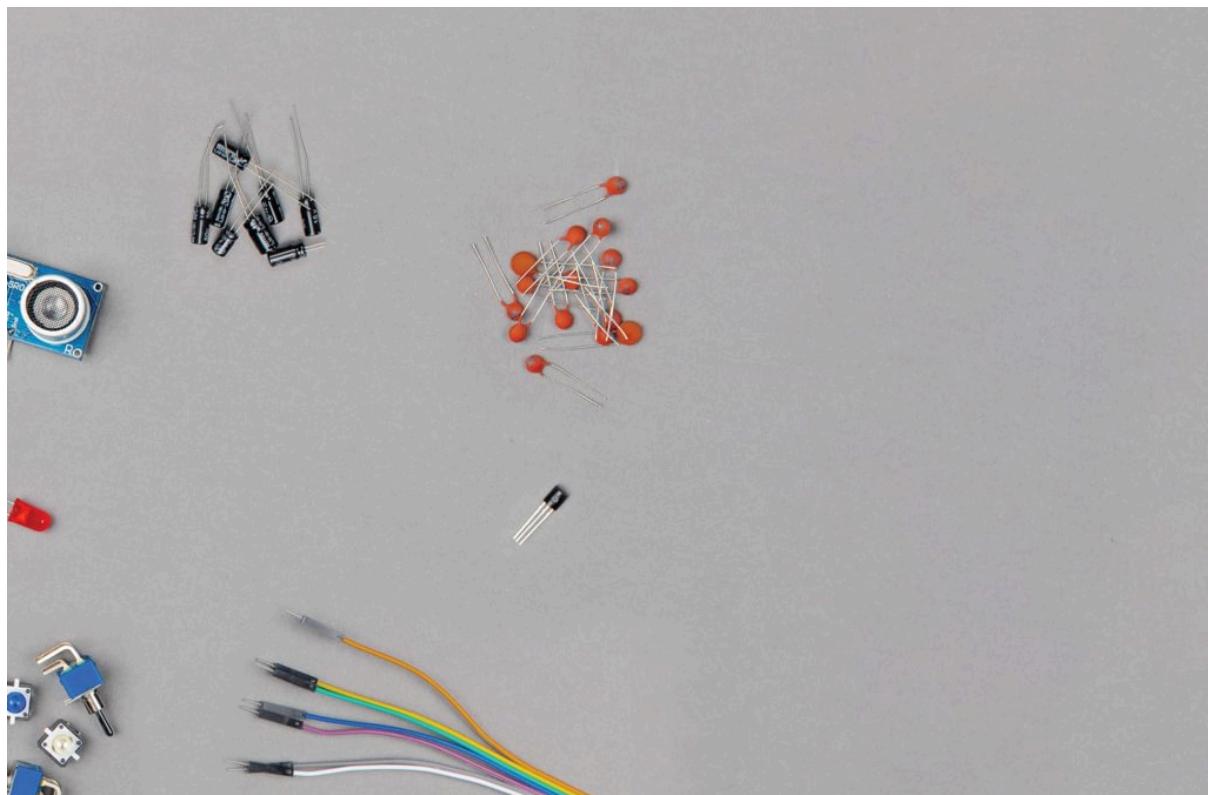


## 50 Electronics Projects for Makers FEATURE LENS

### 50 ELECTRONICS PROJECTS

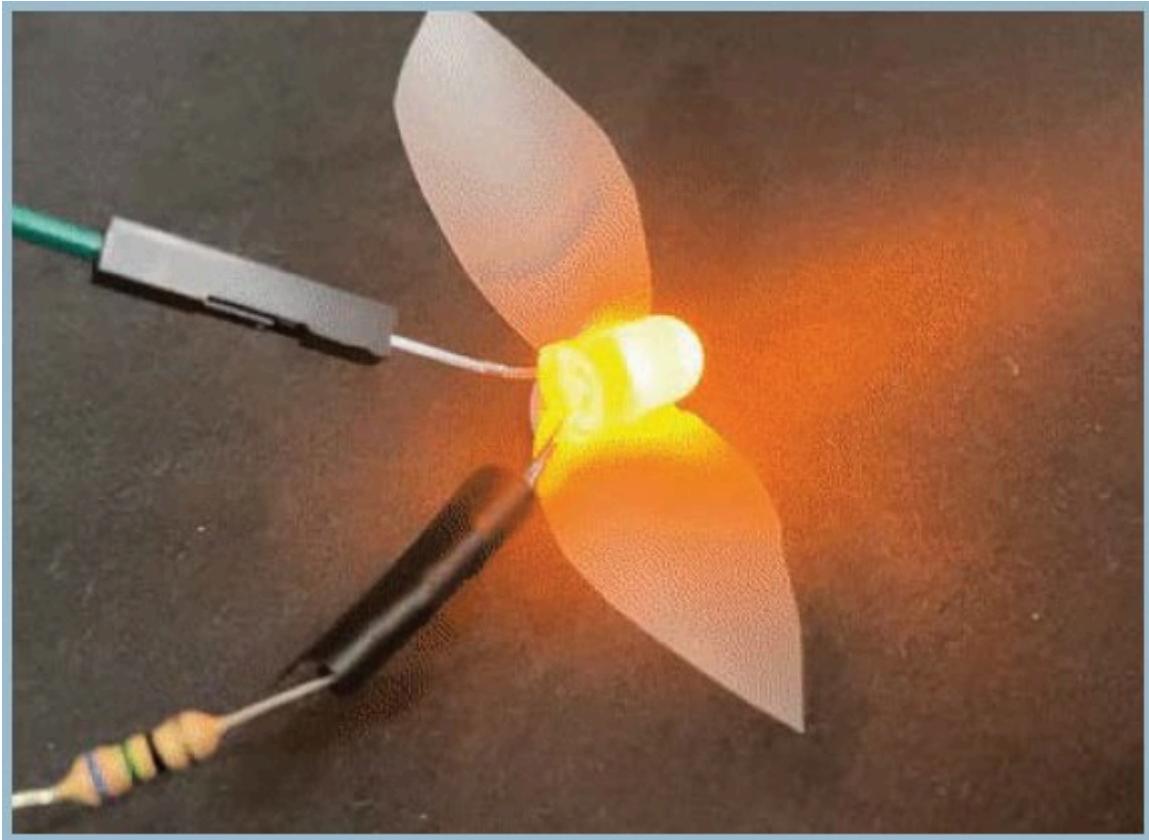
With a microcontroller and a few other components, you can make a vast array of electronics projects...

By Phil King



## ***LED***

When building your first electronics circuit on a breadboard, the easiest output device to use is a standard single-colour LED (light-emitting diode). As with other diodes, current only flows in one direction, so you need to get the polarity right: connect the positive (long) leg to an I/O pin on your microcontroller, and the negative (short) leg to ground. Remember to add a resistor to either connection to limit the amount of current to a safe level.



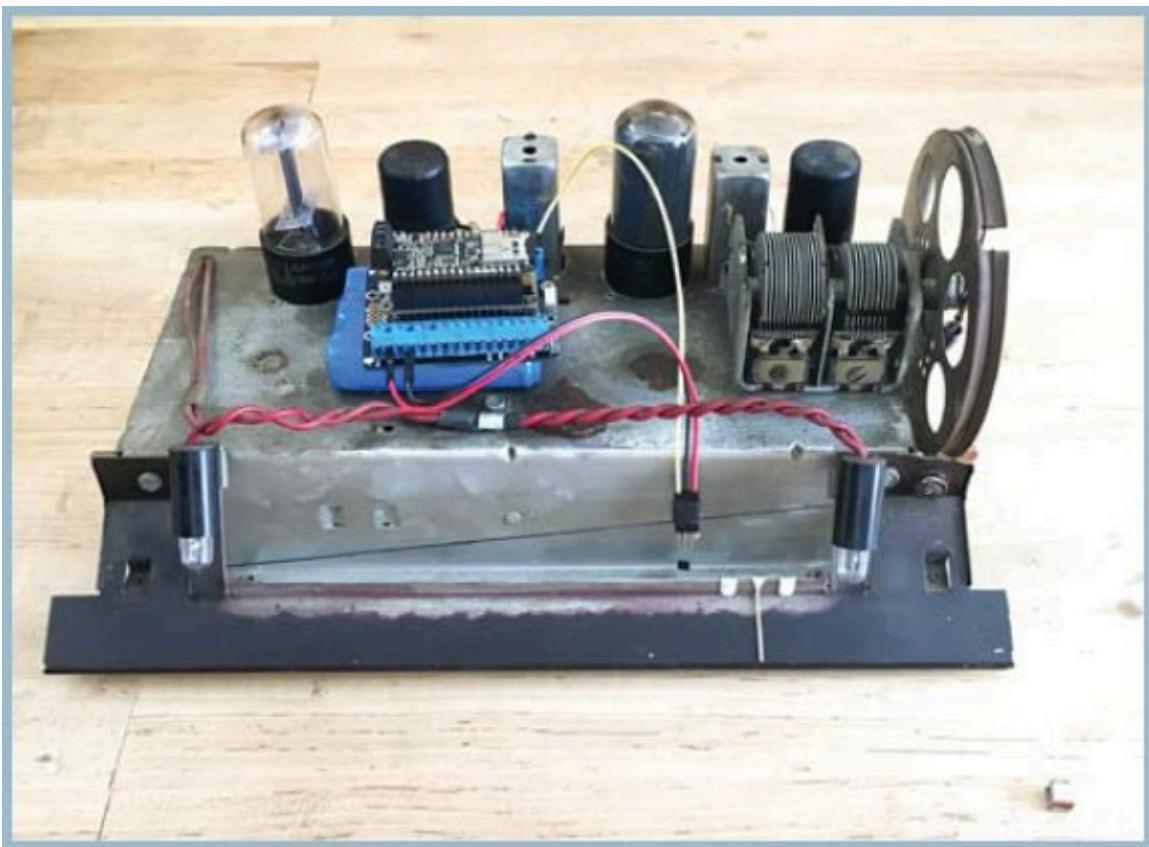
### LED Firefly

A variation on the classic blinking LED starter project, here a yellow LED is given sticky-tape wings and turned on and off by switching a Raspberry Pi Pico I/O pin high and low

[hsmag.cc/LEDFirefly](http://hsmag.cc/LEDFirefly)

## HALL EFFECT SENSOR

Named after the American physicist Edwin Hall, this type of sensor detects changes in a magnetic field: its output voltage is directly proportional to the strength of the field. This enables it to detect the position and movement of magnetic objects. Hall effect sensors have many uses, such as in the automotive industry, to determine a car's fuel tank level and the speed of its wheels.



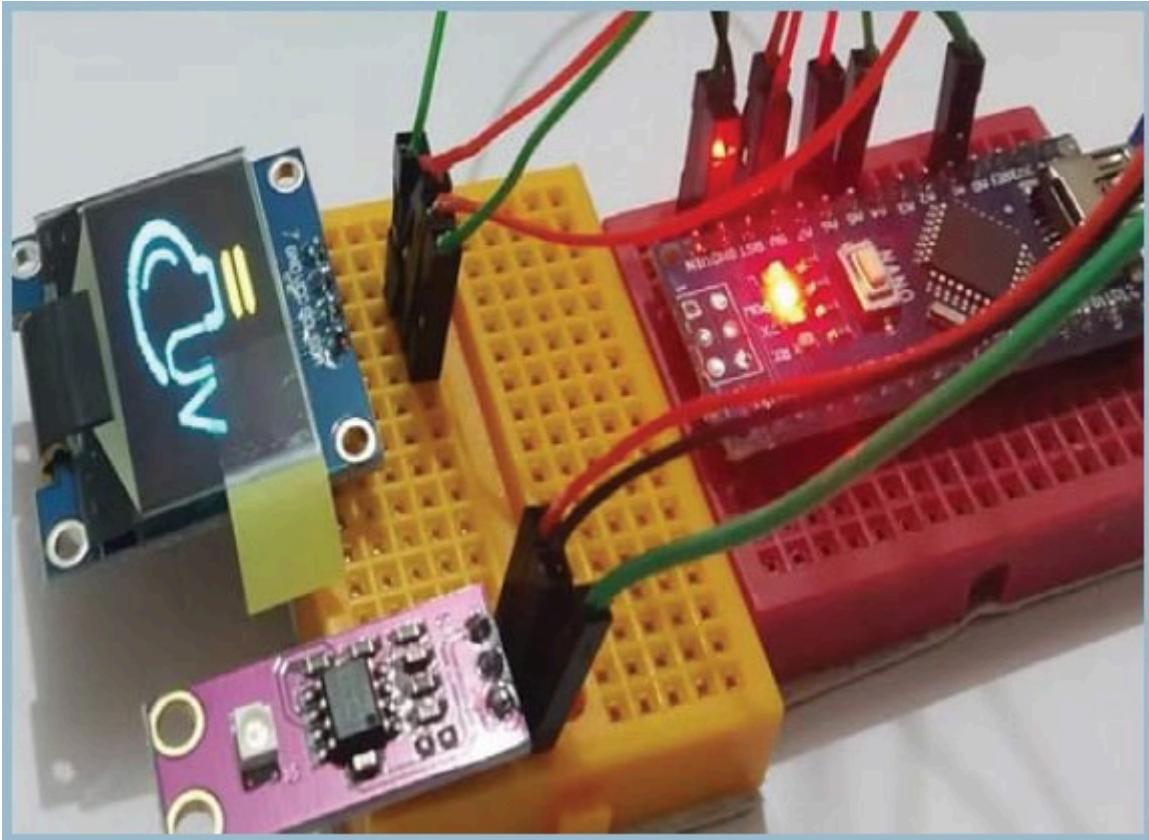
### Haunted Radio

A Hall effect sensor detects the presence of a magnet as you turn the dial, triggering the playback of spooky sounds

[hsmag.cc/HauntedRadio](http://hsmag.cc/HauntedRadio)

## UV SENSOR

This special type of light sensor can detect the level of ambient ultraviolet (UV) light, outputting a relative voltage (or digital data in some sensors). From that output, it's possible to determine the international standard UV index level, so you know how safe it is to go out in the sun and whether to apply sunscreen. Naturally, the sensor needs to be placed outdoors to work effectively.



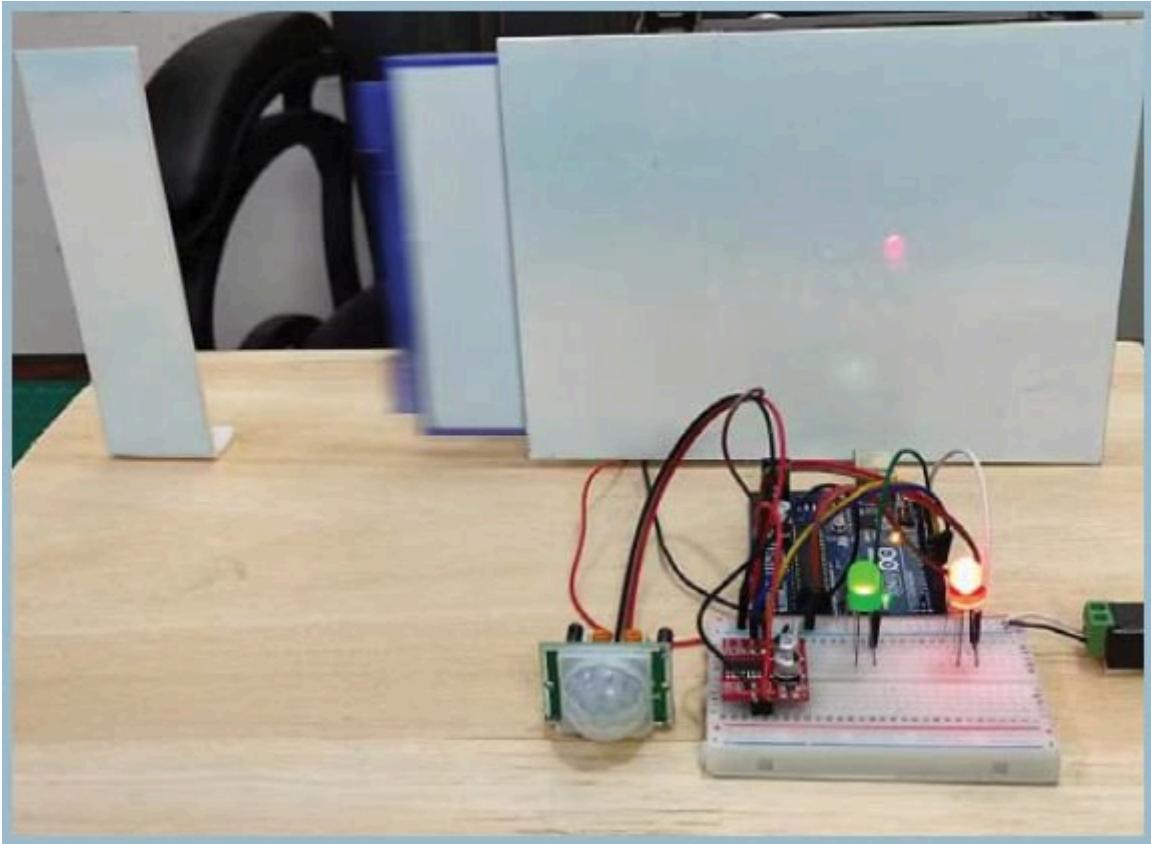
### UV Index Meter

This Arduino project makes use of a GUVA-S12SD ultraviolet sensor and shows the UV index on a mini display

[hsmag.cc/UVIndexMeter](http://hsmag.cc/UVIndexMeter)

## PIR MOTION SENSOR

A PIR (passive infrared) sensor, such as the HC-SR501, can detect movement even in a darkened room, making it ideal for burglar alarms. It detects changes in the area covered by its plastic lens, and outputs a digital signal when it detects movement. The sensitivity threshold and trigger time can be adjusted (typically by turning a couple of screws).



