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| **Make a sensor to test a waterlogged pitch** |
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| Making a moisture sensor that a football referee can use to check that the pitch is fit to play on |
| **Subject(s):** Design and Technology, Engineering**Approx time:** 50-80 minutes |  | **Key words / Topics:** * circuit assembly
* components
* input, process, output
* resistors
* sensors
* soldering
* wiring
* world cup football
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| **Stay safe** Whether you are a scientist researching a new medicine or an engineer solving climate change, safety always comes first. An adult must always be around and supervising when doing this activity. You are responsible for: • ensuring that any equipment used for this activity is in good working condition• behaving sensibly and following any safety instructions so as not to hurt or injure yourself or others  Please note that in the absence of any negligence or other breach of duty by us, this activity is carried out at your own risk. It is important to take extra care at the stages marked with this symbol: ⚠ |
| **Suggested Learning Outcomes**  |  |  |
| * To be able to make a moisture sensor circuit
* To be able to fit and solder components to a PCB
* To be able to test the moisture sensor circuit to check how well it works
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| **Introduction** |  |  |
| This is one of a series of resources designed to allow learners to use the theme of the men’s football world cup to develop their knowledge and skills in Design & Technology and Engineering. This resource focuses on making and testing a moisture sensor that referees can use to check the playability of the pitch. The world cup takes place at the start of the rainy season in Qatar. Can you make a waterlogging sensor that a referee can use to check whether the pitch is fit to play on? |
| **Purpose of this activity**In this activity learners will make use of the theme of the men’s football world cup in Qatar, to make a moisture sensor circuit that can be used to test if a pitch is too wet to play on. They will then test their circuit to see if it works.This activity could be used as a main lesson activity to teach about soldering, assembling circuits and the function of components. It could also be used as part of a wider scheme of learning to support focussed practical skills within Design and Technology and Engineering. |
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| **Activity** |  | **Teacher notes** |
| **Introduction, brief and safety (10-20 minutes)**Teacher to explain the task to learners, introduce the brief below.**Brief**The men’s football world cup is due to be played in Qatar in November and December 2022. This is the start of the rainy season in the country.Your task is to make a waterlogging sensor that a referee can use to check whether the pitch is fit to play on. It should indicate when the pitch is too wet for play to safely take placeTeacher to hand out the tools, equipment and components required. Teacher to explain potential safety issues when using soldering equipment.**Making the moisture sensor circuit (30-40 minutes)**Teacher to demonstrate steps shown below and on the presentation. Learners to then follow these steps to assemble their own moisture sensor circuit* Step 1 – Mount the 470-ohm resistor (yellow, violet, brown) into the holes labelled ‘R1’ on the plastic side of the PCB. Mount the 1 kiloohm resistor (brown, black, red) through the holes labelled ‘R2’. Mount the 1.2 kiloohm resistor (brown, red, red) through the holes labelled ‘R3’. Solder the resistor legs to the pads on the track side of the PCB and use wire cutters to cut away any excess wire. ⚠
* Step 2 - Mount and solder the transistor and LED to the PCB. Make sure that the round and flat sides of each component match the markings on the board. Snip the ends when soldered. ⚠
* Step 3 - Mount and solder the battery snap wires to the PCB. The red wire goes to ‘+’ and the black wire goes to ‘-’. Snip the ends when soldered. Twist the wires together. ⚠
* Step 4 - Connect the battery to the battery snap and stick onto the board with a double-sided sticky pad.

