

8000-100 BC

1600-1950

2028

The History of Agriculture

\$9.89 Billion



0-1600 AD



1950-Present



Drones - Basic Components

- Frame
- Motors
- Electronic Speed Control Modules
- Control Board with Battery
- Inertial Navigation System
- Transmitter and Receiver



Drones - Additional Agriculture Sensors

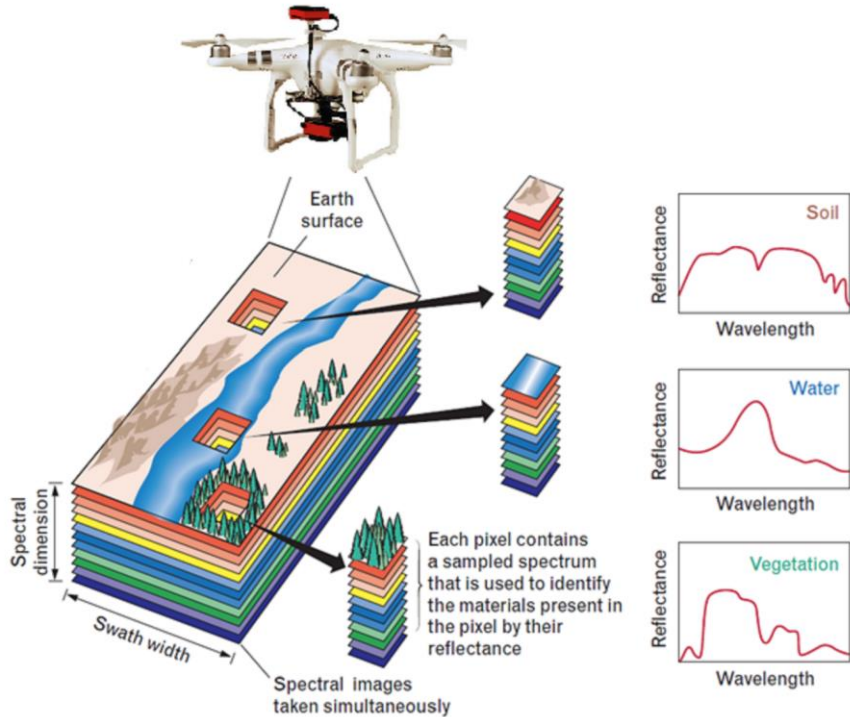


- GPS
- Barometer
- Altimeter
- Ultrasonic Sensor
- Multispectral Camera with gimbal
- Thermal Camera
- LiDAR (light detection and ranging)



Drones (UAV) in Agriculture:

Precision Agriculture



- Soil and Field analysis
- Planting
- Crop Spraying
- Crop Analysis
- Irrigation
- Health Assessment





<https://www.youtube.com/watch?v=-psAtUQY7mE>





Pre- Programmed

Human Controlled



First Person Viewer



Drone Safety - FAA Part 107

- The rules are different if you are flying the drone recreationally or commercially but generally:
 - Drones weighing more than 55 lbs must be registered with the Federal Aviation Administration (FAA)
 - Drones (unmanned aerial vehicles) must stay below 400 feet and outside of restricted areas
 - Do not fly near stadiums, government buildings, or airports without formal approval
 - Do not lose sight of your drone



Weight

Lift

Flying Basics

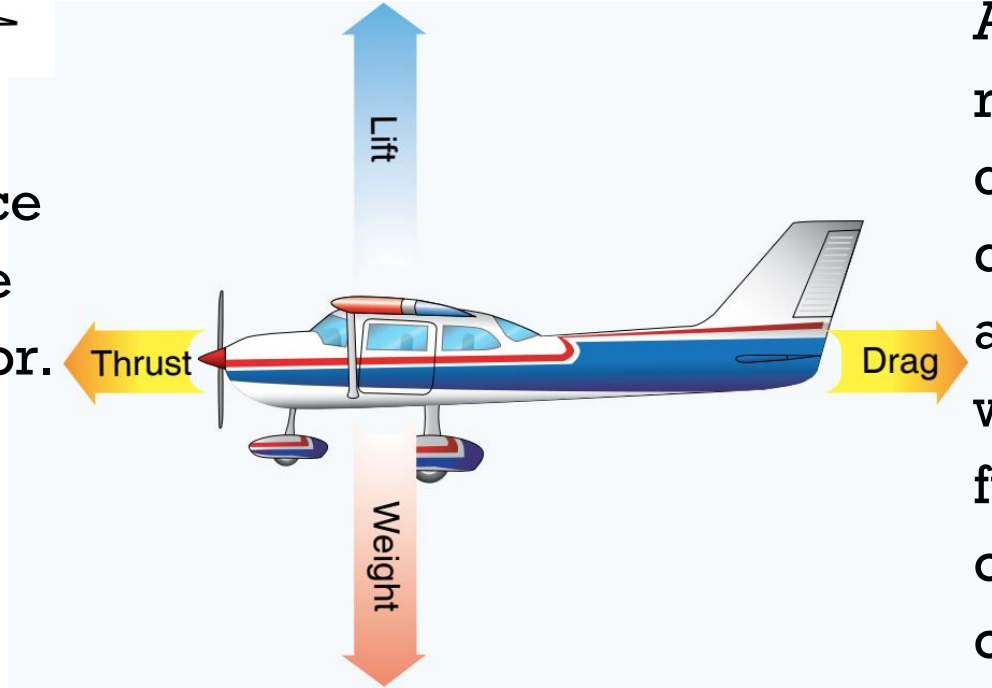
Drag

Thrust



The force produced by the dynamic effect of the air acting on the airfoil.

The forward force produced by the propellor or rotor. It opposes or overcomes the force of drag.



A rearward, retarding force caused by disruption of airflow by the wing, rotor, fuselage, and other protruding objects

The combined load of the aircraft itself, the crew, the fuel, and the cargo or baggage.

