

# IN-CLASSROOM SCIENCE EXPERIMENTS – TEACHER GUIDANCE



12–16 years

## LIVING SWITCHED ON

From special journeys to everyday commutes, the rail network helps get us where we need to be. Even if we're not travelling, we need to be Switched On to the risks the rail environment can pose.

**We can all enjoy life's adventures when we spot signs of danger, look out for our friends and always stay Switched On.**

Young people often make responsible choices around the tracks but there can be times when independent decision-making can be compromised. Living Switched On has been designed to help young people aged 12–16 explore a range of themes such as peer pressure, the perils of group mindset and how at times accidents happen as a result of small bad decisions rather than one big mistake.

Living Switched On encourages young people to gain the knowledge that could keep them safer around the tracks, whilst also exploring the impact ripple that rolls out across communities and the rail industry workplaces when accidents happen.

Although safer behaviour and better decision making are the desired outcomes of this resource, at its heart is a clear examination of young people's vulnerabilities. In the safety of the classroom, we encourage educators to discuss what makes their students 'tick' – particularly when they're out and about as part of a friendship or peer group. Through this process, potential vulnerabilities for flawed decision-making can be identified, explored, and corrected in readiness for real world challenges.

## WHY IS THERE A NEED TO INCORPORATE RAIL SAFETY INTO YOUR TEACHING?

There are 20,000 miles of track, 30,000 bridges, tunnels and viaducts plus thousands of signals, level crossings and stations across our rail network. There are more than 19,000 trespass incidents on the tracks every year.

Learning to hazard spot and address potentially dangerous behaviour is crucial at any age. Schools have recognised the importance of teaching about a range of safety behaviours through PSHE and Citizenship lessons in school. The rail industry wants to support this vital work.

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### GETTING STARTED

- Resources can be accessed via the [Switched On website](#). Living Switched On also incorporates films and activities from You vs Train, an existing Network Rail resource warning about the risks of trespassing on the railway
- Living Switched On hosts a range of resources from films to quizzes and group discussions we recommend that educators familiarise themselves with the content and plan an appropriate approach for their students
- Some resources explore dangerous behaviour and we recommend sharing trigger warnings i.e. let students know the nature of the content and give them the opportunity to opt out if they feel it might trigger difficult emotions

### EXPERIMENT 1

### ELECTRIC FIELDS

### LEARNING OUTCOMES

- To understand that charged objects such as overhead line equipment generate an electric field which is not always visible to the human eye
- To know that humans can get an electric/static shock when coming into proximity with an electric field, reinforcing the importance of maintaining a safe distance from the railway and overhead line equipment

### CURRICULUM LINKS

#### England, Wales, Northern Ireland

##### KS3

- Separation of positive or negative charges when objects are rubbed together: transfer of electrons, forces between charged objects
- The idea of electric fields – forces acting across the space between objects not in contact

##### GCSE

- 4.2.5.2 A charged object creates an electric field around itself. The electric field is strongest close

to the charged object. The further away from the charged object, the weaker the field.

- 4.2.1.2 Electric current is a flow of electrical charge. The size of the electric current is the rate of flow of electrical charge.

#### Scotland

##### BGE

- SCN 2-08a I have collaborated in investigations to compare magnetic, electrostatic and gravitational forces and have explored their practical applications.

##### National 5

- Knowledge that a charged particle experiences a force in an electric field
- Definition of electrical current as the electric charge transferred per unit time

### LESSON OVERVIEW

#### Starter Task (10 mins):

- Ask students if they have ever had a static shock before. This may have been from a shopping trolley, escalator etc. Do they know what causes it?
- Explain that electrical energy can travel through air as an electric arc – this is what lightning is.
- Show the Big Manny video: <https://youtube.com/shorts/HImPV9cvEJs?feature=shared>
- Have a brief discussion with students about the facts from the video:
  - What are the main dangers associated with overhead line equipment as mentioned in the video?
  - How does it make you feel knowing that you can receive an electric shock without touching an overhead wire?
  - Statistics also show that there are 19,000 recorded trespass incidents each year, around 4,000 of these incidents involve children and young people – that's 77 children per week putting themselves in a position of serious danger.
  - Why do you think people might underestimate the danger of overhead line equipment?