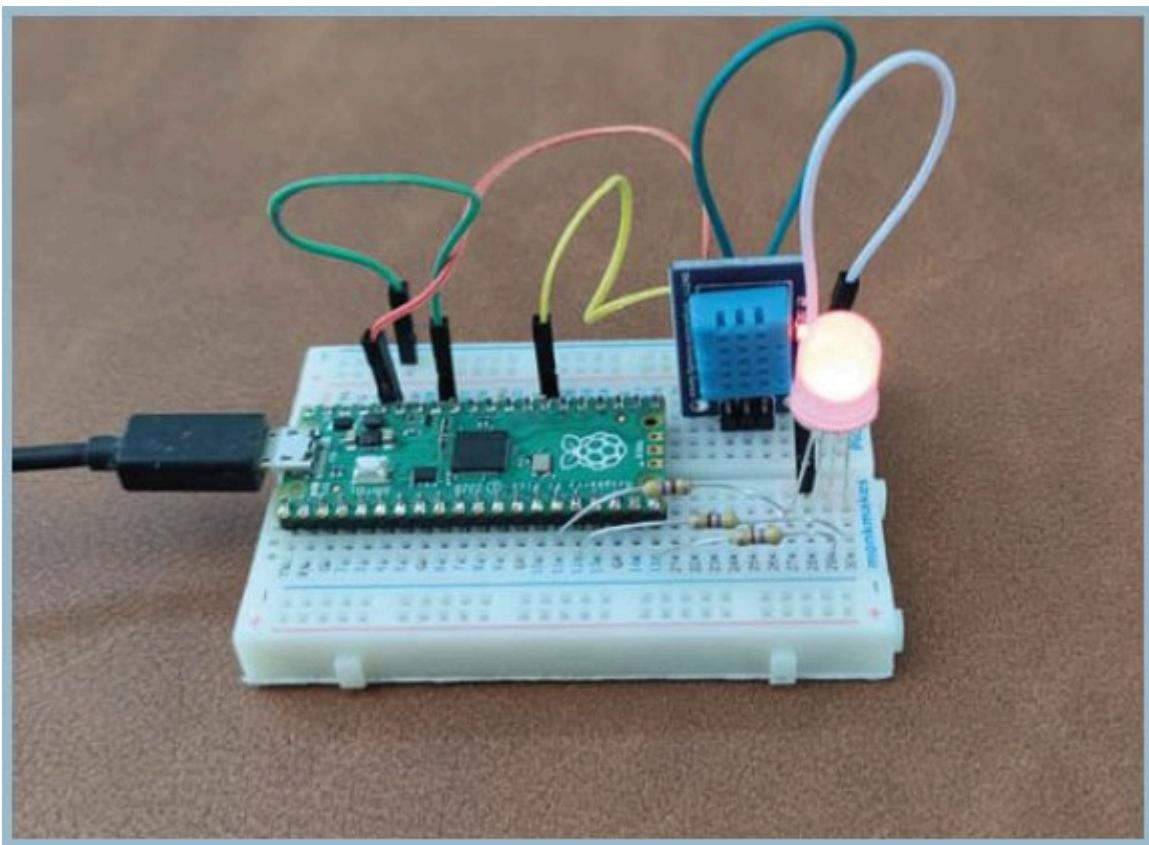
### Automatic Door Opening System

Here, a PIR sensor is used to detect the movement of anything approaching, triggering a sliding door to open. You could scale the concept up to life-size

[hsmag.cc/PIRDoor](http://hsmag.cc/PIRDoor)

## RGB LED

A standard RGB LED is essentially three LEDs in one, with red, green, and blue components. It therefore has four pins: three for the red, green, and blue channels (connected to I/O pins via resistors) and one for either GND or 3V3 (check which type you have). By using PWM (pulse-width modulation) to vary the brightness level of each colour channel, you can get it to show any of the 16 million shades.



### RGB Lamp

In our example tutorial (see page 50), a common-cathode RGB LED is connected to the GPIO pins of a Pico. Varying the PWM frequencies on each channel will alter its colour (here determined by the data from a temperature sensor)

[hsmag.cc/PicoRGBLED](https://hsmag.cc/PicoRGBLED)

## CHARLIEPLEXING

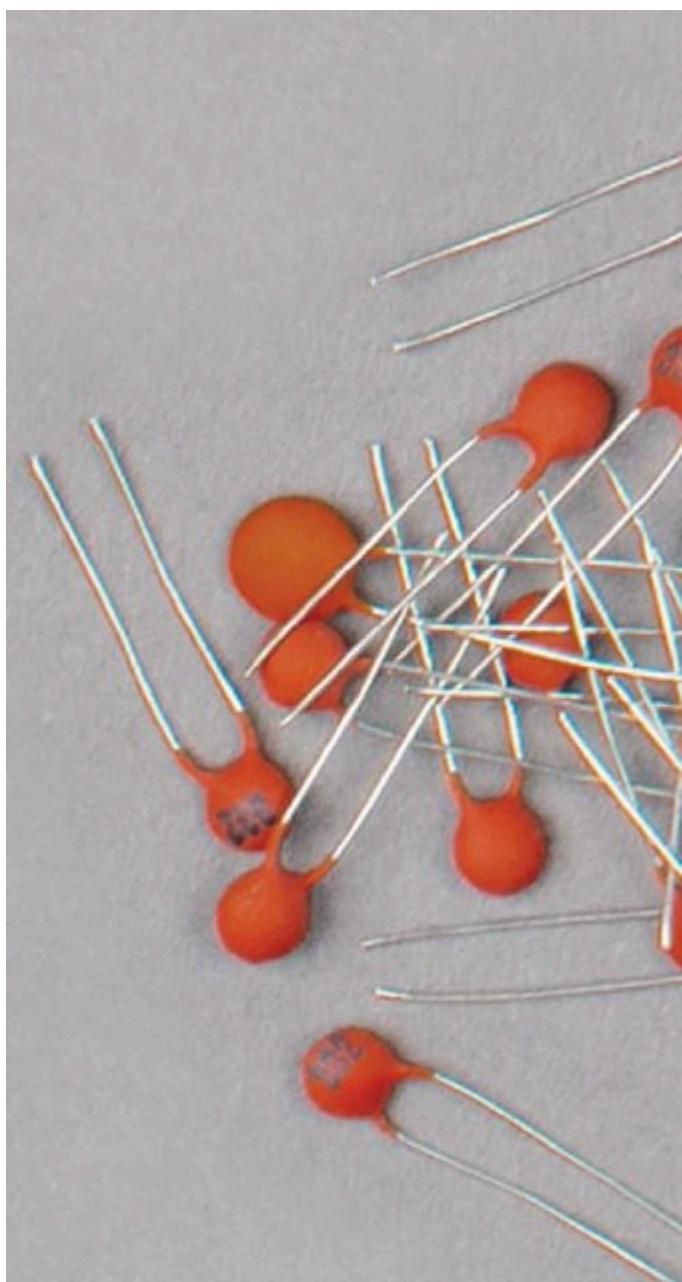
An alternative to using NeoPixels for a display is to multiplex a set of standard LEDs. This involves connecting them in a matrix of addressable rows and columns, thereby reducing the number of GPIO pins needed to control them. A particular type of multiplexing is called charlieplexing, which allows you to drive  $N \times (N-1)$  LEDs with just N pins, making it easy to add multiple standard LEDs to a project.



### Atom Watch

This wristwatch shows the time in analogue form via two concentric circles of 42 LEDs, for hours and minutes. Charlieplexing is used to drive them all from ten pins on an Arduino Pro Mini

[hsmag.cc/AtomWatch](http://hsmag.cc/AtomWatch)



## **NEOPIXEL**

If you want to connect several standard RGB LEDs, you'll soon run out of GPIO pins. That's where smart, individually addressable RGB LEDs come in really useful, enabling you to send a digital number over a single connection to determine the shade. The most popular type is the WS2812B standard, aka NeoPixels, available as individual pixels or more often in sticks, reels, shapes, and matrices. With an integrated driver chip mounted on every LED, only three connections (power, ground, and data) are needed to control as many as you like (so long as enough current is supplied).



### Crystal RGB

This simple Arduino-compatible project places a single WS2812B LED inside a 3D-printed crystal to make it glow in different colours, making it ideal as a desk ornament

[hsmag.cc/CrystalRGB](http://hsmag.cc/CrystalRGB)

## MOISTURE SENSOR

Ideal for monitoring the soil in a pot plant or garden, this kind of sensor is a type of variable resistor with two prongs; one emits an electrical current that is received by the other via the soil (or other medium). The more moisture there is in the soil, the higher the conductivity and thus the greater the current delivered. Some more expensive models have multiple sensor elements at different depths.



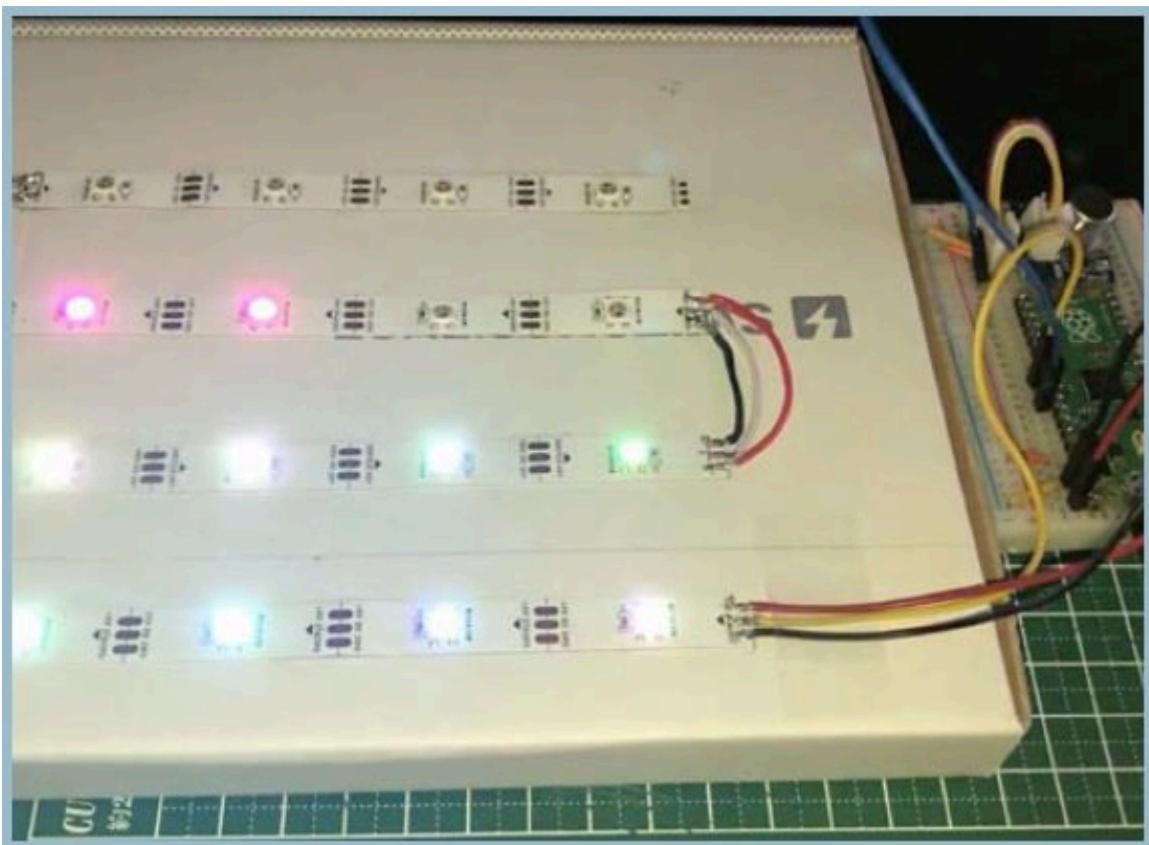
### Plant Waterer

A capacitive soil moisture sensor is used with a Pico microcontroller to trigger a relay switch to turn on a fish tank water pump

[hsmag.cc/PicoPlantWaterer](http://hsmag.cc/PicoPlantWaterer)

## SOUND SENSOR

Equipped with a tiny amplifier, a low-cost sound sensor will trigger a digital output signal whenever a certain ambient noise threshold is reached. This makes it useful as part of an intruder alarm. Most such sensors also have an analogue pin which outputs the sound itself. Sensitivity and noise threshold for the sensor are typically adjusted with small potentiometer screws.



### Sound-Activated RGB LED Matrix

Using a sound sensor, colourful patterns are triggered on an RGB LED matrix in reaction to music or any sound

[hsmag.cc/SoundMatrix](http://hsmag.cc/SoundMatrix)

## FLIGHT CONTROLLER

A next-level project is to build your own aerial drone such as a quadcopter. For this, you'll need a flight controller, either in the form of an all-in-one unit or separate ESC (electronic speed controller) and IMU. Using telemetry data from the IMU, with optional GPS, it adjusts the speed of the propeller motors to keep the drone stable in the air. Another use case for a flight controller is in rocketry, to control a rocket's trajectory and reach the desired altitude.



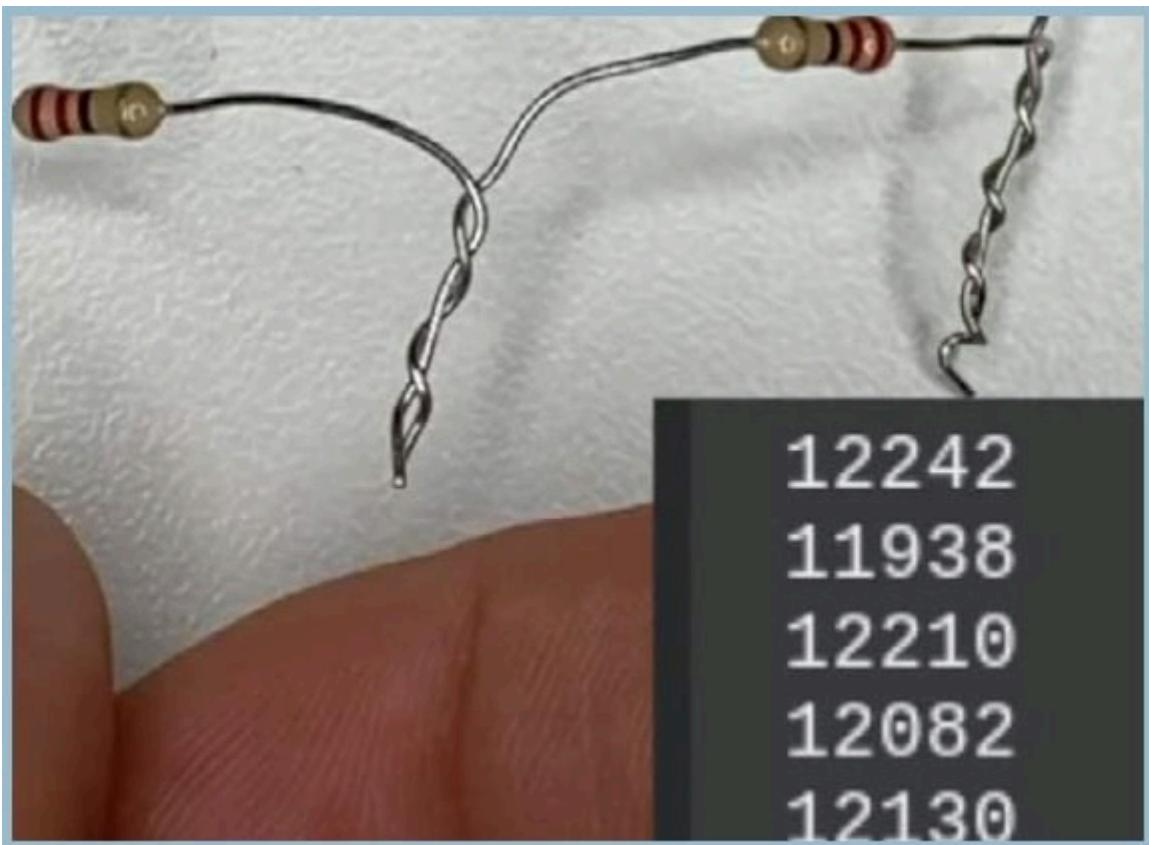
### RC-VTOL-F35-ParkJet

Nick Rehm's highly manoeuvrable aircraft features separate ESC and IMU units for fine control of its propellers and ailerons

[hsmag.cc/F35ParkJet](http://hsmag.cc/F35ParkJet)

## RESISTOR

Resistors limit the amount of current flowing through a circuit, making them especially useful to prevent LEDs burning out due to overcurrent. Resistors can also be used to create a 'voltage divider', to reduce an input voltage; this is typically used to connect the output of a 5 V component (such as an HC-SR04 ultrasonic sensor) to a 3V3 input. Through-hole resistors have coloured bands that represent their power rating, in ohms – see [hsmag.cc/ResistorCalc](http://hsmag.cc/ResistorCalc).