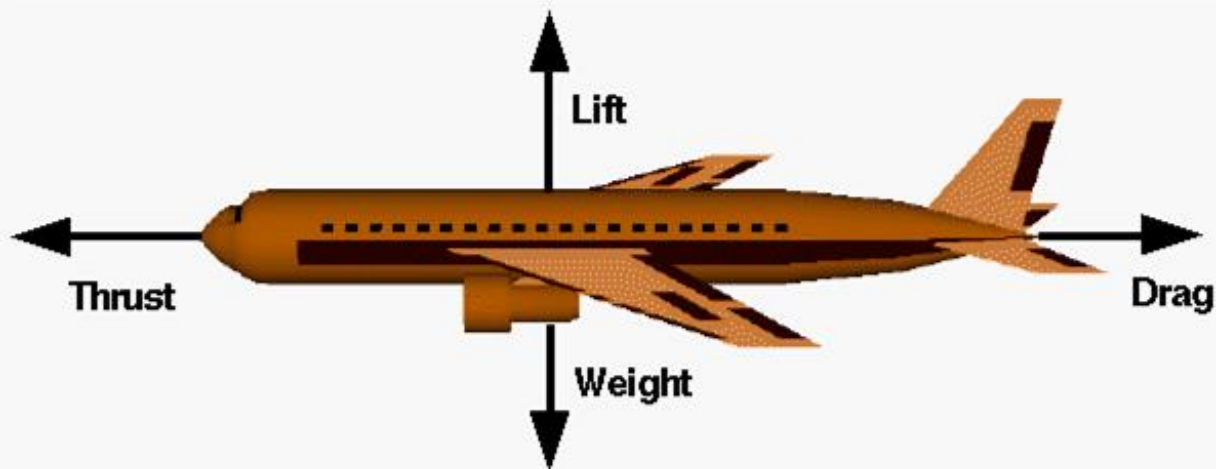




Simplified Aircraft Motion

Unbalanced Forces

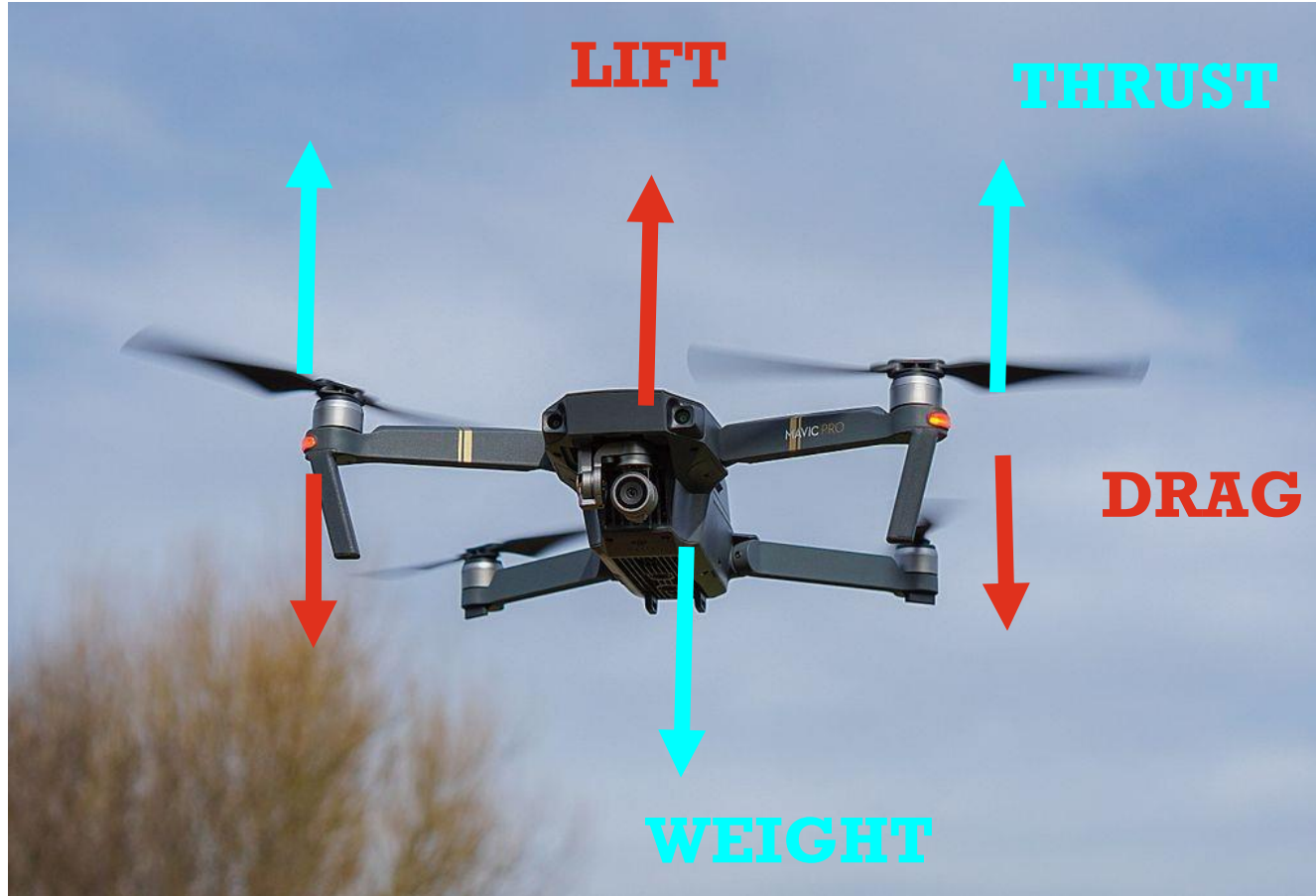
Glenn
Research
Center



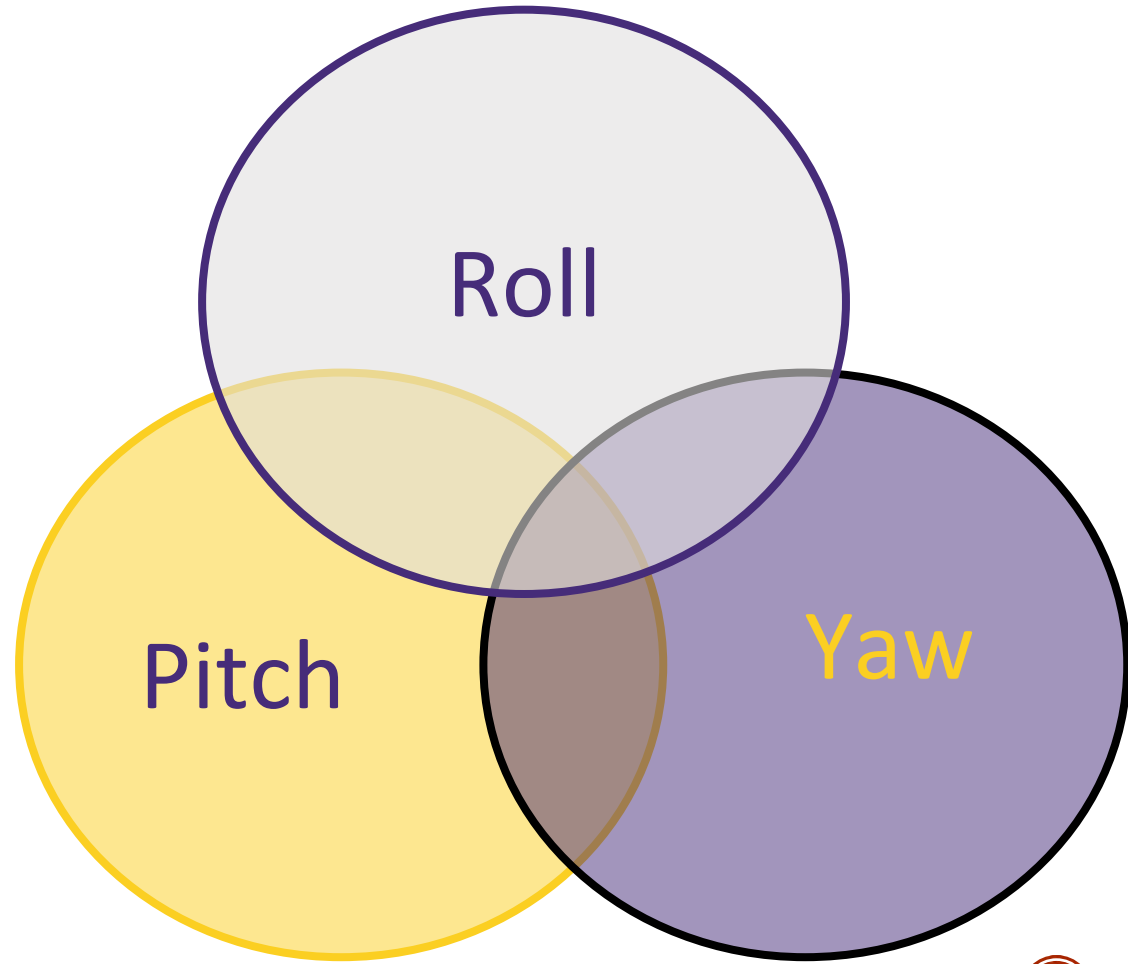
Flight Condition	Effect
$\text{Lift} > \text{Weight}$	Plane Rises
$\text{Weight} > \text{Lift}$	Plane Falls
$\text{Drag} > \text{Thrust}$	Plane Slows
$\text{Thrust} > \text{Drag}$	Plane Accelerates

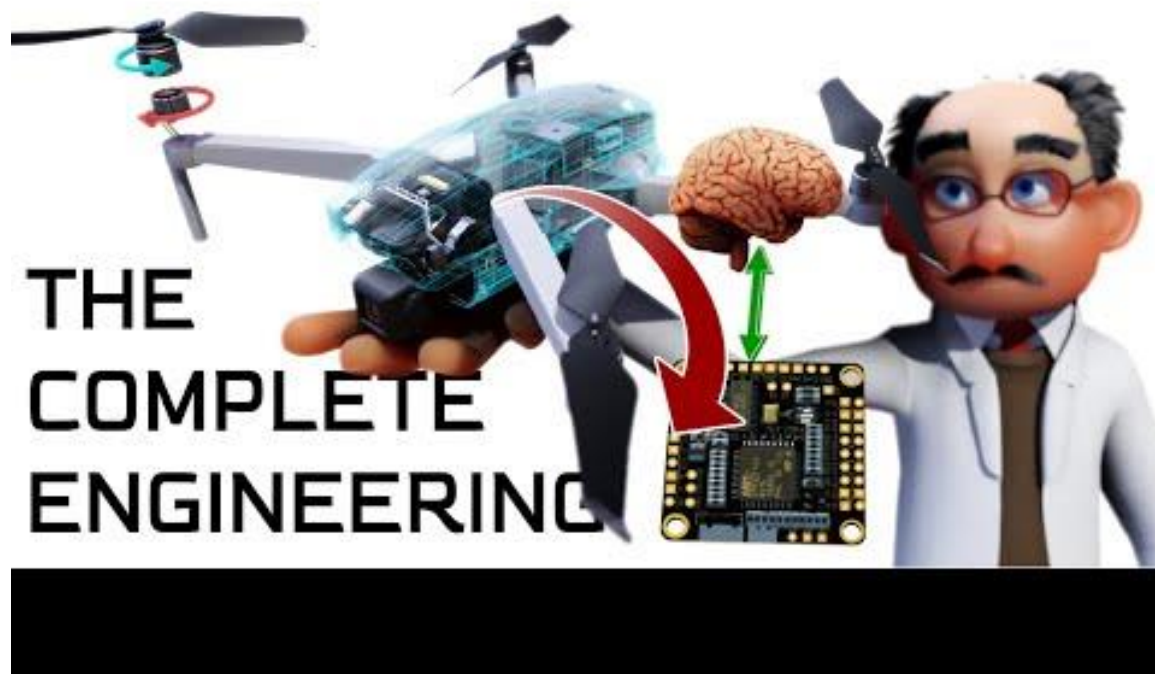


Drones Are A Little Different



Controlling the rotation





