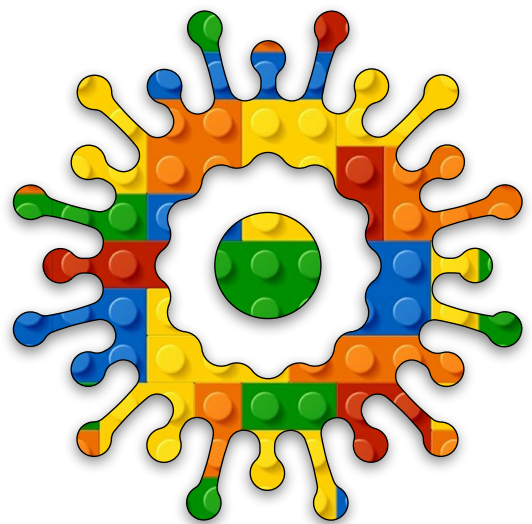


# Internet of Things

## Module A

### Unit #1

## Hardware





## Contents

Introduction to the Internet of Things (IoT)  
Hardware you will need  
Arduino Nano 33 IoT  
Diagram of the Arduino Nano 33 IoT  
USB cable  
Breadboard  
Using the Breadboard  
Adding the Arduino to the Breadboard  
Three LED traffic light module  
Button  
Variable Resistor (Pot)  
Jumper wires  
IMU  
Bluetooth



# Introduction to the Internet of Things (IoT)

## Devices

These are often micro-controllers that are embedded in a smart device. A common example may be something like a smart speaker. An example of a micro-controller is the Arduino Nano 33 IoT. These devices can connect to the Wi-Fi and transmit data from sensors.

## Sensors

You can add a very wide variety of sensors. Whether motion, sound, light, etc.

## Connectivity

This often forms a network of devices that are connected together through Wi-Fi or Bluetooth. They can communicate together and form a mesh network, or communicate independently to a central collection.

## Data Processing

This is where the data collected by the devices is processed and analysed. This can be done on the devices themselves, in the cloud, or on a combination of both. This may also be linked to a machine learning algorithm which can act on the data immediately.

## User Interface

This is how users interact with the IoT system. It can be a web interface, a mobile app, or even a voice assistant. A common one we will be working with is the Arduino Cloud, and with that comes an app which we can see the data transmitted and even send data.

As the number of connected devices and applications continues to grow, the IoT is becoming an increasingly important area of technology and innovation, with the potential to transform many industries and aspects of daily life.



## Why is the Internet of Things important?

The Internet of Things (IoT) has a wide range of applications across various industries and areas of life. Here are some examples of what the IoT can be used for:

**Smart homes:** IoT-enabled devices can be used to automate and control various aspects of a home, such as lighting, temperature, security, and appliances.

**Healthcare:** IoT devices can be used to monitor patients' health, track medication adherence, and improve the efficiency of medical equipment.

**Industrial automation:** IoT can be used to optimise production processes, monitor equipment performance, and improve supply chain management.

**Agriculture:** IoT sensors can be used to monitor soil conditions, weather patterns, and crop health, enabling farmers to optimise yields and reduce waste.

**Energy management:** IoT devices can be used to monitor and control energy usage in buildings, factories, and homes, helping to reduce waste and improve efficiency.

**Transportation:** IoT can be used to optimise traffic flow, monitor vehicle performance, and improve the safety and efficiency of transportation systems.

**Retail:** IoT can be used to create personalised shopping experiences, track inventory, and improve supply chain management.

The Internet of Things has the potential to revolutionise various industries and aspects of life, making processes more efficient, cost-effective, and convenient.





## Hardware you will need

The main bit of kit you will need is a WiFi-enabled board. There are quite a few to choose from that are either made by Arduino or other companies. Using ESP32 boards is a very popular option as they are cheap and easily available.

The board I have plumbed for is the Arduino Nano 33 IoT board for a number of reasons. It is designed for just this purpose. It is also compatible with the Chromebook as well as PCs and Macs. Another reason for using this board is that it has an accelerometer and a gyroscope built-in.

I have endeavoured to keep the amount of electronics to a minimum in this workbook and focus more on the code. However, the whole point of micro-electronics is that you use lots of components and create some wonderful piece of technology or gadget.

To start to develop a good understanding of how you can use the Arduino Nano 33 IoT board, I will introduce you to a small number of components. This will give you a sense of how to integrate them into a project.

So here is a list of hardware (components) you will need. They are easily sourced on [eBay](#), [Amazon](#), or specialist stockists like [PiHut](#) or [Pimoroni](#).

- Arduino Nano 33 IoT (with headers)
- Micro USB cable (to connect it to your computer)
- Breadboard (need a half-size)
- LED traffic light module (they have three LEDs with a resistor built-in)
- Button (push, momentary, tactile)
- Variable resistor (also called a potential divider or pot for short)
- Jumper leads (male to male sort to connect the components on the breadboard)



## Arduino Nano 33 IoT

Important, get the Arduino Nano 33 IoT with pins already soldered on unless you are a dab hand at soldering. Unlike the Uno which operates on 5 volts, the Nano 33 IoT boards work on 3.3 volts. Some components are 5 volts only, some are dual-use and some are designed for 3.3 volts only. Always check the specification.

The purpose of the Arduino Nano 33 IoT is to provide an easy-to-use platform for creating internet-connected projects, or Internet of Things (IoT) projects. Its small size and low power consumption make it ideal for use in portable or battery-powered devices that require wireless connectivity.

With the built-in Wi-Fi and Bluetooth module, the Arduino Nano 33 IoT can connect to the internet and communicate with other devices, sensors, or cloud services. This makes it suitable for a wide range of applications, such as home automation, remote monitoring, data logging, and more.