Resistor Piano

By stringing a series of resistors together, the resistance at each junction is different, enabling it to be used to trigger a particular musical note in this Pico project

[hsmag.cc/ResistorPiano](http://hsmag.cc/ResistorPiano)

## WEATHER STATION

When building a weather station, in addition to including one or more sensors for temperature, pressure, and humidity, you'll want to take other meteorological measurements. A rotating anemometer measures wind speed, while a vane detects wind direction. A rain gauge is another essential item; there are two main types: the simplest uses a rocker switch, while the alternative relies on an infrared beam.



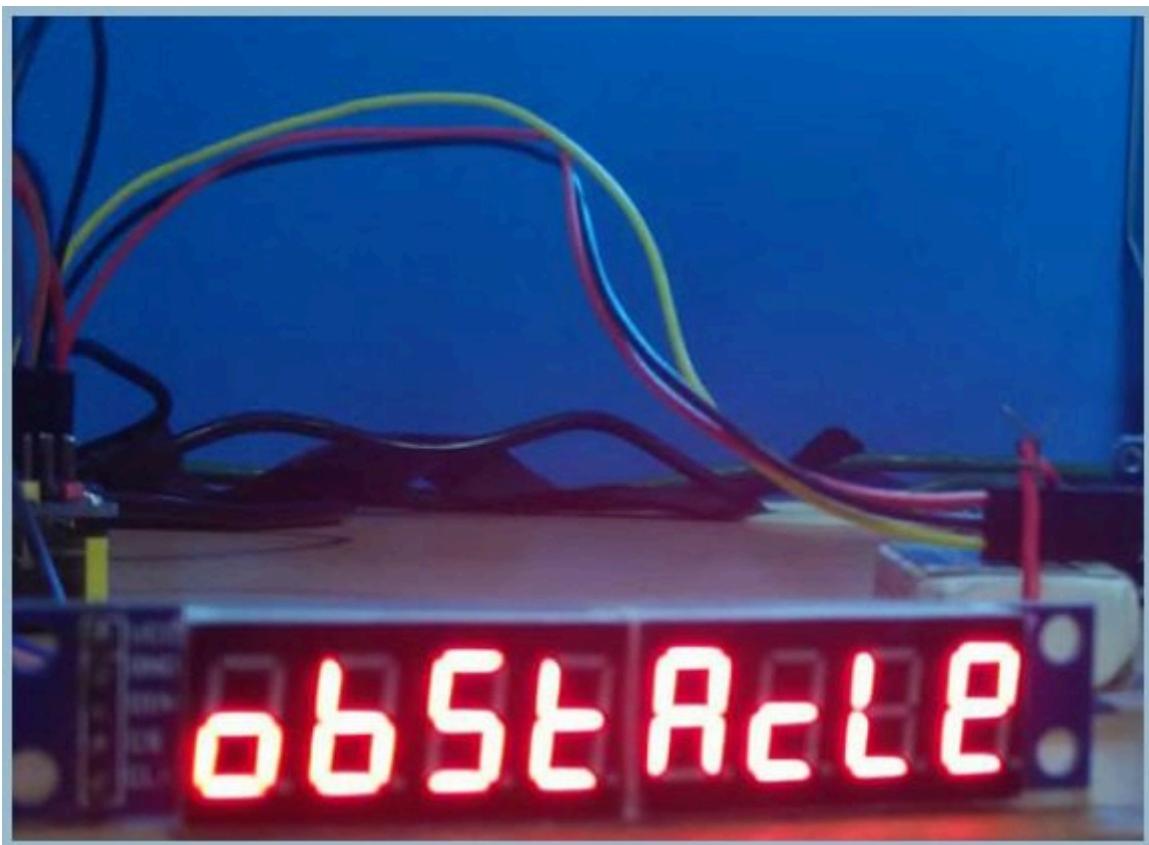
Precise Anemometer

When an anemometer spins in the wind, the number of turns per second indicates the wind speed. This project has a linear LED scale to show it

[hsmag.cc/PreciseAnemometer](http://hsmag.cc/PreciseAnemometer)

## LASER SENSOR

Another useful element of an intruder alarm system is a laser sensor. It may not resemble the impressive laser security systems seen in *Mission Impossible* films, but it works in the same way. A laser beam of a set wavelength is emitted via an on-board lens; when reflected by a wall, or other solid object, it is sensed by a receiver. Thus it can detect when the beam is broken, triggering a digital output. Alternatively, you can use separate laser modules and receiver modules to detect a beam.



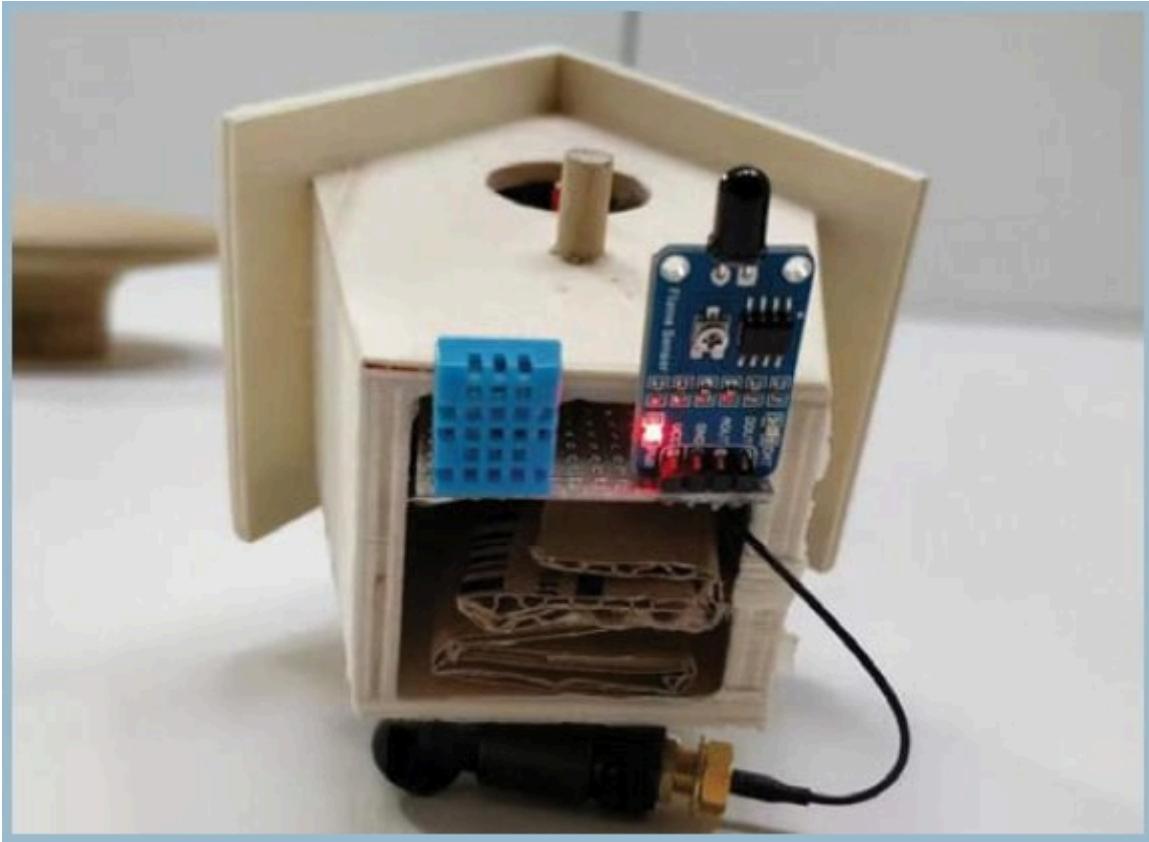
Obstacle Detector

Laser sensors are also useful for obstacle detection, as demonstrated here. They can also be integrated into a wheeled robot for this purpose

[hsmag.cc/LaserObstacle](http://hsmag.cc/LaserObstacle)

## **FLAME SENSOR**

As the name suggests, this type of sensor can detect the presence of a nearby flame. While many commercial sensors use ultraviolet technology, low-cost hobbyist flame sensors rely on PIR to detect the infrared energy emitted by a fire. The sensitivity, and therefore the range, may be adjusted using an on-board potentiometer screw. Along with an analogue output, some may have a digital one.



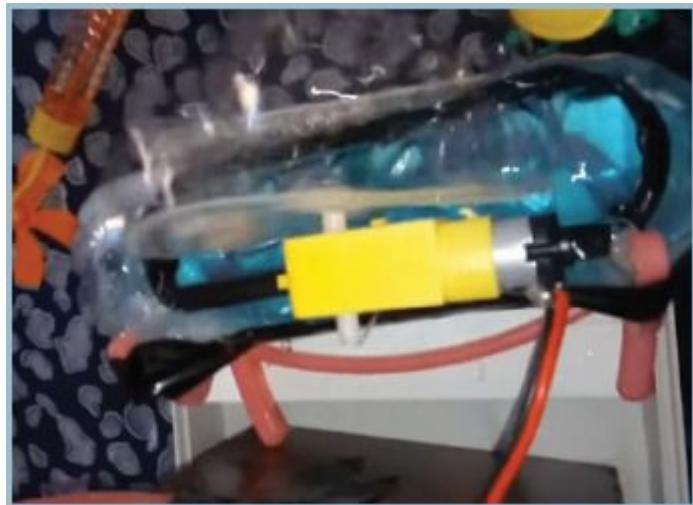
### Forest Fire Detector

Housed in a birdbox-style enclosure, this Arduino-based fire detector features an IR flame sensor and uses the Sigfox communications platform to transmit alerts

[hsmag.cc/SigFoxFire](http://hsmag.cc/SigFoxFire)

## MOTOR

If you want something in your project to move, you'll need one or more DC motors (along with a motor driver). They come in different sizes and types, such as brushed or brushless. Micro metal gear-motors feature a built-in gearbox that can alter the output rpm (i.e. speed) and torque. The higher the gear ratio, the higher the output torque, but lower the top speed. While standard continuous rotation motors are ideal for wheeled robots, servos or stepper motors are far better when precision movement is required.



### Bubble Machine

An H-bridge is used to drive two DC motors: one in a fan that spins to make the bubbles; the other to turn a wheel with holes in it for bubbles to pass through

[hsmag.cc/BubbleMachine](http://hsmag.cc/BubbleMachine)

## ***REAL-TIME CLOCK***

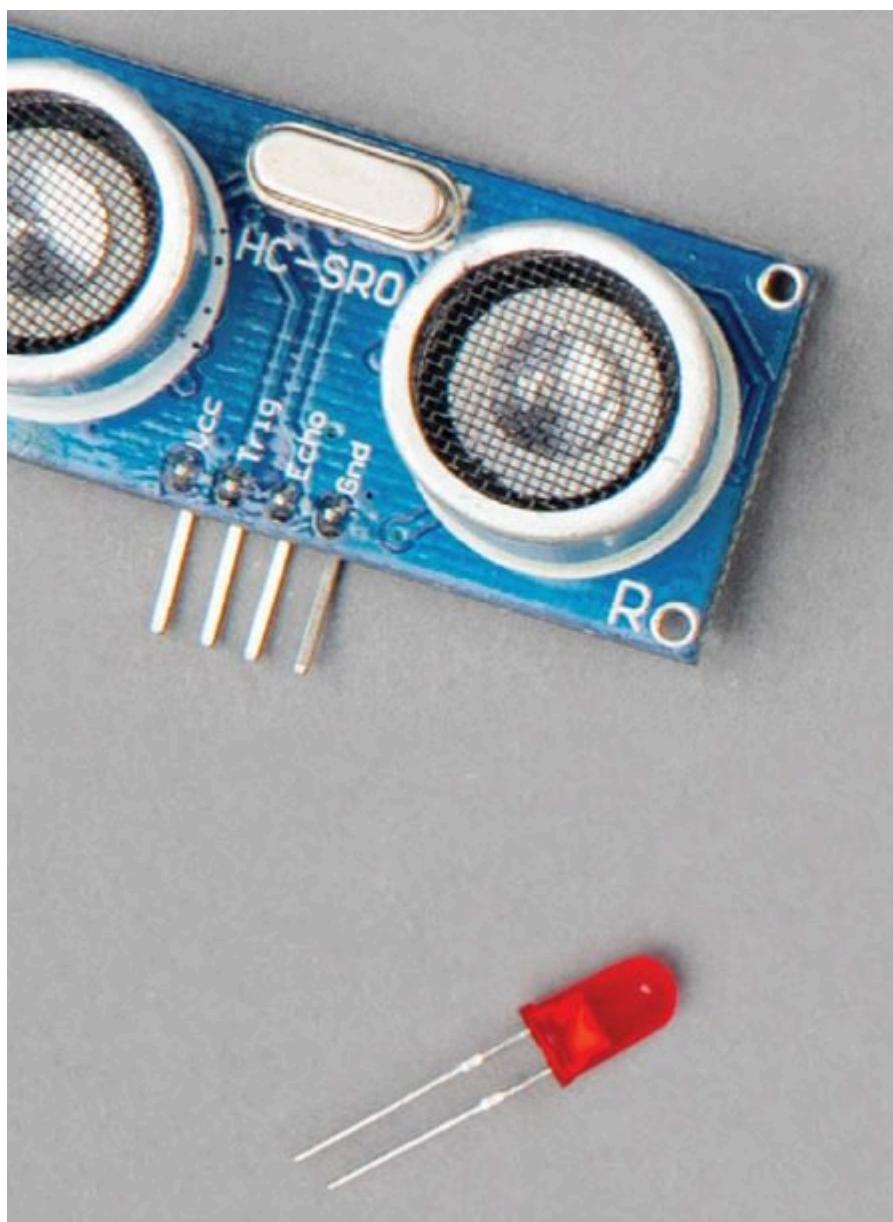
If you want your microcontroller project to keep track of time when it's powered down, you'll need a real-time clock (RTC) module. Powered by a backup battery, usually a coin cell, this type of integrated circuit will supply the correct time when the project is powered back on. It's ideal for use in DIY alarm clocks, calendars, or anything that requires a timer.