https://www.youtube.com/watch?v=N_XneaFmOmU



Altitude Sensor in Agricultural Drones

Barometer
(air pressure)

Measures atmospheric pressure in a static location - Often used to determine/predict weather patterns

vs.

Altimeter
(air pressure)

Measures air pressure in a changing locations - the air pressure is converted to an altitude calculation

vs.

Ultrasonic
(sonar)

Sends out a sonar signal and measures how long it takes to echo back - converts time into distance

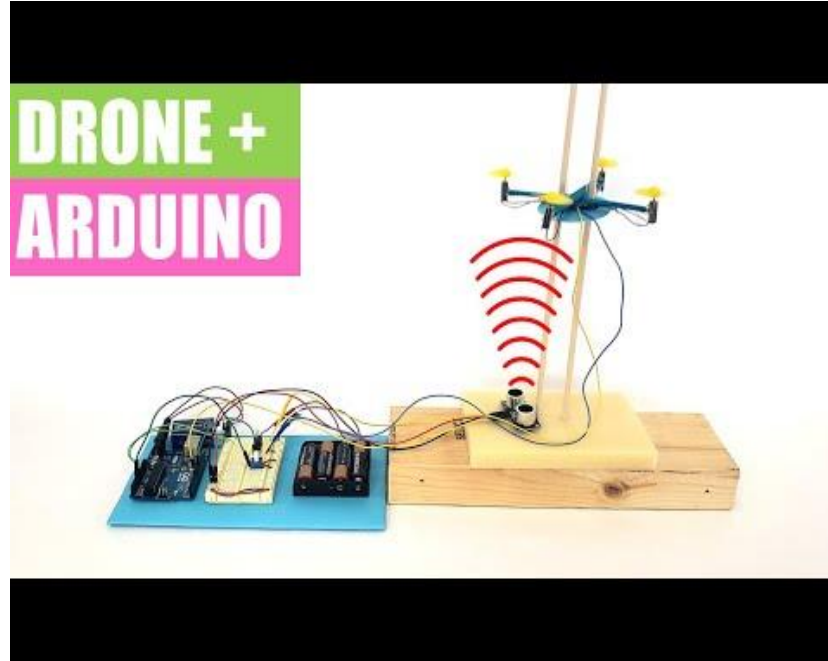


Why is Altitude Important?

