**Short circuit**

This toaster has stopped working.

The fault is a short circuit.



What causes a short circuit?

*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | A loose wire makes a new circuit with very low resistance. |  |
|  |  |  |
| **B** | A loose wire makes a gap in the circuit. |  |
|  |  |  |
| **C** | A very big current damages a component. |  |
|  |  |  |
| **D** | A component wears out and stops working. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Short circuit** |

**Overview**

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| --- | --- |
| Learning focus: | Fuses, circuit breakers and earth connections, used correctly, can prevent excess mains current and electric shocks. |
| Observable learning outcome: | Explain the effects of a short circuit in an appliance or in a mains circuit. |
| Question type: | Simple multiple choice |
| Key words: | Short circuit, electrical component |

**What does the research say?**

In a study of 41 pre-service teachers, Önder, Senyigit and Silay (2017) found that 69% could not explain a short circuit using scientific understanding. 20% described a short circuit as a circuit that did not work, a further 15% that it didn’t work because components had been damaged by excess current, and 12% described a short circuit as an incomplete circuit. Rather, a short circuit is formed by an extra connection between parts of a circuit that provides a very low resistance path for current to flow, leading to increased current in that part of the circuit.

It is a common misunderstanding that if the plug connecting an appliance to the mains contains a fuse, then the appliance cannot give a person an electric shock (Goodenough, 2007). This is not true because a current of 0.15 A through a person can kill them in about 0.1 s and the smallest fuse in a mains plug (in the UK) stops current flowing only when it exceeds 3 A.

A residual current circuit breaker (RCCB) would stop current flowing through the person being shocked in about 0.04 seconds. Without a RCCB fitted, a person touching an exposed live connection from the mains could receive a fatal electric shock, which is why electric lawnmowers and hedge-trimmers should always be used with a RCCB, because accidentally cutting trailing wires is relatively common.

However, a fuse can turn off the current *before* a person touches the live metal casing of a faulty appliance, if the appliance is wired correctly. Common causes of a metal casing becoming live is a movement and pulling on connecting cables that cause the live wire to become loose, or physical damage to the appliance. The casing of a metal appliance should be connected to an earth wire. If the live wire touches the casing there will then be a short circuit, a large current will flow, and the fuse will melt, turning off the current. This happens the first time the appliance is turned on after the fault is caused. Some demonstrations, of how a fuse works, risk giving the false impression that excess current only flows and the fuse makes the appliance safe when it is touched by a person (Harrison, 2017).

**Ways to use this question**

Students should complete the question individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

The answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations, it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

A A loose wire makes a new circuit with very low resistance.

**How to respond - what next?**

A short circuit is a circuit I which the current is able to flow through a ‘short-cut’ that has a much smaller resistance, rather than through electronic component(s). This results in a much bigger than normal current flowing, which can cause heating and a fire hazard and/or damage components in a device.

The three incorrect options each describe common misunderstandings students have, with option B being the most common.

If students have misunderstandings about what a short circuit is, it can help to provide students with an opportunity to observe a short circuit and its effect on a circuit. Once they have observed a short circuit, they could work in pairs or small groups to describe what one is and how it affects a circuit, using their own words to support consolidation of understanding.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: A working fuse

**Acknowledgments**

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Image from Shutterstock

**References**

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

Harrison, M. (2017). Demonstrating Earth connections and fuses working together. *Physics Education,* 52(2)**,** 023008.

Önder, F., Senyigit, Ç. and Silay, I. (2017). The Effects of Misconceptions on Pre-Service Teachers' Ability to Constructing Simple Electric Circuits. *European Journal of Physics Education,* 8(1)**,** 1-10.