

DRONE GATES CHALLENGE

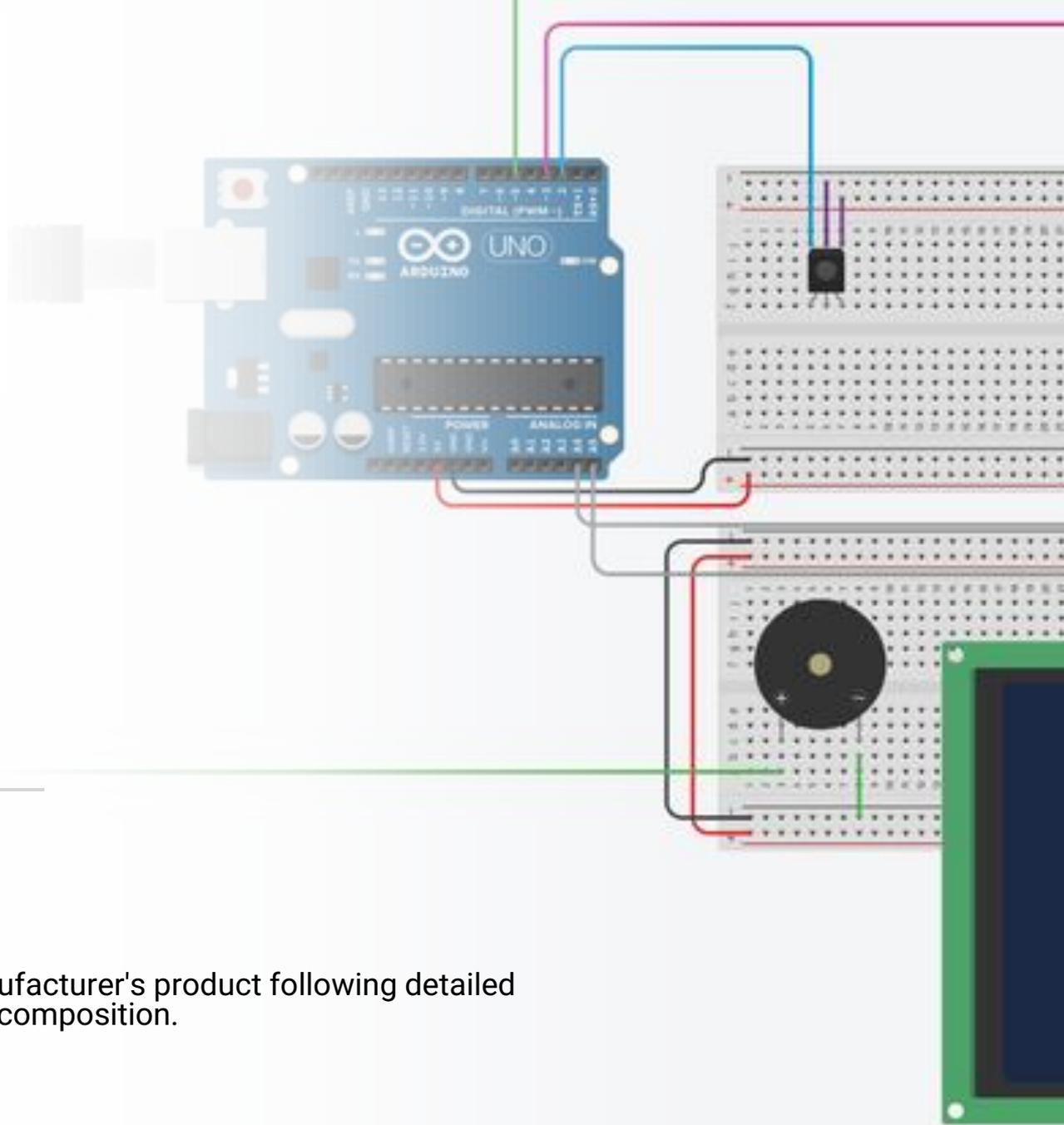
Reverse Engineering

re·verse en·gi·neer·ing

/rəˈvɜrs enjəˈnɪrɪŋ/

noun

1.the reproduction of another manufacturer's product following detailed examination of its construction or composition.



A Note from iNSL T.E.A.M.S.

WARNING!!! DO NOT CONNECT ANY HIGH VOLTAGE DEVICES TO THIS CIRCUIT UNLESS YOU HAVE EXPERIENCE WORKING WITH SUCH DEVICES. MISTAKES WITH HIGH VOLTAGES COULD LEAD TO FIRE, INJURY, OR EVEN DEATH.

Metacognition is the act of thinking about how you think. In designing any curriculum, the developer starts with the question,

“How do students expect to learn this course, and how do I balance that with how they NEED to gather information?”

With electronics, the amount of background knowledge that contributes to each piece can easily overwhelm the practical (physical) act of assembling the whole project. So, developers follow a path similar to engineers, makers & artists. Start with where we need to end and work backwards through the design process. If you find that your brain has filed some piece of knowledge about electricity or circuits behind your fourth-grade teacher’s coffee breath, and you don’t know how to retrieve the memory... just relearn the content.

Lifelong learners spend a lot of time refreshing, relearning and sparking synapses in the brain. Humans are a lot like really complicated electrical projects that need new batteries, fresh input and updated code on a regular basis. Hopefully, the structure of iNSL mini-courses will spark old memories and embed new understanding. Good luck with your project. The team at iNSL can’t wait to see what your team develops next!

Sincerely,

Jeannie Ruiz & the iNSL Development Team

WHAT ARE THE DRONE GATE REQUIREMENTS?

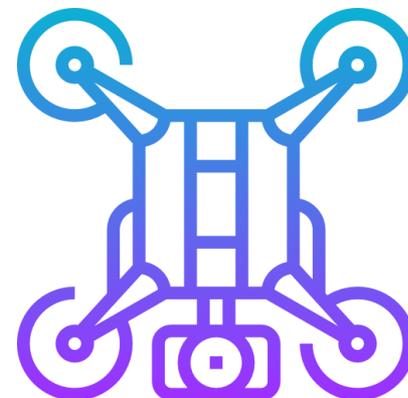
Drone timing gates measure the passage of a drone with an electronic sensor. There are many ways to set up your sensors, and the mini-course offers examples. You are welcome to use any electronic setup that YOUR team prototypes, tests, and showcases.