### PicoClock

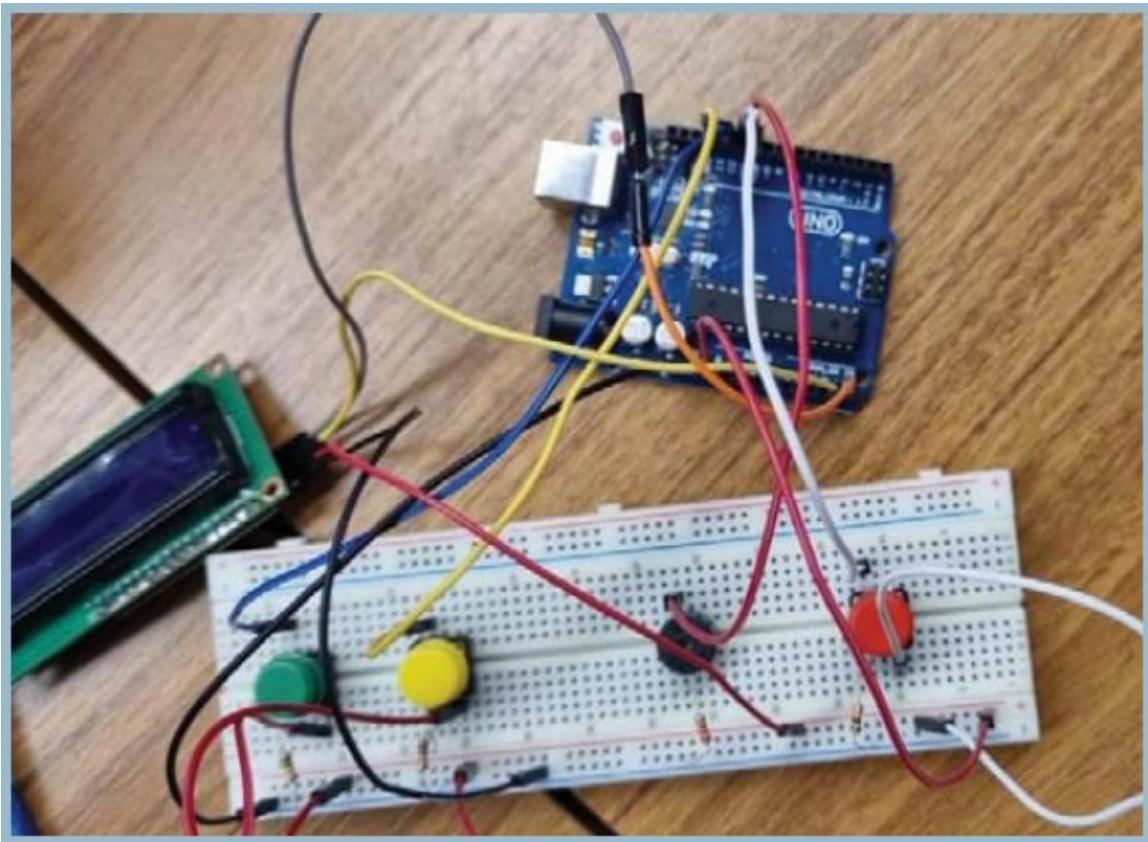
This multifunctional mini clock features a high-accuracy RTC module to keep the right time. A Li-ion battery is used to power the RTC

[hsmag.cc/RTCPicoClock](http://hsmag.cc/RTCPicoClock)



## **SWITCH**

One of the most common input devices in electronics projects is the momentary switch. The most common type only outputs a signal when kept pressed. Another type is the latch switch, which stays on/off after being pressed. They come with two or four legs, only two of which need to be connected to an I/O pin and ground.



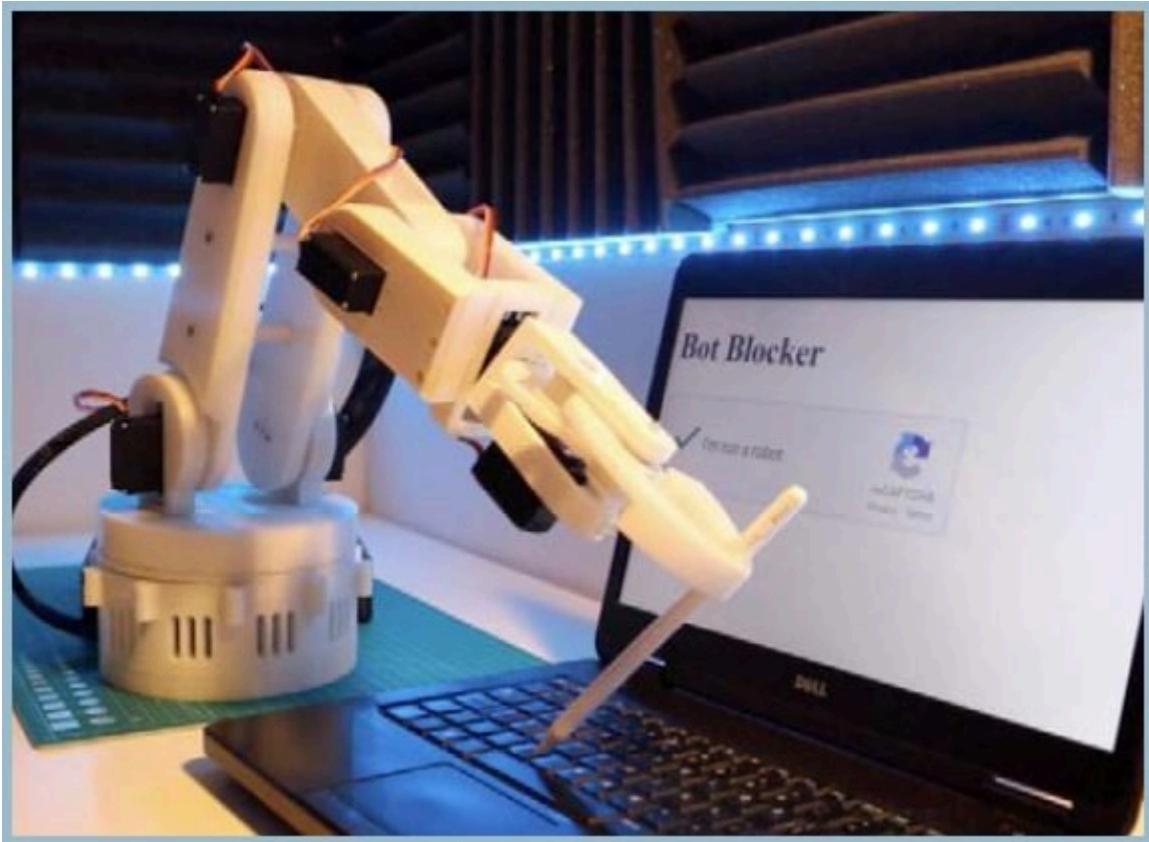
### Morse Code Converter

Using three push-buttons, this Arduino project lets you translate the dots and dashes of Morse code into text on a mini display

[hsmag.cc/MorseConverter](http://hsmag.cc/MorseConverter)

## ***ROBOTIC ARM***

Often used in industry, robotic arms are able to manipulate objects and perform repetitive tasks, such as ‘pick and place’. Hobbyist kits range from lightweight arms to more robust heavy-duty ones – with a very wide price range. The number of degrees of freedom (DOF) indicates how many servo-powered joints they have. Check out the power and accuracy ratings too.



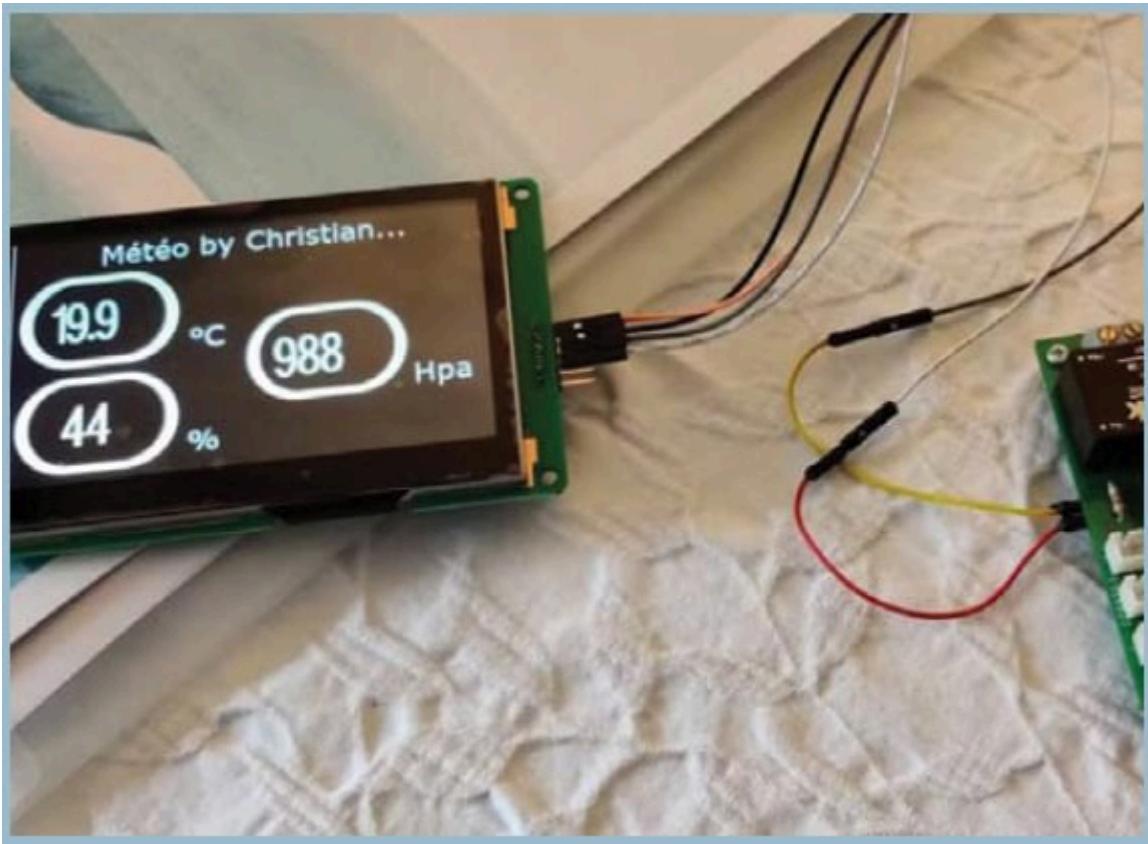
## MARK1

Comprising 3D-printed parts, this Arduino arm has 6DOF and can mimic the hand gestures of the wearer of a glove fitted with sensors

[hsmag.cc/ArduinoArm](http://hsmag.cc/ArduinoArm)

## PRESSURE SENSOR

This type of sensor measures the barometric pressure of the atmosphere, which in turn can be used to calculate the altitude. Some sensors can measure both temperature and pressure (e.g. BMP280) – and some add humidity too, such as the popular BME280. Another type of sensor can measure the pressure of a liquid.



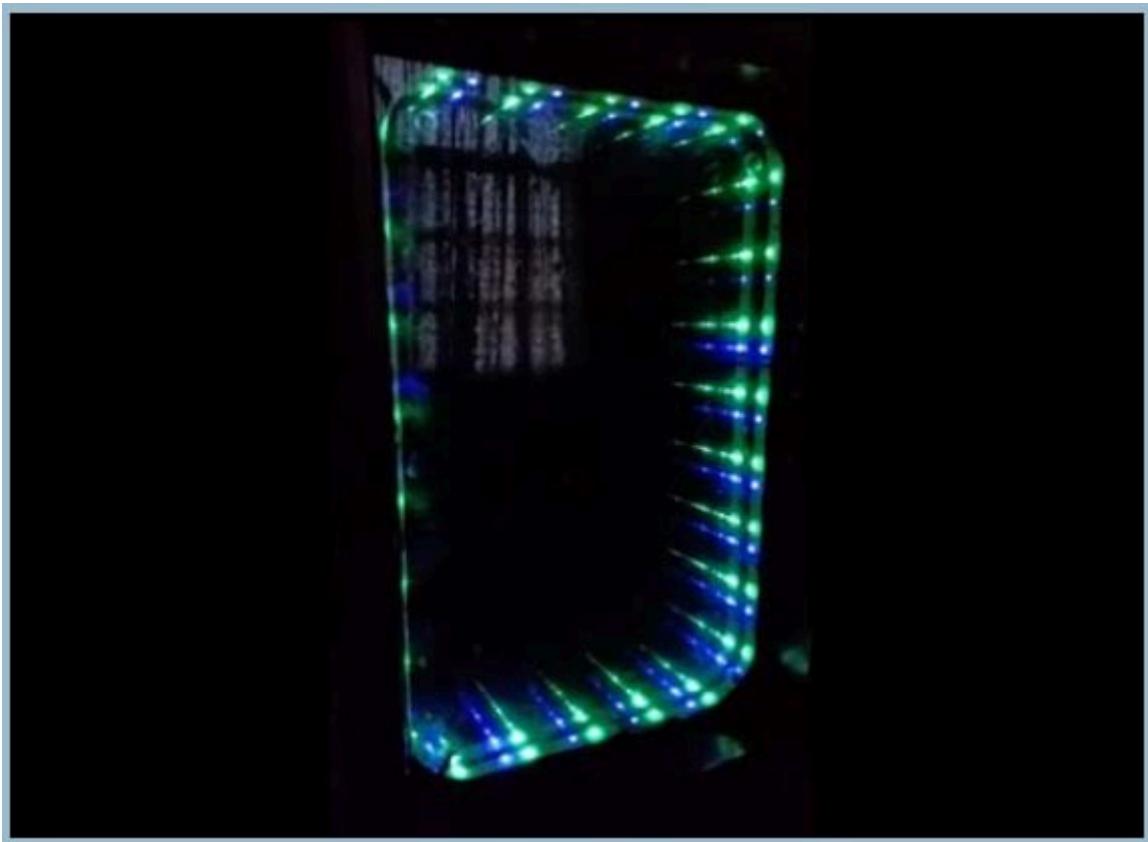
### Touchscreen Barometer

Making use of a BME280 sensor, to measure pressure along with temperature and humidity, this Arduino barometer project outputs the data on a mini touchscreen

[hsmag.cc/ArduinoBarometer](http://hsmag.cc/ArduinoBarometer)

## BIPOLAR JUNCTION TRANSISTOR

The invention of the transistor eliminated the need for vacuum-tube valves for electrical signal switching and amplification. Bipolar junction transistors (BJTs) come in two main types: NPN and PNP, for use in the negative and positive side of a circuit, respectively. A base terminal is used to control the current flowing between the collector and emitter terminals.



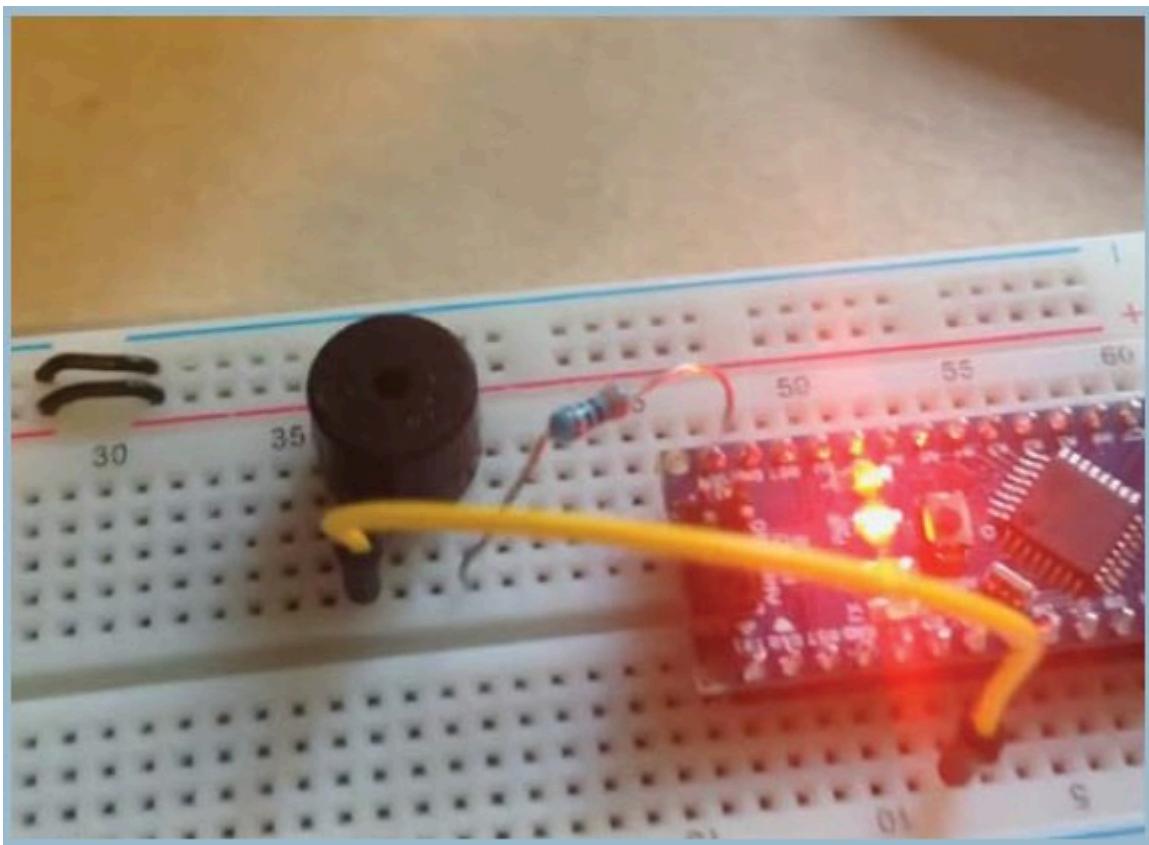
### RGB Infinity Mirror

Comprising two BJTs, Darlington transistors (aka pairs) are used to amplify current. In this project, they're used to drive a long RGB LED strip

[hsmag.cc/RGBIInfinityMirror](http://hsmag.cc/RGBIInfinityMirror)

## PIEZO BUZZER

Another type of output device, a piezoelectric buzzer can emit simple buzzing sounds. By varying the PWM signal to it from your microcontroller, it's even possible to change the pitch to create rudimentary music. There are two main types of buzzer: active and passive. Active buzzers are far easier to use, as they generate their own oscillations for the buzz.



