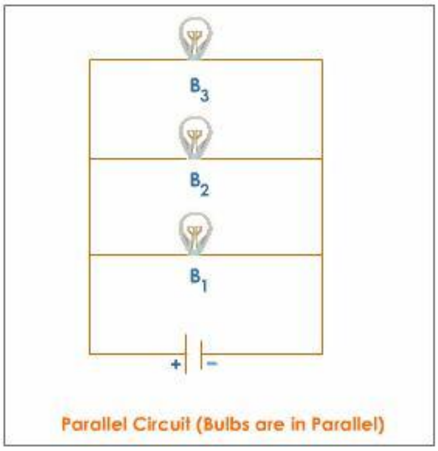
b) How much will the internal energy have decreased in the battery if 12 C of charge passes through it?

c) If the previous battery is connected to a circuit, how much energy will it have transferred if it circulates $1.25 \cdot 10^{26}$ electrons?



A.10. a) Is it possible in the series circuit above that the battery had a voltage of 9 V and that the voltage in the extremes of every one of the identical bulbs was 4 V?

b) If only energy is transferred to the bulbs, and the voltage of the battery is 9 V, and the three bulbs are identical, what will the voltages be in the extremes of the three bulbs?



A.11. a) In the parallel circuit of the picture above, if the battery is 9 V, what will the voltage between the extremes of every bulb be?

b) How is it possible that the battery causes the same voltage in the extremes of the three bulbs?

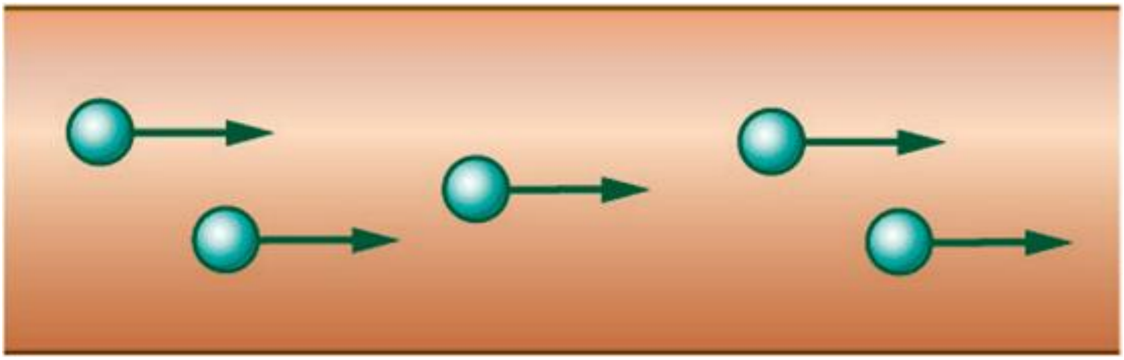
c) Draw a picture of the flow of electrons that you think will occur in the different points of the circuit.

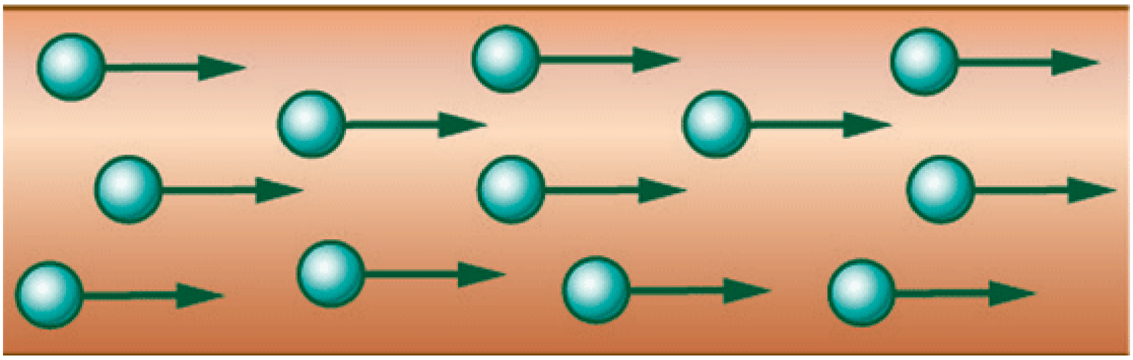
The voltage measures are made with a device called **voltmeter** that has to be connected in parallel, touching both extremes of the element that we want to measure. More information about this device in the following link.