Arduino, RaspberryPi, Micro:Bits and generic options are possible. It's up to you and your teammates to research and design a drone timing gate system that can be assembled, tested in front of an audience, and removed from the staging area in 20 minutes.

The goal is not to clock a fast speed – this is not a race. Judges are concerned with your accuracy, teamwork, design, and electronics.

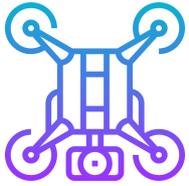
The best drone gates are...

- Durable
- Easy to assemble
- Lightweight
- Portable
- Marketable
- Eye-catching
- Matched to your team branding



Extra Points for Entrepreneurship

1. Provide plans and documentation.
2. Create an “Instructable” for your gate.
3. Develop a “pitch” for your gate product.
4. Develop a DIY video or “unboxing” video.
5. Exhibit amazing teamwork during the showcase.



MEASURING DRONE SPEED

Drone races typically measure speed using a combination of methods, including onboard technology and ground-based tracking systems.

Race organizers may use a combination of methods to ensure accurate and reliable speed measurements. The choice of method often depends on the requirements of the race and the available technology.

In each case, a type of sensor is used to collect a measurement. None of the sensors will explain the reason for a measurement, only recording data itself. Temperature might be recorded every hour, but a data sensor will not tell you WHY the temperature rose or fell.

[GPS \(GLOBAL POSITIONING SYSTEMS\)](#)

[DOPPLER RADAR](#)

[ACCELEROMETERS VS. GYROSCOPES](#)

[TIMING GATES](#)

[TIMING SYSTEMS](#)

[FPV CAMERAS \(FIRST PERSON VIEW\)](#)

[TELEMETRY DATA](#)



WHAT IS A TIMING GATE?



A timing gate includes electronic sensors placed at specified distances that send instances of data back to a hub or collection device for display or data collection.

As you can see, the shape of a timing gate varies widely based on location, weather considerations, mobility and lighting. Your team has an opportunity to be creative with the prototyping and design as well as electronics.



FPV Race Gates @ Pinshape



DIY FPV racing gate by DAquad



WHAT NEEDS TO BE MEASURED?

Speed and Motion are the key factors in this project. Register the motion of an object through its timing gate. Capture data to determine the object's speed.

Speed = Distance / Time

MPH (miles per hour)

KPH (kilometers per hour)

THE HIGHWAY DRONES THAT
"ENFORCE" SPEED LIMITS
CARRY ELECTRONICS AND
CAMERAS TO CAPTURE DATA.



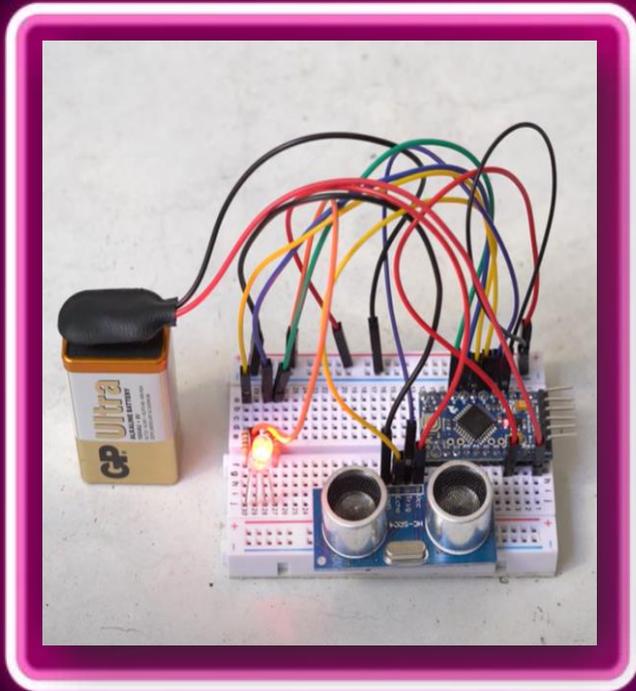
Electronic sensors record but do not calculate. For example, a sensor records passage of an object at Gate 1. A sensor records passage of an object at Gate 2. You use the distance between Gate 1 and Gate 2 to calculate the object's speed. Rather than doing those calculations by hand, humans have developed microcontrollers that contain coded instructions to do each division algorithm very, very quickly.

Algorithms have been in your math book since 1st grade addition. For some reason, teachers decided that your cute little 6-year-old brains couldn't handle the name for all those addition and subtraction problems. Algorithms get more and more complicated as humans try to cram as much calculation into each problem as possible. From $1 + 1 = 2$ all the way through calculus, algorithms are the sequence of numbers you apply to get an answer.

Computers and microcontrollers ALSO follow algorithms in the form of code.

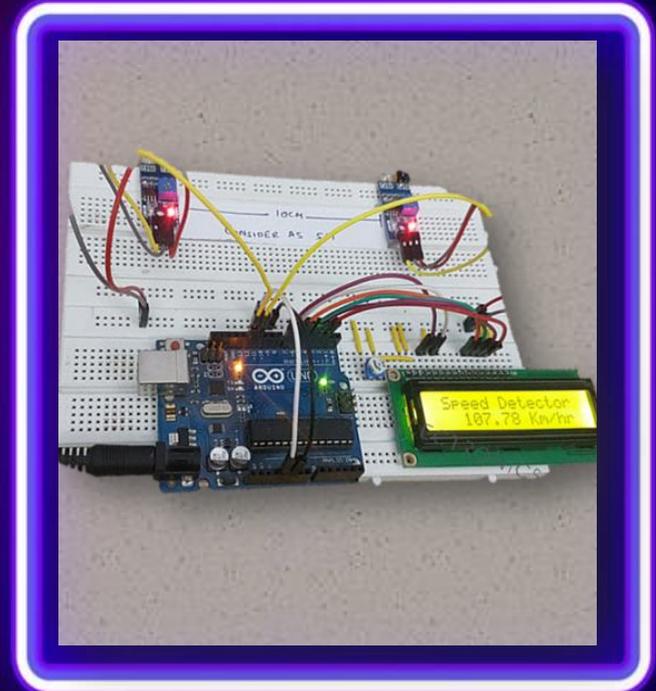
MOTION VS SPEED

Can you spot the differences?