- Getting close enough to crops to spray products
- Camera resolution when getting imagery
- Avoiding obstacles



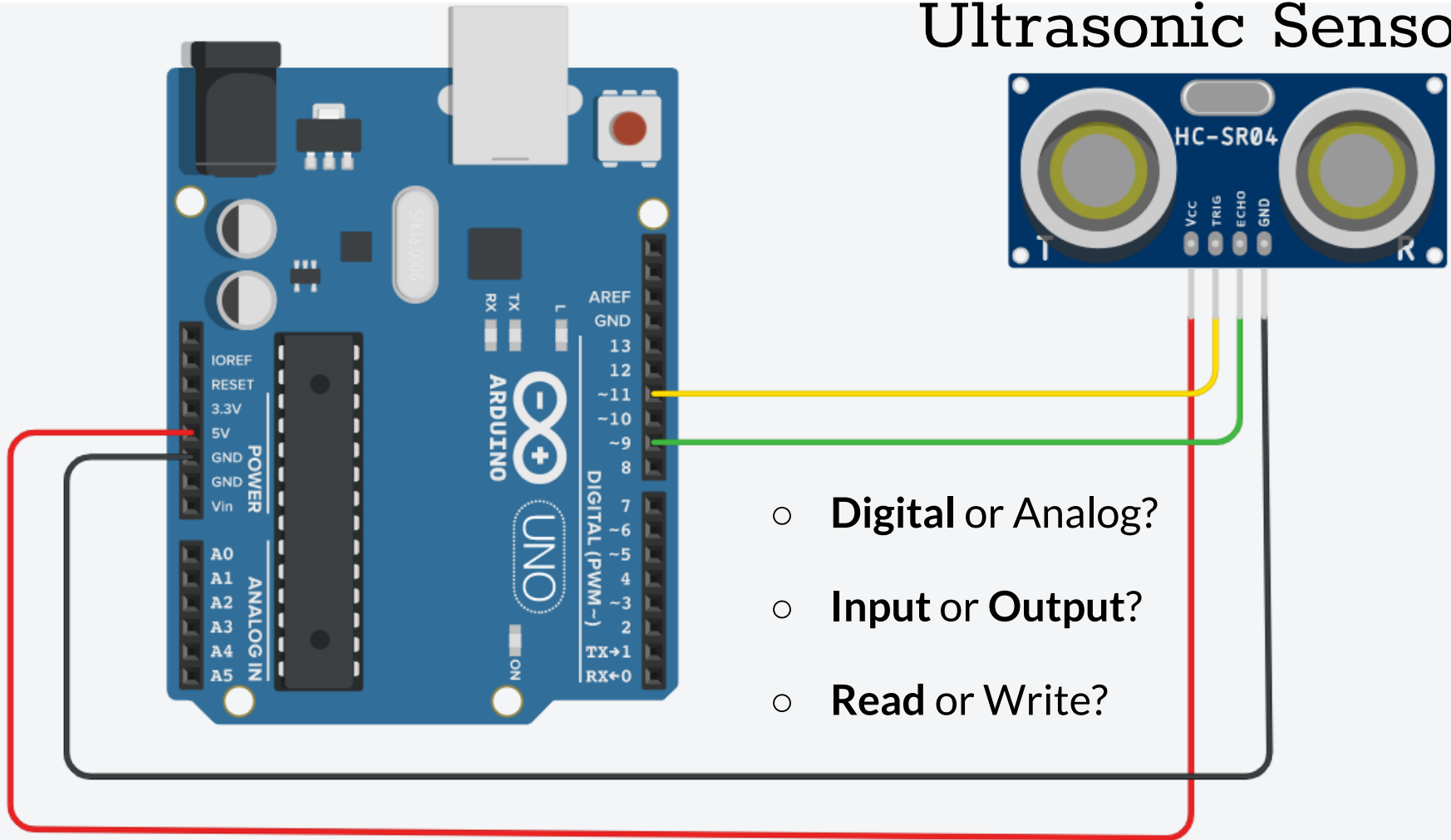
Let's build a drone!



https://youtu.be/1_jAj5GAuZ0



Ultrasonic Sensor



```
// Global variables

const int trigPin = 11;
const int echoPin = 9;

void setup() {
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);

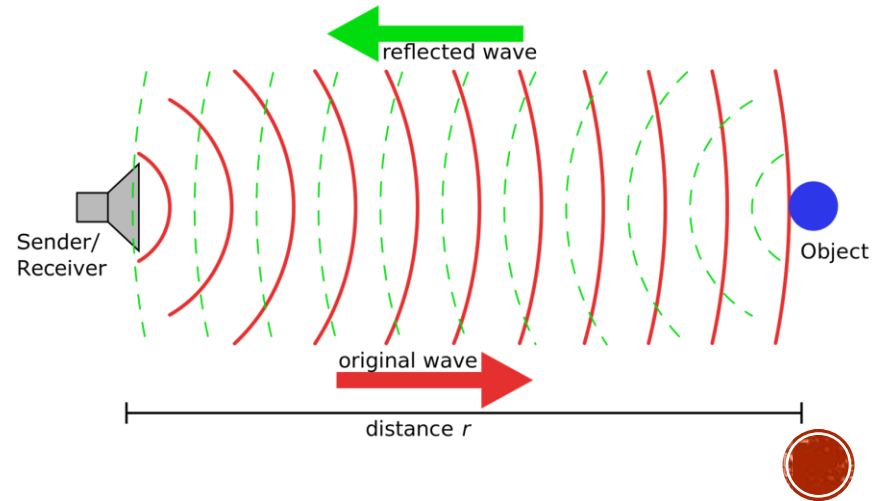
  void loop() {

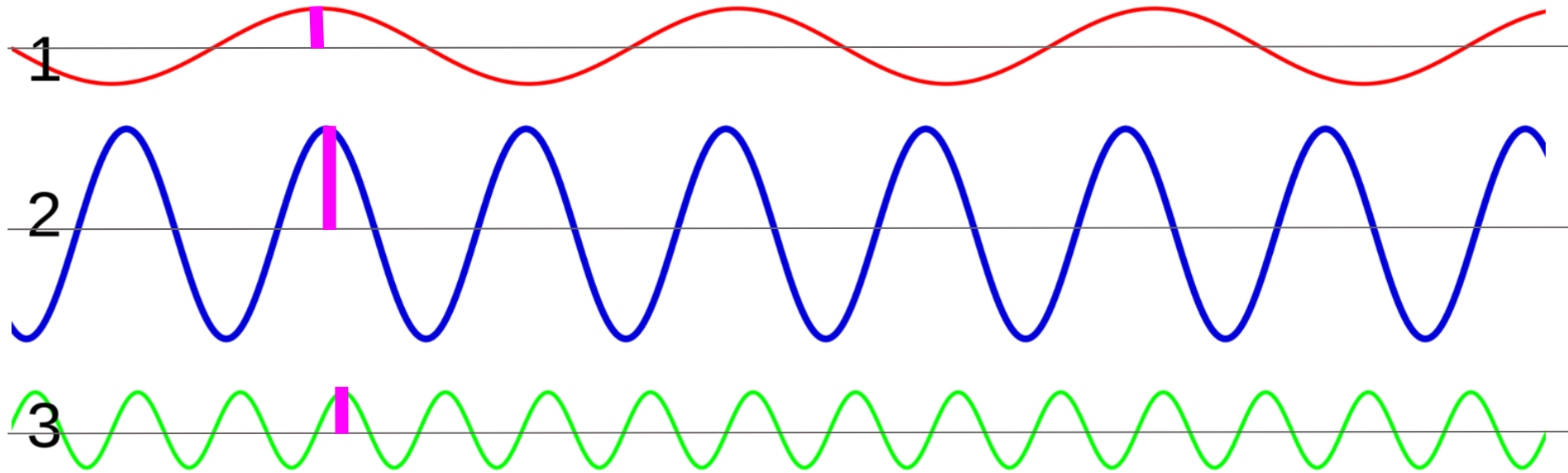
    pulseIn(echoPin, HIGH);
```