The board's compatibility with the Arduino Integrated Development Environment (IDE) also makes it easy for beginners and hobbyists to get started with programming and electronics. The IDE provides a simple and intuitive interface for writing and uploading code to the board, as well as a large community of users and resources for learning and troubleshooting.

The Nano 33 IoT has a series of pins running along each edge of the board. Roughly one side is for analog components and the other side is for digital components. Where the prefix **A** is for analog and the prefix **D** is for digital, followed by a pin number. There are other pins which have various functions, the ones we will be making use of will be the **GND** or ground pins.

To work out which pin is what you will need to use the pin out diagram. The pins are numbered on the back (very tiny), however, we will be using the breadboard so the details will be hidden. The Analog pins can also be used as digital pins if needed see **fig. 3**.

Figure 1: Arduino Nano 33 IoT (top)

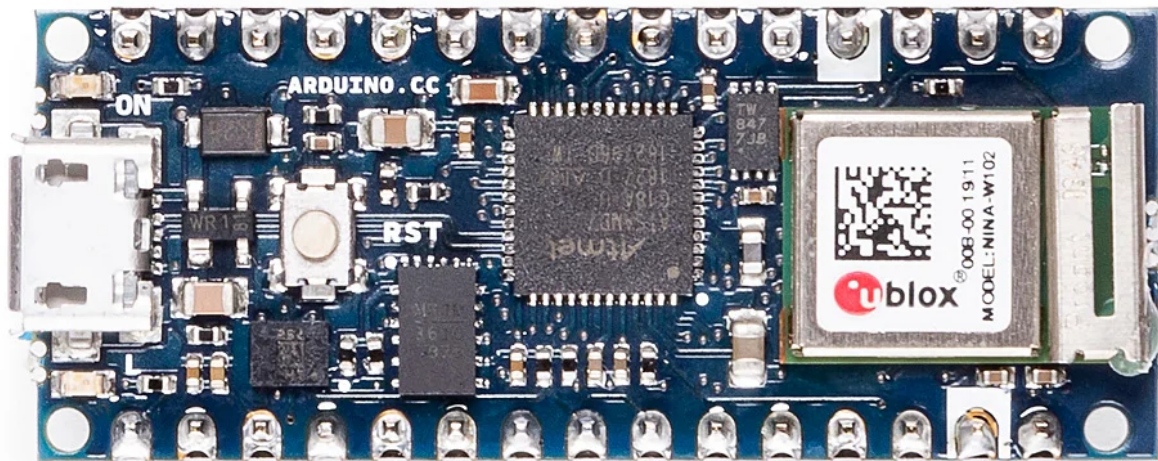
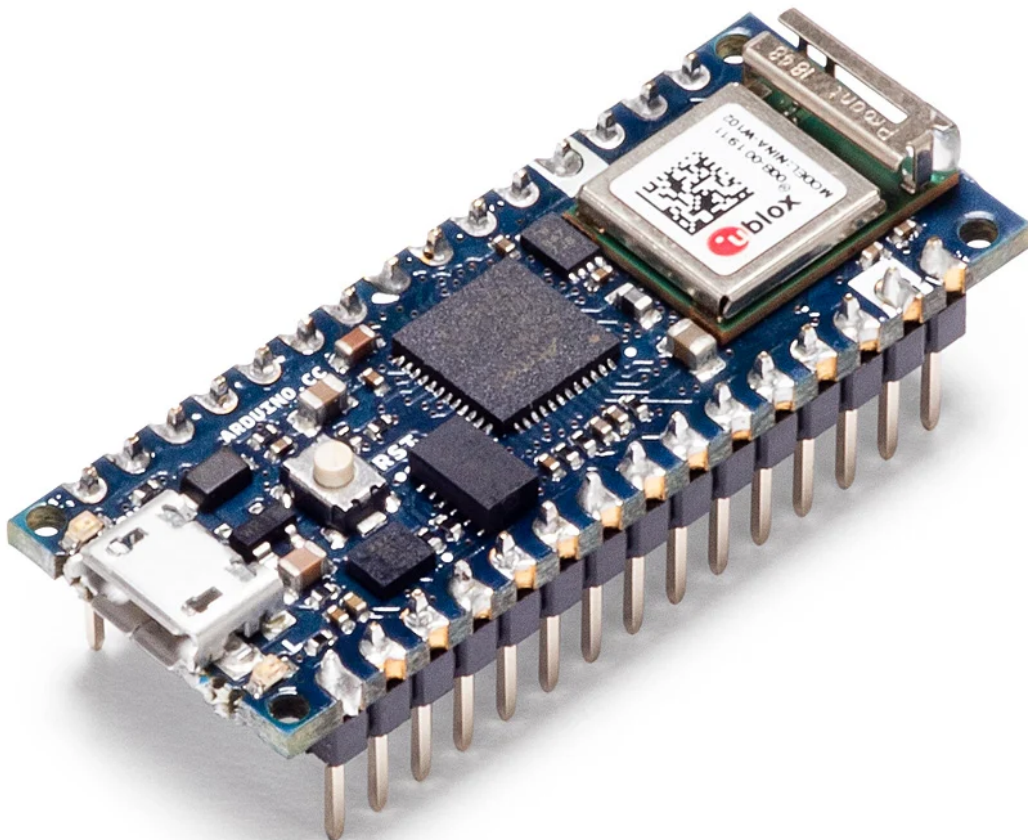