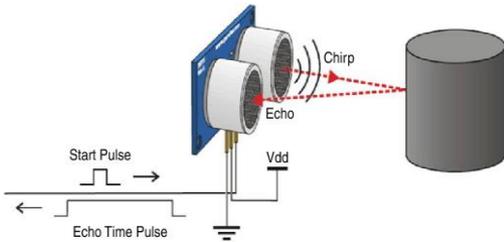
Motion detection involves light or sound sensors.

V
S



Speed detection uses multiple motion sensors plus a micro controller to handle the code.

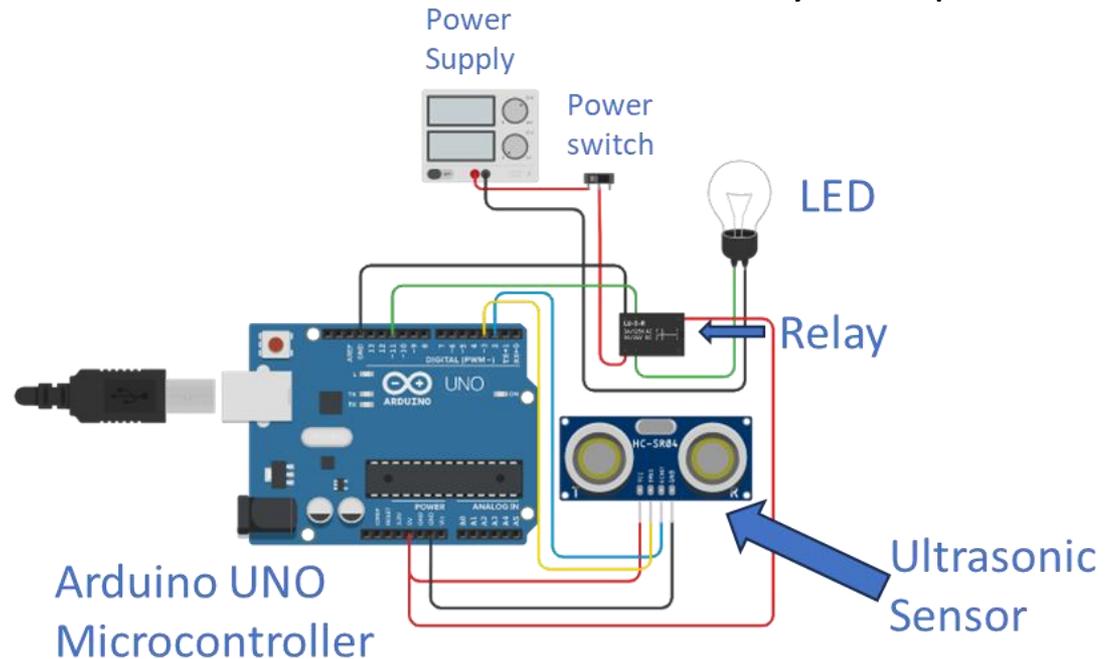
REVERSE ENGINEER A MOTION DETECTOR with Ultrasonic Sensor



An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves.

An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's distance.

Identify each part.



Tinkercad
Interactive
Simulation
with Code

https://www.tinkercad.com/things/kYXfUL9T67J-copy-of-simple-ultrasonic-sensor-switch-relay/editel?sharecode=VrlyEx2JwvG8Hlvmucrv_VDOKLAASZX_6D9FrST05dw

```
<iframe width="725" height="453" src="https://www.tinkercad.com/embed/6NVqiaHqFWH?editbtn=1" frameborder="0" marginwidth="0" marginheight="0" scrolling="no"></iframe>
```

REVERSE ENGINEER A MOTION DETECTOR with PIR Sensor

Identify each part.

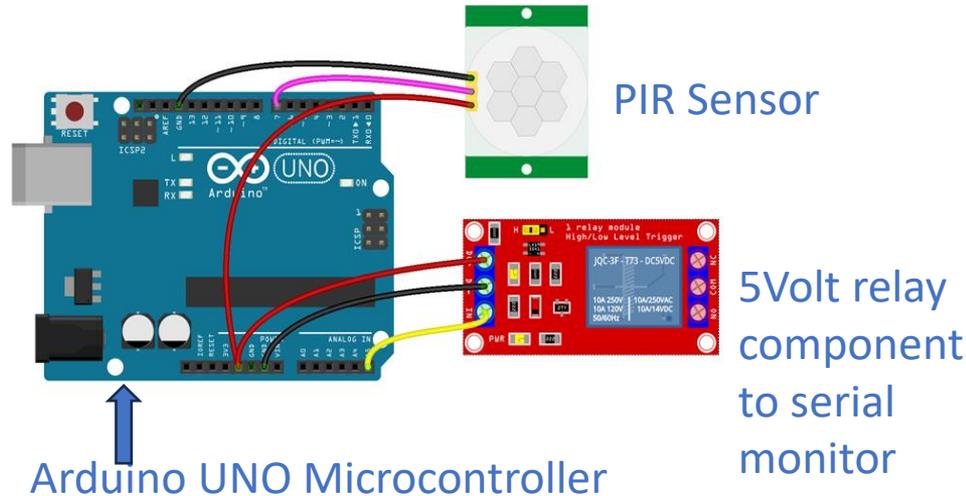
<https://www.circuits-diy.com/motion-sensor-with-relay-arduino-tutorial/>

HOW DOES IT WORK?

The Arduino Uno microcontroller controls a 5Volt relay with a PIR motion sensor to post relay status on a monitor.



Circuits DIY
has the
MOST ORGANIZED
Arduino Tutorials
we have found!



A PIR motion sensor (a.k.a. Pyroelectric Infrared sensor) is a device that detects motion by sensing changes in infrared radiation levels.



The PIR sensor here has two built-in potentiometers to adjust sensitivity (Sx on the right) and time delay (Tx on the left).

REVERSE ENGINEER A SPEED DETECTOR with PIR Sensor

Identify each part of the ElectronicsHub circuit.



