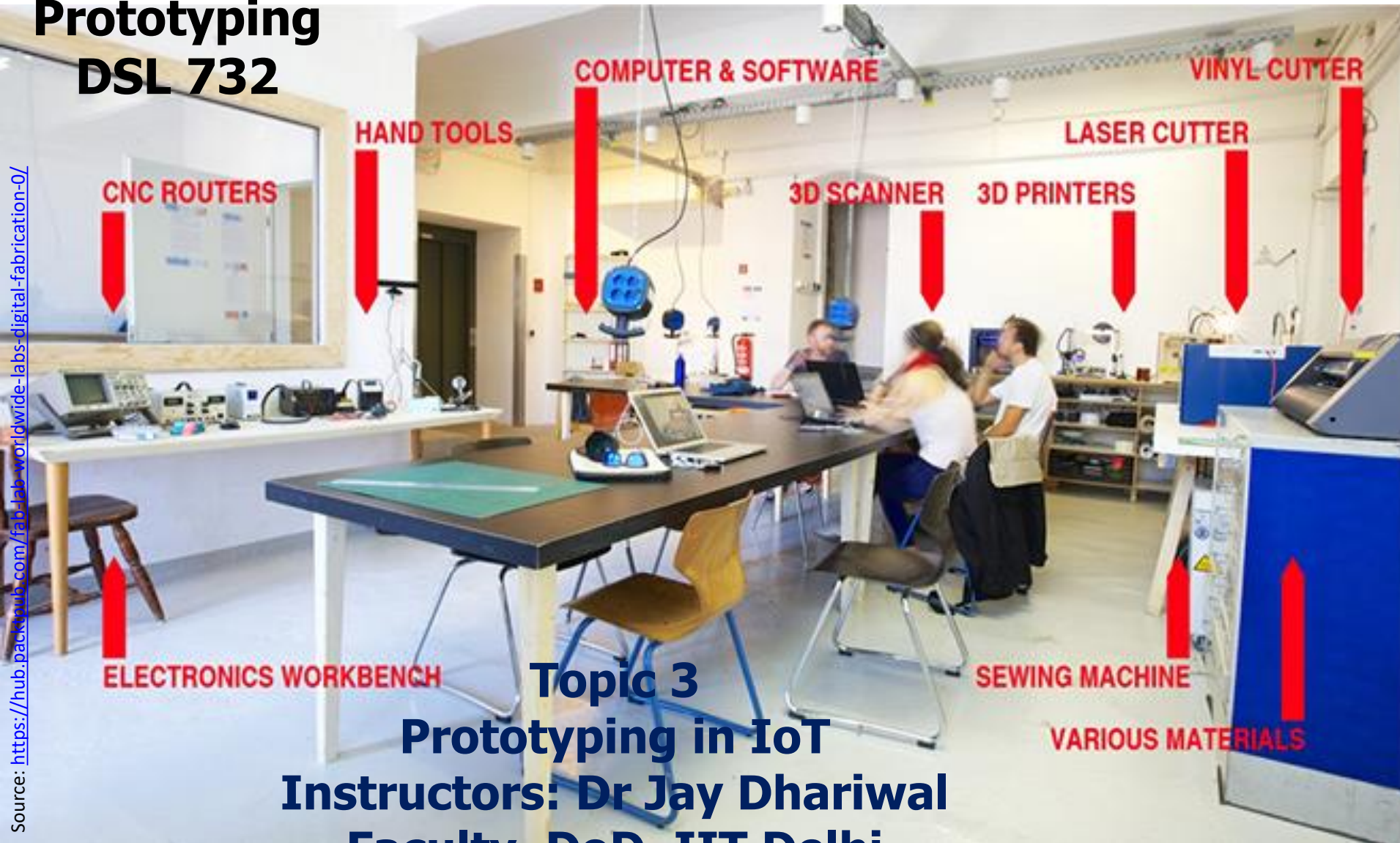


Materials and Prototyping DSL 732

Source: <https://hub.packtpub.com/fab-lab-worldwide-labs-digital-fabrication-0/>

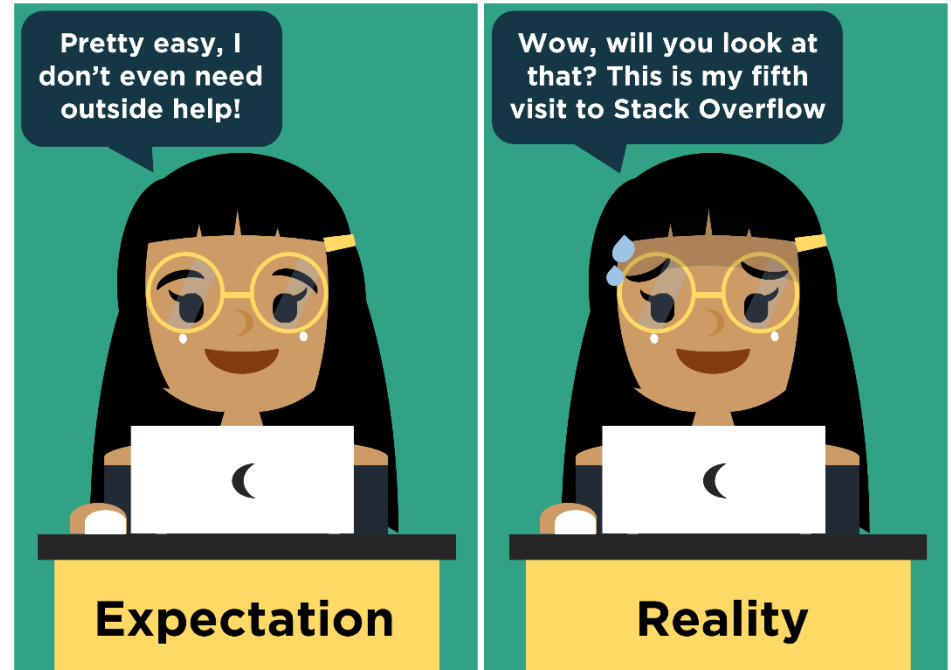


Topic 3
Prototyping in IoT
Instructors: Dr Jay Dhariwal
Faculty, DoD, IIT Delhi