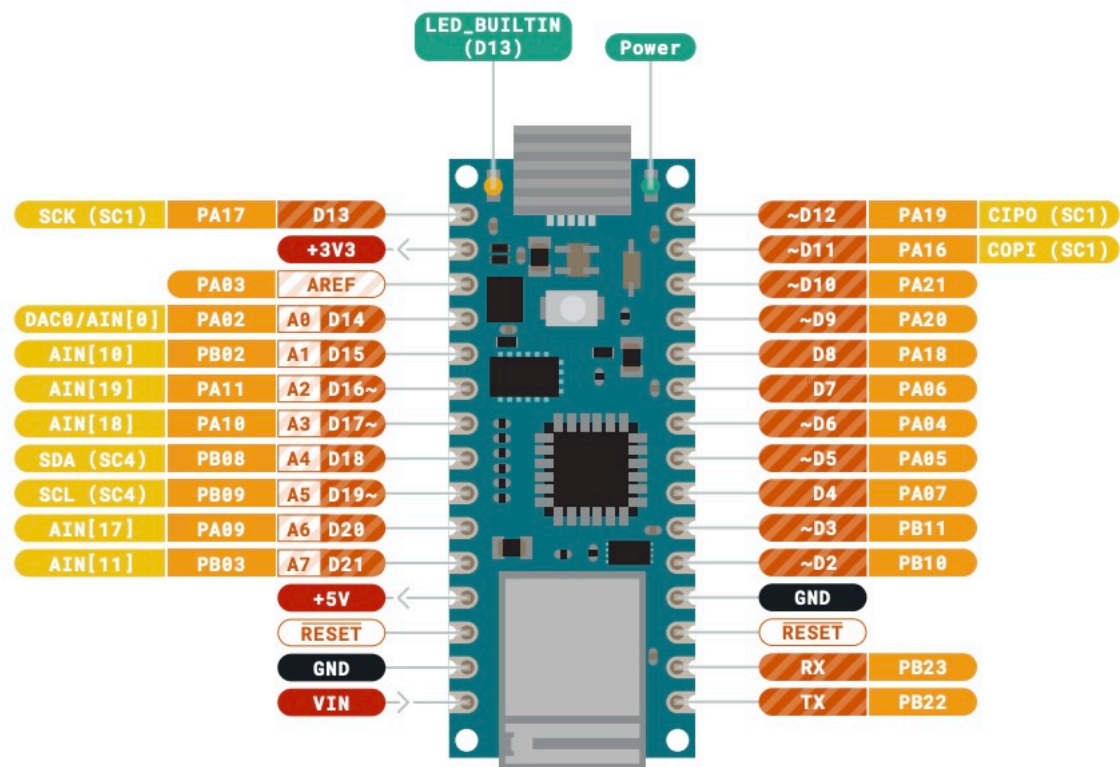
Figure 2: Arduino Nano 33 IoT (oblique)





## Diagram of the Arduino Nano 33 IoT

Figure 3: Arduino Nano 33 IoT pin out diagram







## USB cable

To connect your Nano 33 IoT to your computer and to power it, you will need a micro USB cable (shown below). Make sure you get one that can do both of the following:

1. To power the Nano 33 IoT, from a 5-volt source such as a normal phone charger or battery pack.
2. It sends data to and from the computer and the Nano 33 IoT, such as uploading your code.

Figure 4: micro USB cable





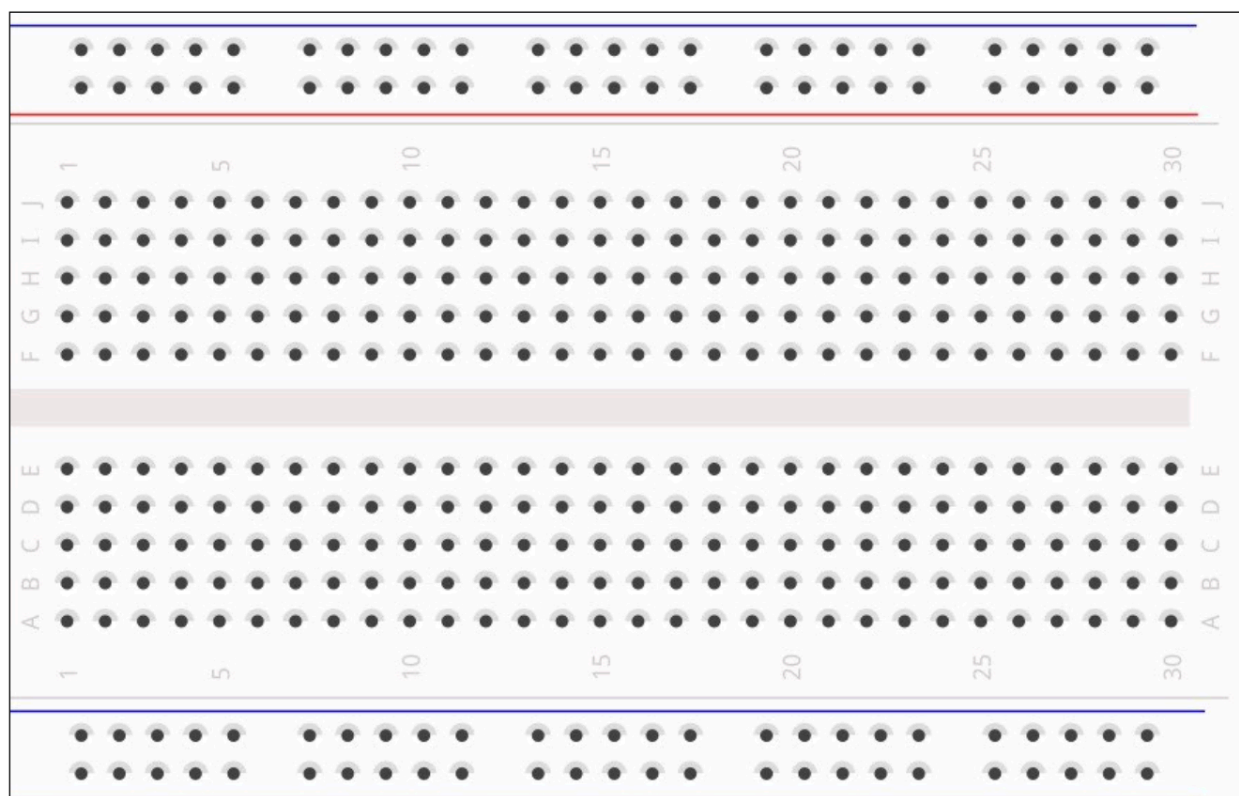
## Breadboard

The breadboard is simply a great way to connect components without having to solder anything. There are strips of metal underneath that connect the holes together.