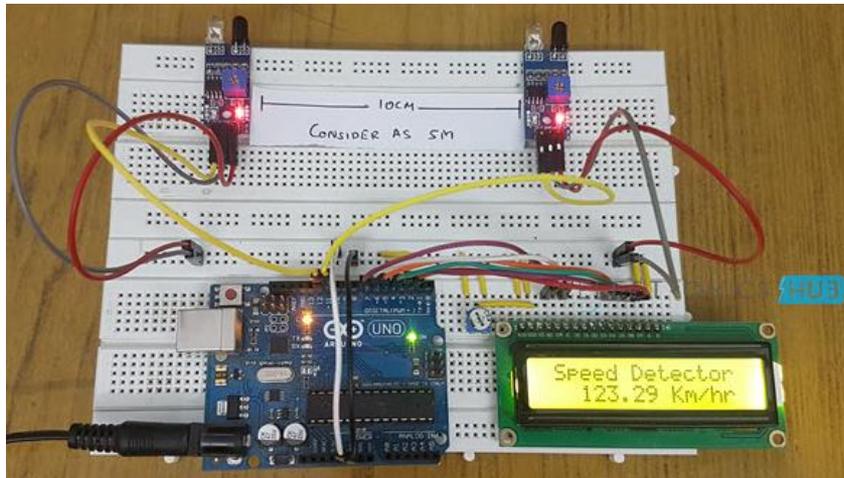
www.electronicshub.org/arduino-car-speed-detector

ElectronicsHub
Infrared Sensors (IR)
Speed Detector



youtu.be/jMnQmDgPCUg
?si=6Zjc-xB_tzbFCLt

Element14 Presents
PIR Sensors



- Arduino UNO
- IR Transmitter LED
- IR Receiver Photo Diode
- 16X2 LCD Display Module
- Breadboard
- Connecting Wires
- Power Supply

<https://youtu.be/hNmacZoweqY>

HOW DOES IT WORK?

The drone passes the IR Sensor #1, activating a timer that continues to measure elapsed time until the drone passes -and is read by- the second IR Sensor. The IR Transmitter and Receiver Pair are placed side-by-side form a Reflective Sensor. The IR Transmitter continuously emits infrared radiation. Passing objects bounce the signal back to the sensor to trigger start or stop actions.



PINOUT DIAGRAMS ARE CROSS-REFERENCE TOOLS

In electronics, a pinout diagram cross-references the contacts (pins) of electrical parts and electronic components with their functions.

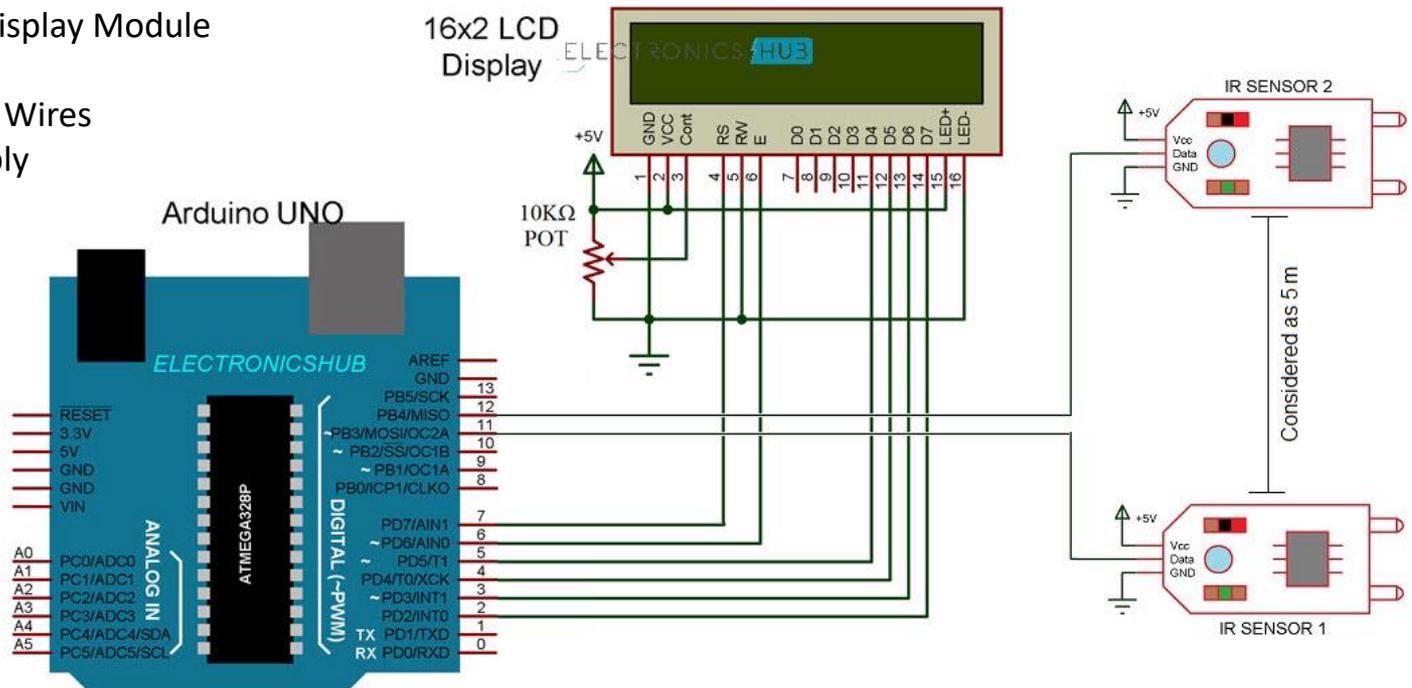


www.electronicshub.org/arduino-car-speed-detector

ElectronicsHub
Infrared Sensors (IR)
Speed Detector

Can you locate each part in the pinout circuit diagram below?

- Arduino UNO
- IR Transmitter LED
- IR Receiver Photo Diode
- 16X2 LCD Display Module
- Breadboard
- Connecting Wires
- Power Supply



LEARN ABOUT COMPONENTS & MICROCONTROLLERS

Now that you can locate the parts of a basic motion detector or speed detector, let's make sure everyone understands how the electronic system works.

