‘Making’ Internet of Things:
Prototyping New Ideas

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Why prototype?

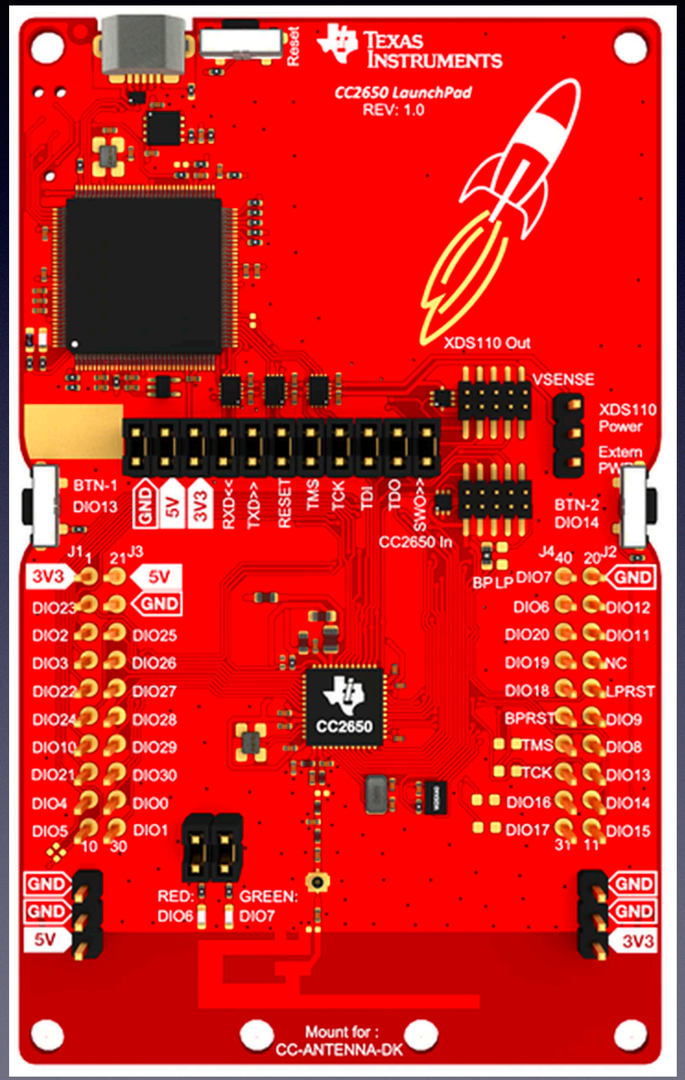
- Make things smarter - how about integrating sensors into everyday things.
- Make use of that old landline phone, reverse engineer it maybe.
- You have a great hardware idea related to **COVID**. And you want to help the people in need.

Flow of this lecturette series

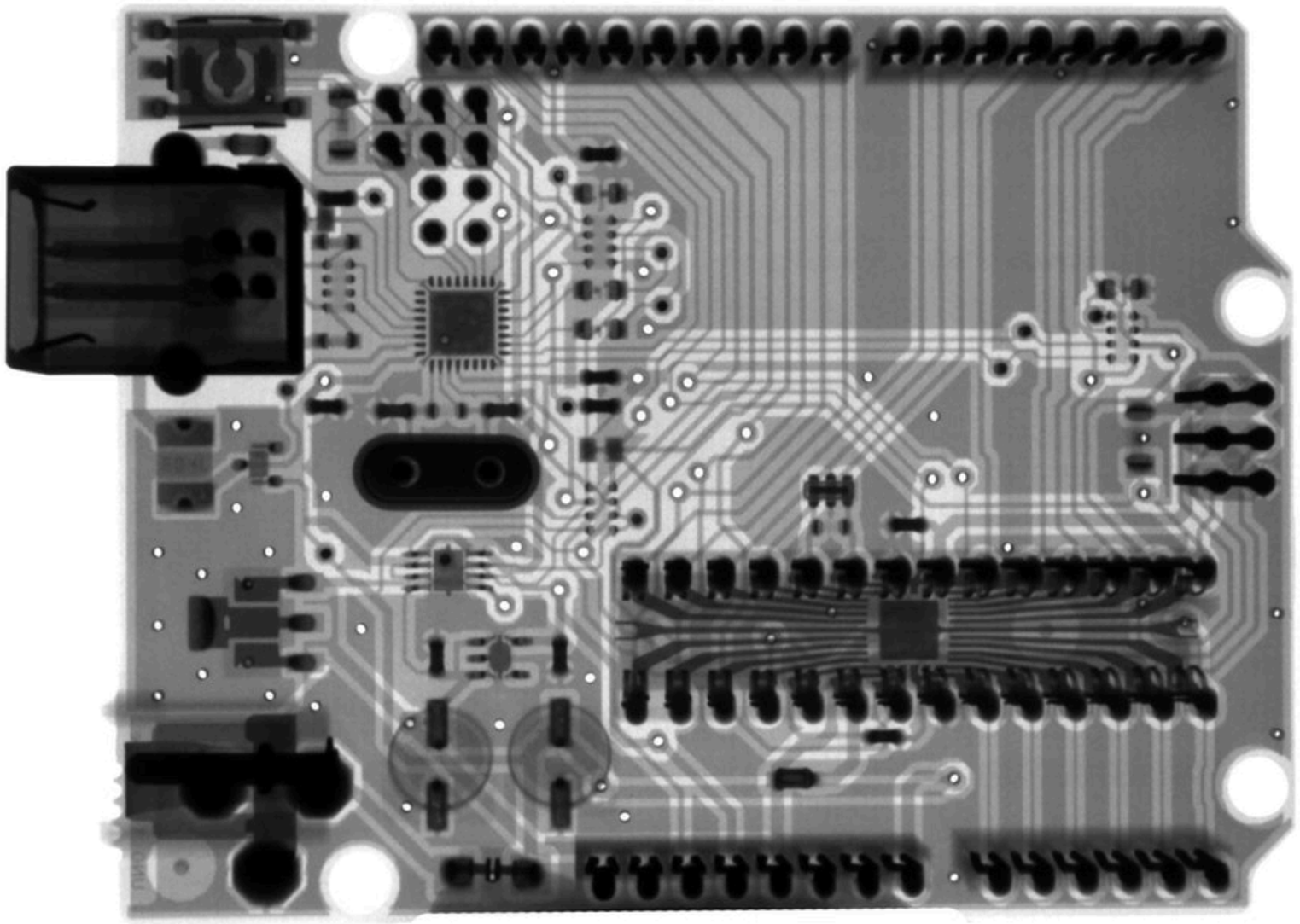
- Lecture 00 (a): From prototype to product: From an engineers' perspective
- Lecture 00 (b): Understanding 'Arduino' and getting started
- Lecture 01: Rapid prototyping with Arduino Part-1
- Lecture 02: Rapid prototyping with Arduino Part-2
- Lecture 03: Wait, I need a smaller form factor? NodeMCU
- Lecture 04: Wait, I need more processing power? SBCs RPi
- Bonus round (optional): Creating custom hardware | PCB Designing