There are many sizes and varieties of breadboards. This one is a **half-size** breadboard; it has **400** pin points. They can be larger (full size) and smaller (mini). The half-size is perfect for our purposes and most projects. Whichever one you get, they all work on the same principle.

I place mine on a coaster, not essential but useful if you were to add components that don't fit onto a breadboard.

Figure 5: Half-Sized Breadboard

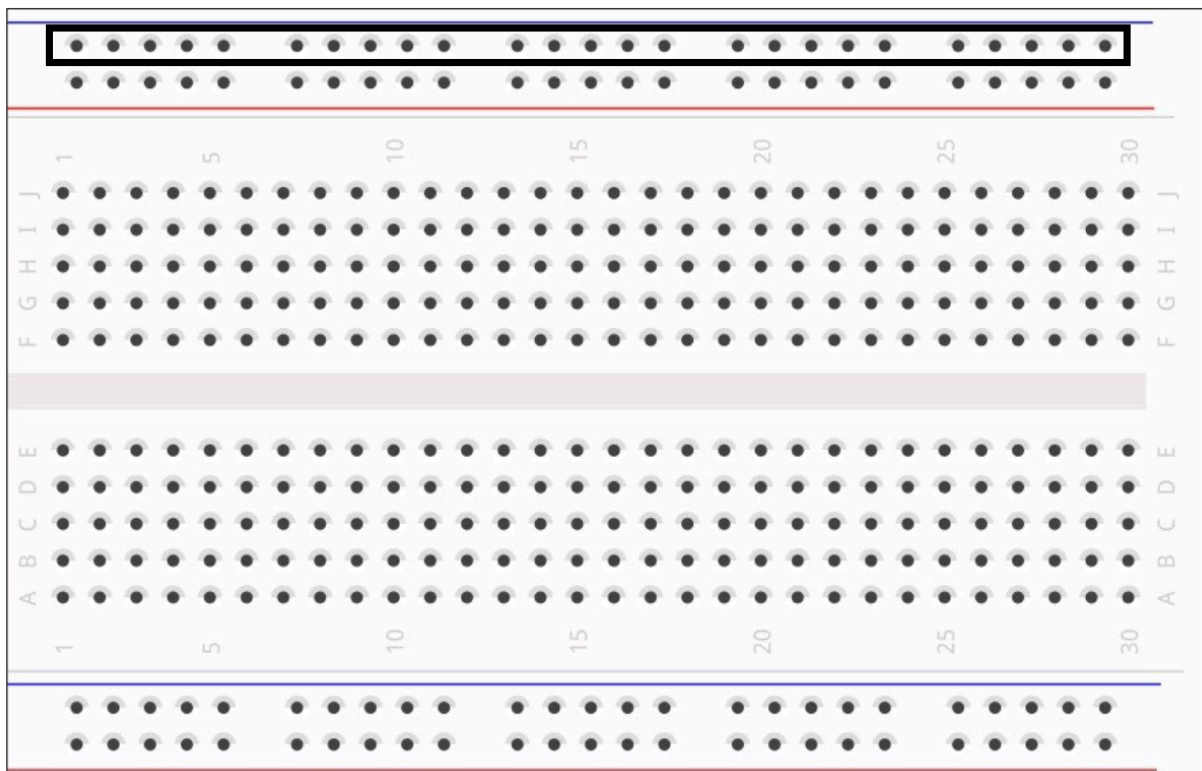




## Using the Breadboard

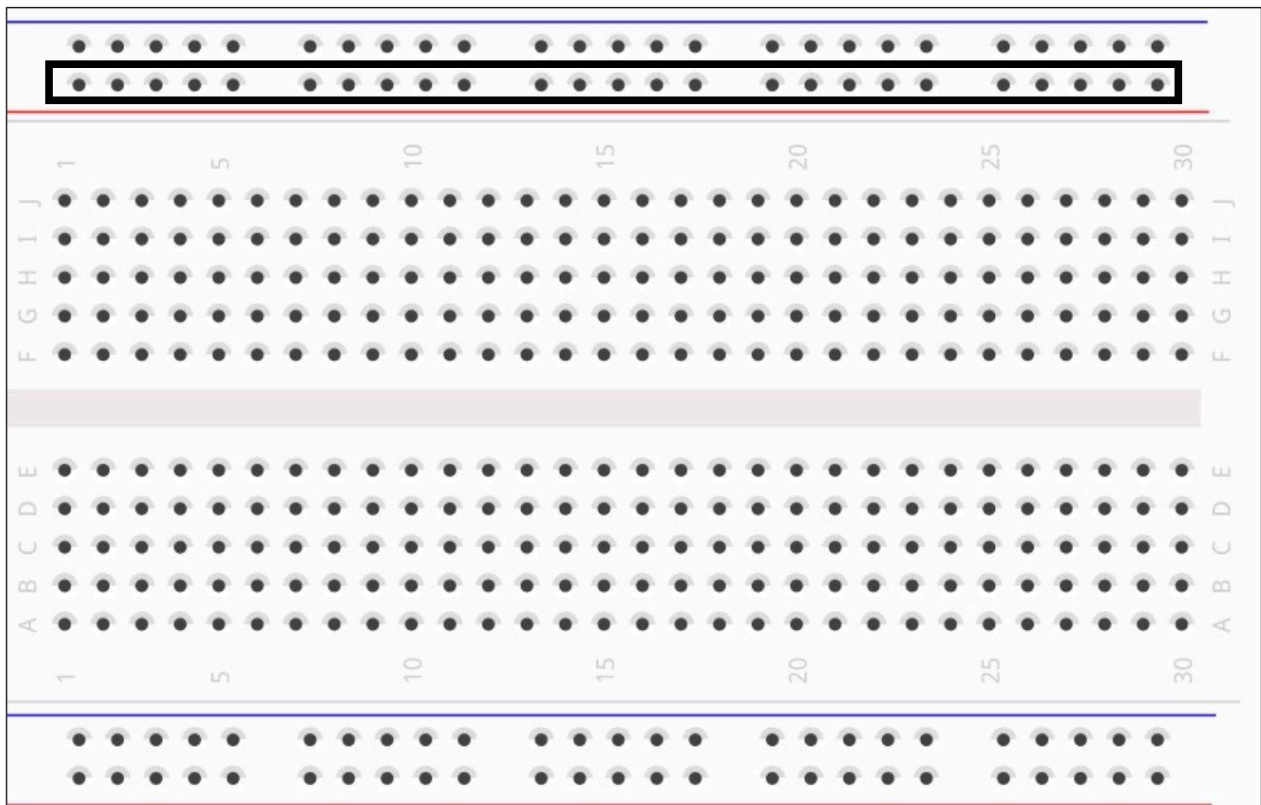
The ground (**GND**) rail is connected along the whole length of the breadboard. This means that if you have a number of components all wanting to connect to the ground (**GND**), you can plug them all into the same one. This is the one near the blue line.