The ultrasonic sensor tells you that an object is $583\text{ }\mu\text{s}$ (microseconds) away from you.
How far away is the object?

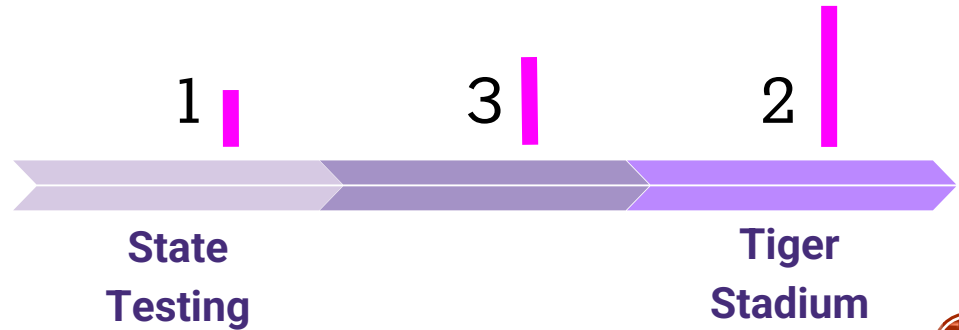
To answer that question, we need to understand the characteristics of sound waves and the speed of sound!

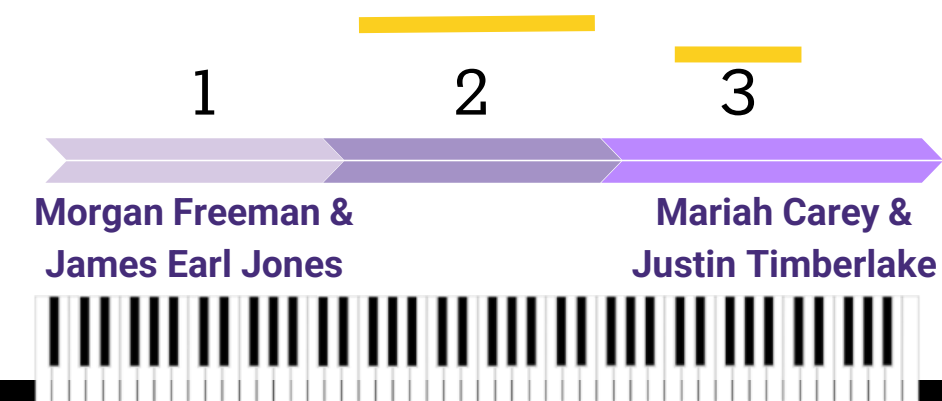
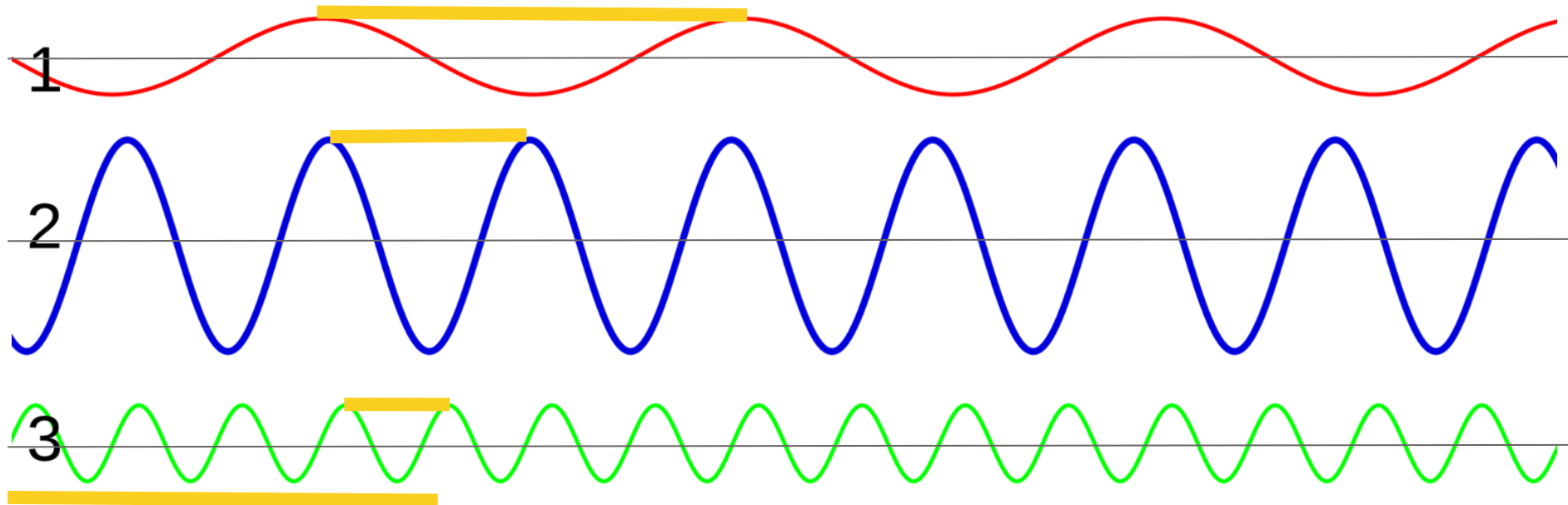