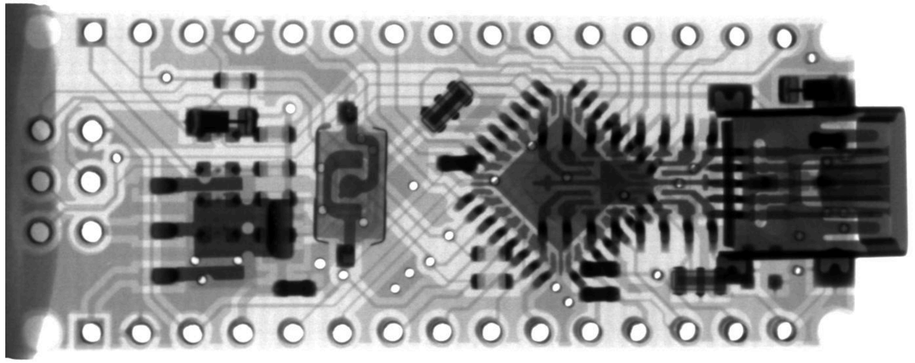
From prototype to product:
From an engineers' perspective

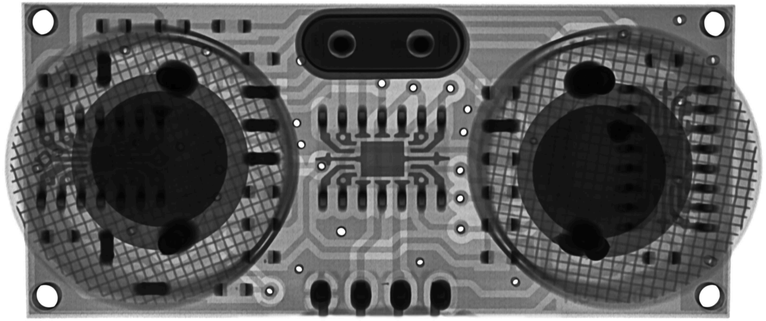
- Select MCU
- Prototype using 'Development boards'
- Work on peripherals (selection?) and code part
- Design new board that uses that specific MCU
- Transfer the MCU from the dev board onto a custom board
- Design the custom board (taking care of BMS++)
- Print the board (where? how?)
- 3D print the enclosure (CAD designing)
- User testing + Iterating



Think of things from different perspectives instead of taking in whatever is available!





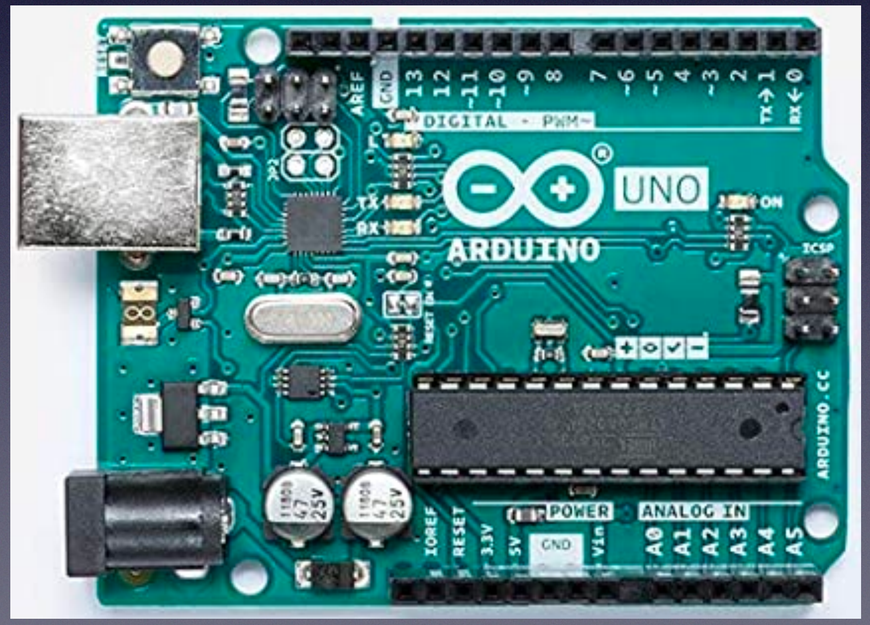


Let’s make Arduino

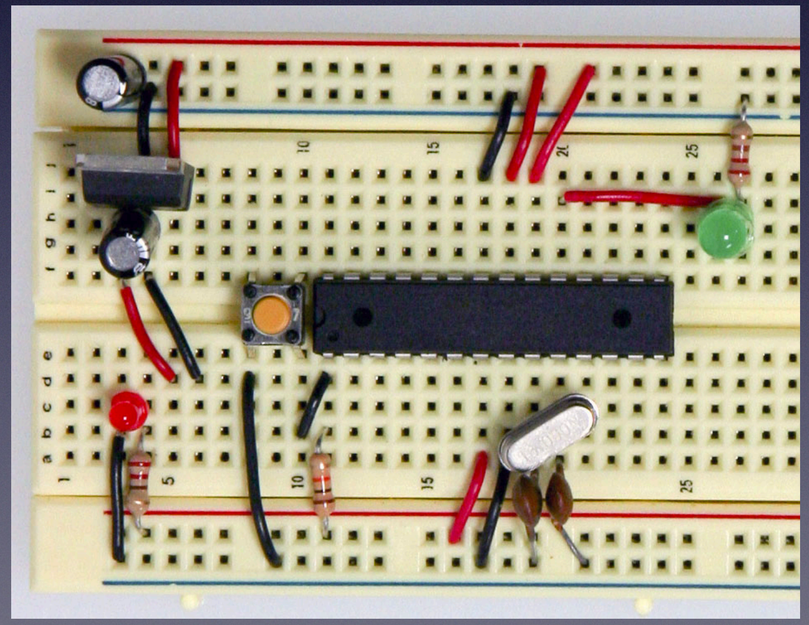
- Take ATMega328P (interested in designing ATMega itself?)
- Burn some codes into it (boot-loaders?)
- Start reading datasheets and don’t be afraid of reading them

It’s cheap…
It’s fast to work with…
But don’t stop there, you need to take it to the next level.

https://www.farnell.com/datasheets/1682209.pdf
https://en.wikipedia.org/wiki/Microcontroller