Figure 6: connecting along the length of the negative/ground rail



The positive (**VCC**) rail is connected across the entire length of the breadboard, as is the ground (**GND**). If you have lots of components that need a 5-volt supply (**VCC**), such as a servo, then you can use this to supply all of them. Convention is to follow the red line.

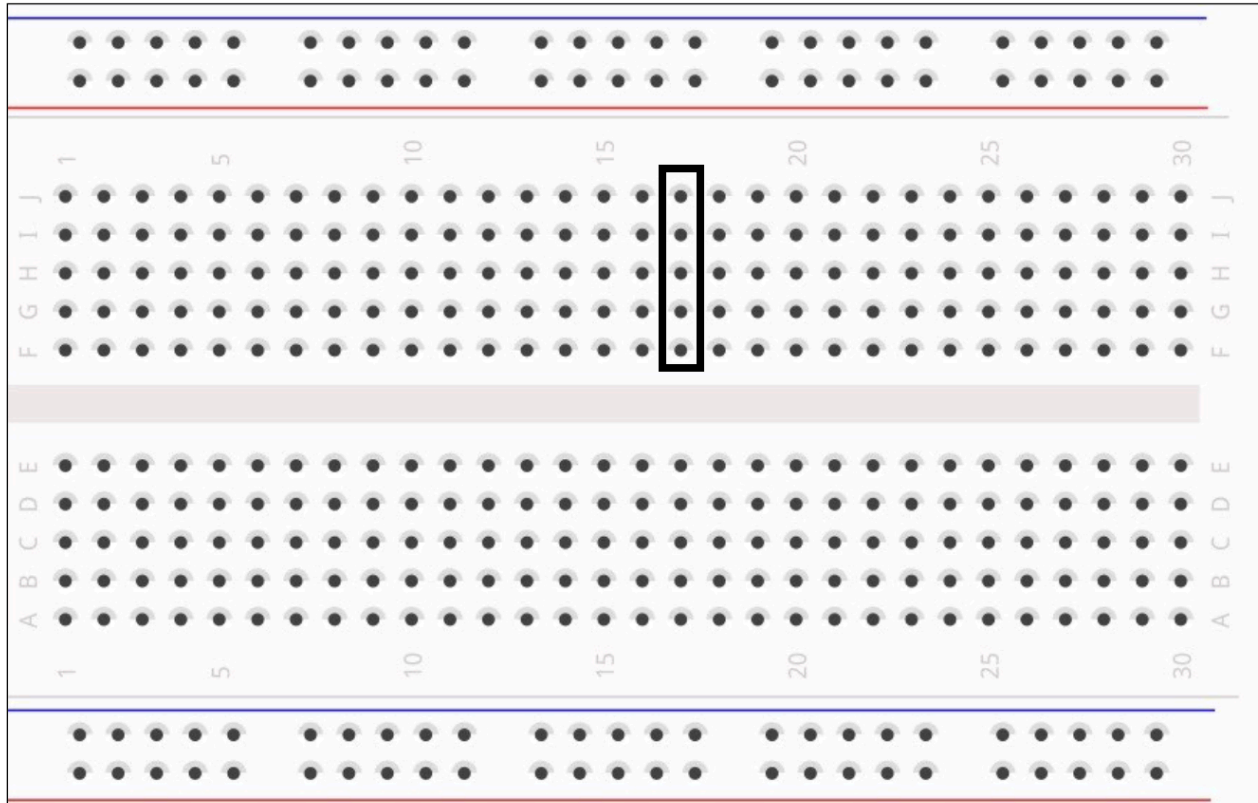
Figure 7: connecting along the length of the positive rail





The holes are connected across in rows of five, so that anything in that row is connected electrically. Each row of five holes is separate from all the other sets of five holes.

