Electric Circuits: Resistance (Grade 10) [NCS]*

Free High School Science Texts Project

1 Resistance

1.1 What causes resistance?

We have spoken about resistors that reduce the flow of charge in a conductor. On a microscopic level, electrons moving through the conductor collide with the particles of which the conductor (metal) is made. When they collide, they transfer kinetic energy. The electrons therefore lose kinetic energy and slow down. This leads to resistance. The transferred energy causes the resistor to heat up. You can feel this directly if you touch a cellphone charger when you are charging a cell phone - the charger gets warm because its circuits have some resistors in them!

Definition 1: Resistance
Resistance slows down the flow of charge in a circuit. We use the symbol **R** to show resistance and it is measured in units called **Ohms** with the symbol Ω.

$$1 \text{ Ohm} = 1\frac{\text{Volt}}{\text{Ampere}}. \tag{1}$$

All conductors have some resistance. For example, a piece of wire has less resistance than a light bulb, but both have resistance. A lightbulb is a very thin wire surrounded by a glass housing The high resistance of the filament (small wire) in a lightbulb causes the electrons to transfer a lot of their kinetic energy in the form of heat[1]. The heat energy is enough to cause the filament to glow white-hot which produces light. The wires connecting the lamp to the cell or battery hardly even get warm while conducting the same amount of current. This is because of their much lower resistance due to their larger cross-section (they are thicker).

An important effect of a resistor is that it *converts* electrical energy into other forms of **heat** energy. **Light** energy is a by-product of the heat that is produced.

NOTE: There is a special type of conductor, called a **superconductor** that has no resistance, but the materials that make up all known superconductors only start superconducting at very low temperatures (approximately -170°C).

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[1]Flourescent lightbulbs do not use thin wires; they use the fact that certain gases glow when a current flows through them. They are much more efficient (much less resistance) than lightbulbs.

1.1.1 Why do batteries go flat?

A battery stores chemical potential energy. When it is connected in a circuit, a chemical reaction takes place inside the battery which converts chemical potential energy to electrical energy which powers the electrons to move through the circuit. All the circuit elements (such as the conducting leads, resistors and lightbulbs) have some resistance to the flow of charge and convert the electrical energy to heat and, in the case of the lightbulb, light. Since energy is always conserved, the battery goes flat when all its chemical potential energy has been converted into other forms of energy.

1.2 Resistors in electric circuits

It is important to understand what effect adding resistors to a circuit has on the *total* resistance of a circuit and on the current that can flow in the circuit.

1.2.1 Resistors in series

When we add resistors in series to a circuit, we *increase* the resistance to the flow of current. There is only **one path** that the current can flow down and the current is the same at all places in the series circuit. Take a look at the diagram below: On the left there is a circuit with a single resistor and a battery. No matter where we measure the current, it is the same in a series circuit. On the right, we have added a second resistor in series to the circuit. The *total* resistance of the circuit has *increased* and you can see from the reading on the ammeter that the current in the circuit has decreased.

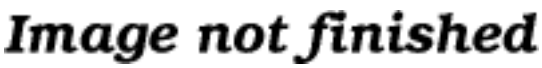

Figure 1

Khan academy video on circuits - 2

This media object is a Flash object. Please view or download it at
<http://www.youtube.com/v/7vHh1sfZ5KE&rel=0>

Figure 2

1.2.2 Resistors in parallel

In contrast to the series case, when we add resistors in parallel, we create **more paths** along which current can flow. By doing this we *decrease* the total resistance of the circuit!

Take a look at the diagram below. On the left we have the same circuit as in the previous diagram with a battery and a resistor. The ammeter shows a current of 1 ampere. On the right we have added a second resistor in parallel to the first resistor. This has increased the number of paths (branches) the charge can take through the circuit - the total resistance has decreased. You can see that the current in the circuit has increased. Also notice that the current in the different branches can be different.

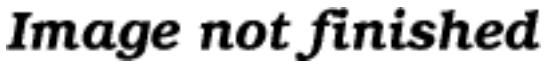

Figure 3

Khan academy video on circuits - 3

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<http://www.youtube.com/v/ZrMw7P6P2Gw&rel=0>

Figure 4

1.2.2.1 Resistance

1. What is the unit of resistance called and what is its symbol? Click here for the solution[2]
2. Explain what happens to the total resistance of a circuit when resistors are added in series? Click here for the solution[3]
3. Explain what happens to the total resistance of a circuit when resistors are added in parallel? Click here for the solution[4]
4. Why do batteries go flat? Click here for the solution[5]

[2] http://www.fhsst.org/lqk
[3] http://www.fhsst.org/lq0
[4] http://www.fhsst.org/lq8
[5] http://www.fhsst.org/lq9