# Hardware devices
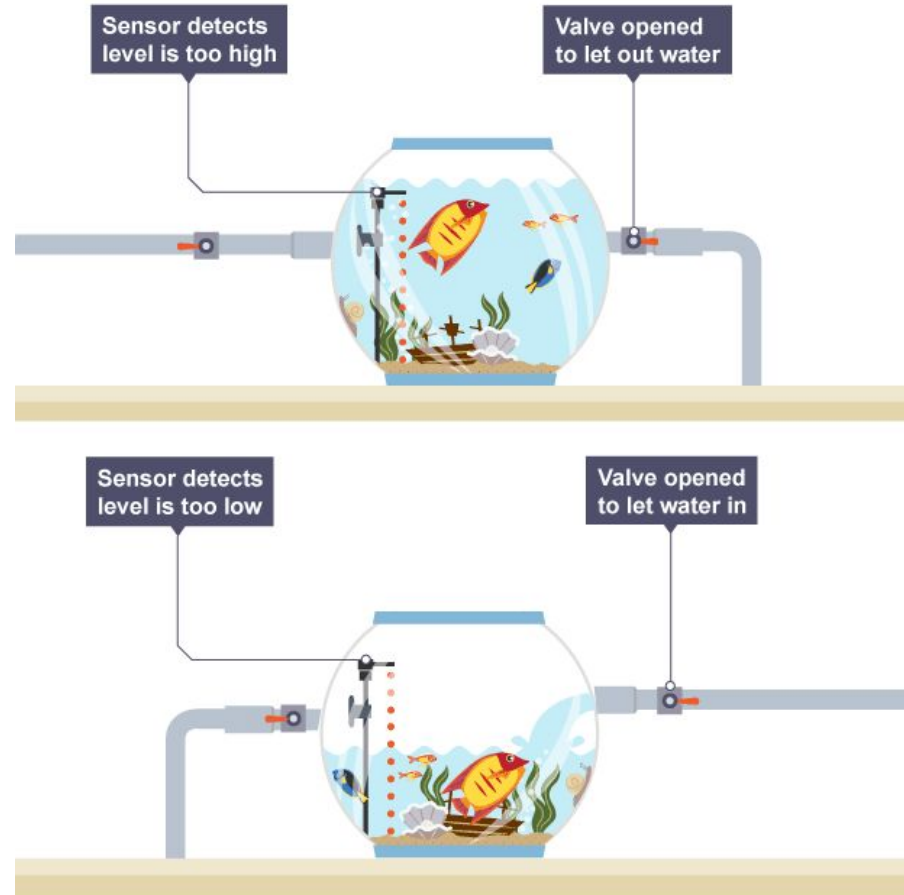
iGCSE Computer Science

# High level overview

# Feedback cycle

Sensor based programs generally work on a feedback cycle.