### Musical Buzzer

By varying the PWM signal, you can get a piezo buzzer to make music, such as the Super Mario theme. You just need to know the required frequency for each note

[hsmag.cc/MusicalBuzzer](http://hsmag.cc/MusicalBuzzer)

## CUSTOM PCB

Using a breadboard or perfboard is fine for prototyping projects, but for a better end product you'll want to create a custom PCB. Designing one is not as daunting as you might think, using free software such as EasyEDA, and you can get it manufactured by a supplier at fairly low cost. Check out the beginner's guide we brought you in HackSpace issue 48 ([hsmag.cc/issue48](http://hsmag.cc/issue48)).



### Reflow Oven PCB

This custom PCB was created to drive a reflow oven for the soldering of surface-mount electronic components to PCBs

[hsmag.cc/ReflowOvenPCB](http://hsmag.cc/ReflowOvenPCB)

## MOSFET

A MOSFET (metal oxide semiconductor field-effect transistor) controls the flow of electricity between its source and drain terminals depending on the voltage applied to its gate terminal. This makes it useful for switching or amplifying high-power DC electronic signals. In particular, it can switch them on and off more quickly than a relay can.



Pico DC Fan Driver

To drive the DC motor load for the fan, a high-power AO4406 N-channel MOSFET is used for fast switching purposes

[hsmag.cc/PicoFanDriver](http://hsmag.cc/PicoFanDriver)

## ***ULTRASONIC DISTANCE SENSOR***

Using a form of sonar, this type of sensor emits ultrasonic pulses and then listens for the echoes; the time delay is used to calculate the distance to a nearby object. This makes it ideal for an obstacle avoidance system in a wheeled robot, which can detect walls or other obstacles and take evasive action. The popular HC-SR04 sensor has a range of 2–400 cm and is accurate to around 3 mm.



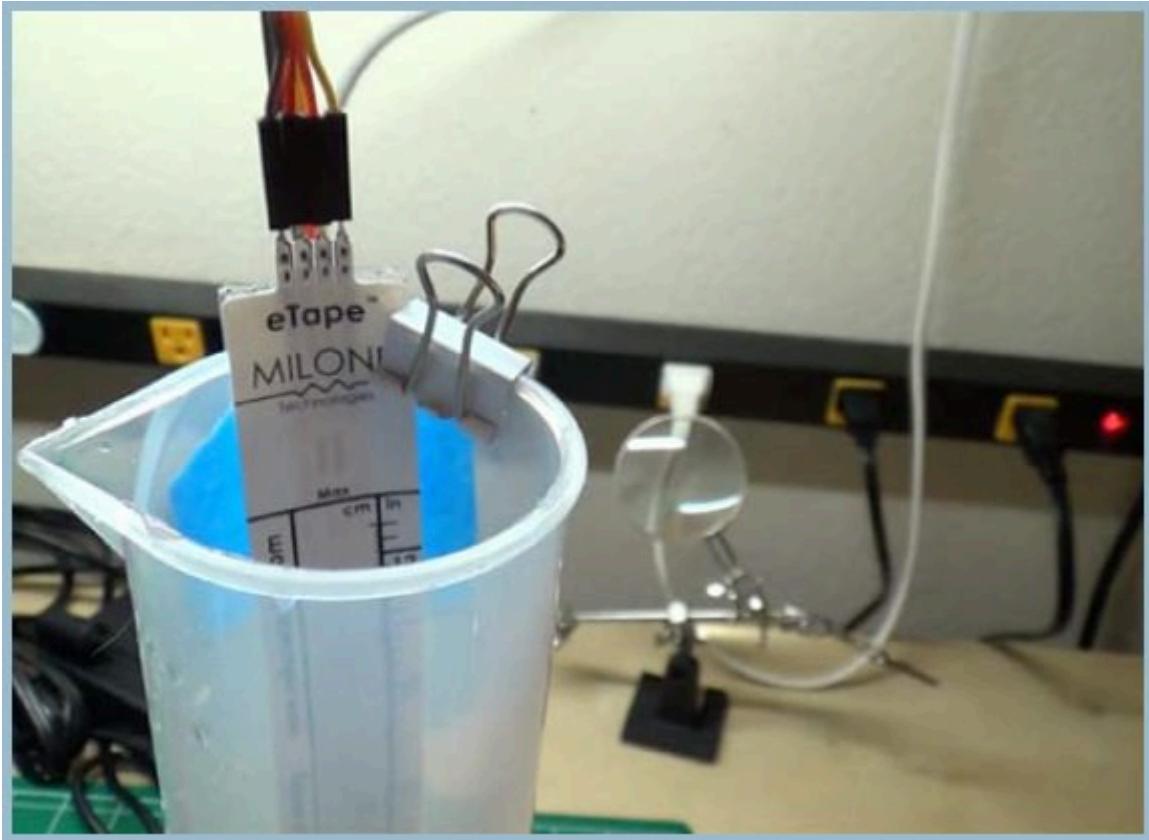
### Parking Aid

Ultrasonic distance sensors are fitted on the rear of many cars to aid parking. This garage parking aid operates in a similar way, using an HC-SR04 sensor on the wall

[hsmag.cc/ParkingAid](http://hsmag.cc/ParkingAid)

## **LEVEL SENSOR**

This type of sensor is ideal for measuring the level of a liquid, such as in a water tank. The most common low-cost version measures the conductance between metal strips or prongs, similar to the method used by a soil moisture sensor. As the water gets higher, the conductivity level increases across the strips, boosting the signal sent from an analogue output.



Smart Measuring Cup

The eTape liquid level sensor here alters its resistance output according to the level of the water in the cup, with the volume displayed on a web page

[hsmag.cc/MeasuringCup](http://hsmag.cc/MeasuringCup)

## POTENTIOMETER

A potentiometer, or ‘pot’ for short, is a type of variable resistor. There are two main types: rotary (with a knob) and linear (slider). As you turn the knob (or move the slider along), the level of resistance is altered, affecting the voltage output from an analogue pin. While pots have many uses, the most common is as a control method, such as for audio volume on a sound system.



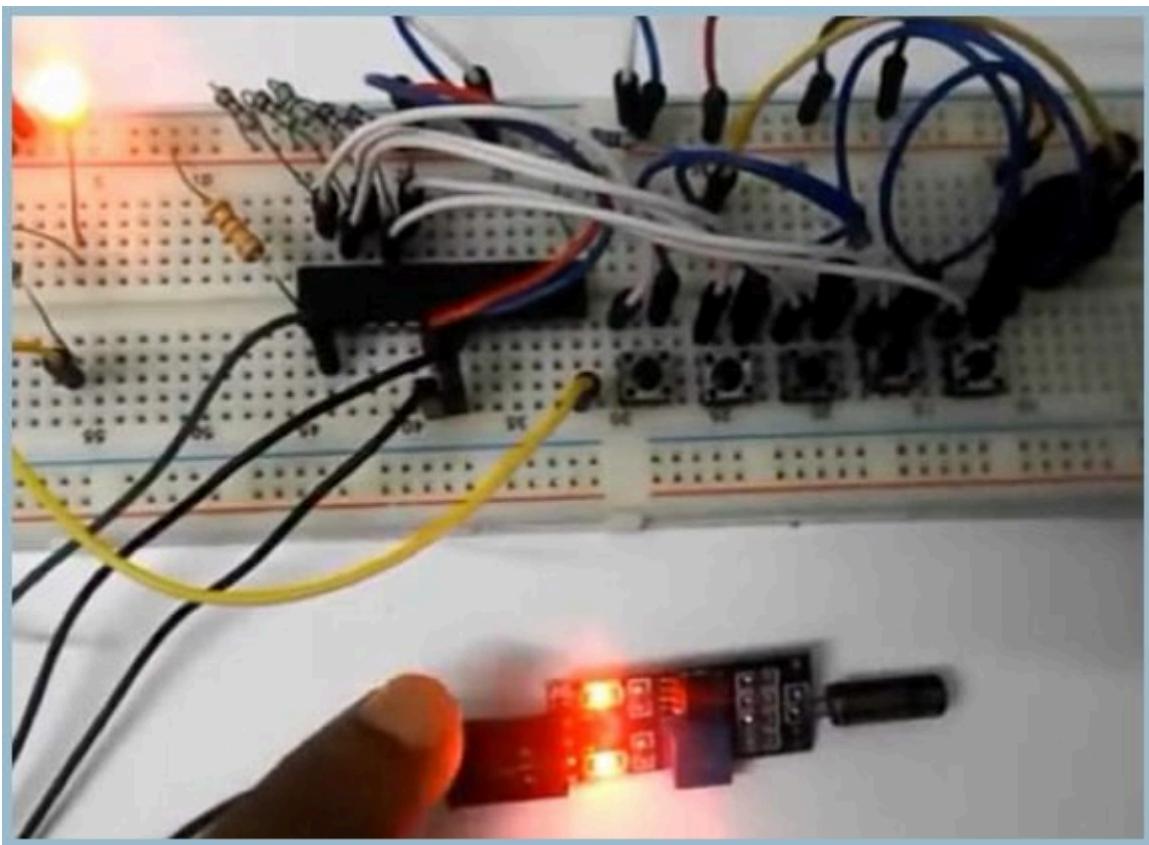
### Bike Stereo System

In this fun project to add a 20 W sound system to a push-bike, a potentiometer is used to adjust the volume of the music

[hsmag.cc/BikeStereo](http://hsmag.cc/BikeStereo)

## **TILT SWITCH**

Old-fashioned tilt switches used mercury, which is highly toxic, so it's best to avoid those. These days, a non-toxic substance is used to conduct electricity between the two contacts of a switch. This only happens when the switch is tilted beyond a certain angle. An alternative type uses a tiny ball in a cage to connect the contacts at an angle.



### Anti-Theft Alert System

A ball-and-cage tilt switch is used for this demonstration of a simple anti-theft alert system, triggering an LED and buzzer alarm when moved

[hsmag.cc/TiltAlarm](http://hsmag.cc/TiltAlarm)

## GAS SENSOR

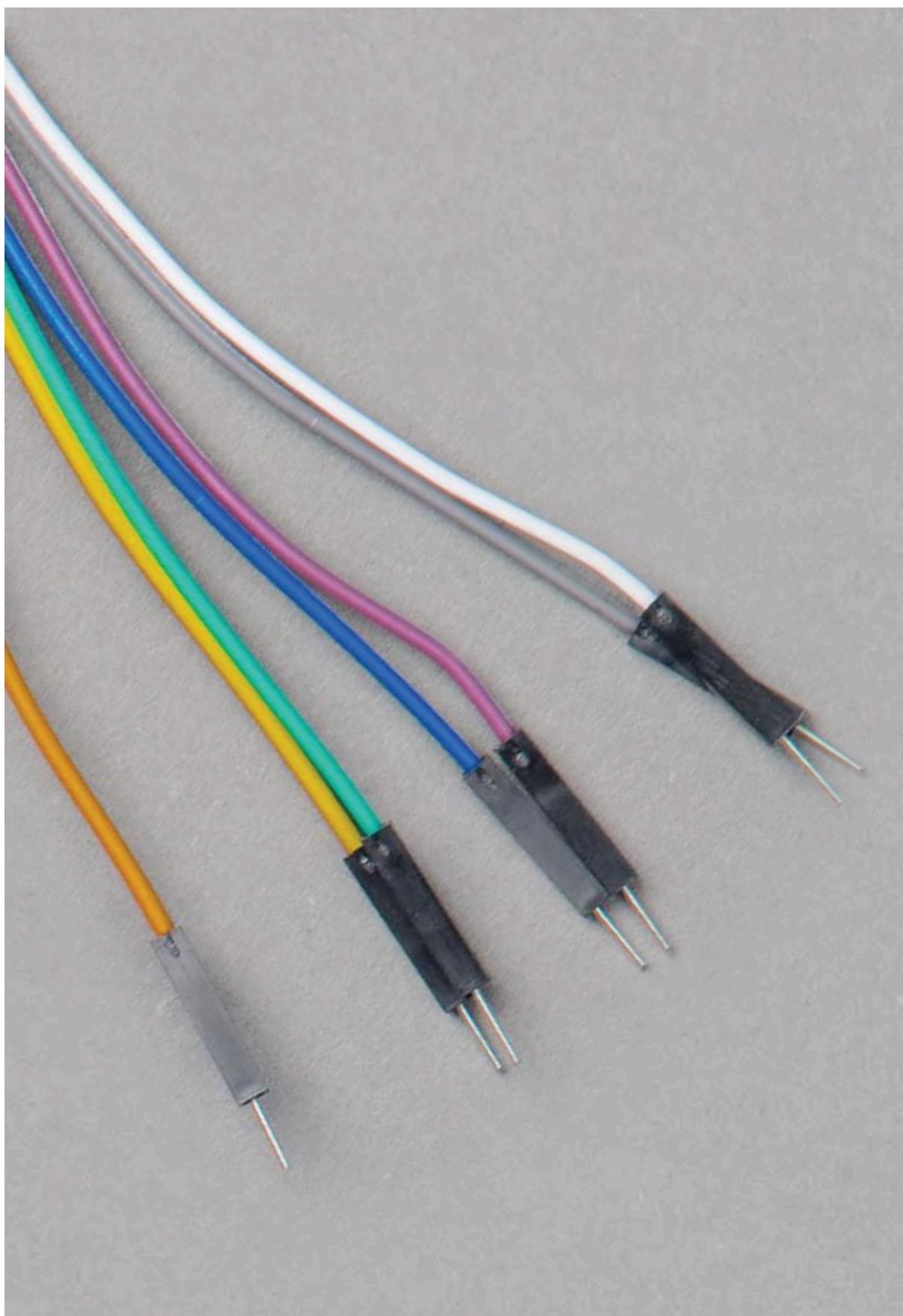
There are several low-cost gas sensors available, each able to detect different toxic gases in the air. For instance, the MQ5 sensor can detect the presence of LPG, natural gas, and coal gas, so is ideal for making a gas leak alarm. The MQ9 can also detect carbon monoxide. While most such sensors have an analogue signal output, some also have a digital one.



### Gas Analyser

This Arduino-based analyser packs three different gas sensors (MQ4, MQ5, and MQ135), along with a DHT11 for temperature and humidity monitoring

[hsmag.cc/GasAnalyser](http://hsmag.cc/GasAnalyser)



## **RFID AND NFC**

Radio-frequency identification (RFID) is a contactless technology that enables devices to send data without a wired connection. NFC (near-field communication) is a subset of RFID that permits two-way data exchange at short range (a few centimetres). Passive RFID and NFC tags require no independent power source, as they're powered by the receiving device's radio waves. Uses include for door entry systems, pet feeders, and triggering home automations.