Amplitude

(Aka Loudness, Wave Height)





Period (T)

(Aka Pitch, Frequency, Wavelength)



Speed of Sound: distance travelled per unit of time by a sound wave as it moves through an elastic medium

<https://www.youtube.com/watch?v=W5Trznre92c>

The medium!!!! (gas, liquid, or solid)



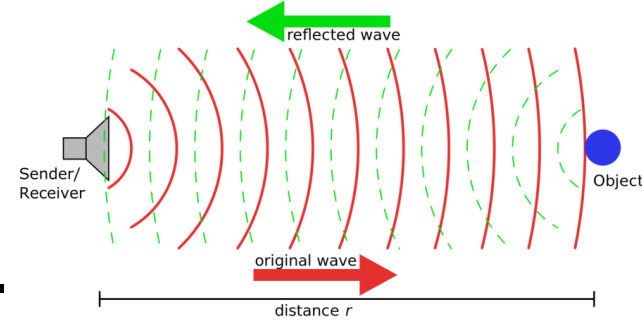
Speed of Sound (through air)

When you hear someone say “The speed of sound”, they are generally referring to the speed that sound travels through air at 20 °C. This value is 343 meters per second (or 767 mph). This is the value that we want use when we interact with the sonar values.



Going back to this question....

The ultrasonic sensor tells you that an object is 583 μs (microseconds) away from you. How far away is the object?



$$\frac{343 \text{ meter}}{\text{second}} \times \frac{100 \text{ centimeters}}{1 \text{ meter}} \times \frac{.000001 \text{ seconds}}{1 \text{ microsecond}} = \frac{.0343 \text{ cm}}{1 \text{ microsecond}}$$

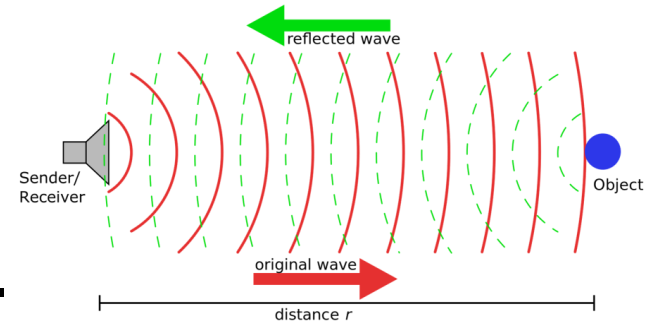
$$\frac{.0343 \text{ cm}}{1 \text{ microsecond}} = \frac{1 \text{ cm}}{x \text{ microseconds}}$$

$$x = 29.154 \mu\text{s}$$



Going back to this question....

The ultrasonic sensor tells you that an object is 583 μs (microseconds) away from you. How far away is the object?



$$583 \text{ microsecond} * \frac{.0343 \text{ cm}}{1 \text{ microsecond}} = 20 \text{ cm}$$

$$583 \text{ microsecond} * \frac{1 \text{ cm}}{29.154 \text{ microsecond}} = 20 \text{ cm}$$

Either way you solve it, this is the distance to the object AND back so you must divide by 2!



Your turn!

The ultrasonic sensor tells you that an object is 1047 μs (microseconds) away from you. How far away is the object?

If your object is 15 cm away, what value will your ultrasonic sensor read?



How will we use the Ultrasonic sensor to control the motors of our drone?

Feedback Control



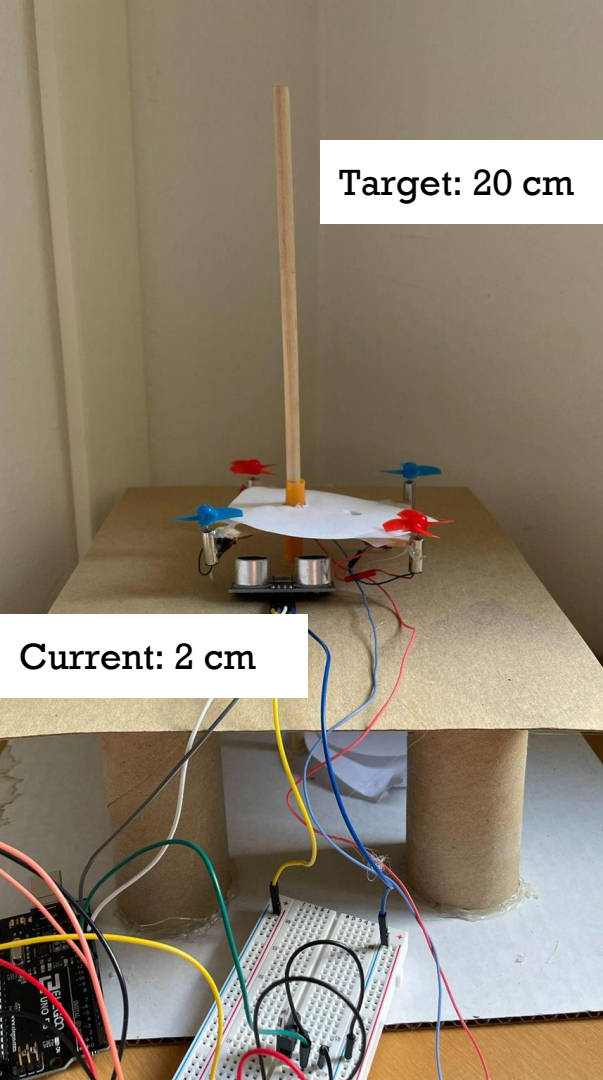
Feedback Control - Defined

In simple terms, the purpose of feedback control is to keep the **controlled variable** close to its **set point**.

Can you think of an example of feedback control in your own life?

Let's look at how we use feedback control in this project.