Sensor detects level is too high

Valve opened to let out water

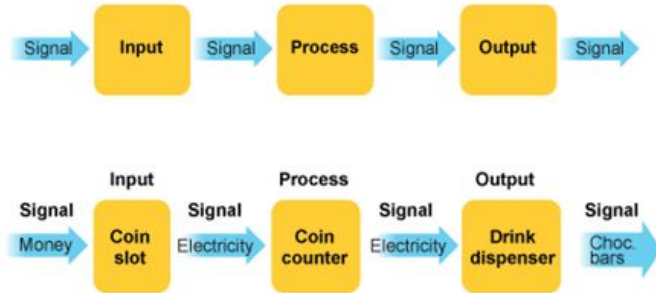Sensor detects level is too low

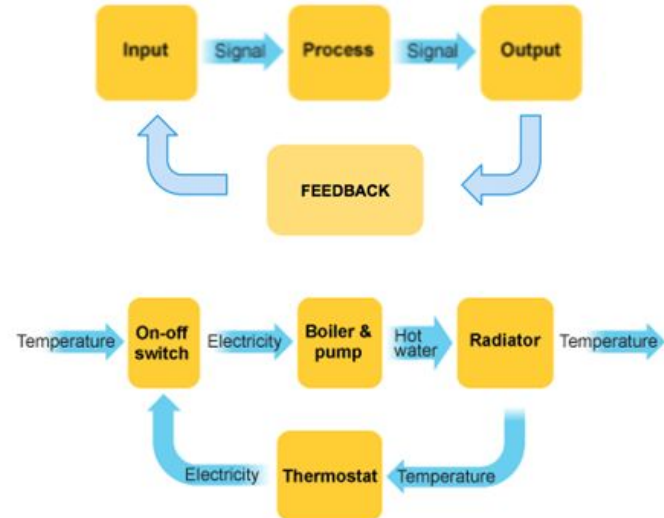Valve opened to let water in

# Open v closed loop feedback cycle

Does the output have a direct impact on future inputs?
- If no, it is open loop
- If yes, it is closed loop
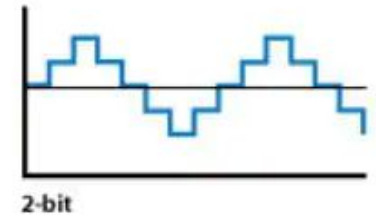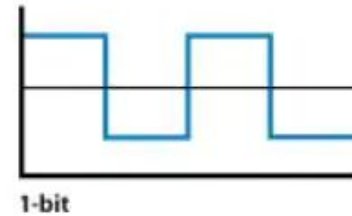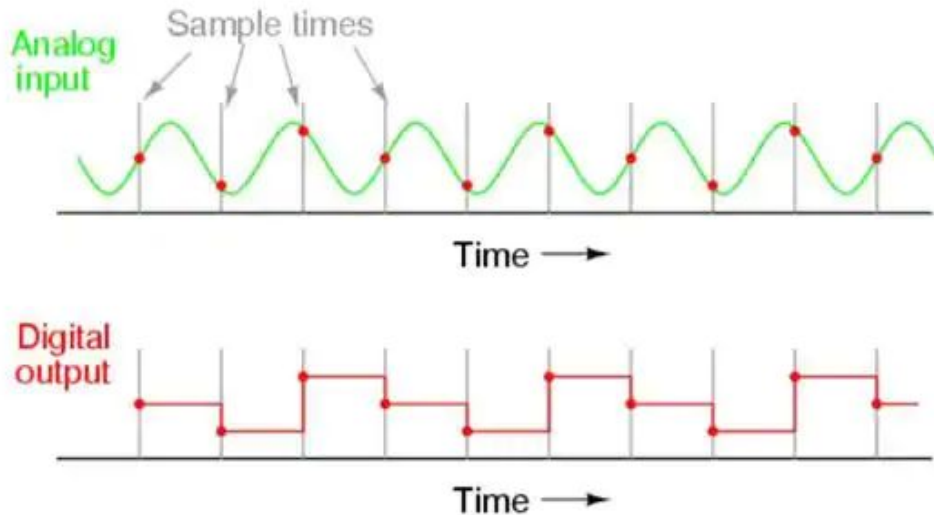
# Analog to digital converter

An analog to digital convertor will sample the power supplied at a set frequency, and use those snapshots to determine the resulting digital signal.

The accuracy of the process will vary greatly depending on how many bits are being dedicated to the process. If a simple on/off is all that is required, then 1 bit is all that is needed.
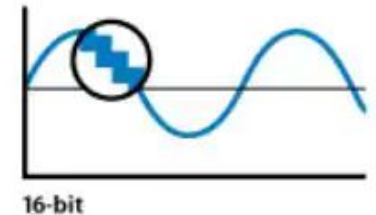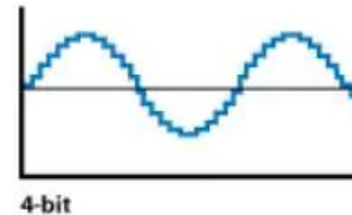
# Digital to analog converter

One of the cheapest and most common methods of converting digital to analog is pulse width modulation.

Pulse width modulation (PWM) is a method of changing the length of on/off pulses of a digital signal such as to produce a analog-like sine-wave output.

