Key Stage 3 – What is resistance?

Notes for teachers

At a glance

The digital age is built on an electrical component called a semiconductor. These are really important in electrical devices, as their electrical properties can be changed. Silicon is the most popular material for a semiconductor, hence the naming of “Silicon Valley” where most of the world’s prominent technology companies operate in, in California.

Researchers studying semiconductors are looking to create new semiconductors that could revolutionize our technology.

Learning Outcomes

1. Describe resistance in an electrical circuit
2. Define an insulator and conductor and predict what a semiconductor is
3. Understand the uses of semiconductors

Each student will need

- Semiconductor activity sheet.
- Graph paper (optional).
- Prior knowledge: Students are expected to already understand what is meant by current, charge and potential difference. And be familiar simple series and parallel circuits.

http://www.oxfordsparks.ox.ac.uk/content/soluble-semiconductors-revolution-printing-21st-century
• The teacher will need a thermistor, bulb, voltage supply and a multi-meter.

**Possible Lesson Activities**

1. **Starter activity:** Describe resistance in an electrical circuit

   • This starter demonstrates resistance in a circuit. Ask all students to line up at one side of the room and tell them they are electrons (charge) in a circuit. Now tell them that a switch has been flicked, the circuit is on and so they must move across the circuit to the other side of the class. (This can be made more challenging by inviting the students to make it into an obstacle course.) When the students have done it at least twice, ask:

     - “What made your journey slow?” [“All these chairs, Miss”]
     - “How did chairs and tables slow you down?” [“I had to crawl under it!”]
     - “Are there chairs and tables in circuits?”
     - “What is there in a wire that might slow down charge, like the tables and chairs did?”
     - “Did other students slow you down?” [“I kept having to wait for Steven”]
     - “Do electrons slow other electrons down?”

   • This obstacle course activity allows the students understand, by analogy, how components can slow down and even stop the movement of electrons (charge) in a circuit. This slowing down is called **resistance**. By building on their interpretation of the analogy, the students are utilizing a **growth mindset**. Prompt with questions such as “Ok, but what if the table was part of a wire? What effect will it have there?”

     - NOTE: The obstacle course activity contains an element of risk. Please ensure you have considered what may make it a dangerous activity and limit any risk.

     - If the obstacle course is not appropriate for your class, the **activity sheet** contains a similar activity where the students **design** an obstacle course. Questioning, as above, can be suitably adapted for the designing version.

   • Once the students have completed the activity and answered your questioning, explain resistance formally as: “A measure of how easy it is for a charge to pass through a component. Resistance is measured in Ohms”

   • To lead into the next activity, explain how resistance is very important to create the electrical devices we use everyday. Especially the really complicated ones.

   • **MISCONCEPTIONS:** Students may say that electrons will slow down current, although it is a good thought, it is not correct. To explain this a further analogy of water flow could be used, where the water flowing is the current and the size of the pipe is the resistance. In this situation, water does not resist water.

[http://www.oxfordsparks.ox.ac.uk/content/soluble-semiconductors-revolution-printing-21st-century](http://www.oxfordsparks.ox.ac.uk/content/soluble-semiconductors-revolution-printing-21st-century)
2. **Main activity:** Compare an insulator and conductor and predict what a semiconductor is

- Metals are used in electrical circuits as they *conduct* electricity because they have low resistance. Therefore charge can easily flow in a *conductor*.

- An *insulator* is a material that has a very high resistance and will not easily allow charge to flow, if at all. Air is a good insulator, but given enough potential difference, the high resistance of air can be overcome (such as lightning).
  - After explaining conductors and insulators, prompt the students to predict what a *semiconductor* is. Explain that it is a mixture of an insulator and a conductor, where it conducts more when temperature increases.
  - CHALLENGE students by asking what would it be like in an obstacle course?

- Show the example of a thermistor and demonstrate the change in resistance by getting a student to hold the thermistor in their hand whilst the resistance is being measured, using a low voltage.
  - Ask your students to describe what happened to the resistance of the thermistor as temperature changed.

- **OPTIONAL:** If time permits, get the students to log the resistance and temperature data and sketch a graph of it using graph paper.

- Now that the students can describe a semiconductor and have seen one, explain that semiconductors are very important in electrical components, as their electrical properties can be changed.

- **Introduce and watch the Oxford Sparks animation.**

**Mini-plenary:** BINGO: Where are semiconductors used?

- Using the *activity sheet*, get students to fill in the bingo square with examples of where semiconductors are used. Once everyone has completed their grid, ask a student to give one of their examples. Any student that has this example can cross it out. Keep going until a student has got a line. (As teacher, you will have to use your judgement of whether a student is correct here. You can follow a rule-of-thumb that any electrical circuit will have a semiconductor in it.)

- **MISCONCEPTIONS:** Some students may have heard of a superconductor and think it is the same as a semiconductor. The key difference is that a superconductor has *zero* resistance.
3. **Plenary** Understand the uses of semiconductors

- This plenary is to get students thinking about new technology and the properties of resistance that they have learnt this lesson.

- Semiconductors are very important in electrical components, as their electrical properties can be changed. Silicon is the most popular material for a semiconductor, hence the naming of “Silicon Valley” where most of the world prominent technology companies operate in, in California.

- The research group at Oxford looks into creating a different kind of semiconductor called a *soluble* semiconductors. As stated in animation, these are cheaper, more efficient and more technologically usable.

- Using the points discussed in the animation and the activity sheet, get the students to judge the new research. Prompt the students and assess their learning by asking:
  - “What is an example of a semiconductor and what are they usually made of?”
  - “Why are semiconductors important?”
  - “When did you last use a semiconductor?”
  - “What new technologies could be achieved with better semiconductors?”
  - “Do you think the researchers will achieve their goal?” (As teacher, you should say your opinions on this.)

- Once the students have made a judgement, point out that the research group leader, Donal Bradley, has been recognized by numerous awards and accolades – Ask the students if this changes their mind.
  - (EU Descartes Prize, the Royal Society Bakerian Medal and the IOP and IET Faraday Medals. Also elected a Fellow of the Royal Society and awarded a CBE for services to science.)

**Web links**

- Oxford Sparks animation on Semiconductors: [http://www.oxfordsparks.ox.ac.uk/content/soluble-semiconductors-revolution-printing-21st-century](http://www.oxfordsparks.ox.ac.uk/content/soluble-semiconductors-revolution-printing-21st-century)

- The semiconductor research group at Oxford: [https://www2.physics.ox.ac.uk/research/physics-and-application-of-soluble-semiconductors](https://www2.physics.ox.ac.uk/research/physics-and-application-of-soluble-semiconductors)

- Donal Bradley’s profile on the Royal Society website: [https://royalsociety.org/people/donal-bradley-11123/](https://royalsociety.org/people/donal-bradley-11123/)