3.2. Current intensity

Current intensity is defined as the amount of charge that passes through a specific point of a conductor in the time unit. Have you ever seen wires crossing a road? They measure the number of cars that pass over them per time unit (for example every hour) and this information is used to know the traffic intensity in different places.

Imagine that the cars are electrons, the road is the conductor that electrons pass through and the considered point is the place where the wires have been situated. What does it mean if we say the traffic intensity is high or low? Try to explain it.



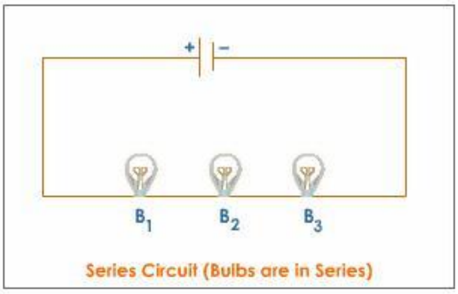


Talking about electrons, current intensity will be calculated dividing the amount of charge (in coulombs) that is passing through a concrete point per time (in seconds). So the current intensity unit in the Unit International System is the **Ampere** (A). 1A means that one coulomb has circulated per second at a specific point.

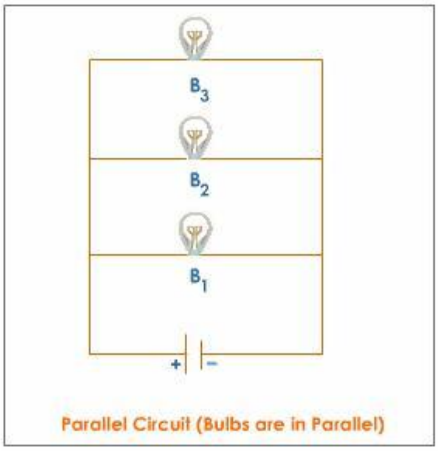
A.12. a) What does it mean if we say that a current intensity of 5 A passes by a point in the circuit?

b) How much charge will pass by that point in 10 seconds?

c) How many electrons will pass by that point in that time?



A.13. In the series circuit of the picture above, what do you think the current intensity that passes by every one of the bulbs will be?



A.14. In the parallel circuit of the picture above, what do you think the current intensity that passes by every bulb will be? Take into account that the bulbs are identical.

The intensity current measures are made by a device called an **ammeter** that has to be connected in series with the rest of the circuit, so that all the current passes through it. There is more information about this measuring device in the following link.

A.15. The parallel circuit of the previous activity draws an electric sketch putting an ammeter in different positions. If in one of the branches where there is a bulb the ammeter marks 0,1 A ,what will it mark at different points ? Remember to consider that the three bulbs are the same.

3.3. Power

Power measures the quantity of energy that is transferred per time unit and it gives us an idea of the speed energy it is transferred at. The power unit in the Unit International System is the **Watt** (W). Any device has a power of 1 W if it is capable of transferring 1 joule of energy every second.

A.16. a) What does it mean if we say an electric radiator has a power of 1000 W?

b) What will be the difference from one of 2000 W? How can we notice it?

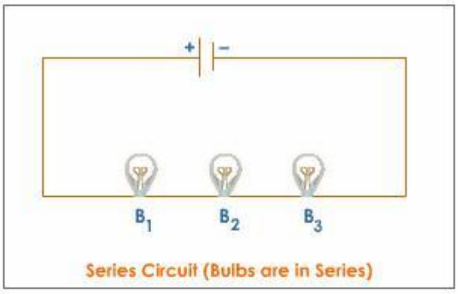
c) What is the difference between a 50 W bulb and a 100 W one? How do you notice the difference?

A.17. Taking into account the units, deduce the mathematical relationship that there must be between voltage, current intensity and electric power. Use it to calculate the electrical power of an ordinary locomotive that works at a 3000 V voltage and a 1900 A current intensity. Repeat the calculation for the AVE locomotive that works at a 25000 V and 350 A. Which one is more powerful? How can we notice this bigger power?