Other methods are used where more accuracy is required, but these come at greater expense.
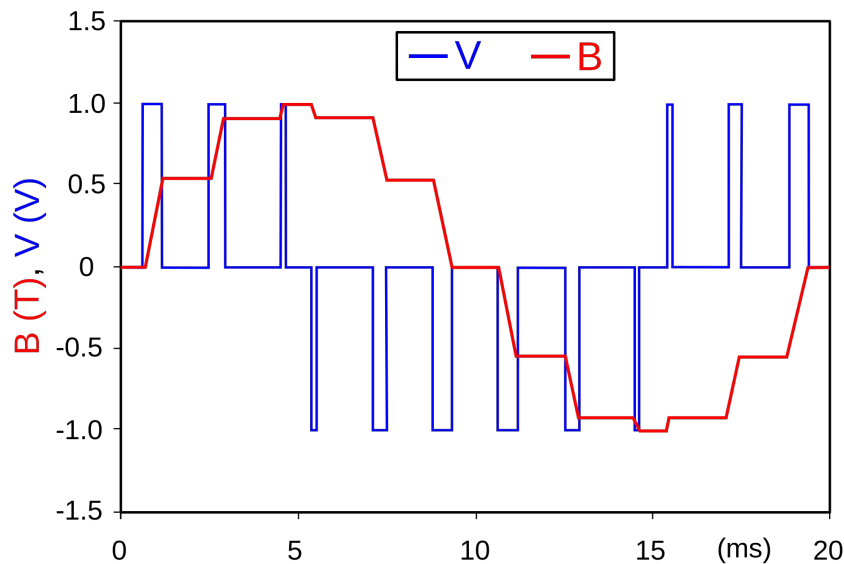
# What is USB, very briefly

USB = Universal serial bus.

A serial port is just one which transmits information sequentially, one bit at a time.
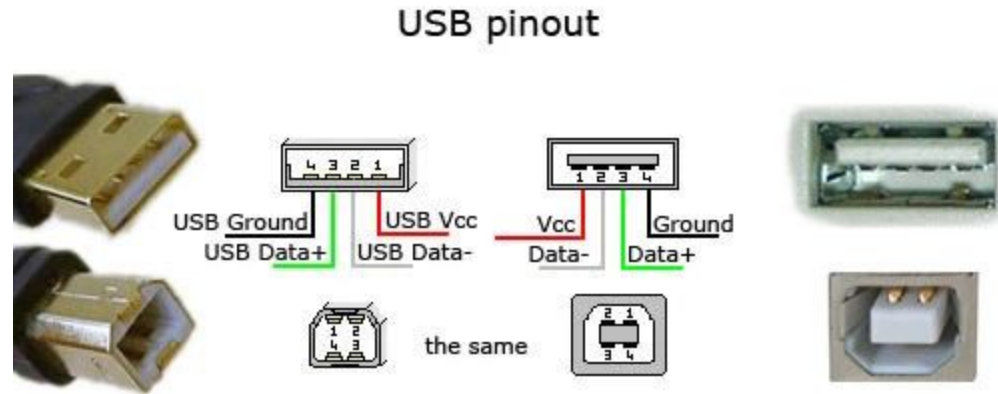


USB pinout

USB is a serial bus. It uses 4 shielded wires: two for power (+5v & GND) and two for differential data signals (labelled as D+ and D- in pinout)

http://pinouts.ru/Slots/USB_pinout.shtml

# Sensors

1.3.3 Input devices (part 2)

Candidates should be able to:

- describe how a range of sensors can be used to input data into a computer system, including light, temperature, magnetic field, gas, pressure, moisture, humidity, pH and motion
- describe how these sensors are used in real-life scenarios, for example: street lights, security devices, pollution control, games, and household and industrial applications

# Active vs passive

Active sensor - require separate electrical power in order to measure environment signals.

Passive sensor - don't require separate electrical power for measuring environment signals.

Examples:

- The ultrasonic range finder is active as it requires you to supply power to it via the VCC and GND pins.
- The light sensitive resistor is passive. It will chemically vary it's resistance naturally based on the light around it and doesn't require a power supply to function.
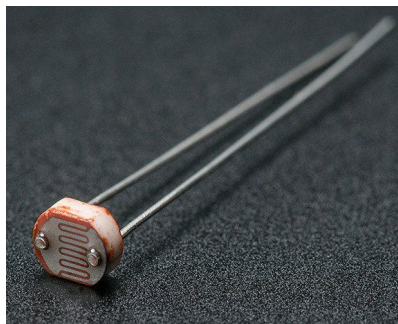
# Connection with microprocessor and your program

The sensor does not "detect an object" and then send the signal to the processor. The sensor (if powered up) is always sensing and sending data to the processor. It is the program you run on the processor that determines the significance of that data.