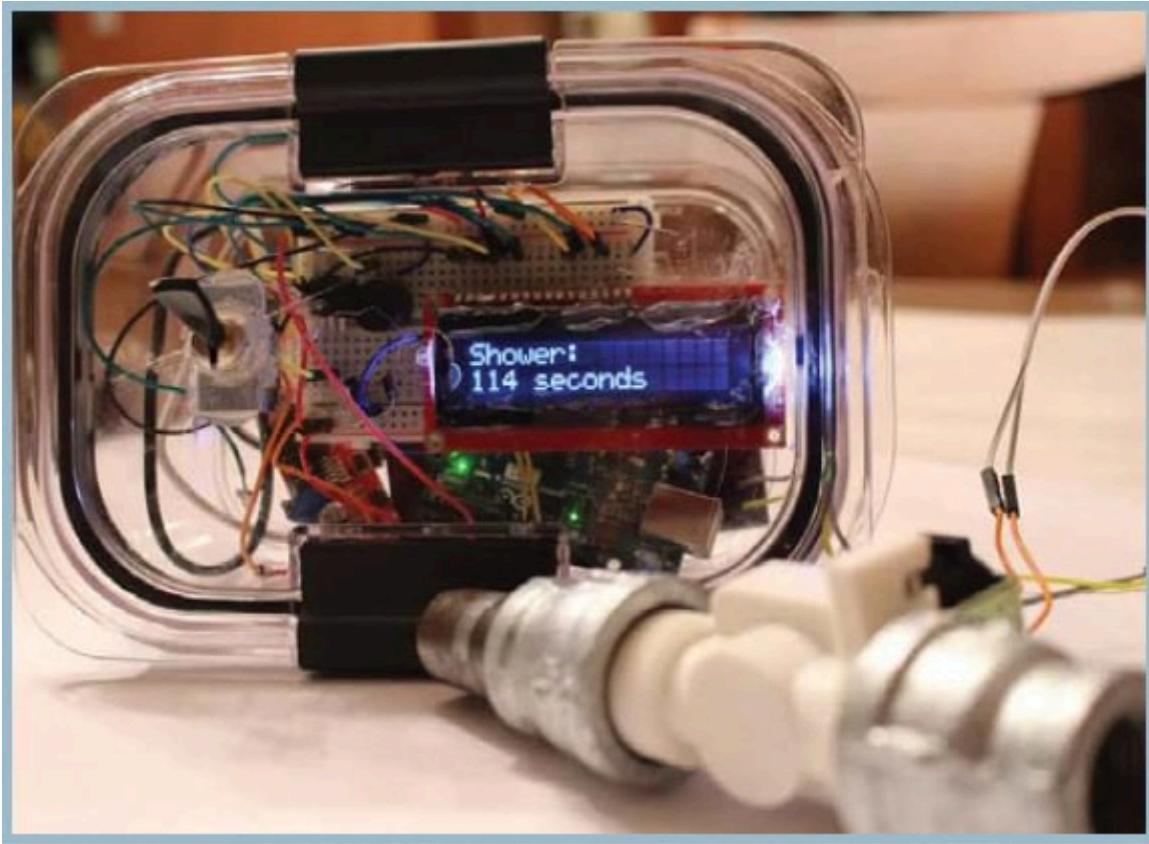
**Paper Man**

An Arduino NFC shield is used here to transfer messages from a phone to the 'paper man', who then spits them out via a thermal printer in his mouth

[hsmag.cc/PaperMan](http://hsmag.cc/PaperMan)

## **SOLENOID**

A solenoid is an electromagnet in which the core can move back and forth, making it useful as a switching mechanism. Solenoids often have a spring to return the core to a rest position when the voltage is turned off. Note that since solenoids require more power than a microcontroller can supply, you'll need a driver board or circuit to use them.



Shower Regulator

A solenoid can be fitted in a valve to control the flow of water, such as in this Arduino project that limits your time in the shower before shutting off the water

[hsmag.cc/ShowerRegulator](http://hsmag.cc/ShowerRegulator)

## SIGNAL FILTERING AND AMPLIFICATION

With the use of capacitors along with resistors or inductors, an electronic signal (such as that generated by an oscillator circuit) can be filtered, enabling only certain frequencies to pass through, thus reducing unwanted signal noise. Signals can also be boosted with a transistor-based amplifier circuit. These concepts are used in IC-based op-amps, sophisticated differential amplifiers with high gain.



### Metal Detector

In this simple metal detector, a Colpitts oscillator comprising an inductor and two capacitors produces stable sinusoidal oscillations for the electromagnet field to detect metal objects

[hsmag.cc/MetalDetector](http://hsmag.cc/MetalDetector)

### **MINI DISPLAY**

If you want to show a readout of data without connecting your microcontroller to a computer, you'll need a mini display. They come in a range of sizes and types, such as standard LCD (liquid crystal display), TFT (thin-film-transistor LCD, and OLED (organic light-emitting diode). Or there's the classic seven-segment LED type. Another option is an e-ink/e-paper screen, which only uses power when updating.



### PiConsole

Mini colour displays are ideal for use in portable video game systems such as this Pico-powered retro console, which features a 1.54-inch OLED

[hsmag.cc/PiConsole](http://hsmag.cc/PiConsole)

## REED SWITCH

These magnetically operated switches typically feature two thin, flexible 'reeds' – metal wires or blades – with a small gap between them in a sealed glass bubble. When a magnetic field is applied, it pushes the reeds together so they make contact. That's in the most common, normally open (NO) variety – in a normally closed (NC) switch, the reeds are pulled apart. There's also the changeover type, in which a reed is moved to switch contact between two other reeds.



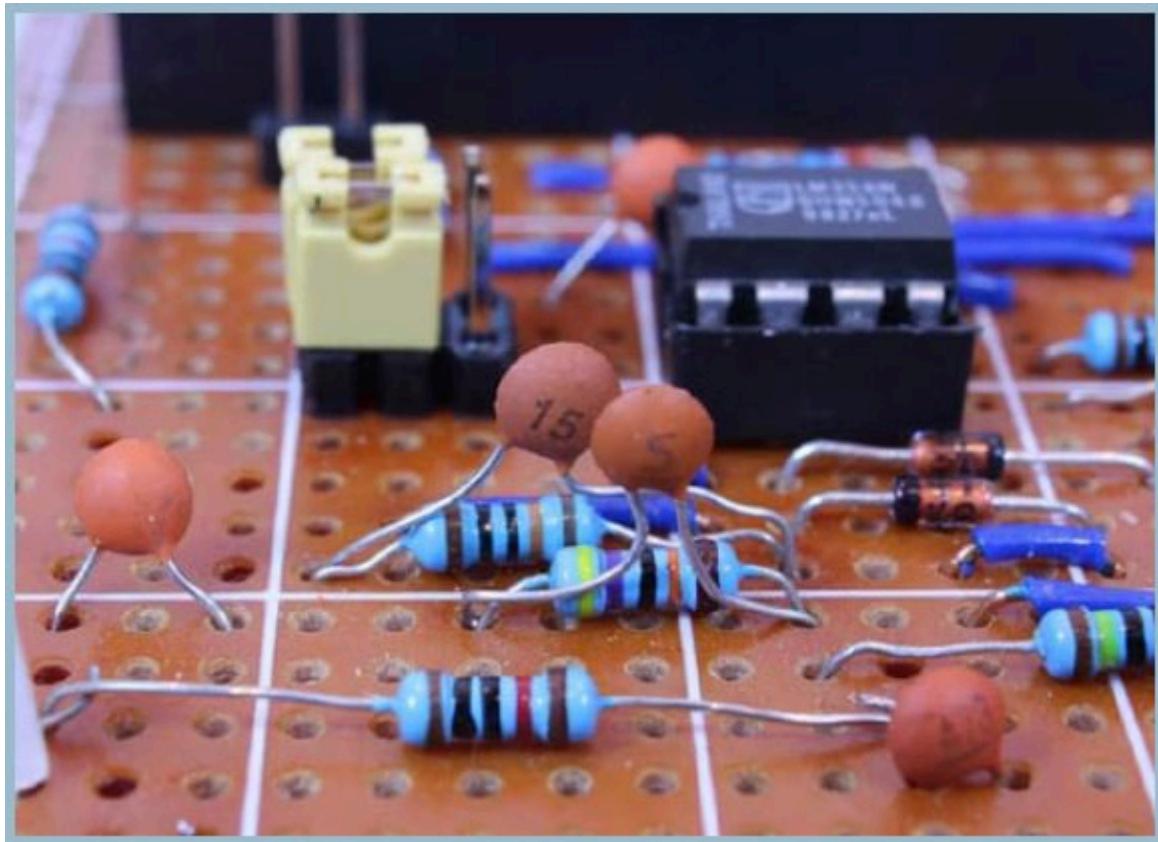
### Bike Speedometer

A reed switch (on the wheel spokes) and magnet (on the bike frame) are used to count the wheel rotations and calculate the bike's speed

[hsmag.cc/BikeSpeedo](http://hsmag.cc/BikeSpeedo)

## CAPACITOR

Found in most electrical devices, capacitors are able to store electrical charge, similar to a battery but able to discharge far more quickly. Uses include power regulation and signal filtering. They come in a variety of values, shapes, sizes, and materials. A capacitor's 'breakdown voltage' is the highest it can accept before breaking down, so make sure not to exceed that.



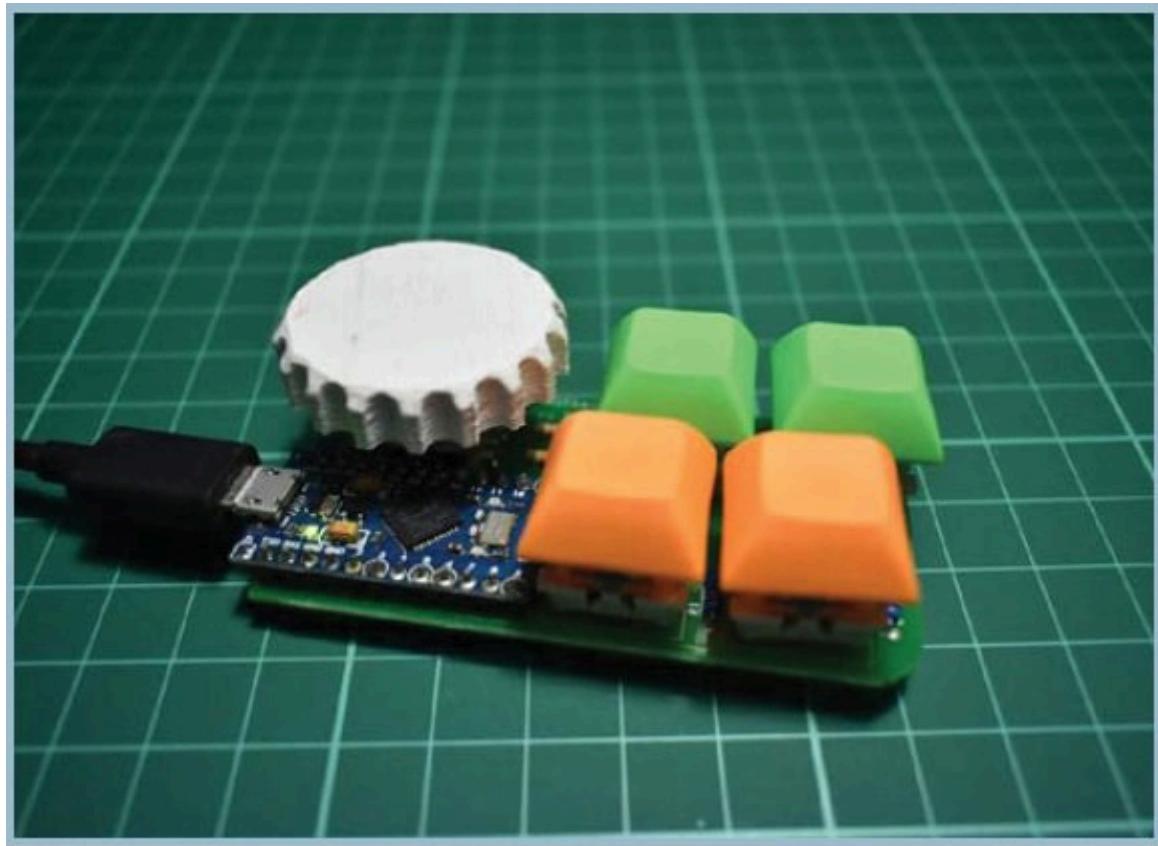
Stripboard Oscilloscope MkII

The performance of this Pico-based oscilloscope was improved by simply adding two capacitors in the feedback path of the LM358 op-amp

[hsmag.cc/PicoOscilloscope](http://hsmag.cc/PicoOscilloscope)

## **ROTARY ENCODER**

Unlike the similar-looking rotary potentiometer, an encoder generates digital (not analogue) signals as you turn the knob. There are two main types of encoder: absolute (which detects the position set) and incremental (which only senses movement in either direction). So make sure you pick the right one for your project. Encoders typically double as a push-button when you press them in. There is also no limit to the number of rotations that can be made, unlike a pot.



### HotKeys v2

Rotary encoders are often included in mechanical keyboards, for the scrolling of pages etc. This one is in a programmable macro keypad

[hsmag.cc/HotKeys](http://hsmag.cc/HotKeys)

## **CONDUCTIVE MATERIALS**

You don't have to use jumper wires to connect components in a prototype circuit. Alternatives include conductive thread, ideal for wearables, and conductive ink. Used with a rollerball pen, the latter enables you to scribble a working circuit design on a piece of paper – great for learning. Or you can use pieces of copper tape to create a circuit. There's also conductive paint, although that may be more useful for creating capacitive touch inputs.



### Sparkle Skirt

Conductive thread is great for connecting components in wearable projects such as this light-up sparkle skirt controlled by an Adafruit FLORA microcontroller

[hsmag.cc/SparkleSkirt](http://hsmag.cc/SparkleSkirt)

## **DIODE**

While an LED is a specialised type of diode, the key property of diodes in general is that they allow electrical current to only flow in one direction. In addition to standard diodes, Zener and Schottky diodes have special characteristics. Common diode uses include power rectification (including converting AC current to DC), back EMF protection to prevent very high voltages, power gates to switch between two sources, and clamps to limit voltage.



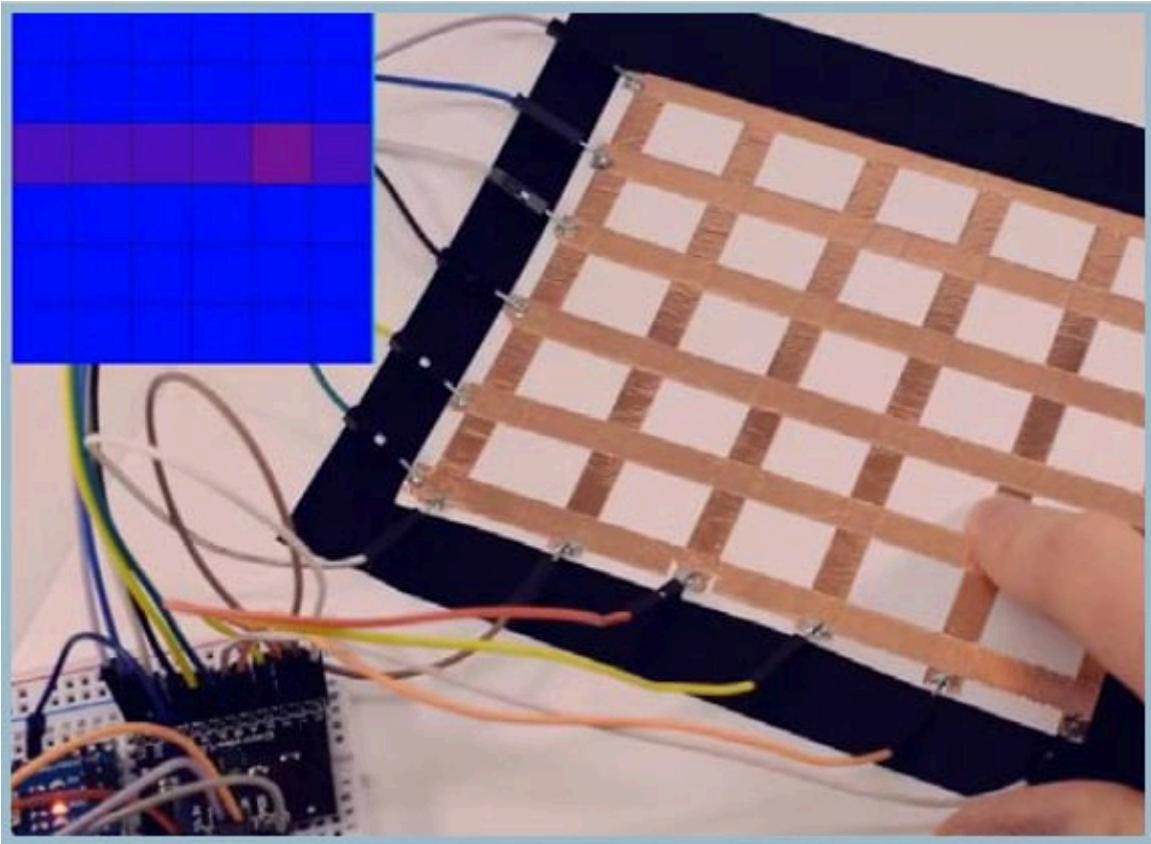
### Flame Painting

Diodes are useful for regulating the power supply to NeoPixels, such as in this illuminated artwork, to avoid damaging spikes

[hsmag.cc/FlamePainting](http://hsmag.cc/FlamePainting)

## TOUCH INPUT

As well as for screens, capacitive touch can be used for touch-activated switches. While you can buy capacitive touch pad breakouts, you don't need one to try out the concept. Simply connect a high-rated (e.g. 1 megohm) pull-down resistor between a microcontroller ground pin and I/O pin, with a jumper wire coming from the latter to act as a touch input. Or you can connect the wire to any conductive item, such as a piece of aluminium foil or even a piece of fruit.