Figure 8: five connected pin holes



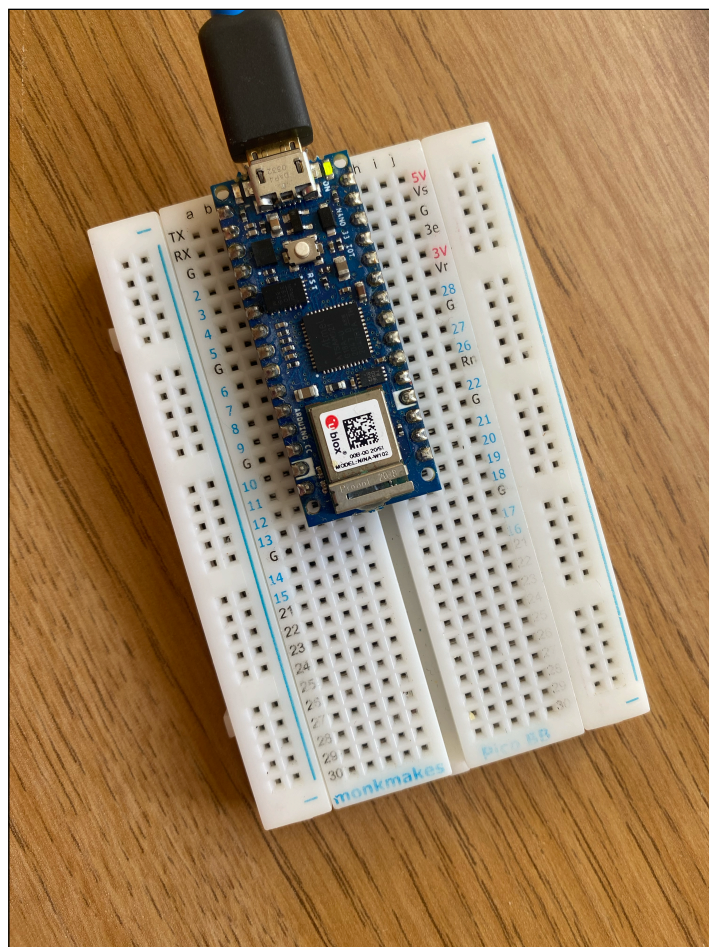


## Adding the Arduino to the Breadboard

One of the reasons for getting the Arduino Nano 33 IoT with headers (pins) already soldered on is so that we can add it to the breadboard. Take care when doing this so that you do not bend the pins. Notice that it does sit centrally, so it has to be offset to the left or right, it doesn't really matter but suggest do what I have done because we use the digital pins side more than the analog side.

Also notice that when it is connected (and powered) a little green LED tells you that it is on.

Figure 9: nano 33 IoT on the breadboard





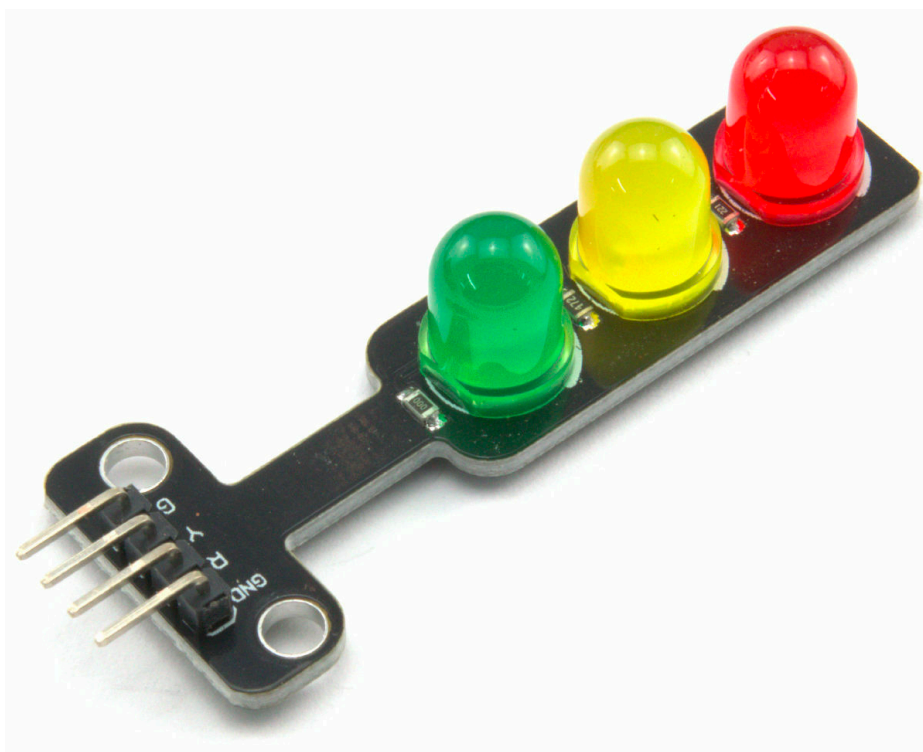
## Three LED traffic light module

These have three LEDs (and their resistors) built into a module to make life much easier for you. There are four pins that can be pushed into the breadboard. Here is a picture of one. The four pins are:

- Ground (GND),
- Red LED (R),
- Green LED (G) and
- Yellow LED (Y).

The beauty of using this is that you don't have to worry about using resistors. They are already built in and also you have three LEDs to play with and use. We will be using all three later on. We connect them to the digital pins on the device.

Figure 10: LED traffic light





## Button

The button is a tactile, momentary type button, so it only completes the circuit while it is pressed (or breaks the circuit). They come in a variety of sizes (and colours), and mainly they fit on the breadboard, although modules don't.

One of the issues is that they will need a resistor in series so that the current isn't too high (this is also the case with LEDs). You can simply place a resistor in series or use a module that has a resistor already built in. A third option is to use an internal resistor already within the board itself called a pull-up resistor.

For simplicity, we will use a version of fig. 12 and use the pull-up feature of the Nano 33 IoT.

Figure 11: button module



Figure 12: button





## Variable Resistor (Pot)

The variable resistor is also called a potential divider or pot for short, I will call it a pot for future reference. There are a variety of types of variable resistors and values. The most common is a **10K $\Omega$**  which stands for **10,000 Ohms** (the measure of the resistance). They are variable by turning a knob from **0** to **10,000 ohms( $\Omega$ )**.

