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| **7. Adding extra loops  LESSON PLAN**  **—** | | |
| **PROJECT ACTIVITY**  **1.** Please [click here to read part 5a](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=28) from the 5. Practical Work section of the EEF Improving Secondary Science Guidance Report  **2.** Please follow this [Link](https://docs.google.com/forms/d/e/1FAIpQLSeilAuQJ0PpCmi7h-tpGuBoHtW0YaIJ0j08Bv5pYZUzLlKlmw/viewform?pli=1) to answer the questions below.  **a.** (Multiple choice) How confident are you that your pupils would be able to tell you the purpose of any given piece of practical work?  **b.** (Optional) Please share any ideas you have for how to ensure pupils understand the purpose of a piece of practical work. (NB these could apply across many classes and modules). | | |
| **LESSON SUMMARY**  This lesson introduces the idea of a parallel circuit. Firstly, we see physical parallel circuits and their abstract representation, learning the terminology necessary to | | describe them. Then we see that branches can be switched on and off independently of each other, and explore the effect of adding parallel loops on current. |
| **OBJECTIVES** | **1.** Know what a parallel circuit is  **2.** Know what happens if we have multiple loops | |
| **EQUIPMENT LIST** | **•**  DEMONSTRATION:  Building a parallel circuit: a battery, 4 wires, 2 bulbs, visualiser (optional) OR PhET  *(NB check that the brightness of the bulb does not change when adding a bulb in parallel, as per the notes on slide 9)* | |
| **RESOURCES** | **•**  PowerPoint presentation  **•**  Worksheet | |

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| **TIMETABLE & DESCRIPTION OF ACTIVITIES** | | |
| TIME  ACTIVITY  RESOURCES | DESCRIPTION | RESEARCH |
| 00:00 – 00:10  Starter  PowerPoint | **Slide 6:**  Interleaved questions | 4c. Memory: Provide opportunities for pupils to retrieve knowledge they previously learnt [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=26) |
| 00:10 – 00:30  What is a parallel circuit?  Demo equipment:   * Battery * 4 wires * 2 bulbs * Visualiser   PowerPoint  Worksheet | **Demonstration**: Set up the series circuit shown, under the visualiser if one is available. Prepare the second bulb with two wires, as shown.   1. Attach the second bulb across the first bulb. Questioning as you do this: “What determines the size of the current? (PD and resistance)”. Both bulbs are now lit. The brightness of the first bulb **has not changed**!   *(NB please check that the circuit you are using shows this clearly before showing the class)*   1. Disconnect the second bulb, and attach it again across the battery. Again, both bulbs are now lit, and the brightness of the first bulb has not changed.   Things to point out:  There are now two paths the electrons can take (trace these out with your finger): one through the first bulb, one through the second bulb. *(NB A note on tracing: where possible, try to avoid encouraging pupils to consistently trace circuits starting from the battery – this can reinforce the misconception that electricity is stored in the battery. Instead, try to encourage pupils to start and finish at an alternative component.)*  The two ways of connecting the circuit are **equivalent** because the two possible paths are the same in each case – through the battery, then through a bulb.  Electrons **cannot** pass through both bulbs! The battery provides the same potential difference to each bulb as it did when there was just one loop, so the current is the same in each, and the same as it was before the second bulb was added. *(NB this is a good opportunity to check that students understand that the electrons are already in the wires and components throughout the circuit. Once this is ascertained, then the teacher can ask their class what the battery does to the electrons in each branch. This line of questioning can elicit the understanding that the battery pushes the electrons in each branch equally – and also the same as it would if there was only one branch connected.)*  It makes no difference to the electrons how many wires they are moving through. The resistance of the wires is extremely low, so the current, and the bulb brightness, is the same in the second loop, regardless of whether the branch is attached across the first bulb (more wires in the second loop) or across the battery (fewer wires in the second loop).  **Slide 10:** Students copy notes, including important terminology: branch, junction, parallel, series.  **Slide 11:** Quick check to see whether students have understood the difference between series and parallel.  **Slide 12:** Demonstrate how two different circuit diagrams can refer to the same circuit. Challenge students to represent these two examples as a circuit diagram (see slide for details)  **Slide 14:** Explicitly demonstrate how to tell apart similar circuit diagrams (see slide notes for details).  **Task 1:** Odd one out. Choose which circuit is not equivalent to the rest. This activity links to lesson 2 (circuit diagrams).Answers provided on subsequent slides for self- or peer-assessment.  Exercise 2 taken from University of York resources, specifically dealing with the misconception on the right. **Further practice questions of this type included as optional homework.** | 5c. Practical work: Use practical work to develop scientific reasoning. – Every time you do an experiment, you can model some aspect of scientific reasoning. This is worked into the script for the demonstration. [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=30)  6a. Language of science: Carefully select the vocabulary to teach and focus on the most tricky words. –key vocabulary is kept to a minimum and tested in the worksheet (series, parallel, branch, junction, loop). In particular, ‘branch’ and ‘loop’ are easily confused**.** [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=33)  Misconceptions research on IOP Spark: Many pupils cannot identify reliably from a diagram whether two resistors in a circuit are in parallel when they are drawn in an unfamiliar format [Link](https://spark.iop.org/many-pupils-cannot-identify-reliably-diagram-whether-or-not-two-resistors-circuit-are-parallel-when)  4a. Memory: Pay attention to cognitive load – structure tasks to limit the amount of new information pupils need to process. – Use worked examples or partially solved examples that take pupils through each step of a process**.** [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=25) |
| 00:30 – 00:55  What happens if we have multiple loops?  PowerPoint  Worksheet | **Slide 20:** Explanation of what happens to current in a parallel circuit.  “What happens to the current in a parallel circuit? This is not so clear, because before we had a single (series) loop, and the current was the same everywhere.  Now we don’t have a single loop, we have two (or maybe more!). What can we say about the current?  **The potential difference is the same across each branch.** What happens when there is a potential difference? A current can flow. What else determines the current? The resistance.  So the current in each branch is determined by the resistance.  What happens at a junction?  The electrons from one branch meet the electrons from the other branch – so the current **adds up.**  **This means the current through the battery is the sum of the currents in each branch**.”  **Slide 21:** Worked example (see slide for details)  **Task 2:** Parallel circuit problems. Solutions given on **slides 23-24.** | 2b. Self-regulation: Model your own thinking to help pupils develop their metacognitive and cognitive knowledge – explicit modelling of working out (slides 20-21). [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=16)  4a. Memory: Pay attention to cognitive load – structure tasks to limit the amount of new information pupils need to process. – Use worked examples or partially solved examples that take pupils through each step of a process**.** [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=25) |
| 00:55 – 01:00  Plenary  PowerPoint | **Slide 26:** What happens when an extra branch is added? See slides for questions, answers and possible misconceptions that may arise. | Misconceptions research on IOP Spark: Many pupils think that a battery supplies the same current, regardless of the circuit in which it is used. [Link](https://spark.iop.org/many-pupils-think-battery-supplies-same-current-regardless-circuit-which-it-used) |