### Sensing Grid

This Arduino project uses a capacitive touch sensor breakout to turn a grid of copper tape strips on some paper into a multi-touch input device

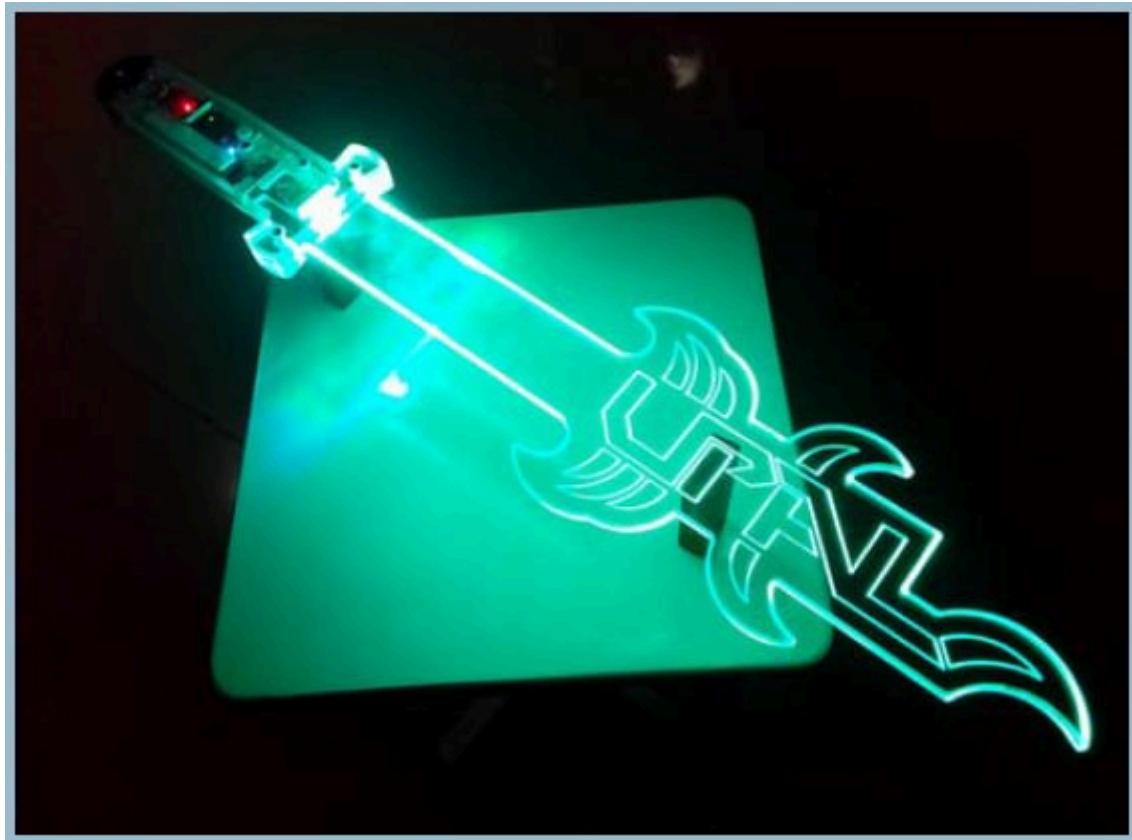
[hsmag.cc/SensingGrid](http://hsmag.cc/SensingGrid)



## COLOUR SENSOR

As the name suggests, this type of optical sensor (such as the TCS230 or TCS3200) can detect a variety of colours. Some of its multiple photodiodes are equipped with different

coloured filters (typically red, green, and blue), enabling it to calculate the shade of a nearby surface illuminated by a bright white LED.



Light Painting Sword

This smart light-up sword has a colour sensor on the hilt that picks up the shade of the wielder's clothes so the RGB LED colour can be matched

[hsmag.cc/LightSword](http://hsmag.cc/LightSword)

## **BUCK CONVERTER**

When powering multiple parts of a project from a single source, you may well need to reduce the voltage for your microcontroller or other components. A buck (aka step-down) converter will do this, while also helping to regulate the power supply and eliminate voltage spikes. You can also boost a battery's voltage, if needed, using a step-up converter. For more info, see the 'Don't forget the batteries' tutorial in HackSpace issue 76 ([hsmag.cc/issue76](http://hsmag.cc/issue76)).



### Dog Ball Launcher

This 3D-printed dog ball launcher needs power for two 12 V motors, but just 3.3 V for the Pico microcontroller, for which it uses a DC buck converter

[hsmag.cc/DogBallLauncher](http://hsmag.cc/DogBallLauncher)

## **LIGHT SENSOR**

The most basic form of light sensor is an LDR (light-dependent resistor), whose output voltage alters according to the light level falling on its surface. It's not very accurate, but fine for detecting changes in the light level, making it usable in an intruder alarm. Other, more sophisticated light sensors, such as the LTR-559, give accurate digital readings.



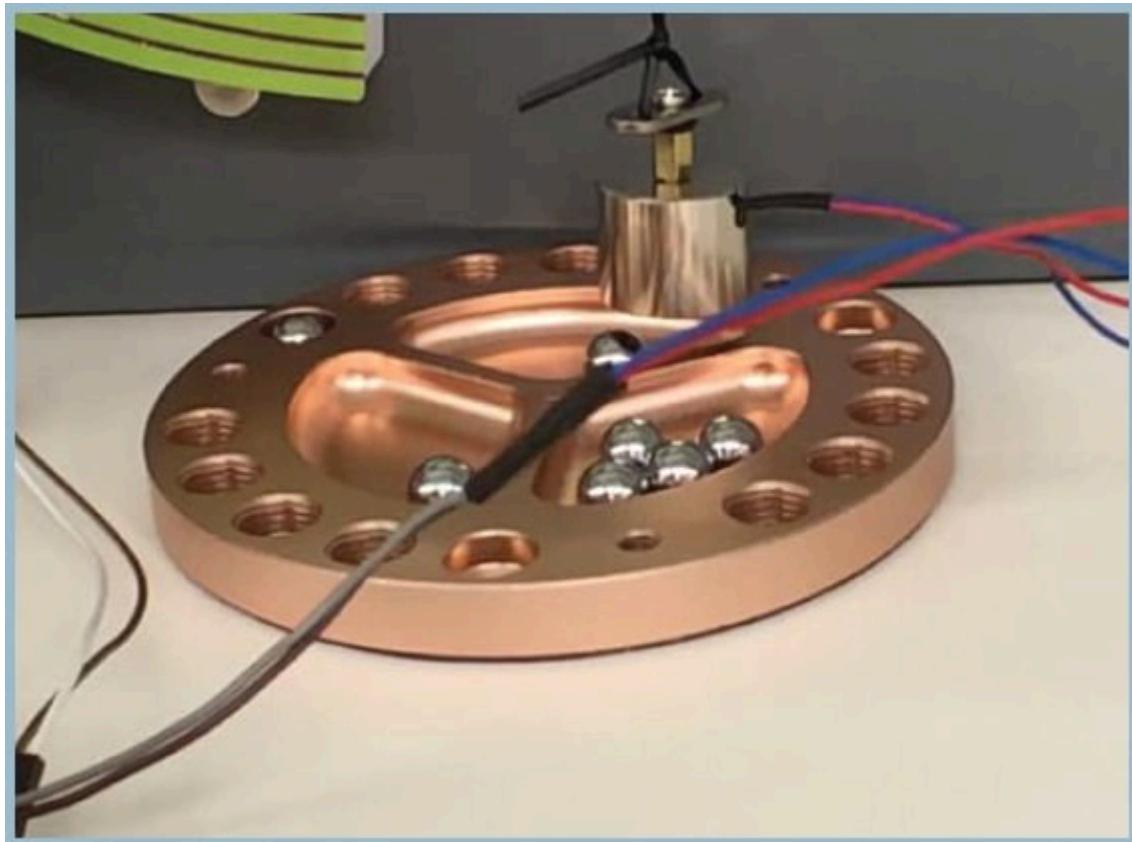
### Optical Glove Controller

This glove controller has a flexible tube that has an LDR and LED at either end – when flexed, the drop in the light level is sensed

[hsmag.cc/OpticalGlove](http://hsmag.cc/OpticalGlove)

## ***INDUCTOR / ELECTROMAGNET***

At its most basic, an inductor is a coil of wire; when you apply a voltage to it, a magnetic field is generated and grows stronger. When the field eventually collapses, the stored electricity is released. Therefore, inductors are useful for storing and delivering energy, as well as for slowing current surges and spikes. Wrap the coil round a metal core and you can create an electromagnet, which is only magnetic when power is applied.



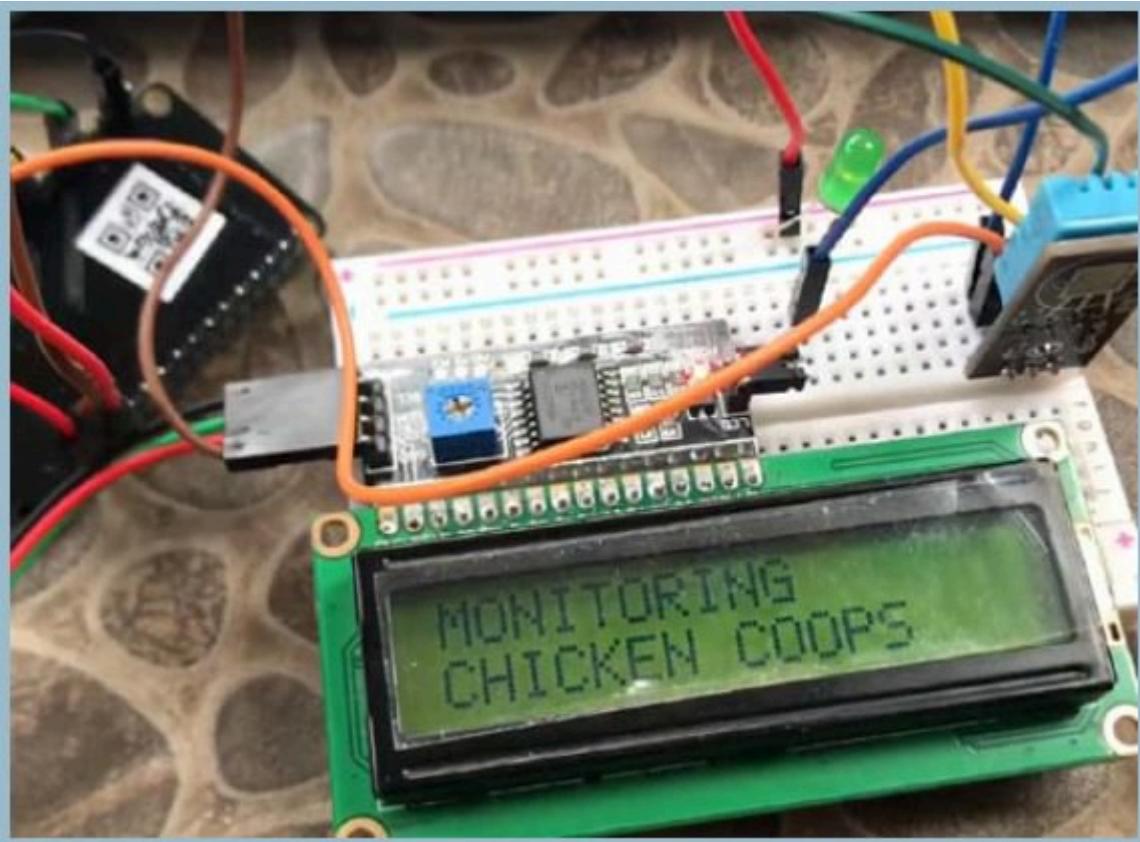
### Mag-Neat-o

An electromagnet can be turned on and off to pick up and drop metal objects such as ball bearings, as in this project

[hsmag.cc/MagNeato](http://hsmag.cc/MagNeato)

## **TEMPERATURE SENSOR**

There are many types of temperature sensor, some of them housed in a metal probe on a wire that can be placed in a medium such as soil. A couple of the most common types are the low-cost DHT11 and DHT22, which also measure relative humidity and give a digital output. They're a little basic, but fine for most hobbyist projects.



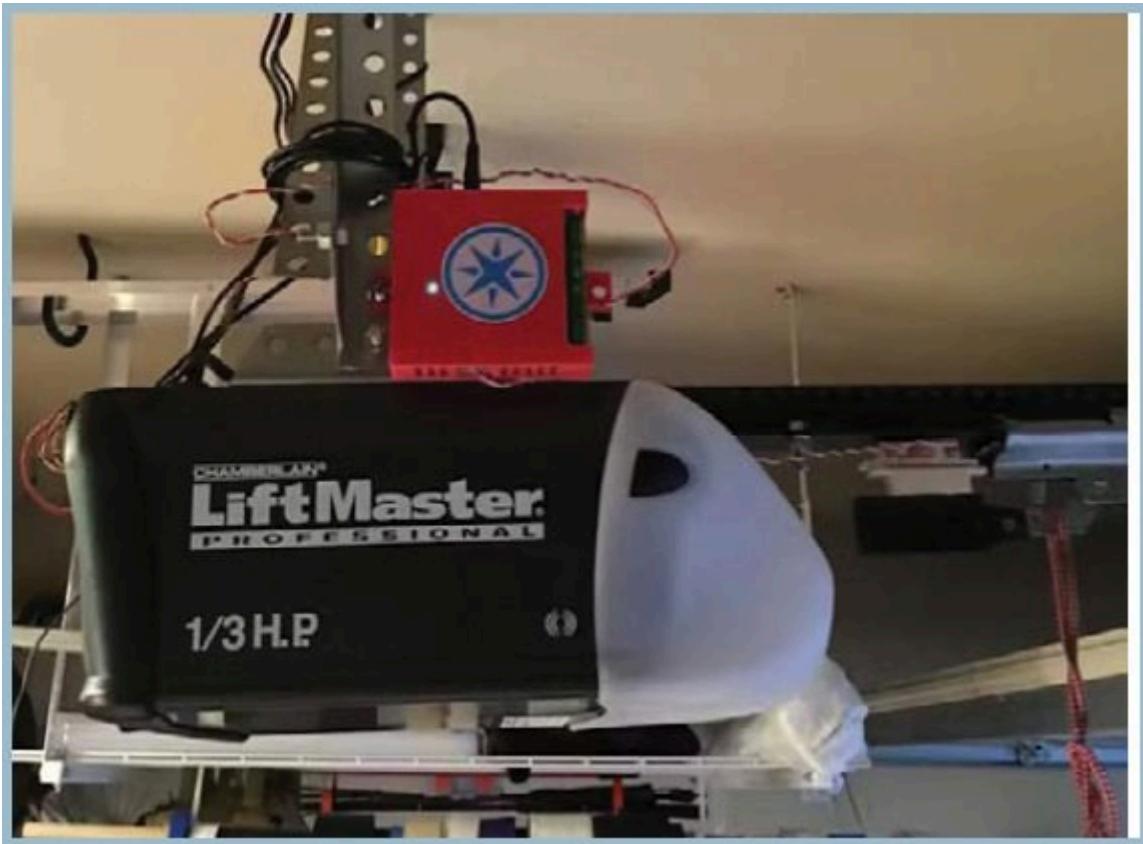
Chicken Coop Monitor

Here, a DHT11 temperature sensor wired to an ESP32 microcontroller is used to monitor the conditions in a chicken coop to help ensure the birds' well-being

[hsmag.cc/ChickenCoopTemp](https://hsmag.cc/ChickenCoopTemp)

## ***RELAY***

A relay is an electromechanical switch that can be closed or opened by applying a control signal. It is especially useful when you need to switch higher voltage or currents than your microcontroller can handle – make sure to note the relay's maximum load, however. While some relays can handle mains AC voltage, you shouldn't attempt this unless you really know what you're doing – even then, make sure to use an RCD.