Microcontrollers

- Arduino
- Raspberry Pi
- Micro:bit

Boards & Wires

Pins vs. Soldering

Wires

Components

Passive vs. Active

Sensors

Infrared (IR)

Pyroelectric Infrared (PIR)

Ultrasonic

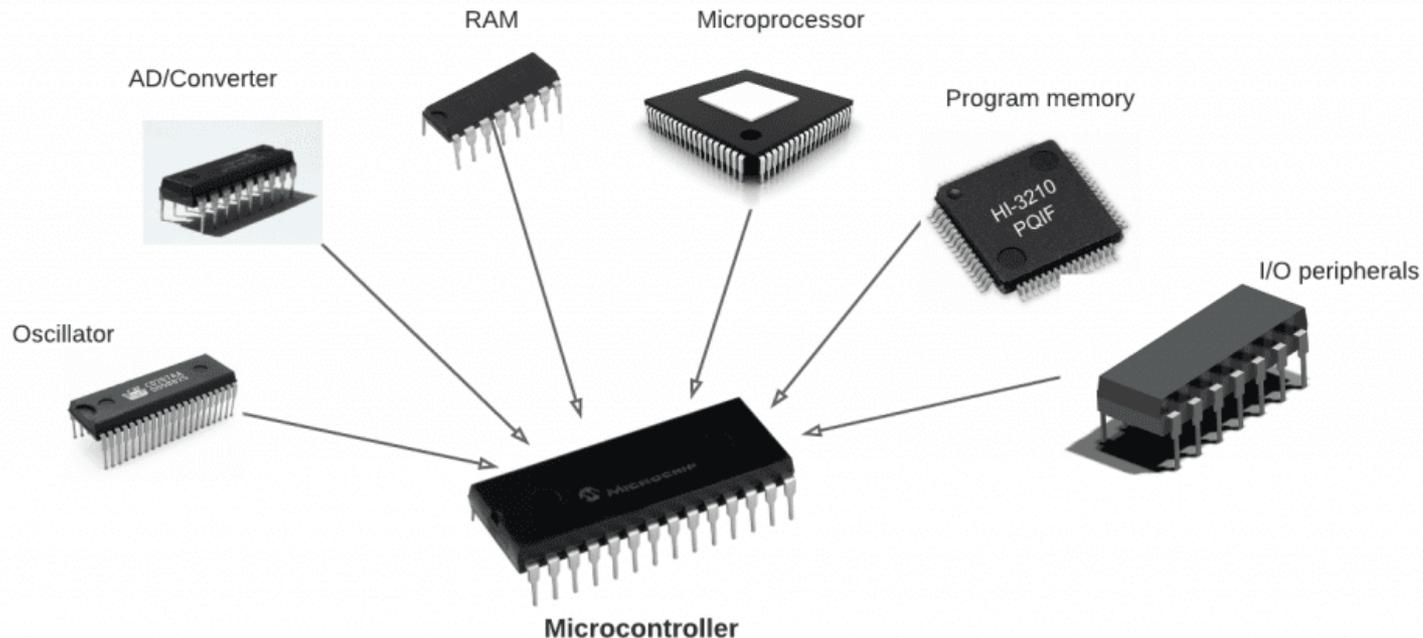
MICROCONTROLLER SYSTEMS LIKE ARDUINO

A microcontroller system is a collection of parts or devices with three features: input, process, and output.

A system accepts at least one input, performs some action on that input, and produces one or more outputs.

A microcontroller system is embedded in an integrated circuit (IC).

A typical microcontroller has a processor, program memory, RAM, input/output pins, and more functions on a single chip.



Microcontrollers can be used to control a wide variety of electronic devices from ovens to PCs and sensors.

MICROCONTROLLERS: ARDUINO



You can learn
Arduino in 15
minutes.

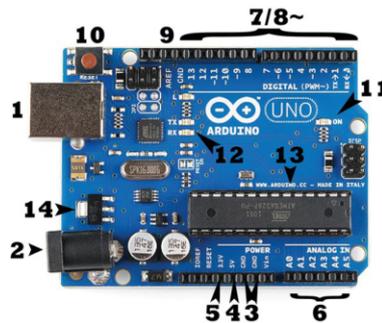
[youtu.be/nL34zDT
Pkcs?si=ICVoR67g
mbnTRMiu](https://youtu.be/nL34zDTPkcs?si=ICVoR67gmbnTRMiu)

Some microcontrollers have an integrated development environment (IDE) for programming.

Development boards are PCBs that contain a particular microcontroller IC and all supporting external circuitry for easy prototyping.

Introduction to Arduino Boards

Open-source electronic prototyping platform used to create interactive electronic objects.



REFERENCES & RESOURCES

SparkFun.com Arduino Image & Vocabulary
<https://learn.sparkfun.com/tutorials/what-is-an-arduino/all>

AfroTechMods – Intro to Arduino Video
<https://youtu.be/nL34zDTPkcs>

1. **Power (USB / Barrel Jack)** - The Arduino UNO can be powered from a USB cable coming from your computer or a wall power supply. The USB connection is also how you will load code onto your Arduino board. The recommended voltage for most Arduino models is between 6 and 12 Volts.

2. **Barrel Jack** – connects to power

Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF) - The pins on your Arduino are the places where you connect wires to construct a circuit plus a breadboard and some wire. Black plastic 'headers' plug a wire right into the board. The Arduino has several different kinds of pins labeled on the board and used for different functions.

3. **GND** - Short for 'Ground'. GND pins on the Arduino can be used to ground your circuit.

4. **5V Pin** - 5V pin supplies 5 volts of power.

5. **3.3V Pins** - 3.3V pin supplies 3.3 volts of power.

6. **Analog** - A0 through A5 on the UNO are Analog In pins. These pins can read the signal from an analog sensor (like a temperature sensor) and convert it into a digital value.

7. **Digital** - Digital pins (0 through 13 on the UNO) can be used for both digital input and digital output.

8. **PWM** - The tilde (~) symbol next to some digital pins (3, 5, 6, 9, 10, and 11 on the UNO) means these pins act as normal digital pins, but they can also be used for Pulse-Width Modulation (PWM).

9. **AREF** - Analog Reference is not used often but can be used to set an external reference voltage (between 0 and 5 Volts) as the max limit for analog input pins.

10. **Reset Button** - Temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino. This can be very in testing code multiple times.

11. **Power LED Indicator** - This LED next to the "ON" should light when the Arduino is powered.

12. **TX RX LEDs** - TX is short for transmit, RX is short for receive and indicate the pins responsible for serial communication. TX and RX appear by digital pins 0 and 1, and a second time next to the TX and RX indicator LEDs. These light up when the board is transmitting or receiving.

13. **Main IC** - Integrated Circuit is black with little metal legs and acts as the Arduino's brainpower and varies from board to board.

