**ACTIVITY: Sensing moisture**

**Activity idea**

In this activity, students construct a simple, effective moisture sensor that is then used to give warning of dry, damp or wet conditions.

By the end of this activity, students should be able to:

* construct a simple moisture sensor
* conduct a series of experiments to investigate how various moisture sensors work.

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[A4 drawing and diagram of the moisture sensor](#A4)

**Introduction/background**

Water is an important but occasionally hazardous substance. Persistent drought and flooding are obvious hazards, but equally damaging can be prolonged dampness. This tends to encourage rusting of steel and the growth of microorganisms that cause rot or disease.

The operation of the circuit has been described for the student, but a transistor like this will have a hundred times more current flowing from the top (collector) into the bottom (emitter) than into the centre (base). This allows small current changes in the wires to appear as larger changes in the brightness of the LED.

**What you need**

For each group of students:

* Copies of student instructions [Making a moisture sensor](#experiments)
* [A4 drawing and diagram of the moisture sensor](#A4)
* A5 sized piece of heavy cardboard or soft particleboard per circuit
* 2 x 30cm lengths of braided wire
* 9 volt battery
* Battery connector
* 1000 ohm resistor (any wattage)
* LED (preferably red)
* NPN transistor (BC547 or similar)
* Paperclips
* Desk or wall stapler

**What to do**

1. Introduce the concept of moisture sensors and discuss how they might be used.
2. Give each student a copy of the student instructions [Making a moisture sensor](#experiments) and the [A4 drawing and diagram of the moisture sensor](#A4) and have them complete steps 1–3.
3. Have students complete step 4 and discuss. Possible actions are using dry fingers versus wet fingers, squeezing the wires harder, touching your tongue with the wires (small tingle), wires across skin versus clothing.
* What causes the difference in the brightness of the LED? (The amount of moisture, how large the contact area is and how far apart the wires are on the skin – more resistance makes it dimmer.)
* Why does the LED light up? (Transistors are switches that can be operated by a small electric current. When a small flow of electric charges occurs through the wires, the transistor is turned on. This allows a larger flow of electric charges between the other legs of the transistor, and this lights up the LED. The resistor protects the LED from too many electric charges flowing through it. As more electric charges flow through the wires, the transistor builds up the current and the LED gets brighter. However, there is a limit, which is why connecting the wires straight together does not always turn the transistor fully on – the flow of electric charges is so great the transistor becomes temporarily overloaded.)
1. Have students complete step 5 and discuss. (This is a simple quick task that illustrates the sensitivity. The repeat(s) allow students to continually reduce the amount of water and realise that it takes time for the paper to get damp.)
* How much water do you need to turn the LED on? (Very little indeed.)
1. Have students complete step 6 and discuss. (The scenario given could equally apply to water moving into fault planes or steam (heat) rising in geothermal areas. Soil, sawdust or sand can be used. Two probes (e.g. nails) buried a set distance apart is all that is required. Alternatively, students could try to detect water between two plates of metal – something that would require just a sheet of dry paper between the plates. If the paper gets damp, electric charges flow between the plates.
* How much dry sand did you use? Could be a volume (e.g. 3 cups) or a weight (e.g. 1 kg).
* What’s the smallest amount of water it could detect? (Will depend on time allowed for water to move through it and the area of the probes used.)
* Did the amount of water it could detect vary? (A good design will have less variability.)
1. Have students complete step 7 and discuss. (Lie detector machines are discredited in most countries. They rely on measuring a range of factors such as breathing, blood pressure and skin responses. Each test lasts 90–180 minutes and claims to improve reliability by intimidating the guilty and relaxing the innocent beforehand. The activity only points out to students the variability and weakness of testing using their moisture sensors. It is best if students develop their own questions, rather than being interrogated by their classmates.)
* How could you beat a lie detector machine? (Relax, lie confidently, deny everything, purposely give wrong answers, use antiperspirants, apparent insensitivity of moisture sensor, stress levels insufficient to get a response etc.)

**Making a moisture sensor**

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| 1. Fold the A4 drawing and diagram of the moisture sensor around an A5 sized board of sturdy cardboard or soft particleboard and staple the paper in place.
2. Using either the circuit drawing or circuit diagram side, staple the components in place, taking care to connect them.
* The resistor can be placed either way around.
* It is important the longest lead on the LED is towards the positive on the battery.
* It is important the flat face on the transistor faces the way shown on the diagram.
1. Check that the moisture sensor works, by holding the bare ends of the wires with damp fingers. If it is working, the LED should light up. (Note: Touching the wires together does no harm but will not always turn the LED on.)
2. Find 3 different ways of touching the wires to make the LED shine brighter or dimmer.
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1. Using paperclips or staples, connect your wires to a sheet of dry paper. Keep the paperclips about 5cm apart. Slowly drop water onto the paper. Start again with dry paper, but find the least amount of water needed to turn the LED on.
2. All hydroelectric dams leak water into the surrounding rock and soil. Knowing how much they usually leak is important because an increase may give warning of the possible collapse of the dam. Using dry sand or soil, build a moisture sensor that will give a warning when sand starts to get damp, not just when the sand is wet. Your device must work reliably three times, and you must know how much water is in the sand.
3. Lie detectors are moisture sensors that rely (in part) on somebody becoming nervous when lying and therefore sweating more. Create 12 questions about yourself and get somebody to ask you the questions while the moisture sensor wires are taped to your fingers. Lie about some of the answers – the challenge is for them to tell when you are lying.