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### MAIN EXPERIMENT (30 mins)

- Use a Van de Graff generator to show electric arcing by bringing the grounding ball near the generator when it is running.
- Discuss that the rate of transfer of charge is known as 'current'. You can explain here that this is safe as the current will be extremely small.
- Students can have their hair stand on end by putting hands on the Van de Graff.
- Students can get a single shock from a Van de Graff if they volunteer.
- Ensure all health and safety guidance is followed. See here for more information on operating it safely: <https://spark.iop.org/van-de-graad-generator-safety>
- Finally, bring a fluorescent light tube near to the Van de Graff to reveal how it lights up within the electric field but without coming into contact.
- Repeat this demonstration using other objects such as:
  - Balloons – students can observe how a blown-up balloon will be attracted or repelled, showing an electric current is present
  - Paper clips – place paper clips on the metal globe, these will either stand on end or repel
- If more than one Van de Graff generator is available, students can be placed into groups to experiment with the different objects. Ensure they are supervised, and all health and safety guidelines are followed. Alternatively, complete the experiment as a whole class, inviting a few volunteers to demonstrate.
- Ask the students to consider what would happen if they were in proximity of a much larger electric field such as near the power lines above train tracks. Reinforce the fact that overhead line equipment carries high voltage of electricity (25,000 volts) and that electricity in the overhead

lines can jump 3 metres so there is a high risk of getting an electric shock even without touching the overhead line equipment. Potential consequences of electric shocks include:

- Burns
  - Brain damage
  - Heart damage
  - Fatality
- Mention that there are strict safety measures in place to prevent accidents such as warning signs and barriers to prevent accidents.

### PLENARY (10 mins)

- [Watch and discuss Harrison's Story with students](#), exploring the consequences of going near an electrified railway track.

## EXTENSION IDEAS

### Starter Task (10 mins):

- [Explore the 'Switched On reaction game'](#) teaching students about the types of electric current (AC/DC) present in railway tracks.
- Show the class the warning sign for overhead line equipment. Ask the class to use what they have learned to create their own warning sign.

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### EXPERIMENT 2

## CONDUCTORS AND INSULATORS

### LEARNING OUTCOMES

- To know that certain materials including the human body conduct electricity.
- To be able to use this information to understand the potential dangers associated with the third rail and overhead line equipment and make correct safety decisions.

### CURRICULUM LINKS

#### England, Wales, Northern Ireland

##### KS3

- Understand the differences in resistance between conducting and insulating components

##### GCSE

- Understanding the difference in the microstructure of conductors, semiconductors and insulators makes it possible to design components and build electric circuits
- 4.2.1.2 For electrical charge to flow through a closed circuit the circuit must include a source of potential difference
- 4.2.2 There are two ways of joining electrical components, in series and in parallel

#### Scotland

##### BGE

- SCN1-09a I can describe an electrical circuit as a continuous loop of conducting materials. I can combine simple components in a series circuit to make a game or model.
- SCN 2-09a I have used a range of electrical components to help to make a variety of circuits for differing purposes. I can represent my circuit using symbols and describe the transfer of energy around the circuit.

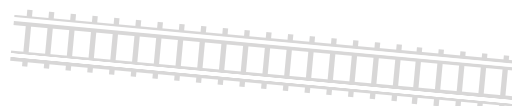
##### National 5

- Application of the rules for current and potential difference (voltage) in series and parallel circuits.

### LESSON OVERVIEW

#### Starter Task:

- Show the Big Manny video: <https://youtube.com/shorts/pRWfvt9aFKE?feature=shared>
- Have a brief discussion with students about facts from the video:
  - What did the video say are potential consequences of coming into contact with the third rail?
  - Knowing the facts of the third rail and its electric current, how could you ensure the safety of yourself and others when on a train platform?
- Ask the students where they have heard the word 'circuit' before. For example, a race circuit. Explain that a circuit is a closed, continuous loop. For an electric circuit to work, it must be closed.
- Circuits also require conductors. Conductors are materials that allow the flow of an electrical charge.
- Materials that do not allow electric charge to flow are called 'insulators'. These can be used as protection against electric currents.
- Introduce different materials and ask students if they think they will conduct electricity or not. For example:
  - Aluminium foil – conductor
  - Paper clips – conductor
  - Glass – insulator
  - Plastic utensils – insulator



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### MAIN EXPERIMENT

- Set up a simple circuit with a power supply, a lamp, and wires and show that it works when turned on.
- Invite students to investigate the electrical conductivity of various materials by connecting them in the circuit and seeing if the lamp lights.
- Prepare a beaker of saturated salt water and use aluminium foil to create two electrodes in the salt water, ensuring they do not touch each other. Connect your circuit to these electrodes and the lamp will light, showing that saltwater conducts electricity.
- Ask students what humans are mainly made of, encouraging them to realise that we contain a lot of salt water and so will conduct electricity.
- Compare students' circuits to being in contact with the third rail using these key facts:
  - It has 750 volts of electricity and a current of 5,000 amps which is enough to give a human an electric shock and cause severe if not fatal injuries.

### PLENARY

- [Watch and discuss Teegan's story with students](#), exploring the consequences of encountering the third rail.

### EXTENSION IDEAS

- Include an ammeter and voltmeter to this task and ask students to measure the current and potential difference with each material.
- Allow students to research and compare the current and potential difference between the amount of electricity used to run a household and to run a train.

### Differentiation

- **For learners with lower cognitive or literacy skills who would benefit from additional support or a slower pace of learning** you may wish to draw on resources from the 'Switched On for every journey' programme, which are designed for students aged 7–11. These revisit key rail safety messages in a more supported and accessible way.