3.4. Electrical resistance

This magnitude gives us an idea of the difficulty that a specific object has when the current passes through it, which is measured in **Ohms** by the Unit System International (Ω). An object with many ohms has a greater resistance when the current passes (insulator). An object with fewer ohms allows the charge to pass without difficulty (conductor).

Different materials can be classified into conductors, insulators and semiconductors. The last category would be a kind of intermediate situation. The most important thing is to understand the reasons why matter is a conductor or an insulator. These reasons are related to the force the atoms´ nucleuses attract their electrons: if it is very weak, the electrons can move easily and so the matter is a good conductor; if the electrons are strongly connected to the nucleuses they will not be able to move, so we will have an insulating matter.

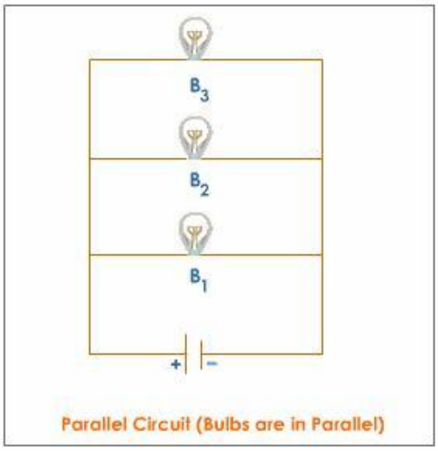


A.18. Let´s now suppose that the electric resistance of the three bulbs in the series of the circuit in the picture increases from B1 to B3 (that is B1< B2< B3):

a) In which bulb will the electrons lose more energy? In which, less?

b) What will happen with that energy?

c) Make a prediction of the brightness that we will expect in each one.



A.19. Let´s now suppose that the electrical resistance of the three bulbs in parallel of the circuit in the picture increases from B1 to B3 (that is B1< B2< B3):

a) Which bulb do you think that the electrons will run more easily by? Which one will be more difficult?

b) Which one will have a bigger current intensity?

c) Make a prediction of the brightness that we will expect in each one.

A.20. Why do you think that the birds do not suffer a shock when resting on power lines?

3.5. Ohm's Law

If your answers to the last activities were right , you have used, without noticing it, at least qualitatively, what is known as the most important equation about electricity, Ohm´s Law

$$I = \frac{V}{R}$$

The following video will show you how to use it.

A.21. Connect an electrical heater to a plug that gives a 220 V voltage and with an ammeter we check that is circulating a 4 A current intensity.

a) Which is the electrical resistance of the heater?

b) If we connect the same heater in the USA with a 125 V voltage, what is the electrical resistance? Which current intensity will circulate now?

c) In which of the two cases will it be more dangerous to suffer an electrical discharge?

A.22. Using the following links, 1, 2 and 3, perform simulations of simple electrical circuits.

4. COMMONLY USED ELECTRONIC DEVICES

A.23. Looking for information on the Internet, investigate the 10 most used electronic devices in the world. Write a brief report explaining each one.