**Testing the moisture sensor circuit (10-20 minutes)**Learners to place the moisture sensor in wet soil or grass to see if it works! Teacher to discuss how successful the making of each moisture sensor has been with learners. |  | **Resources**Lead free solder should be used for safety. If permanent fume extraction is not present in the room then portable extraction units will be needed. Safety glasses should be worn during all soldering and wiring activities.The circuit board used in this example is the Rapid Electronics Moisture sensor PCB, available here: <https://www.rapidonline.com/Catalogue/Product?Id=70-0040> . Alternatively, a custom-made PCB based around a simple transistor switching circuit could be produced, or stripboard could be used.A BC548B or BC108 transistor could be used depending on what is in stock or easily available – both will work fine.**Making**Step 1 - The resistors should be mounted as flat as possible on the plastic side of the PCB. As they are non-polarised it does not matter which way round they are placed, but usual convention is to place them with the gold tolerance band to the right.Demonstrate safe use of soldering equipment prior to learners attempting this step. A visualiser or small webcam linked to a projector screen would help with this. Safety glasses should be worn at all times. All soldering should be done on a mat or board to avoid damage to desks. A sponge should be used to regularly clean the soldering iron tip. The iron should be placed in its stand at all times when not in use.Step 2 - The transistor and LED are polarised components so must be connected the right way round – as shown on the circuit board markings (transistor flat side to the left, LED flat side to the right).Step 3 - The battery snap wires must be connected as shown or the circuit will not work. Twisting the wires together will make the wiring neater and less likely to break.A finished example is shown on slide 10 of the teacher presentation. Remember to disconnect the battery to save power when not in use.**Testing**When the soil/grass is wet the LED should light up. When it is dry it will not. This is because the moisture causes current to flow across the sensor and therefore ‘makes’ the circuit. If the circuit does not work check for dry joints or short circuits in the soldering, or polarised components that are connected the wrong way round. |
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| **Differentiation** |  |  |
| **Basic** |  | **Extension** |
| * Pre-cut solder and battery wires to size.
* Pre-mount components to circuit board so that learners can move straight onto soldering them in place.
 |  | * Design and make a casing for the circuit.
* Use CAD software to design an improved circuit that has a green LED to indicate when the pitch is dry and a red LED to indicate when it is wet.
* Design a range of other systems that could assist the referee, such as an electronic score counter.
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| **Resources** |  | **Required files** icon-docicon-pdficon-ppt |
| * A soldering iron, stand, sponge and mat/base
* Solder
* Moisture sensor circuit board
* A 9-volt battery and battery snap
* A 470-ohm, 1 kiloohm and 1.2 kiloohm resistor
* A transistor
* A 5 mm red LED
* A sticky pad
 |  |  Presentation Pitch waterlogging sensor |
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| **Additional websites** |  |  |
| * **FIFA – World cup 2022:** Official website for the FIFA men’s world cup 2022 in Qatar. <https://www.fifa.com/tournaments/mens/worldcup/qatar2022>
* **Rapid Electronics – Moisture sensor PCB:** Link to order the Rapid moisture sensor PCB. <https://www.rapidonline.com/Catalogue/Product?Id=70-0040>
* **Circuit Digest – Moisture sensor circuit:** Circuit diagram for a more advance moisture sensor circuit. <https://circuitdigest.com/electronic-circuits/soil-moisture-sensor-circuit-diagram>
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| **Related activities (to build a full lesson)** |  |  |
| **Starters** (Options) * Research components to be used and discuss their function in the circuit.
* Draw a schematic and wiring diagram for the circuit.
 | **Extension** (Options)* Design and make a casing for the circuit.
* Use CAD software to design an improved circuit that has a green LED to indicate when the pitch is dry and a red LED to indicate when it is wet.
* Design a range of other systems that could assist the referee, such as an electronic score counter.

**Plenary*** Self and peer assessment of the quality of fitting, soldering, and wiring for each circuit board produced.
* Evaluate the results of testing.
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| **The Engineering Context** film |
| * The football world cup will require engineers of a wide range of disciplines to make sure that it runs smoothly and effectively. From structural engineers in charge of stadium design to textile engineers producing the players’ kits, the importance of engineers is huge.
* Electrical and electronic engineers need to have basic skills in circuit construction, including soldering components and testing electronic PCBs.
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| **Curriculum links** |
| **England: National Curriculum**Design & Technology * KS3 2a, 4c

**GCSE D&T**AQA D&T* 3.1.2, 3.1.4, 3.2.5, 3.2.8, 3.3.6, 3.3.10, 3.3.11

Edexcel D&T* 1.3.2a, 1.3.3, 1.6.1a, 1.6.2b,c 1.6.3a,c, 5.1.1, 5.2.1c, 5.2.2b,g, 5.2.3b, 5.5.1c, 5.6.1b, 5.7.1a, 5.7.3, 5.8.1c

Eduqas D&T* Core: 3, 5
* Electronic systems: 1, 2, 6

OCR D&T* 1.1a, 5.4a iii, 6.4a i, 6.4b i, 7.2a ii
 | **Northern Ireland Curriculum**Technology & Design* KS3 Manufacturing - selecting and using materials fit for purpose; safe use of a range of tools and processes appropriate to materials, demonstrating accuracy and quality of outcome
* KS3 Control – incorporate control systems, such as mechanical,

electronic or computer-based, in products and understand how these can be employed to achieve desiredeffects* KS3 Objective 1 - Abide by health and safety rules when using tools, machines and equipment
* KS3 Learning outcomes - demonstrate practical skills in the safe use of a range of tools, machines and equipment.
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| **England: GCSE Engineering*** 3.2.5, 3.3.2, 3.3.3, 3.4.2, 3.6

**Scotland: Curriculum for Excellence**Technologies* TCH 3-09a TCH 3-12a
* TCH 4-12a
 | **Wales: National Curriculum** Design and Technology* KS3 Skills: Making 1, 2, 3
* KS3 Systems: 16, 18
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| **Assessment opportunities** |
| * Informal teacher assessment of practical skills through observation of learners.
* Formal teacher assessment of the completed moisture sensor circuit.
* Self/peer assessment of soldering and wiring skills used.
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