Feedback Control - Pseudocode

Read my current distance from Ultrasonic

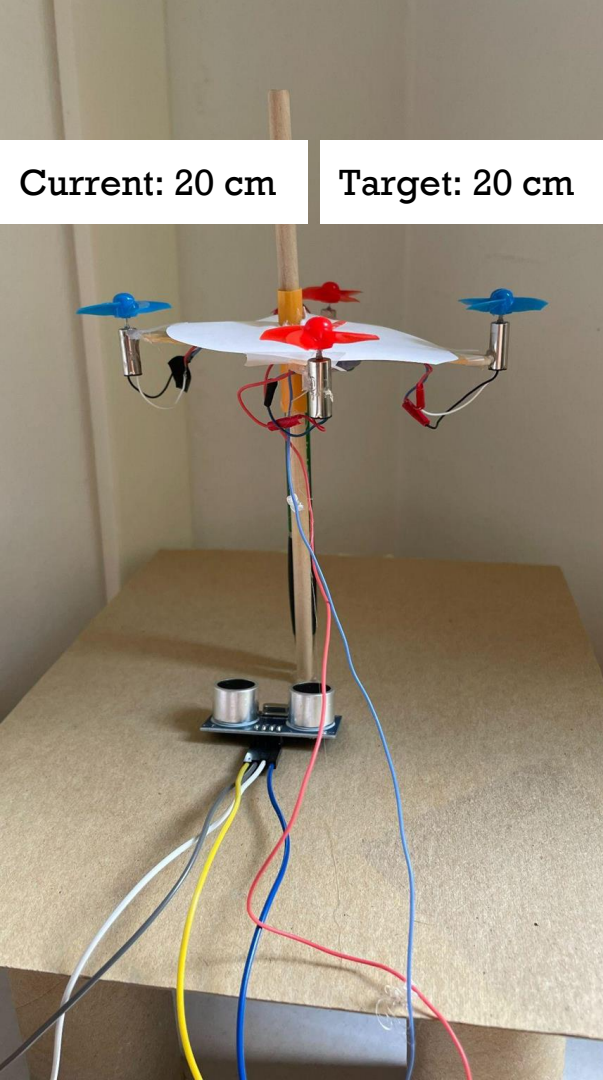
Check my target distance (set by potentiometer position)

Compare my current distance to my target distance (2 cm versus 20 cm)

Take action based on condition ($2\text{ cm} < 20\text{ cm}$)

- Increase motor speed (increase thrust) to get from 2 cm to 20 cm. This increase is proportional to how far away you are from the target





Feedback Control - Pseudocode

Read my current distance from Ultrasonic

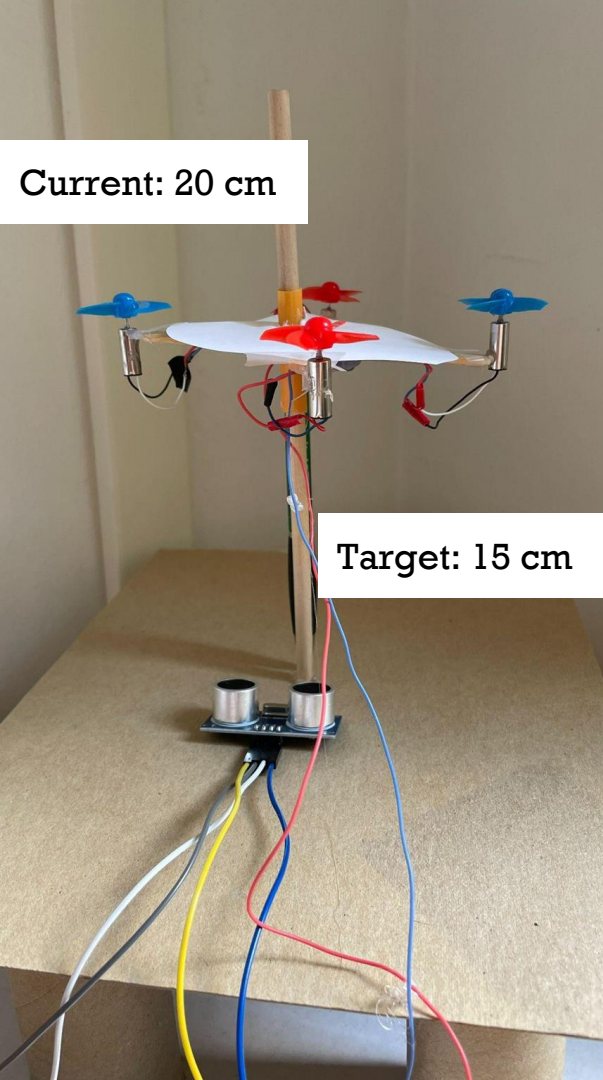
Check my target distance (set by potentiometer position)

Compare my current distance to my target distance (20 cm versus 20 cm)

Take action based on condition (20 cm = 20 cm)

- Maintain current motor speed to stay at target





Feedback Control - Pseudocode

Read my current distance from Ultrasonic

Check my target distance (set by potentiometer position)

Compare my current distance to my target distance (20 cm versus 20 cm)

Take action based on condition (20 cm > 15 cm)

- Slow motors down (decrease thrust)



Reading the Ultrasonic with Arduino

```
duration = pulseIn(echoPin, HIGH);
```

```
cm = (duration / 29) / 2
```



8 bits

- **Char:** Stores single characters: "A", "#"



16 bits

- **Int:** Stores integer values up to 5 digits: 6, 0, -10
- **Bool:** stores True/False



32 bits

- **Float:** Stores decimals up to 7 places: 3.57, -10.2
- **String:** Stores multi-character phrases: "Hello World"



64 bits

- **Long:** Stores integer values up to 19 digits



What is a function?

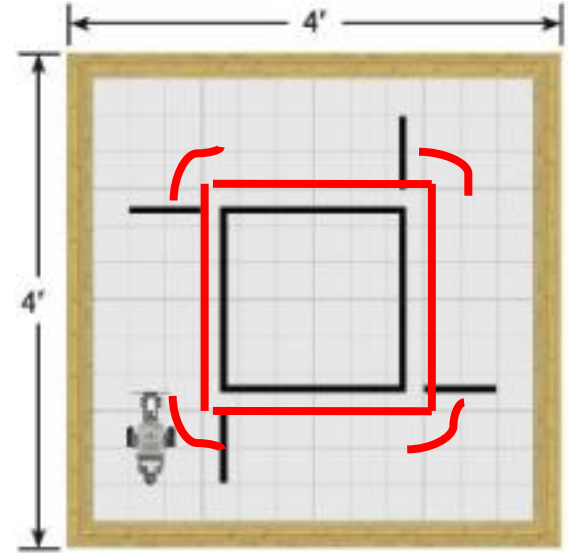
Modular pieces of code that perform a defined task that can be used more than once.