This is the single most common test mistake!
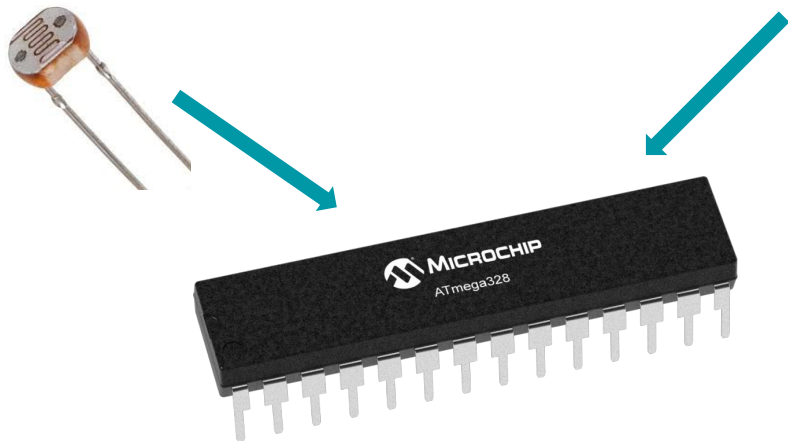


```
int threshold = 500;             // Light/dark value to trigger action

void setup() {
  Serial.begin(9600);
  pinMode( 10, OUTPUT );         // Initialise output pin
}

void loop() {
  int LDRValue = analogRead(A0); // read the value from the LDR
  Serial.println(LDRValue);      // print the value to the serial port
  if (LDRValue < threshold) {
    digitalWrite(10, HIGH);      // turn something on
  } else {
    digitalWrite(10, LOW);       // turn something off
  }
  delay(100);                    // wait a little
}
```

# Light sensor

There are two commonly used types:

Photosensitive resistor - CdS cells are little light sensors. As the squiggly face is exposed to more light, the resistance goes down. When its light, the resistance is about ~1KΩ, when dark it goes up to ~10KΩ.

Transistor Light Sensor - is a simple sensor that detects ambient light. It's kind of the opposite of an LED - when light hits the little chip inside, it induces current to flow from the long pin to the short pin.
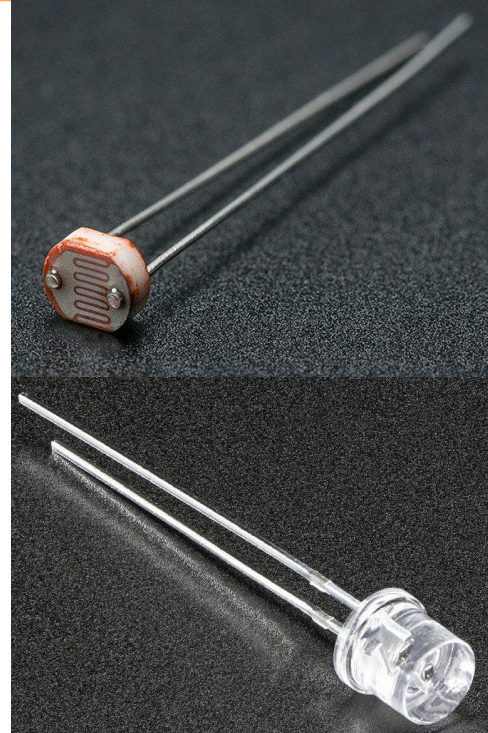
# Temperature sensor (thermistor)

Active sensor that returns a temperature value in degrees celsius.

# Magnetic field (hall effect)

An active sensor that detects the presence of a magnet.