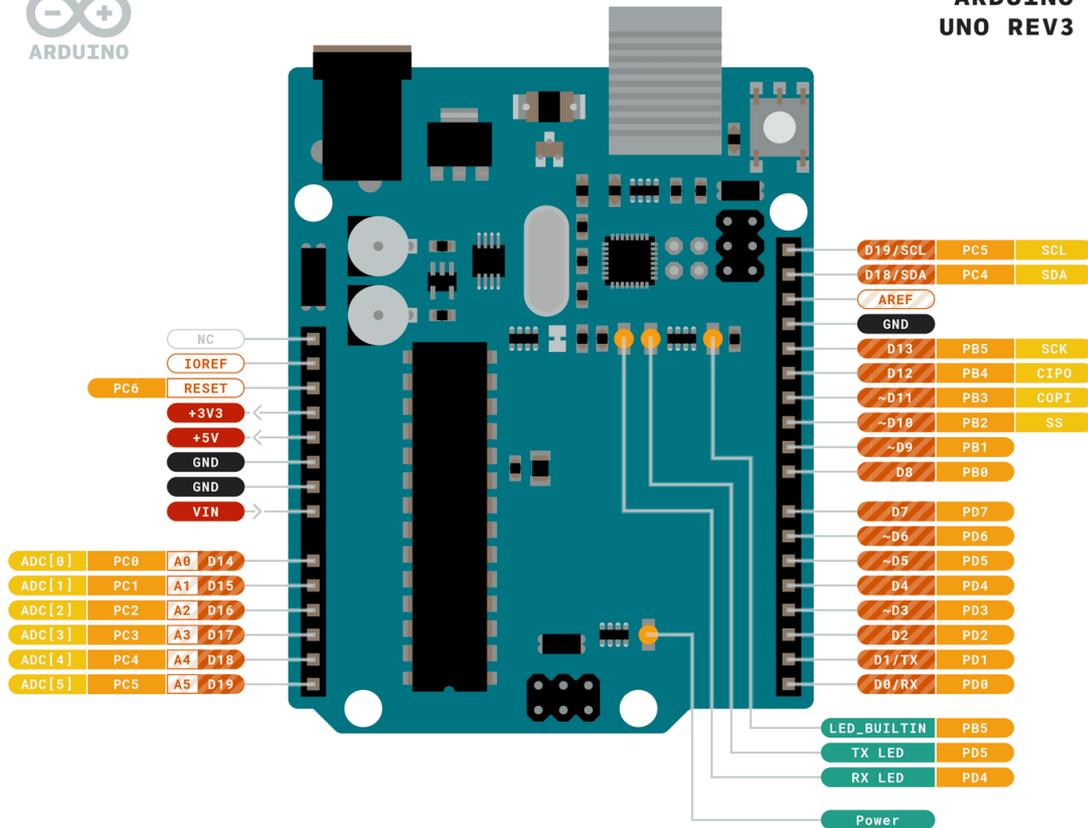
14. **Voltage Regulator** - The voltage regulator controls the amount of voltage that is let into the Arduino board. It will turn away an extra voltage that might harm the circuit, like including ANYTHING greater than 20 volts.

Driving STEM Copyright 2020 All Rights Reserved ArtofSTEM.com

MICROCONTROLLERS: ARDUINO UNO



ARDUINO UNO REV3



- 14 digital input/output pins
- 6 analog input pins
- a 16 MHz quartz crystal
- USB connection for programming and power
- power jack
- reset button
- a power LED
- built-in LED

The board can be programmed using the Arduino IDE, a software development environment that makes writing and uploading code to the board easy.

The Arduino IDE is based on the C++ programming language. You can access a library of pre-written code (known as "sketches") that are easy to modify and adapt.

■ Ground	■ Internal Pin	■ Digital Pin	■ Microcontroller's Port
■ Power	■ SWD Pin	■ Analog Pin	
■ LED	■ Other Pin	■ Default	

ARDUINO.CC



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MICROPROCESSORS: RASPBERRY PI

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV and uses a standard keyboard and mouse. These small single-board computers can browse the internet, play high-definition video, make spreadsheets, do word-processing and play games.

At this stage of beta testing development, the Raspberry Pi Code Editor enables learners to:

Write and run Python code in the browser with no download required.

LINK HERE:

editor.raspberrypi.org/en/



Raspberry Pi 3B

Alternate Function					Alternate Function
	3.3V PWR	1		2	5V PWR
I2C1 SDA	GPIO 2	3		4	5V PWR
I2C1 SCL	GPIO 3	5		6	GND
	GPIO 4	7		8	UART0 TX
	GND	9		10	UART0 RX
	GPIO 17	11		12	GPIO 18
	GPIO 27	13		14	GND
	GPIO 22	15		16	GPIO 23
	3.3V PWR	17		18	GPIO 24
SPI0 MOSI	GPIO 10	19		20	GND
SPI0 MISO	GPIO 9	21		22	GPIO 25
SPI0 SCLK	GPIO 11	23		24	GPIO 8
	GND	25		26	GPIO 7
	Reserved	27		28	Reserved
SPI0 CS	GPIO 5	29		30	GND
	GPIO 6	31		32	GPIO 12
	GPIO 13	33		34	GND
	GPIO 19	35		36	GPIO 16
	GPIO 26	37		38	GPIO 20
	GND	39		40	GPIO 21
					SPI1 CS0
					SPI1 MOSI
					SPI1 SCLK



Raspberry Pi explained in 100 seconds by Fireship.

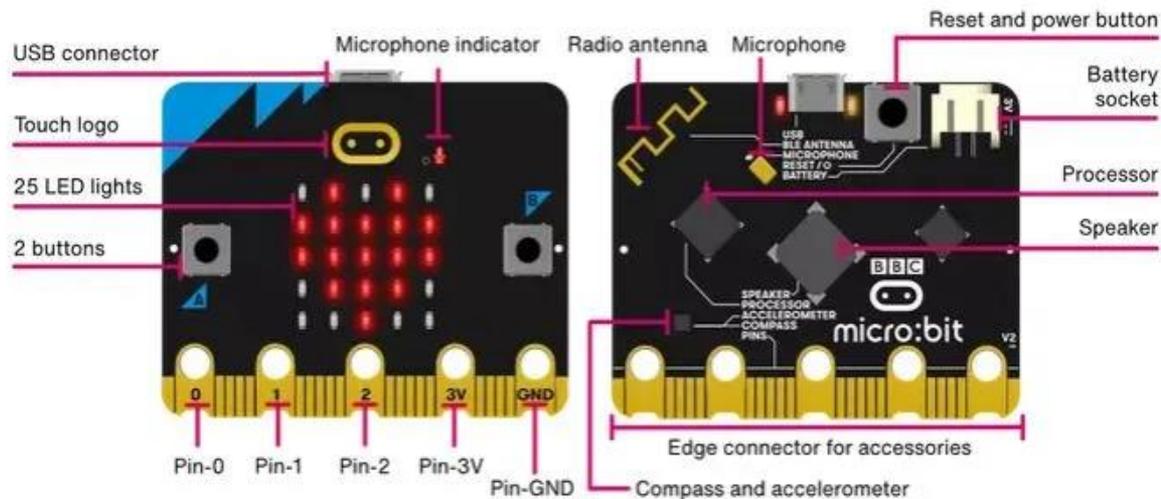
<https://youtu.be/eZ74x6dVYes?si=C1THlycejmd8CTj9>

MICROPROCESSORS: micro:bit

The BBC calls its micro:bit a pocket-sized computer that introduces software and hardware. It has an LED light display, buttons, sensors and many input/output features plus sound sensing and playback capabilities.