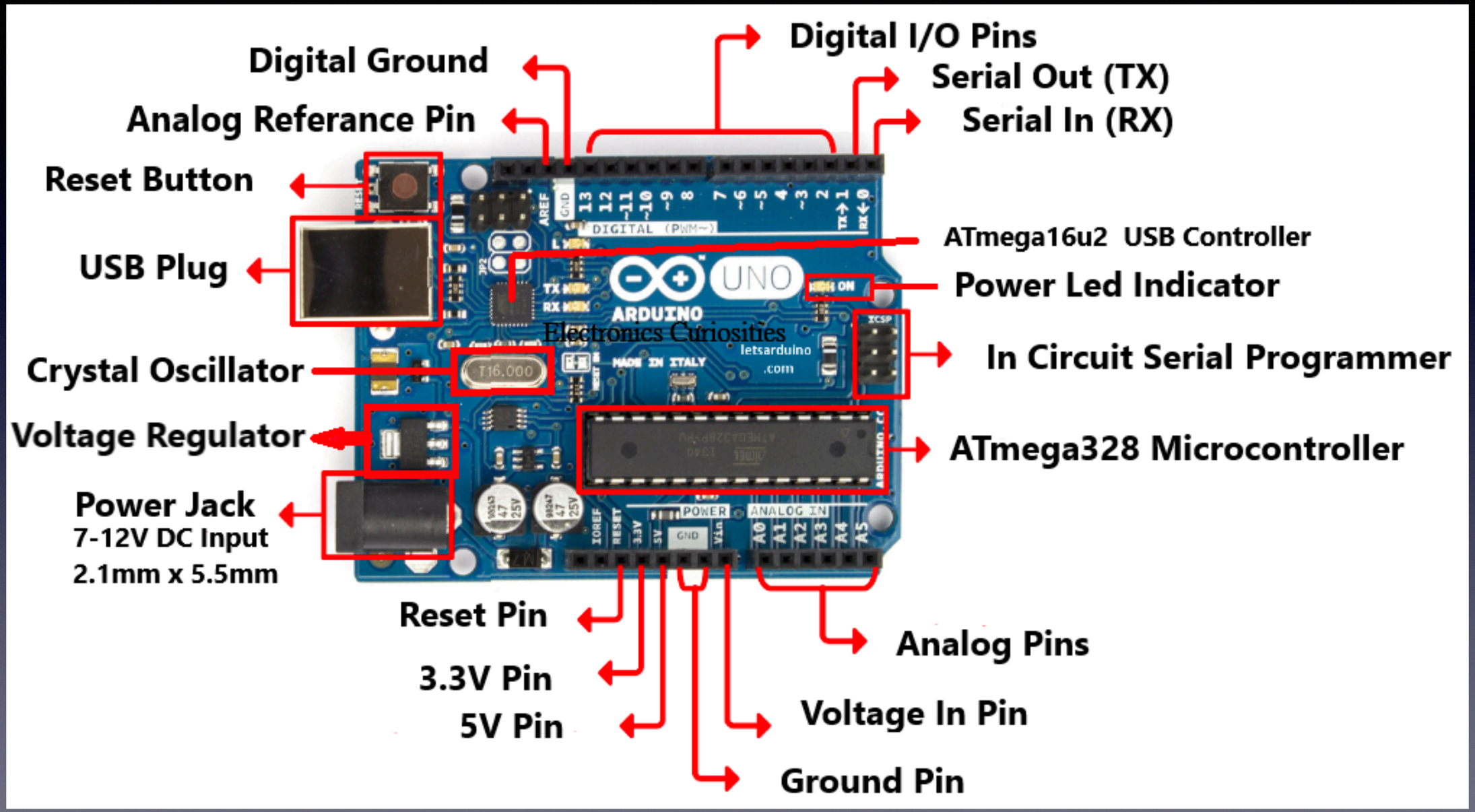


Can you identify the components?



How about now?

? Questions to consider



?

?

?

Meet the creators

Arduino was started in 2005 by Massimo Banzi and other co-founders from Interaction Design Institute Ivrea (IDII) in Ivrea, Italy. It was named after the bar where the co-founders visited often. The name of the bar is named after King Arduin.

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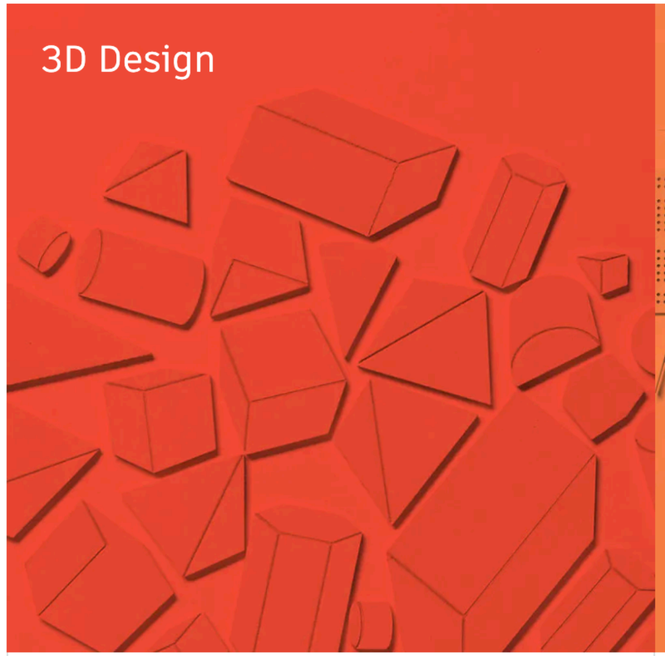
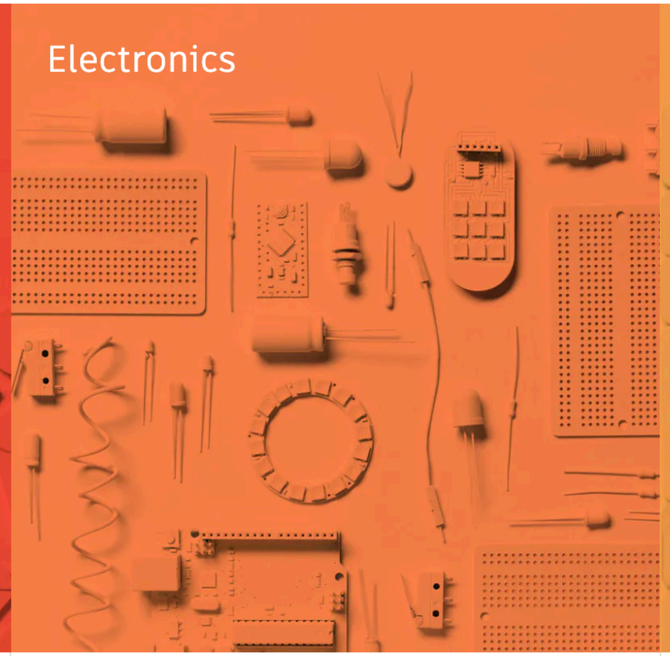
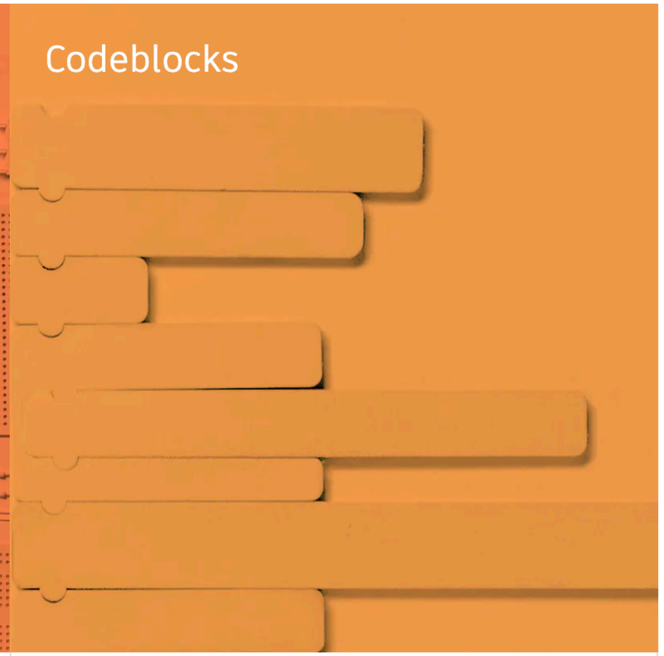


Recommended for grades 3-8. Students can create designs with a simple drag and drop of shapes.