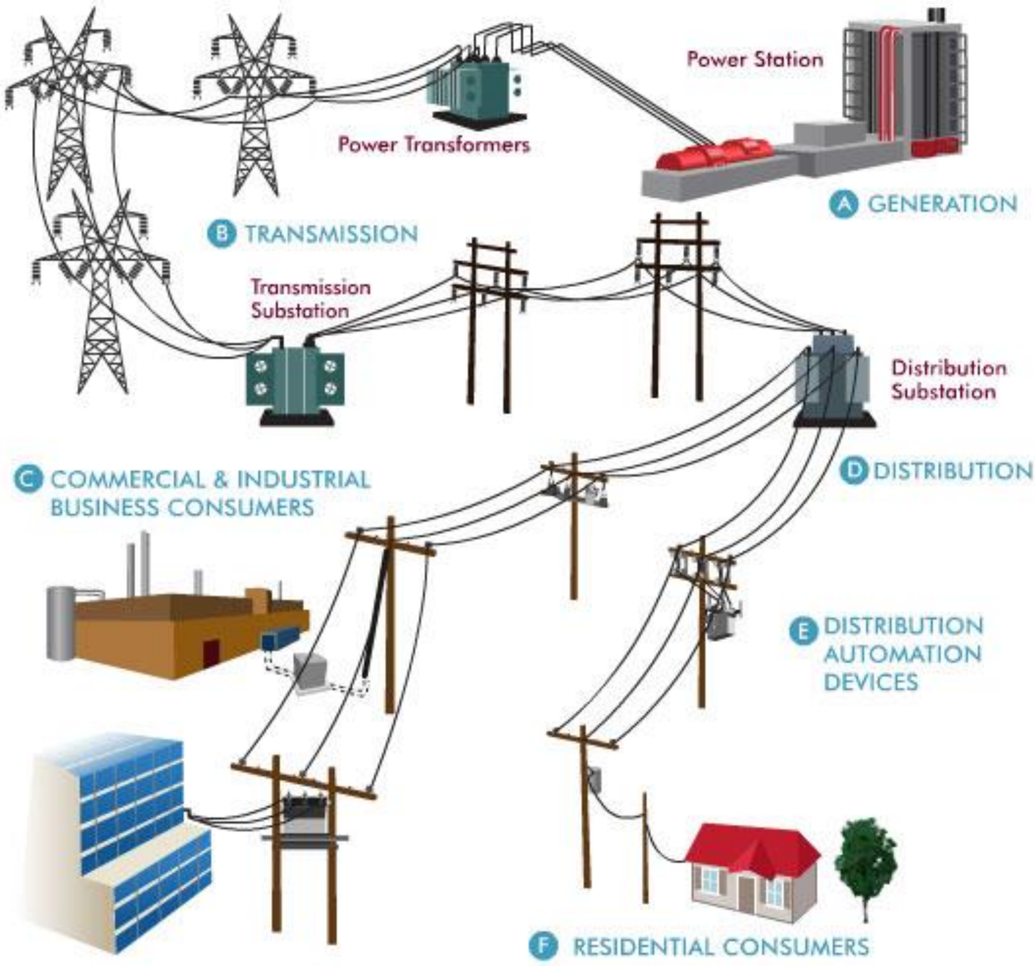
5. ELECTRIC ENERGY GENERATION

Have you ever seen a bike´s dynamo? It is the easiest system of electrical current production that we use in our daily life.

On a greater scale this system is similar but much bigger. It is a turbine that can be moved by water, wind or steam.

(A steam turbine in the picture)

The turbine makes the coil turn in the presence of a magnet (or electromagnet) and then the alternating current occurs (you can see it in the next flash animation). This current arrives at our houses after several transformations and manipulations. You can see a complete sketch of the complete process of the current transformation in the diagram below.



6. SOURCES OF ENERGY

A.24. Using the next links, 1 and 2, answer these questions:

a) Write a list of energy sources currently used in the world, distinguishing renewable from non-renewable sources.

b) Make a pie chart indicating the sources of energy consumed in the world.

c) Think in a small group about the advantages and disadvantages of renewable versus non-renewable sources of energy.

7. RATIONAL USE OF ENERGY

A.25. Make a list with small tips to save energy in our daily live.

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APPENDIX 1: GENERAL VOCABULARY OF THE UNIT