The board contains a microcontroller that can be programmed to perform specific tasks, but it also has input and output devices like buttons and an LED display. It's more like a microprocessor that also has memory, storage and physical input/output devices.

New micro:bit with sound



Find projects & code at
makecode.microbit.org



micro:bit explained
in 1 minute 40
seconds by BBC

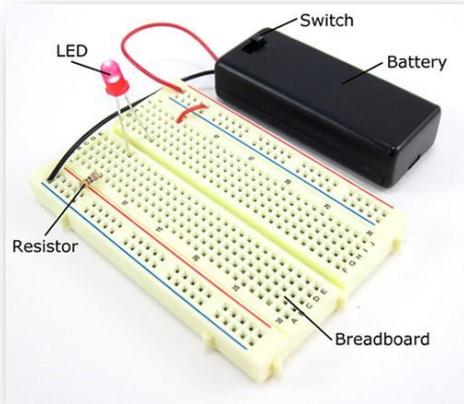
<https://youtu.be/Wuza5WXiMkc?si=6PeVzSyplrcBvxTJ>

The micro:bit is available as a single board unit or in a starter kit version called micro:bit Go. The kit includes a micro:bit board as well as a battery holder, batteries, and USB cable to connect to a device and start coding.

MAKING CONNECTIONS

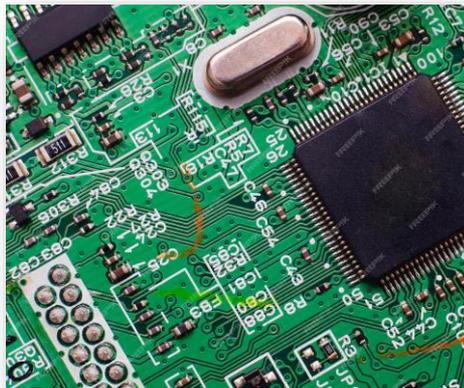
Printed Circuit Boards (PCB) vs Breadboards

A breadboard requires no soldering connections and is commonly used before developing a fully soldered Printed Circuit Board (PCB).



Breadboard

- Can be reused
- Easier and quicker to assemble
- Easily test different scenarios
- Limited by current carrying capacity due to connections.
- More common in DIY & Prototyping



Printed Circuit Board

- Board is permanent = connections are soldered
- Better current carrying capacity since you can make wider traces that allow greater current to flow through components.
- A PCB has a cleaner look with more components.
- More commonly found in electronic devices.



Simply Electronics
How to Use a
Breadboard

[https://youtu.be/05ZrbtwUzMk?
si=NeUdcym-fidWxkGO](https://youtu.be/05ZrbtwUzMk?si=NeUdcym-fidWxkGO)



Science Buddies:
How to Use a
Breadboard

<youtu.be/6WRfFkfrUlk>



How Circuit
Boards Are Made
[youtu.be/cZ0e4VDHn8Y?
si=wrB3VGh9DD3429Zv](youtu.be/cZ0e4VDHn8Y?si=wrB3VGh9DD3429Zv)

MAKING CONNECTIONS: TRY THIS PROJECT

Jumper wires are wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering.

Female to Female

Connectors with pins on both ends.



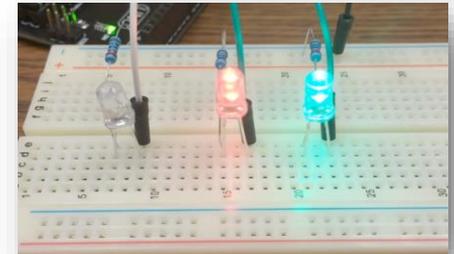
Male to Male

This refers to connectors with pins or prongs on both ends, typically used for connecting two devices together.

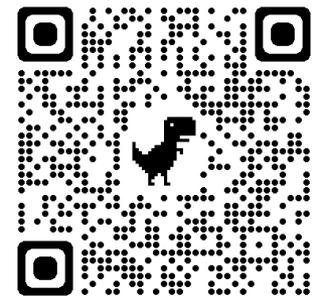


Male to Female

These connectors have pins or prongs on one end and a receptacle on the other end, allowing for the connection of devices with different genders.



Drone How
Arduino Beginner Project:
LED Sequential Control
www.youtube.com/watch?v=e1FVSpkw6q4



ELECTRICAL COMPONENTS VOCABULARY LIST

- 1. Terminals and Connectors:** Components to make electrical connection.
- 2. Resistors:** Components used to resist current.
- 3. Switches:** Components that may be made to either conduct (*closed*) or not (*open*).
- 4. Capacitors:** Components that store electrical charge in an electrical field.
- 5. Magnetic or Inductive Components:** Electrical components that use magnetism.
- 6. Network Components:** Components that use more than 1 type of Passive Component.
- 7. Piezoelectric devices, crystals, resonators:** Components able
8. to generate an electric charge in response to applied mechanical stress.**Semiconductors:**
Electronic control parts with no moving parts.
- 9. Diodes:** Components that conduct electricity in only one direction.
- 10. Transistors:** A semiconductor device capable of amplification.
- 11. Integrated Circuits or ICs:** A microelectronic circuit incorporated into a chip or semiconductor

ELECTRICAL COMPONENTS ARE ACTIVE OR PASSIVE

Active components are devices that require a source of electrical energy (usually a power supply) to function. They can control, amplify, manipulate or process electronic signals.

Passive components do not need a source of electrical energy to perform basic functions. They mainly store, filter, or dissipate electrical energy but do not control or amplify signals.