Hall Effect Sensor
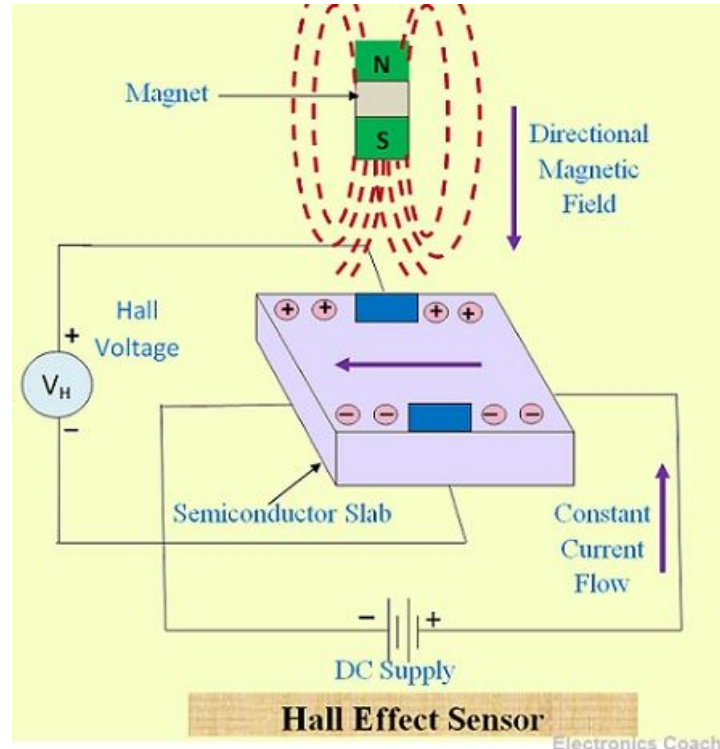
# Gas sensor

The MQ-2 smoke sensor is sensitive to smoke and to the following flam

LPG
Butane
Propane
Methane
Alcohol
Hydrogen
The resistance of the sensor is different depending on the type of the gas.

The smoke sensor has a built-in potentiometer that allows you to adjust the sensor sensitivity according to how accurate you want to detect gas.

Demo project here
https://create.arduino.cc/projecthub/Aritro/smoke-detection-using-mq-2-gas-sensor-79c54a

# Pressure sensor

Passive sensor that

# Moisture sensor

The soil moisture sensor consists of two probes that are used to measure the volumetric content of water. The two probes allow the current to pass through the soil, which gives the resistance value to measure the moisture value.

When there is water, the soil will conduct more electricity, which means that there will be less resistance. Dry soil conducts electricity poorly, so when there is less water, then the soil will conduct less electricity, which means that there will be more resistance.

This sensor can be connected in analog and digital modes.

*Should we get a self watering plant for 333?*
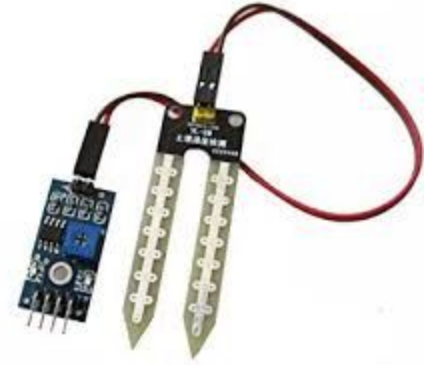
```
int sensor_pin = A0;
int output_value ;

void setup() {
  Serial.begin(9600);
  Serial.println("Reading From the Sensor ...");
  delay(2000);
}


void loop() {
  output_value= analogRead(sensor_pin);
  output_value = map(output_value,550,0,0,100);
  Serial.print("Mositure : ");
  Serial.print(output_value);
  Serial.println("%");
  delay(1000);
}
```

# Humidity sensor



Provides a floating point number that can be used to approximate humidity in the surrounding air.

# pH sensor

Measures the acidy/basic pH of a solution.

# Motion sensors



Accelerometer - measures orientation in the X, Y and Z plane (looks like a microchip but it actually has tiny moving parts within it). Compare current orientation to past orientation and you can determine movement.

Tilt ball sensor - measures True/False for if the ball bearing inside is making a connection across the pins.



Ultrasonic range finder - Will transmit an ultrasonic sound frequency pulse when the trigger pin is activated. The echo pin will activate when it hears an ultrasonic pulse. Your software can use the time delay based on the speed of sound, to calculate the distance to an object.
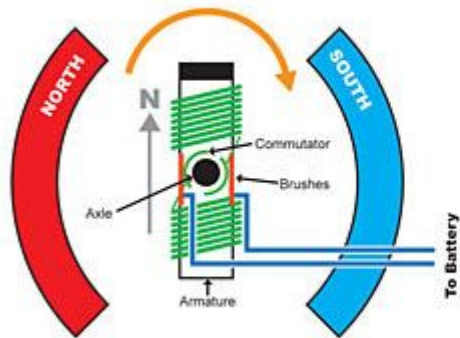
Infrared - Using an IR LED and an IR detector, your program can detect if something is blocking the path between the two elements or not