Accurate	/'ækjərət/	Exacto, certero, preciso
Advice	/əd'vaɪs/	Consejo
Aim	/eɪm/	Objetivo
Battery	/'bætəri/	Pila, batería
Bodywork	/'bɒdiwɜ:rk /	Carrocería
Bottom	/'bɒtəm/	Parte de abajo
Branch	/bræntʃ //brɑ:ntʃ/	Rama
Briefly	/'bri:fli/	Brevemente
Bulb	/bʌlb/	Bombilla
By means of	/mi:nz/	Por medio de Mediante
Circuit	/'sɜ:kɪt/	Circuito
Clue	/klu:/	Pista, clave
Coil	/kɔɪl/	Bobina, carrete
Cork	/kɔ:rk /	Corcho
Despite	/dɪ'spaɪt/	A pesar de
Device	/dɪ'vaɪs/	Dispositivo, mecanismo
Electric radiator	/'reɪdieɪtər /	Radiador eléctrico
Fully	/'fʊli/	Completamente
Fuse	/fju:z/	Fusible
Gain	/geɪn/	Ganancia
Generator	/'dʒenəreɪtər /	Generador
Glass mount	/maʊnt/	Soporte de vidrio
Ground	/graʊnd/	Tierra
HI-FI High fidelity	/'haɪfaɪ/	Equipo de música Alta fidelidad
Inflammable	/ɪn'flæməbəl/	Inflamable
Insulation	/'ɪnsə'leɪʃən /	Aislamiento
Leather	/'leðər /	Cuero, piel
Lethal	/'li:θəl/	Letal, mortal, mortífero
Marble	/'mɑ:rbəl /	Canica
Means	/mi:nz/	Medio

Motion	/'məʊʃən/	Movimiento
Neutral	/'nu:trəl //'nju:trəl/	Neutro
Pictorial	/pɪk'tɔ:riəl/	Pictórico, en imágenes
Pie chart	/paɪ tʃɑ:t/	Diagrama de sectores
Quadrillion	/kwŏ-drĭlˈyən/	Cuatrillón
Ray	/reɪ/	Rayo
Resistor	[rɪ'zɪstər]	Resistencia
Rubber	/'rʌbər /	Goma, caucho
Rubbing	/rʌbɪŋ/	Frotamiento
Screw thread contact	/skru:/ /θred/	Contacto del hilo con la rosca
Sketch	/sketʃ/	Dibujo, esbozo, apunte
Steam	/sti:m/	Vapor
Stream	/stri:m/	Chorrito
Switch	/swɪtʃ/	Interruptor
Synthetic	/sɪn'θetɪk/	Sintético
Theoretical	/'θiə'retɪkəl/	Teórico
Throughout	/θru:'aʊt/	Por todo/s
To attract	/ə'trækt/	Atraer
To avoid	/ə'vɔɪd/	Evitar
To carry	/'kæri/	Llevar, transportar
To circle	/'sɜ:rkəl / /'sɜ:kəl/	Circular
To connect	/kə'nekt/	Conectar
To deduce	/dɪ'dju:s/	Deducir, inferir
To disconnect	/'dɪskə'nekt/	Desconectar
To electrify	/ɪ'lektrɪfaɪ/	Electrificar
To ensure	/ɪn'ʃɔ:(r)/	Asegurar
To exchange	/ɪks'tʃeɪndʒ/	Intercambiar
To follow	/'fɒləʊ/	Seguir
To hang	/hæŋ/	Colgar
To notice	/'nəʊtɪs/	Darse cuenta
To relate	/rɪ'leɪt/	Relacionar
To repel	/rɪ'pel/	Repeler
To sum up	/sʌm/	Resumir

To switch on	/swɪtʃ/	Encender, conectar
To switch off	/swɪtʃ/	Apagar, desconectar
To take into account	/ə'kaʊnt/	Teniendo en cuenta
To throw	/θrəʊ/	Arrojar, lanzar
Top	/tɒp/	Parte de arriba
Trolley	/'trɒli/	Carrito de supermercado
Tungsten filament	/tʌŋ.stən/ /'fɪləmənt/	Filamento de tungsteno
Turbine	/'tɜ:rbaɪn /	Turbina
Weak	/wi:k/	Débil
Wire	/'waɪə(r)/	Cable, alambre
Witness	/'wɪtnəs /	Testigo