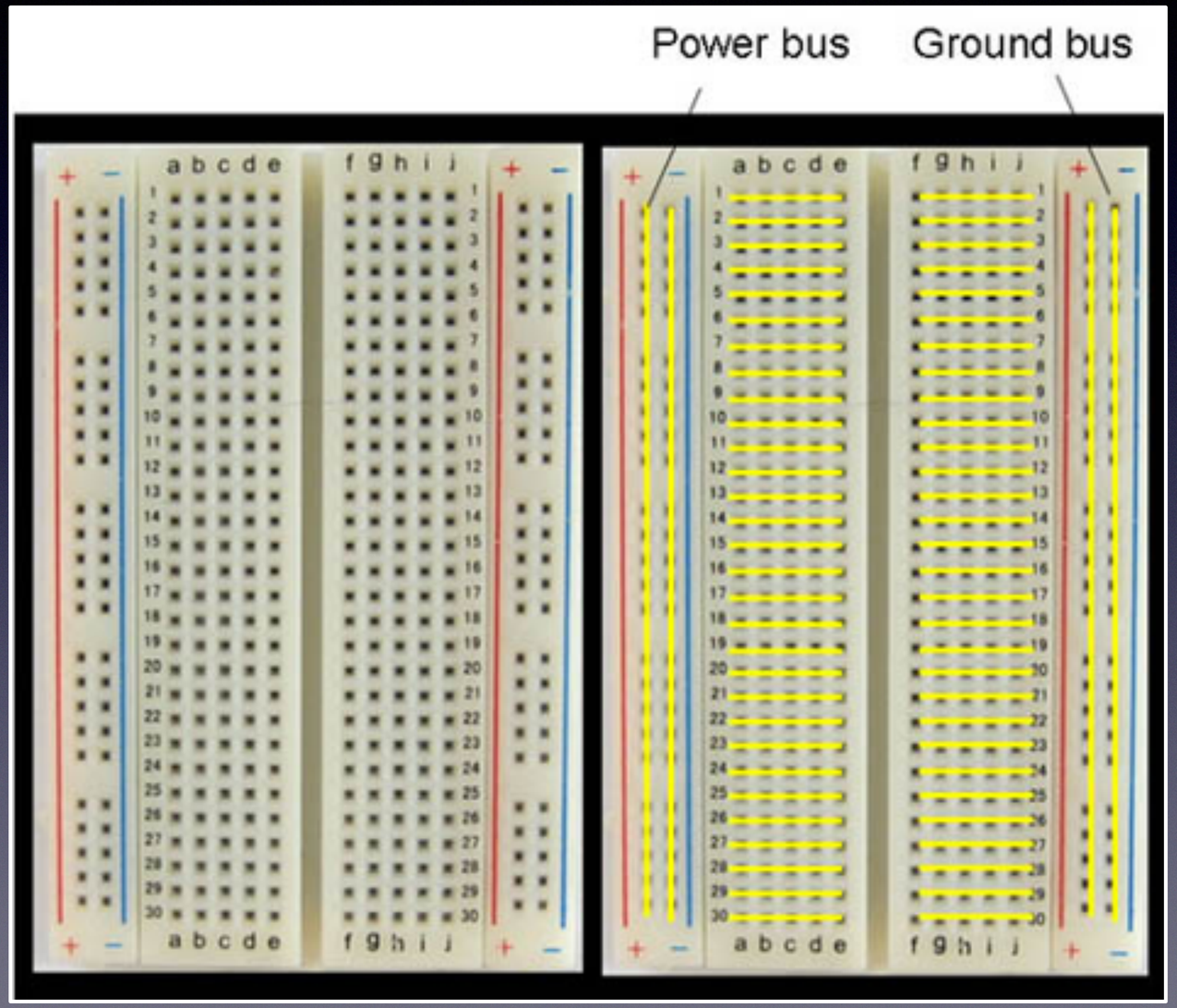


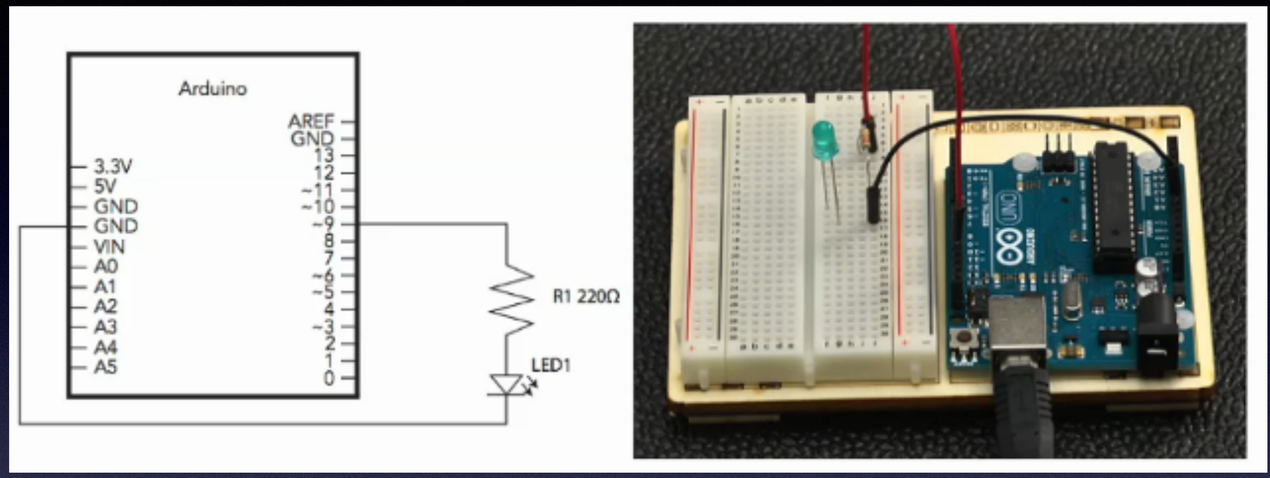
Recommended for grades 5-12. Teach simple circuits to programming an Arduino board.



Recommended for grades 3-12. Students learn code while producing their own 3D models.