Device specific remarks

# Actuators



**Brushed DC Motor**

NORTH

SOUTH

N

Commutator

Brushes

Axle

Armature

To Battery

**Brushless DC motor**

ESC/Battery

Field Magnet

Coils

**Servo**

GEARBOX
- 60 RPM
- HIGH TORQUE

POTENTIOMETER
- VARIABLE VOLTAGE
- RELATIVE TO THE ANGLE

DC MOTOR
- HIGH SPEED
- LOW TORQUE

CONTROL CIRCUIT
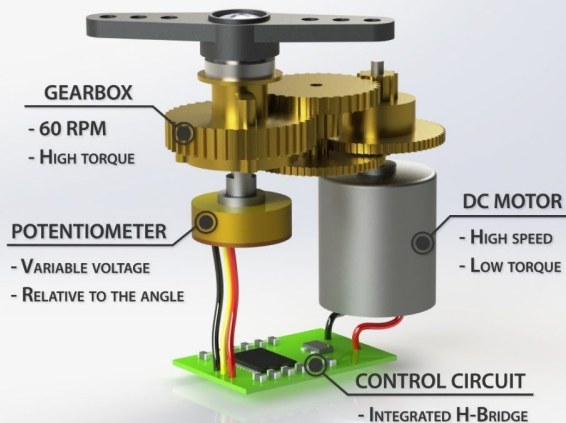- INTEGRATED H-BRIDGE
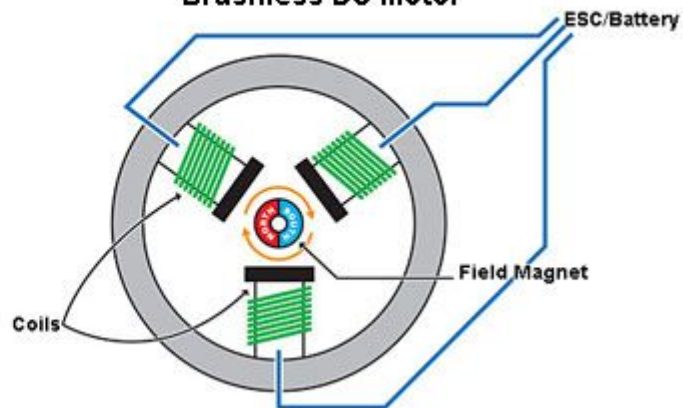
Closing comments

# Common questions

- There will always be one barcode or QR code question
- There will always be a image capturing question - camera, scanner etc
- There will always be a touch screen question - resistance, capacitive, infrared

# Inkjet vs Laser printer

- Laser printer
  - A spinning barrel that uses static charges to put toner particles onto the paper
- Inkjet printer
  - Uses a mechanical system that moves across the page to squirt ink droplets onto the paper.
- Inkjets are a lot cheaper upfront but far more expensive in the long term if you are printing in bulk.

# Touch sensors: Capacitive

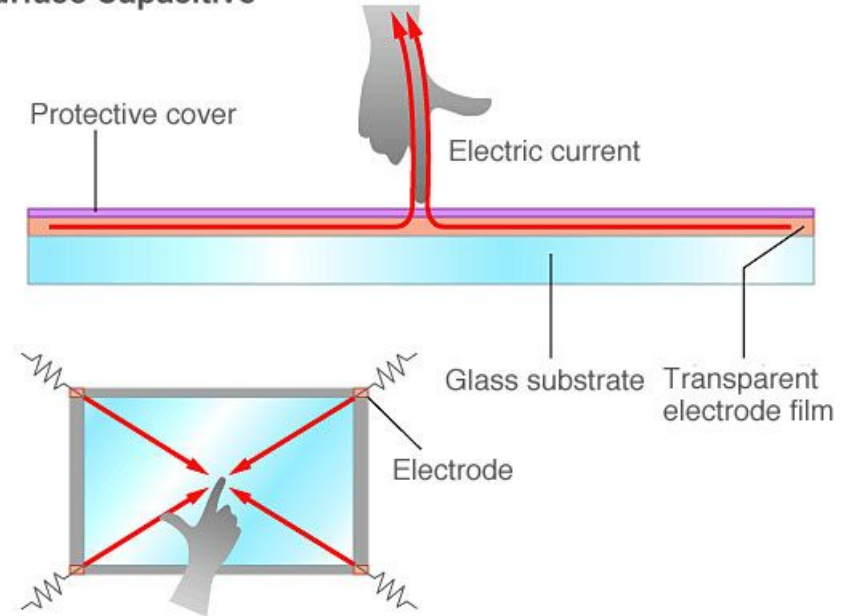There is almost always a question asking how a touch screen works!