They have three pins: the two outside ones are for the ground (**0** volts, **GND**) and the **3.3** volts input (**VCC**) inputs. The middle one is the **output** voltage, which is related to the position of the knob and gives you a value from **0** to **3.3** volts. We connect the pot to the analog pins on the Nano 33 IoT.

I have shown three versions below, all good in their own right; you might see using a mixture of them.

Figure 13: pot 1

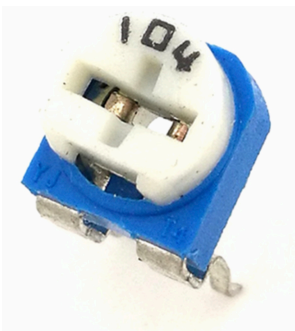


Figure 15: pot 3

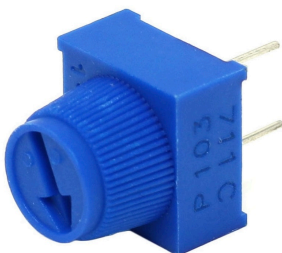


Figure 14: pot 2







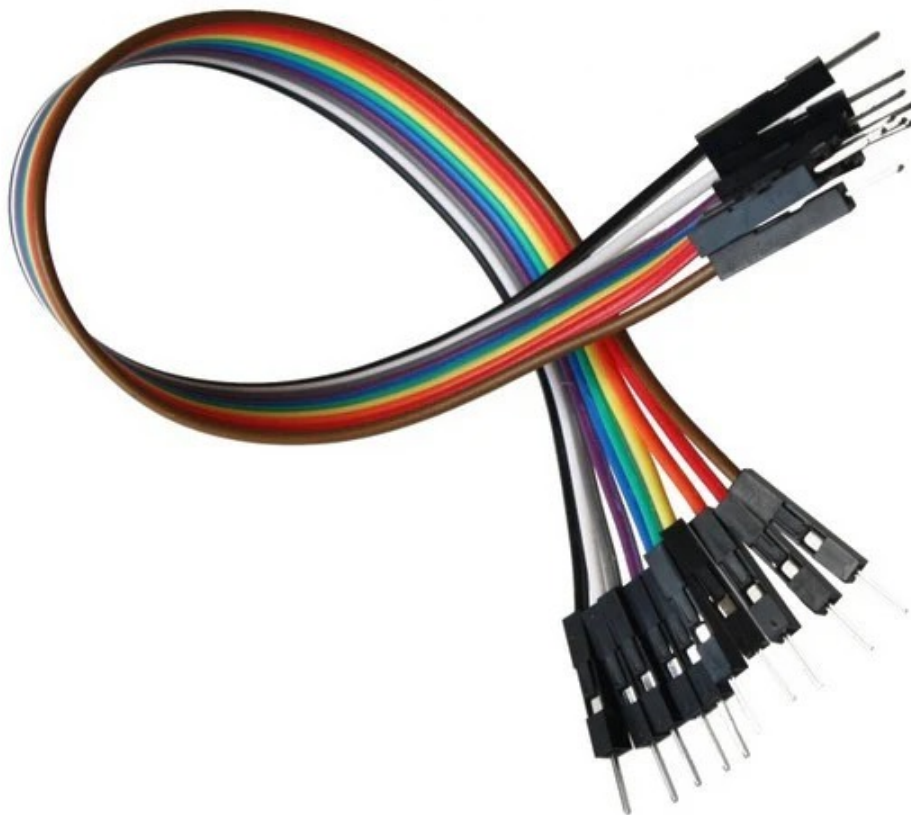
## Jumper wires

These are wires widely used in electronics to connect components on the breadboard. They have pins sticking out or holes at the ends of the wires. Get ones that are as long as possible or, better still, get a mixture of lengths. There are three main types:

- Male-to-Male connectors
- Male-to-Female connectors
- Female-to-Female connectors

What you will need are **Male-to-Male** and they usually come in packs of ten, which is plenty. You might also want to get Female-to-Male and Female-to-Female while you are at it.