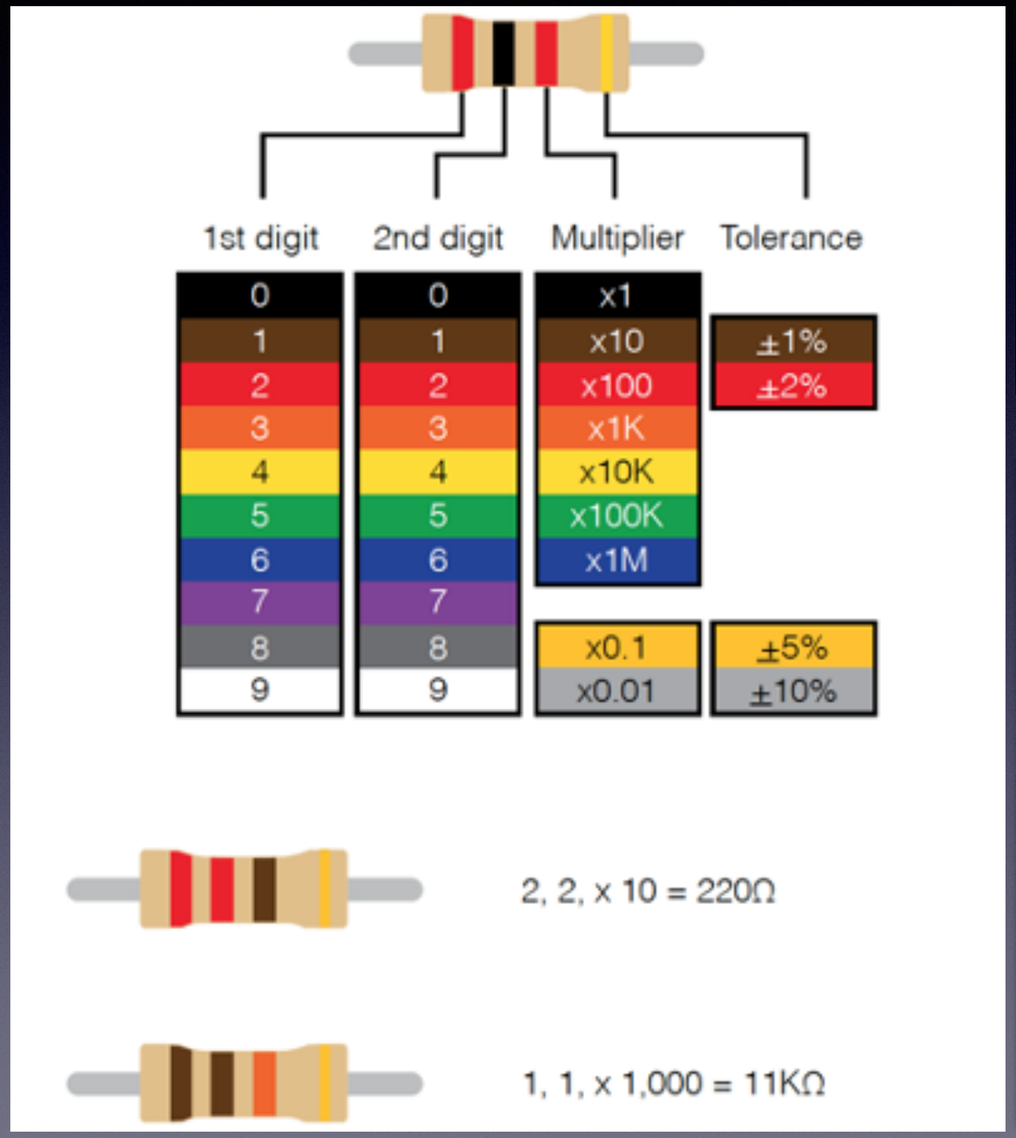
Going through some basics

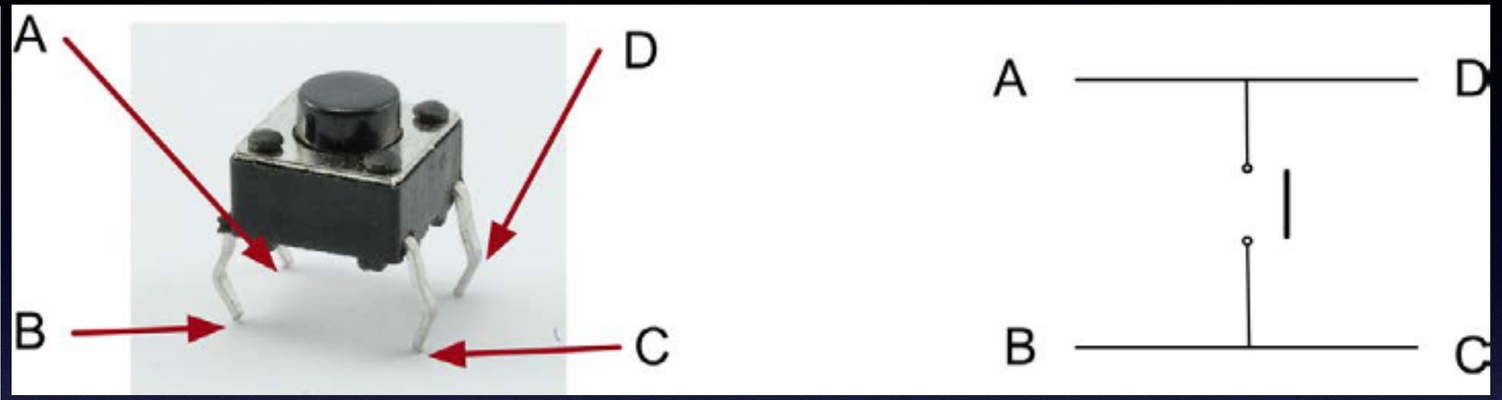


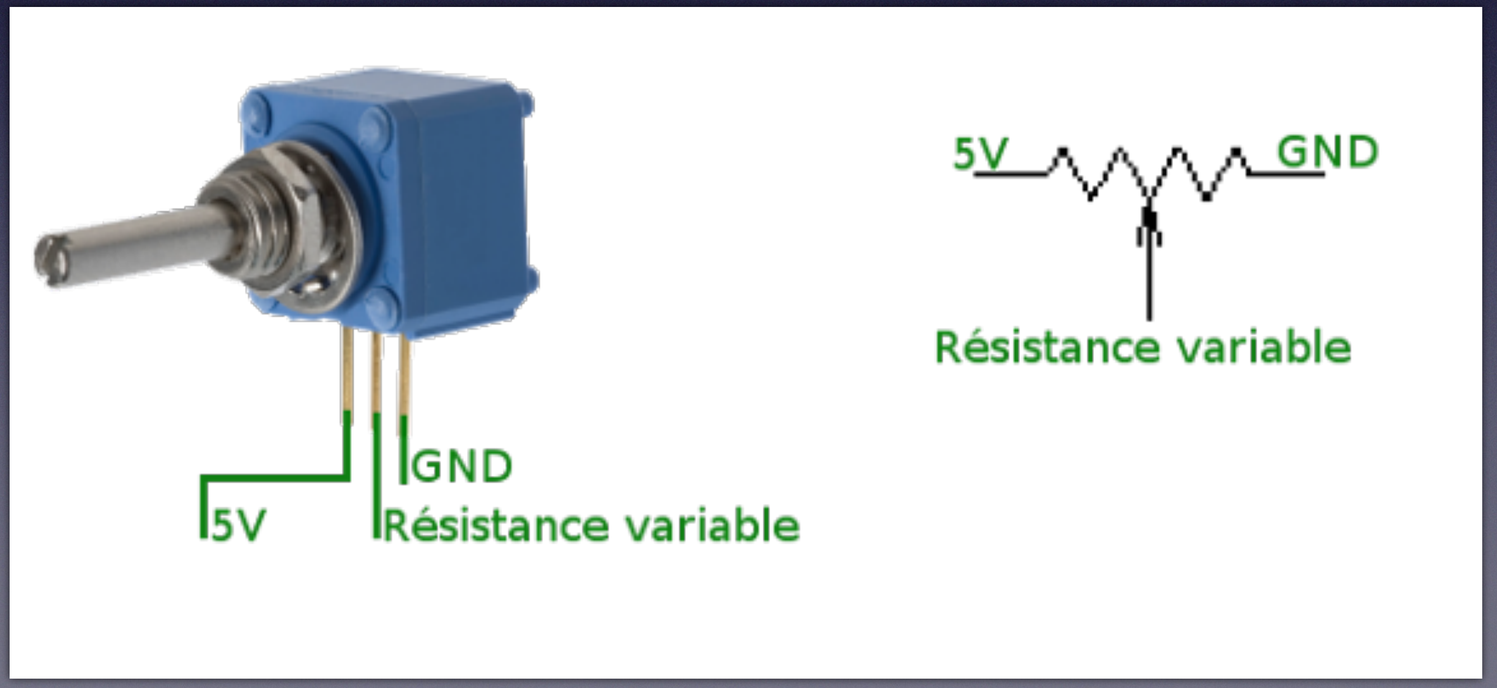


LEDs
Resistors - see resistance color coding
Capacitors

Resistances, push buttons, pots







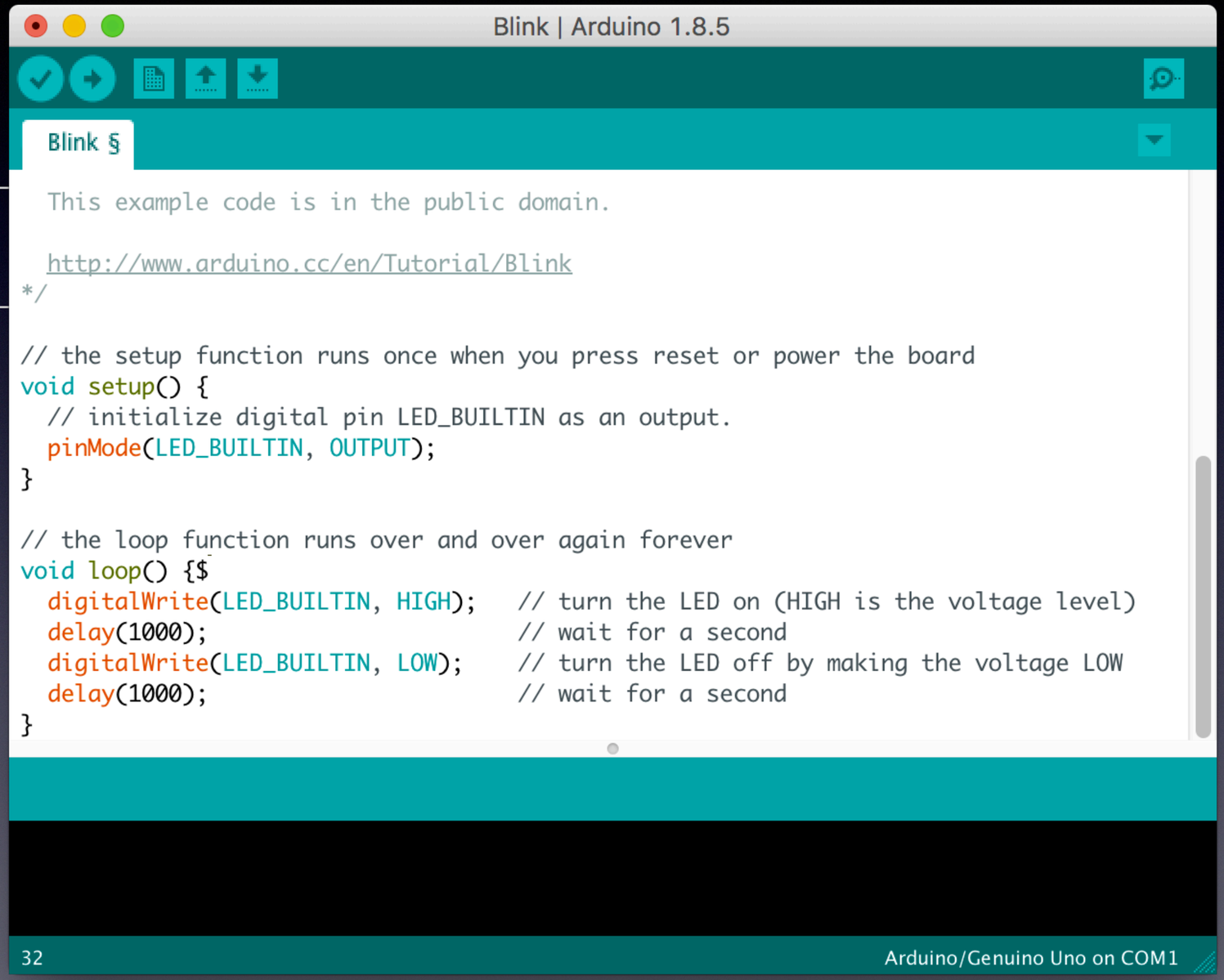
Some syntaxes from *arduino.h* library