Capacitive touch
A capacitive (charge holding) coating is applied to (usually) glass panel. When touched, the capacitance of the person is detected (ie: small electrical charge transfers from the device to the person - this loss is detectable).

Sensors at the corners measure the relative difference in capacitance so the processor can calculate coordinates of the touch.

Only works when touched by electrically conductive items (such as people!).



**Surface Capacitive**

Protective cover

Electric current

Glass substrate   Transparent electrode film

Electrode

# Touch sensors: Resistive

There is almost always a question asking how a touch screen works!

Resistive touch screens use at least two layers. When the top layer is touched, the two layers will make contact and the point of contact can be calculated.

Works when touched by anything (so gloves is ok). Can't detect multi-touch gestures though.



Resistive Film

Insulator

Film

Spacer dot
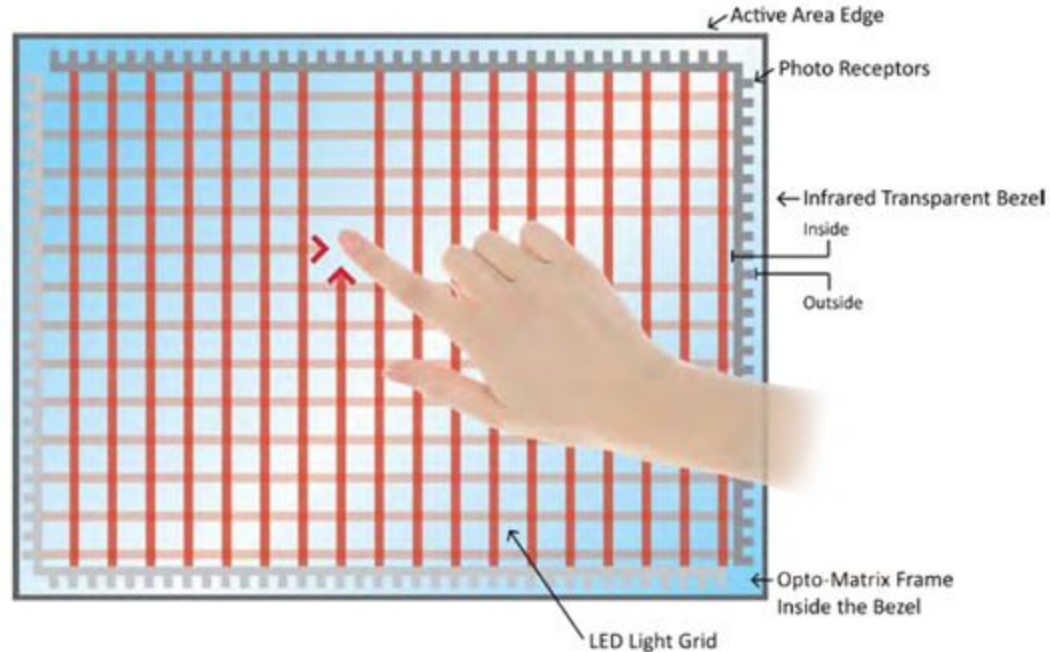
Glass

Transparent electrode film
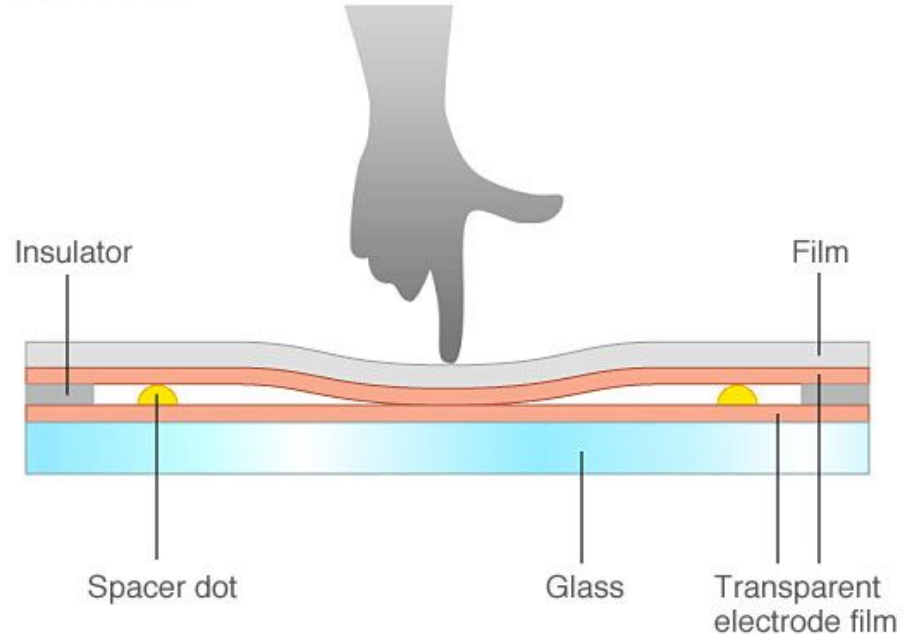
# Touch sensors: Infrared

There is almost always a question asking how a touch screen works!

Infrared rays are sent across screen to sensors at the other end.
The rays form a grid across the screen.
When a ray is broken, the coordinates can be used to locate the touch.

# Capturing images

Captured images to digital photo files
- Light is focused through a lens onto a charged couple device
- The photons hit the CCD according to intensity of the image
- The intensity striking the individual CCD determines the voltage for that pixel