Figure 16: male-to-male jumper leads







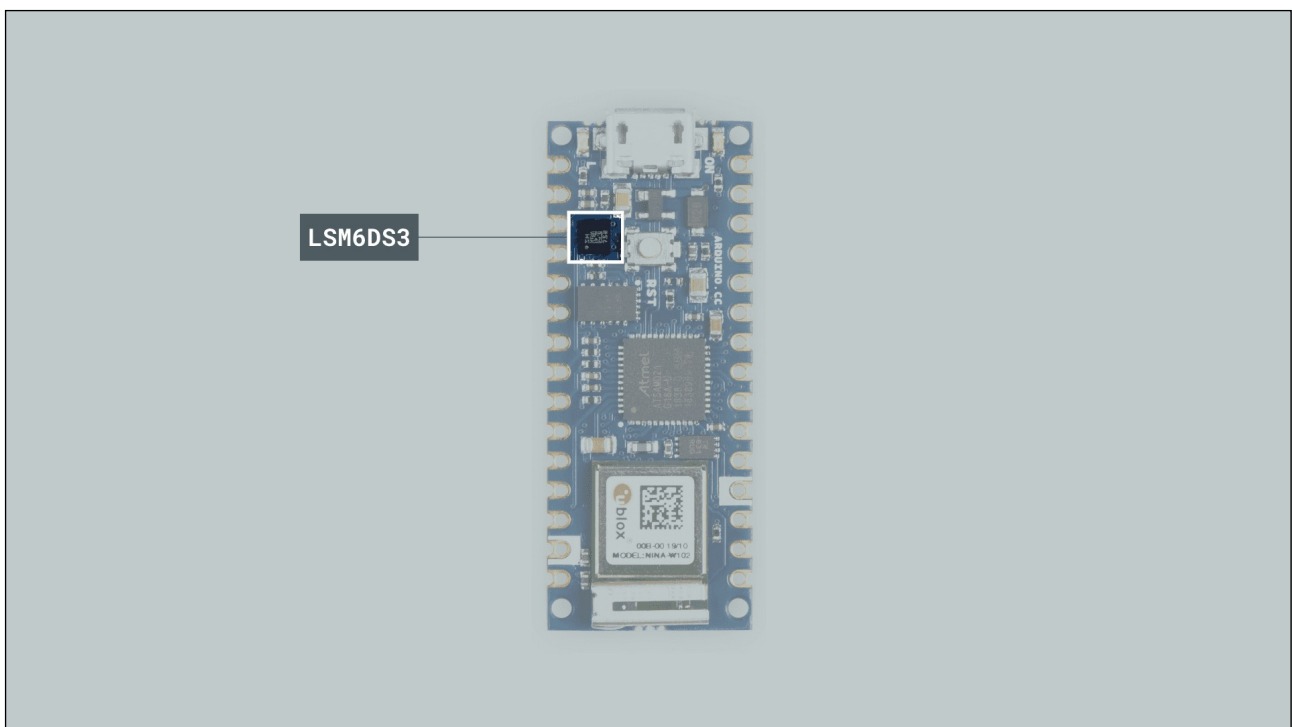
## IMU sensor LSM6DS3

The Arduino Nano 33 IoT has a built-in sensor called an IMU.

IMU stands for inertial measurement unit. It is an electronic device that measures and reports a body's specific force, angular rate, and the orientation of the body, using a combination of accelerometers, gyroscopes, and oftentimes magnetometers. In this tutorial, we will learn about the LSM6DS3 IMU module, which is included in the Arduino Nano 33 IoT Board.

The LSM6DS3 is a system-in-package featuring a 3D digital linear acceleration sensor and a 3D digital angular rate sensor. In other words, an accelerometer and a gyroscope, which gives it 6 axes of measurement.

Figure 17: LSM6DS3 IMU module

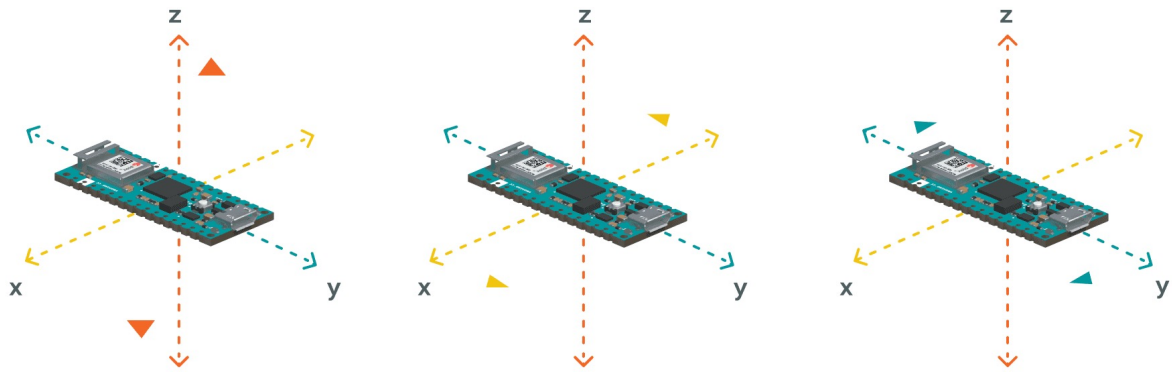




## Accelerometer

This measures horizontal and vertical movement.

Figure 18: accelerometer

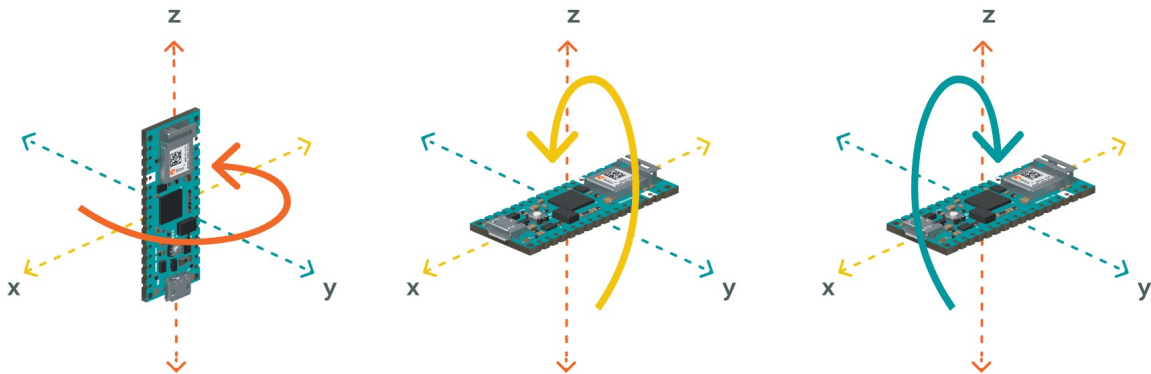




## Gyroscope

The gyroscope measures rotational movement.

Figure 19: gyroscope





## Bluetooth

The Nano 33 IoT also has Bluetooth, which means it can communicate with other Bluetooth devices, sending data to each other. There are two types of Bluetooth:

Bluetooth Classic: which can send lots of data but is energy-hungry, so only useful if powered directly.

Bluetooth Low Energy: which is, as the name suggests, low energy because it is reserved for small amounts of data and therefore is more suitable for battery-powered devices.

The board in Bluetooth mode is either a peripheral device or a central device, depending on whether it is sending data or receiving it.

For obvious reasons, we will need two devices for that demonstration. They don't have to be the same device.