pinMode(pin, INPUT/OUTPUT)

digitalWrite(pin, HIGH/LOW)

delay(ms)

Pauses the program for the amount of time (in miliseconds) specified as parameter



C programming - revisited

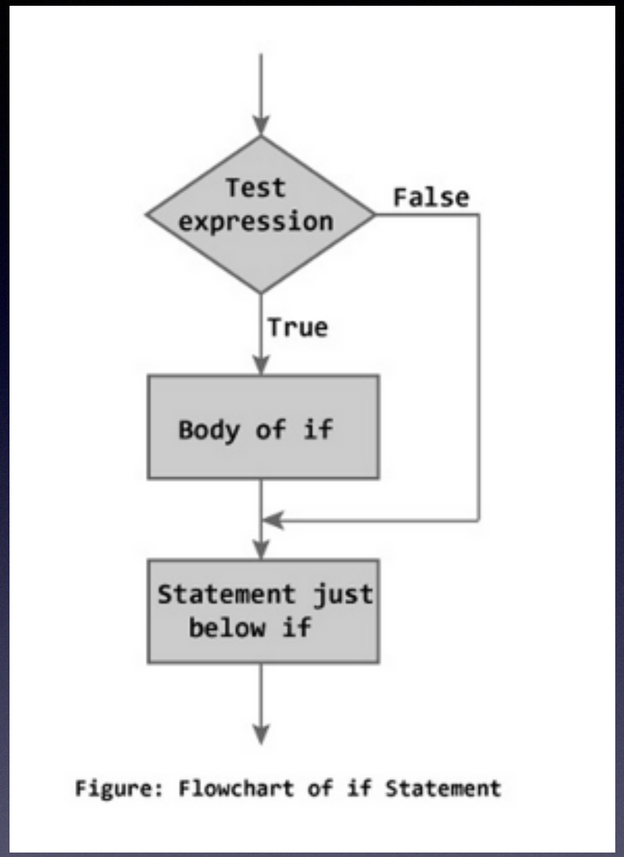


Figure: Flowchart of if Statement

```
if (x > 120) {
  digitalWrite(LEDpin1, HIGH);
  digitalWrite(LEDpin2, HIGH);
}
```

