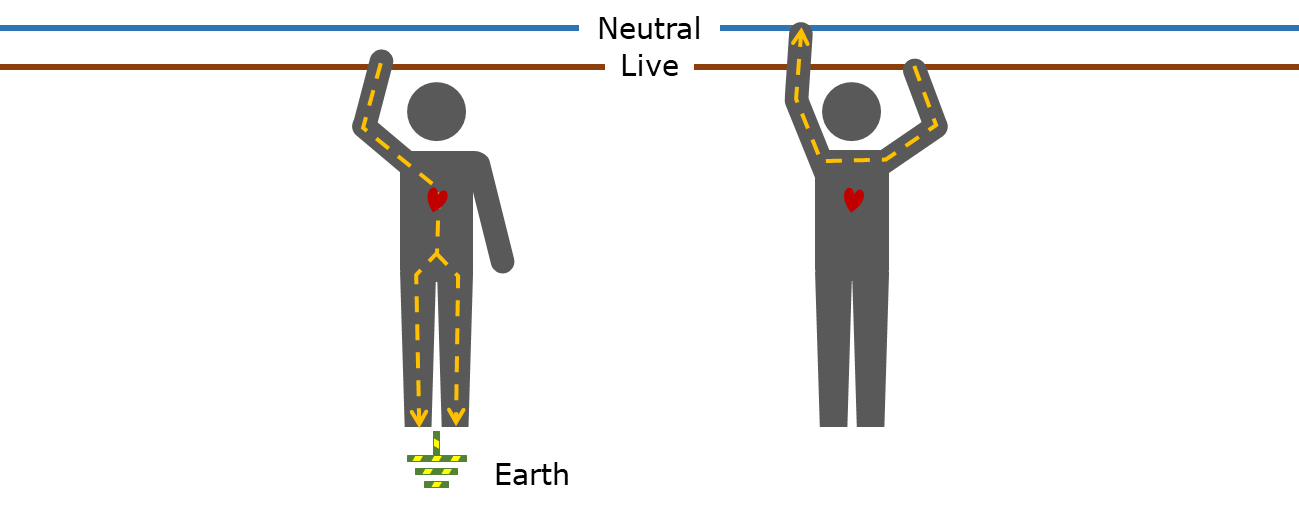
**Shocking calculations**

In the UK mains voltage is 230 V.

An electric shock is more dangerous when current is bigger.

The size of the current often depends on the resistance of skin.



*Current through the heart can cause a heart attack.*

For each situation, calculate the current through the body.

Which currents are dangerous to life?

|  |  |  |  |
| --- | --- | --- | --- |
| **Description** | **Resistance**\* | **Current / A** | **Dangerous to life?** |
| Dry skin | 50 kΩ |  |  |
| Sweaty skin | 2 kΩ |  |  |
| Moist skin | 300 Ω |  |  |
| Skin after soaking in a bath | 100 Ω |  |  |

*\* The resistance depends on skin condition at two different points of contact and on other factors.*

**Extension question:**

*How do you think this idea could be used to make a lie detector machine?*

*Physics > Big idea PEM: Electricity and magnetism > Topic PEM8: Mains electricity > Key concept PEM8.1: Electrical safety*

|  |
| --- |
| **Response activity** |
| **Shocking calculations** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Fuses, circuit breakers and earth connections, used correctly, can prevent excess mains current and electric shocks. |
| Observable learning outcome: | Explain why there are no standard mains sockets in a bathroom. |
| Activity type: | Application and practice - problem |
| Key words: | Mains socket, shaver socket, electric shock |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic question:

* Diagnostic question: Resisting a shock

**What does the research say?**

In order to develop a good understanding of mains electrical safety, students need first to understand that the severity of an electric shock is largely due to the size of current passing through a person’s body and the route it takes. The size of current passing through a person is determined by the potential difference (p.d.) across the person, perhaps between an exposed live wire and the ground, and the resistance\* of their skin (Goodenough, 2007), which can decrease by a factor of several hundred when the skin is wet (Brown, 1986). A high p.d. can cause a dangerously large current to flow through a person, but in a steamy bathroom the same p.d. can cause a current to flow that is several hundred times bigger.

Goodenough (2007) describes in detail the effects of current on the human body. A current of 0.5 mA through a person’s body can be felt and a current of 0.5 – 10 mA would be painful. At some point, between 10 mA and 50 mA, a person’s nervous response would be affected so they are unable to release a grip and if the current is maintained it can cause involuntary muscle contractions, difficulty breathing and disturb heart function. Higher currents than 50 mA can stop the heart, stop breathing and cause burns and other tissue damage. The main cause of death from an electric shock is ventricular fibrillation, which is when the heart stops beating rhythmically and becomes unable to pump blood. Alternating current is more likely to affect the rhythm of the heart than direct current.

*\*Strictly speaking, the resistance to alternating currents is called impedance and includes the resistive effects of capacitance and inductance. This understanding is usually covered in undergraduate courses at university.*

**Ways to use this activity**

This activity gives students the opportunity to practise applying their understanding and to clarify their thinking through discussion. To support this, students should answer the question in pairs or small groups.

Listening to individual groups as they work often highlights any difficulties they might have. These can often be overcome, through a whole class clarification or redirection part way through the activity.

Asking students to share their answer is a useful check. After a group has fed back, it might be helpful to model an even better answer. You could do this, for example, by asking another group to add to, or clarify, the first observation. Then ask another group to sum up the important part of the observation, and so on.

*Differentiation*

If some students are working with a teaching assistant, then a list of prompt questions for the TA could help to make this activity more purposeful.

**Expected answers**

|  |  |  |  |
| --- | --- | --- | --- |
| **Description** | **Resistance**\* | **Current / A** | **Dangerous to life?** |
| Dry skin | 50 kΩ | 0.0046 | No – but a painful shock |
| Sweaty skin | 2 kΩ | 0.12 | Yes |
| Moist skin | 300 Ω | 0.77 | Very dangerous |
| Skin after soaking in a bath | 100 Ω | 2.30 | Very dangerous |

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG) based on figure 1 in Goodenough (2007)

**References**

Brown, C. (1986). Electric shock and the human body - or 'Is it amps or volts that kill you, sir?'. *Physics Education,* 21(6)**,** 350.

Goodenough, H. (2007). Electrical safety. *Catalyst.* Oxfordshire: Philip Allan Updates.