ACTIVE COMPONENTS

can boost weak electrical signals and can switch or modify signals.

An amplifier turns a weak signal into a stronger output signal.

A diode allows current to flow in only one direction.

Active components use electrical power.

ACTIVE

Transistor		
Diode		
LED		
Photodiode		
Integrated Circuit		-
Operational Amplifier		
Seven Segment Display		
Battery		

PASSIVE

Resistor		
LDR		
Thermistor		
Capacitor		
Inductor		
Switch		
Variable Resistor		
Transformer		

PASSIVE COMPONENTS

are used for voltage division, filtering & energy storage.

Resistors slow the flow of electric current into LEDs and active components.

Capacitors store electrical energy in an electric field.

Inductors store electric energy in a magnetic field.

IDENTIFY ELECTRICAL COMPONENTS

- Terminals and Connectors:** Components to make electrical connection.
- Resistors:** Components used to resist current.
- Switches:** Components that may be made to either conduct (*closed*) or not (*open*).
- Capacitors:** Components that store [electrical charge](#) in an electrical field.
- Magnetic or Inductive Components:** These are Electrical components that use magnetism.
- Network Components:** Components that use more than 1 type of Passive Component.
- Piezoelectric devices, crystals, resonators:** Passive components with piezoelectric effect.
- Semiconductors:** Electronic control parts with no moving parts.
- Diodes:** Components that conduct electricity in only one direction.
- Transistors:** A semiconductor device capable of amplification.
- Integrated Circuits or ICs:** A microelectronic circuit incorporated into a chip or semiconductor

ACTIVE			PASSIVE		
Transistor			Resistor		
Diode			LDR		
LED			Thermistor		
Photodiode			Capacitor		
Integrated Circuit		-	Inductor		
Operational Amplifier			Switch		
Seven Segment Display			Variable Resistor		
Battery			Transformer		

Symbol	Image	What does this component DO?	Passive <input checked="" type="checkbox"/>	Active <input checked="" type="checkbox"/>
				
				
				
				
				
				
				
				
				



Core Electronics has a great deep-dive to help you choose motion sensors.

youtu.be/LNeSz5hfTLI?si=qM3tMRD6WvhSMZ7L

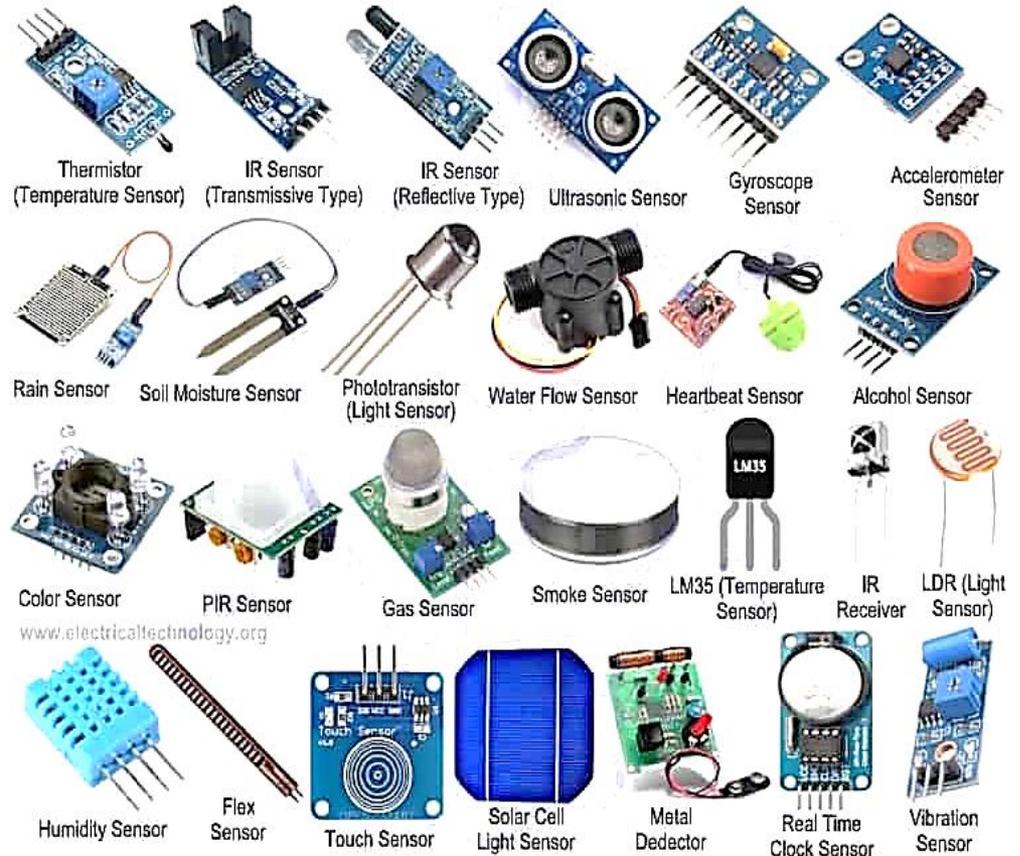
A **sensor** is defined as a device or a module that helps to **detect any changes in physical quantity** like pressure, force or electrical quantity like current or any other form of energy.

The sensor sends the detected input to a microcontroller or microprocessor.

Active sensors are the type of sensors that produces output signal with help of external power supply.

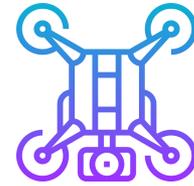
Passive sensors produce output signal without any extra stimulus or voltage

IDENTIFY ELECTRICAL SENSORS: Can you find the sensors for motion?



ELECTRONICS STEMVESTIGATION

Use your game tech kit to assemble a sample detector.



Plan your investigation project.

Choose a focus: Motion Detector or Speed Detector

- Download the Arduino IDE software.
- Locate your tutorial.
- Place parts & components on a mat or tray before assembling.
- Enter the relevant code.
- Note the types of pins, location of tracks and traces (wire paths), and resistors needed to limit current through the Light Emitting Diode (LED).

In your logbook, make a sketch of your assembly and note issues that will help you troubleshoot your design project. Bonus logbook points will be issued for using computer aided design programs like Tinkercad or Visuino to practice simulating circuit diagrams.

[Tinkercad.com](https://www.tinkercad.com)

[Arduino IDE](https://www.arduino.cc/en/Main/Software)