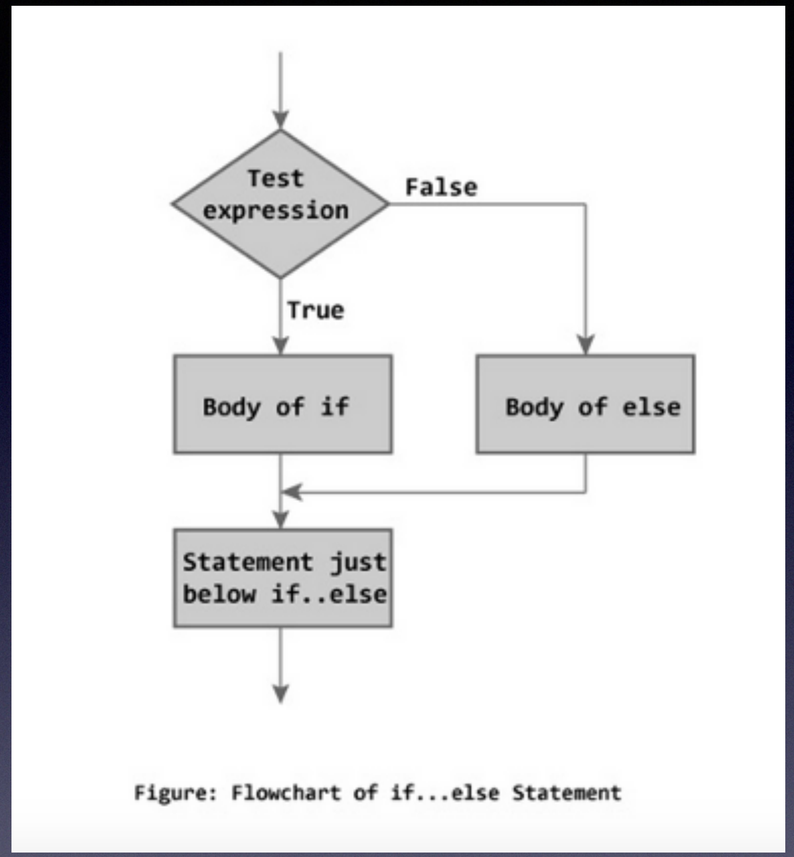


Figure: Flowchart of if...else Statement

```
if (x > 120) {
  digitalWrite(LEDpin1, HIGH);
  digitalWrite(LEDpin2, HIGH);
}  else {
  digitalWrite(LEDpin1, LOW);
  digitalWrite(LEDpin2, LOW);
}
```

```
if (x > 120) {
  digitalWrite(LEDpin1, HIGH);
  digitalWrite(LEDpin2, HIGH);
}  else if  (x > 200) {
  digitalWrite(LEDpin1, LOW);
  digitalWrite(LEDpin2, HIGH);
}  else {
digitalWrite(LEDpin1, LOW);
  digitalWrite(LEDpin2, LOW);
}
```

```
char grade = 'B';
   switch(grade)
   {
   case 'A' :
      printf("Excellent!\n" );
      break;
   case 'B' :
   case 'C' :
      printf("Well done\n" );
      break;
     …
```

C programming - revisited

```
int i = 10;
while ( i > 0 ) {
      printf("Hello %d\n", i );
      i = i - 1;
}
```

```
do{
  delay(50);
  x = readSensors();
} while (x < 100);
```

```
for(byte r = 0; r < 255; r++) {
  if (analogRead(0) > 250) { goto bailout;}
  }

bailout:
```