- The analogue voltage is converted to a digital signal using an ADC
- Image is turned into a grid of pixels
- Each pixel is given binary values to represent the color
- Pixels are stored in sequence (in a file)
- Metadata is stored to describe the dimensions/resolution of the image

# Detection vs measurement

After seeing your review questions, it bears repeating. Sensors do not detect, they measure. It might seem like semantics but you will not be awarded the mark if you say "the sensor detects a person etc". It is the program running on the processor that decides how to interpret the data from the sensor.

Consider the ultrasonics we programmed with the Raspberry Pi

```
Nearest object is 16 centimeters
Nearest object is 15 centimeters
Nearest object is 16 centimeters
Nearest object is 15 centimeters
Nearest object is 14 centimeters
Nearest object is 15 centimeters
Nearest object is 14 centimeters
Nearest object is 13 centimeters
Nearest object is 12 centimeters
Nearest object is 13 centimeters
```
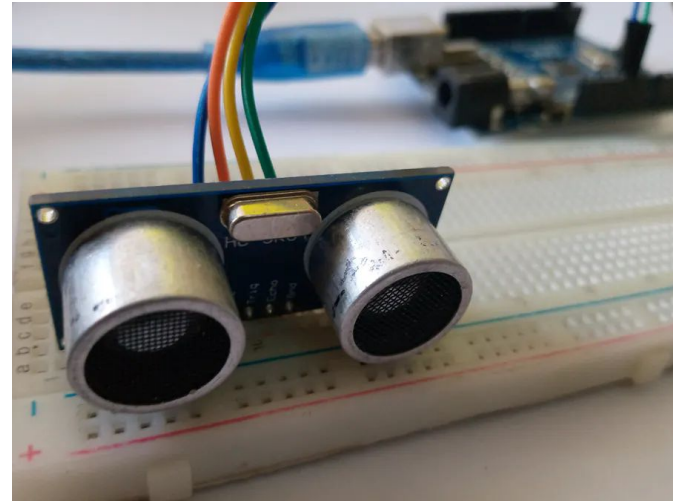
# Now what?

Remaining schedule:
- Today: Check your review question responses against the answer key
- Friday: No online lesson
- Monday: How to connect your Raspberry Pi over VNC so you can use it at home.
  - I am happy for you to borrow any equipment you want to experiment with the Raspberry Pi over the summer.

Summer reading:
- Chapter 5 - Memory & storage

Summer programming:
- Do some! Don't let your programming get rusty.

Next term:
- Computer internals (memory, storage, operating system)
- Computer networks & security