APPENDIX 2: SPECIFIC VOCABULARY OF THE UNIT

Electricity /ɪlek'trɪsəti/ The physical phenomena arising from the behavior of electrons and protons that is caused by the attraction of particles with opposite charges and the repulsion of particles with the same charge.	**Electricidad**
Electric charge /tʃɑ:rdʒ / A form of charge, designated positive, negative, or zero, found on the elementary particles that make up all known matter.	**Carga eléctrica**
Neutral /'nju:trəl/ Of or relating to a particle, an object, or a system that has neither positive nor negative electric charge.	**Neutro**
Charge induction /ɪn'dʌkʃən/ The displacement of charge in an isolated conductor when placed in an electric field (for example, from a charged body).	**Inducción de carga**
Van de Graaff generator /'dʒenəreɪtər / A Van de Graaff generator is an electrostatic generator which uses a moving belt to accumulate very high electrostatically stable voltages on a hollow metal globe on the top of the stand.	**Generador de Van de Graaff**
Faraday's cage /keɪdʒ/ A Faraday cage's operation depends on the fact that an external static electrical field will cause the electrical charges within the cage's conducting material to redistribute themselves so as to cancel the field's effects in the cage's interior.	**Jaula de Faraday**
Electric Current /'kʌrənt/ A flow of electrons moving along a wire or conductor.	**Corriente eléctrica**

Electric circuit /'sɜ:kɪt/ An electrical device that provides a path for electrical current to flow.	**Circuito eléctrico**
Continuous current /kən'tɪnjuəs//'kʌrənt/ The unidirectional flow of electric charge.	**Corriente continua**
Alternating current /'ɔ:ltərneɪtɪŋ / In alternating current (AC) the movement (or flow) of electric charge periodically reverses direction.	**Corriente alterna**
Voltmeter /vəʊltmi.tər/ An instrument for measuring electric potential in volts.	**Voltímetro**
Ammeter /æm.i.tər / An instrument that measures electric current in amperes.	**Amperímetro**
Connection in series /kə'nekʃən/ /'sɪəri:z/ Components connected in series are connected along a single path, so the same current flows through all of the components.	**Conexión en serie**
Connection in parallel /'pærəlel/ Components connected in parallel are connected so the same voltage is applied to each component.	**Conexión en paralelo**
Voltage /'vəʊltɪdʒ/ A measure of electrical potential, expressed in volts (V).	**Voltaje**
Coulomb /ku.lɒm/ The standard unit of measurement for electric charge.	**Culombio**
Volt /vəʊlt/ The unit of electric potential.	**Voltio**

Joule /dʒul/ The joule (symbol J), named for James Prescott Joule, is the unit of energy in the International System of Units.	**Julio**
Current intensity /'kʌrənt/ Current intensity is defined as the amount of charge that passes through a specific point of a conductor in the time unit.	**Intensidad de la corriente**
Ampere ['æmpeəʳ] The ampere (symbol: A) is the SI unit of electric current.	**Amperio**
Watt /wɑ:t / The watt (symbol: W) is a derived unit of power in the International System of Units (SI). It is equal to 1 joule per second.	**Vatio**
Electric resistance /rɪ'zɪstəns/ A material's opposition to the flow of electric current; measured in ohms.	**Resistencia eléctrica**
Ohm /əʊm/ The standard unit of electrical resistance (symbol: Ω) in the International System of Units (SI).	**Ohmio**
Conductor /kən'dʌktər / A material which contains movable electric charges.	**Conductor**
Insulator /ɪn.sjʊ.leɪ.tər/ A material which electricity cannot go through.	**Aislante**
Semiconductor /sem.i.kəndʌk.tər/ A material, such as silicon, which allows electricity to move through it more easily when its temperature increases.	**Semiconductor**
Ohm’s law Electric current is directly proportional to voltage and inversely proportional to resistance.	**Ley de Ohm**

Electric energy generation /'dʒenə'reɪʃən/ Electricity generation is the process of creating electricity from other forms of energy.	**Generación de energía eléctrica**
Dynamo /'daɪnəməʊ/ A device which changes energy of movement into electrical energy.	**Dinamo**
Turbine /'tɜ:rbaɪn / A turbine is a rotary engine that extracts energy from a fluid or air flow and converts it into electric energy.	**Turbina**
Magnet /'mægnət / A device that attracts iron and produces a magnetic field.	**Imán**
Electromagnet /ɪlek.trəumæg.nət/ A device made from a piece of iron that becomes magnetic when a changing current is passed through the wire that goes round it.	**Electroimán**