Example: Move robot around this square

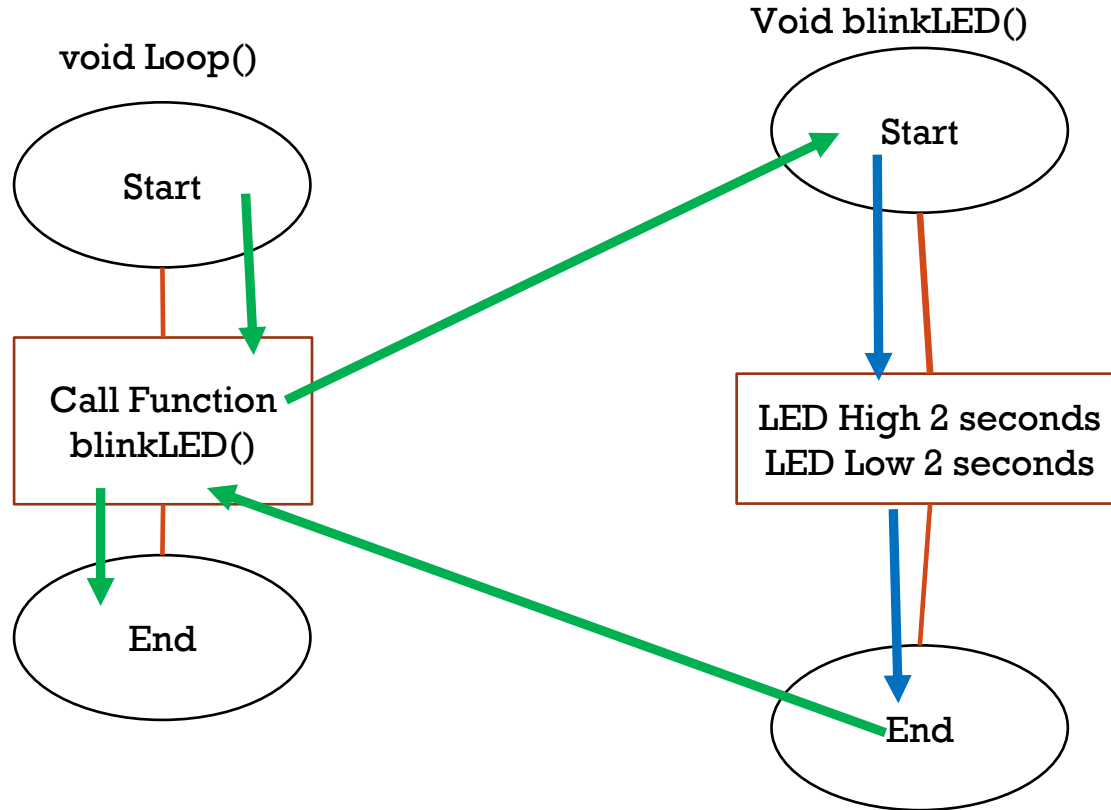
Requires:

Move forward (4 times)

Turn 90° right (4 times)



FUNCTION LOGIC



PARTS OF THE FUNCTION

1. Declare Your Function outside of your void Loop()

```
void blinkLED() {
```

2. Define what you want the function to do

```
    digitalWrite(redLED, HIGH);  
    delay(2000);  
    digitalWrite(redLED, LOW);  
    delay(2000);  
}
```



PARTS OF THE FUNCTION

3. Call the function within void loop()

```
void loop() {  
    blinkLED();  
    blinkLED();  
    blinkLED();  
}
```



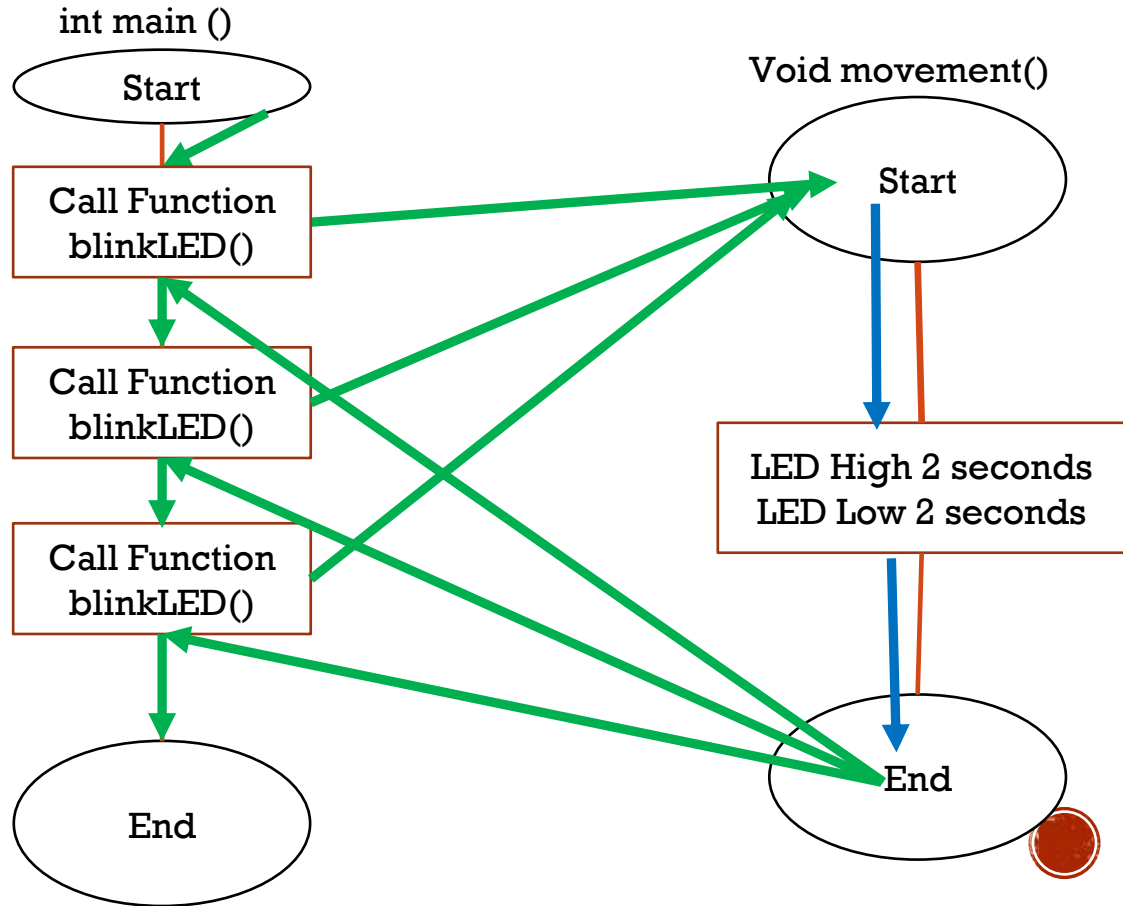
Calling movement() 3 Times

```
int redLED = 9;

void setup() {
    pinMode(redLED, OUTPUT);
}

void blinkLED() {
    digitalWrite(redLED, HIGH);
    delay(2000);
    digitalWrite(redLED, LOW);
    delay(2000);
}

void loop() {
    blinkLED();
    blinkLED();
    blinkLED();
}
```



Advantages of Functions

- Organization and conceptualization
- Easily debug small pieces
- Save space and reduce complexity
- Readability and reusability