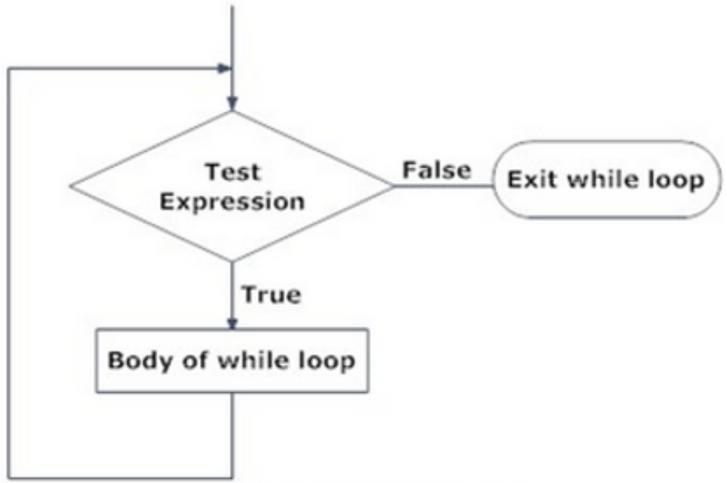


Figure: Flowchart of while loop

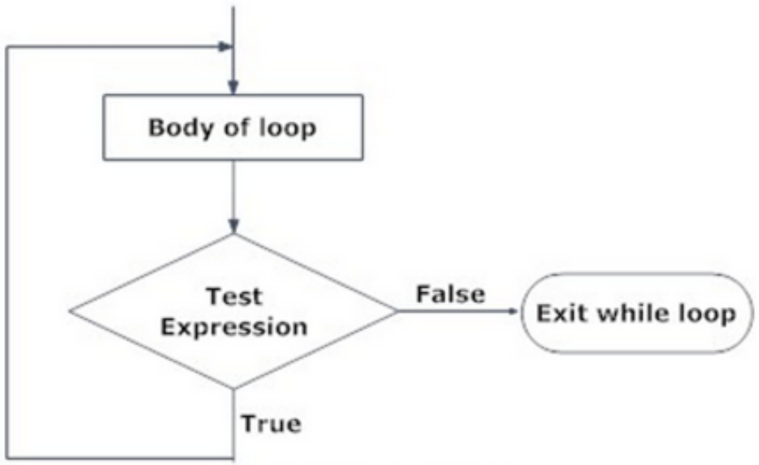


Figure: Flowchart of do...while loop

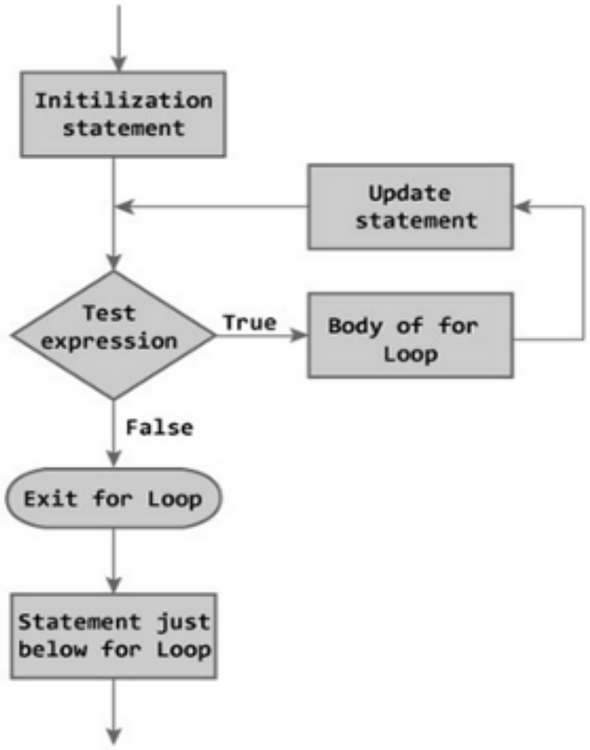


Figure: Flowchart of for Loop

C programming - revisited

```
for (x = 0; x < 255; x ++) {
    analogWrite(PWMpin, x);
    sens = analogRead(sensorPin);
    if (sens > threshold) {
       x = 0;
       break;
    }
    delay(50);
}
```

```
for (x = 0; x < 255; x ++) {
    if (x > 40 && x < 120){
        continue;
    }

    analogWrite(PWMpin, x);
    delay(50);
}
```

Functions

```
int checkSensor()

{
    if (analogRead(0) > 400) {
        return 1;
    else{
        return 0;
    }
}
```

```
Single line comment
// ….
Multiple lines comment
/*
…..
*/
```

Preprocessors

```
#define Name value //macro
#define ledPin 3

#include  <Wire.h>
```

C programming - revisited

Comparison Operators

==	(equal to)
!=	(not equal to)
<	(less than)
>	(greater than)
<=	(less than or equal to)
>=	(greater than or equal to)

Compound Operators

++	(increment)
--	(decrement)
+=	(compound addition)
-=	(compound subtraction)
*=	(compound multiplication)
/=	(compound division)
%=	(compound modulo)
&=	(compound bitwise and)
|=	(compound bitwise or)

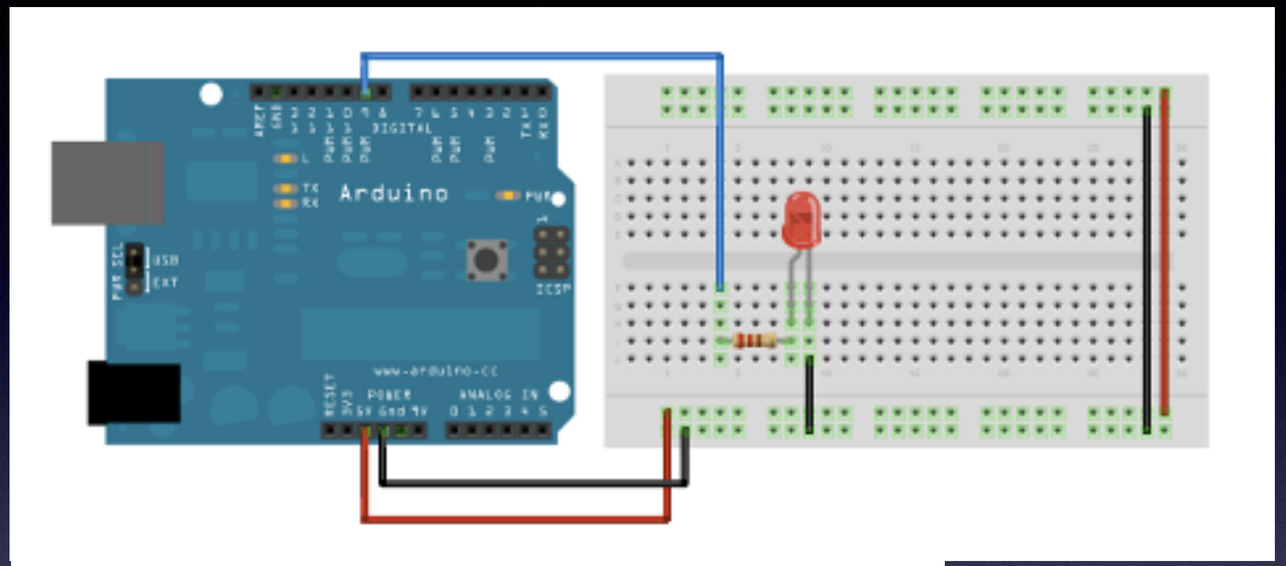
Arithmetic Operators

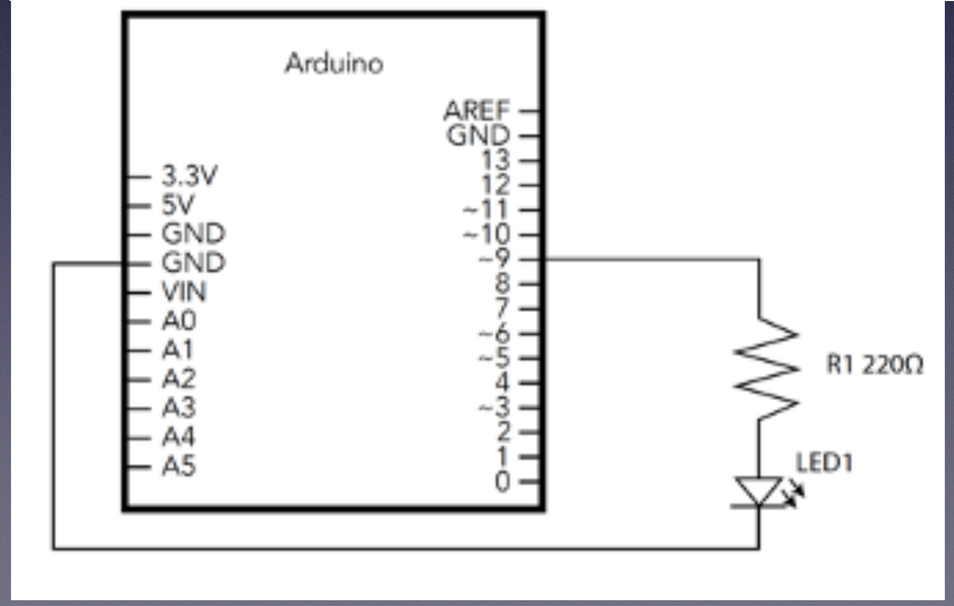
=	(assignment operator)
+	(addition)
-	(subtraction)
*	(multiplication)
/	(division)
%	(modulo)

Boolean Operators

&&	(and)
||	(or)
!	(not)

Blinky!





Write a sketch to turn on one LED. Use digital pin 12 and use digitalWrite.

Write a sketch to blink one LED

(DIY) Write a sketch to alternate blinking 2 LEDs

Small solution

```
// the setup function runs once when you press reset or power the board

void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(12, OUTPUT);
}

// the loop function runs over and over again forever

void loop() {
  digitalWrite(12, HIGH);   // turn the LED on (HIGH is the voltage level)
}
```