### Hands-Free Garage Door

Equipped with a high-power relay shield, a Particle Spark Core microcontroller board is able to drive a motorised garage door opener

[hsmag.cc/GarageDoor](http://hsmag.cc/GarageDoor)

## SERVO

A servo is a special type of DC motor that (in most cases) only moves within a limited range, typically 180 degrees. The upside is that, with a built-in potentiometer, the angle can be set by a PWM control signal. This enables any component attached to the servo's 'horn' to be moved to the desired position. Among other uses, servos feature commonly in robotic arms, legs, and grippers.



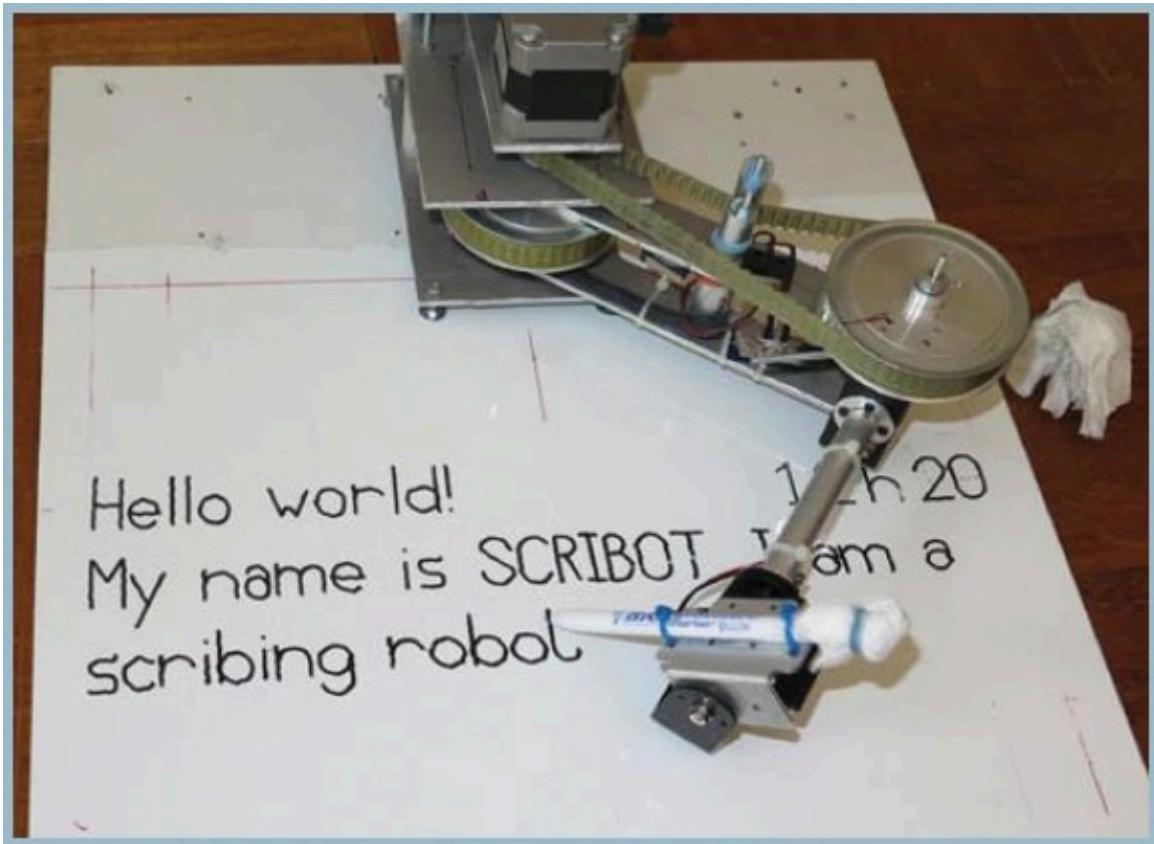
Robotic Hand

This 3D-printed hand features five servos, each of which pulls a thin wire to move a finger to match the movements of a glove with flex sensors

[hsmag.cc/RoboticHand](http://hsmag.cc/RoboticHand)

## **STEPPER MOTOR**

An alternative to a servo motor, this is a type of brushless DC motor that divides a full 360° rotation into a number of steps – determined by the step angle. Unlike a servo, it does not require a feedback mechanism for a microcontroller to read its position, since it can be commanded to move a set number of steps. Stepper motors are commonly used in 3D printer mechanisms and CNC machines.



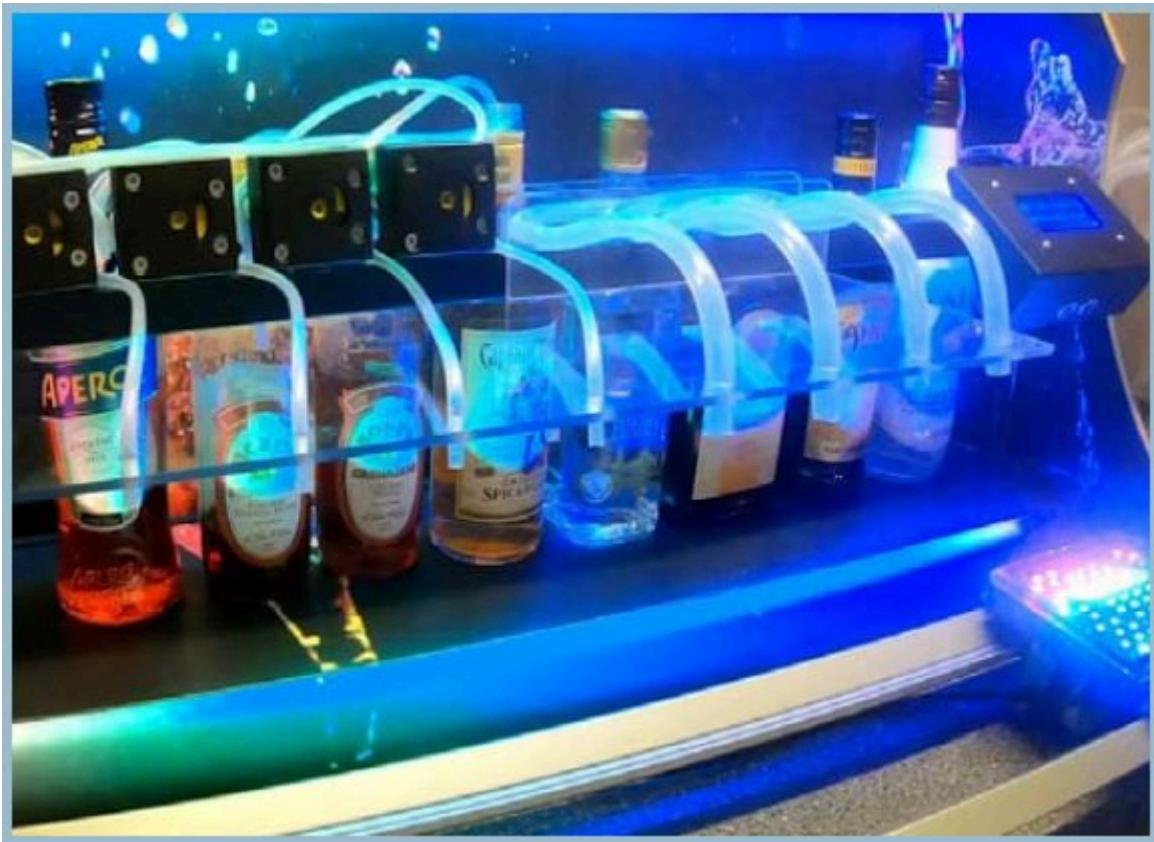
### Scribot

This scribing robot arm is equipped with stepper motors for precision movement as it faithfully reproduces vector letters to write messages

[hsmag.cc/Scribot](http://hsmag.cc/Scribot)

## **LIQUID PUMP**

The ability to control the pumping of a liquid through a tube is useful in projects such as a plant waterer or drinks dispenser. The most common type of pump used in hobbyist electronics is the peristaltic pump. Using a high-torque DC motor to alternately squeeze and relax a flexible silicone tube, it never comes into contact with the liquid.



### Cocktail Machine

The makers of this Arduino-based drinks dispenser opted to use air pumps, rather than peristaltic ones, for faster pouring

[hsmag.cc/DIYCocktail](http://hsmag.cc/DIYCocktail)

## ***IMU***

An inertial measurement unit (IMU) enables you to sense how a device or vehicle is moving and oriented. It usually comprises an accelerometer, gyroscope, and magnetometer. IMUs are used in commercial products such as smartphones, fitness trackers, and some game controllers. For DIY projects, they're most often seen in robots or drones, aiding balance and navigation.



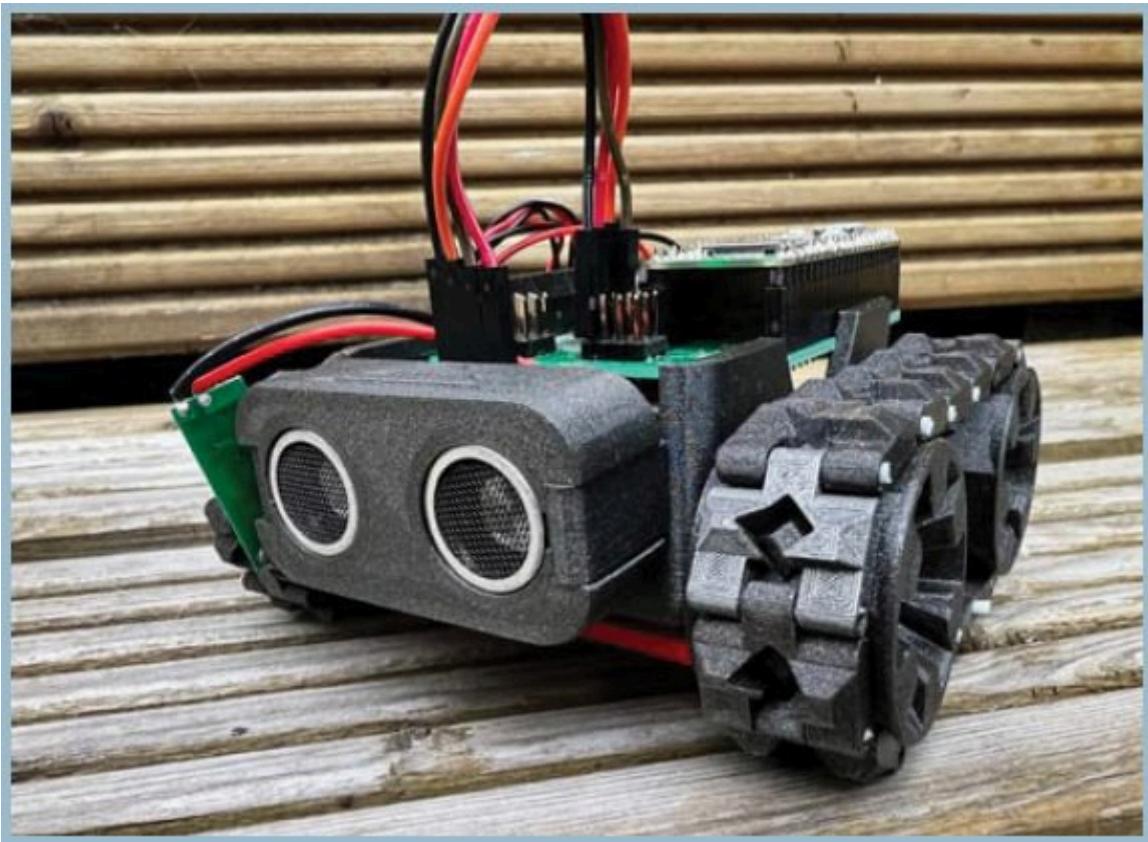
### Balancing Robot

Based on an ESP-01 microcontroller with a 6DOF IMU, this simple robot is able to balance on two wheels using a double-stage PID controller

[hsmag.cc/BalancingRobot](http://hsmag.cc/BalancingRobot)

## **WHEELED ROBOT**

The most popular type of hobbyist robotics involves the building of wheeled vehicles. There are countless kits available, as well as a vast array of chassis and components for building custom robots. You'll need one or more H-bridge motor drivers to enable you to power wheels and spin them forwards and in reverse. For a self-driving robot, you'll also need to include sensors and/or a camera to aid obstacle avoidance.



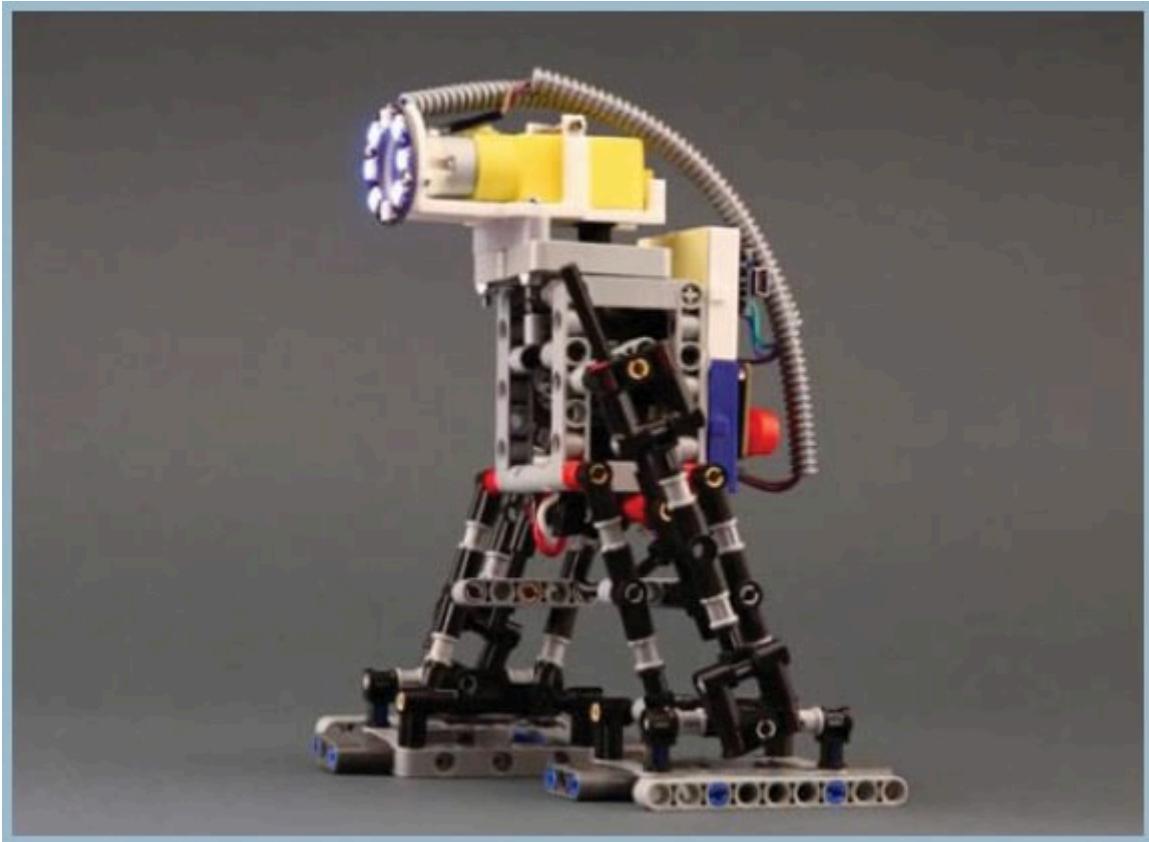
### PicoSMARS 2

Based on the Screwless Modular Assemblable Robotic System (SMARS), this 3D-printed robot is controlled by a Pico W and has tank tracks

[hsmag.cc/PicoSMARS2](https://hsmag.cc/PicoSMARS2)

## **WALKING ROBOT**

A more advanced robotics project is to build a walking robot with servo-powered joints. The more legs it has, the easier it is for it to stay upright, such as in spider- or insect-like robots. An IMU is highly recommended to help a bipedal bot maintain its balance. Creating a custom humanoid robot from scratch isn't easy, so it's better to try building a kit first.



### Biped Robot

While many legged robots use servos in their joints, a far simpler method is to use a DC motor and cogs to create a walking motion, as in this LEGO robot

[hsmag.cc/BipedRobot](http://hsmag.cc/BipedRobot) ■