Dated: 3rd March, 2022

Programming

- Programming – instruction to perform task
- English or Hindi – grammar, similarly programming languages have syntax
- How would you add two numbers?

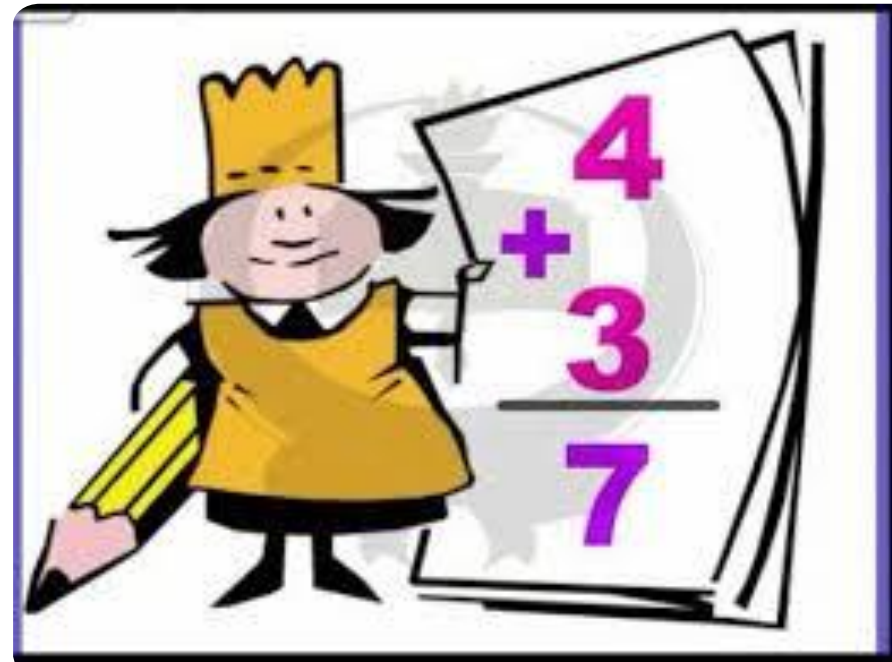
“Programmers: Expectation VS Reality”



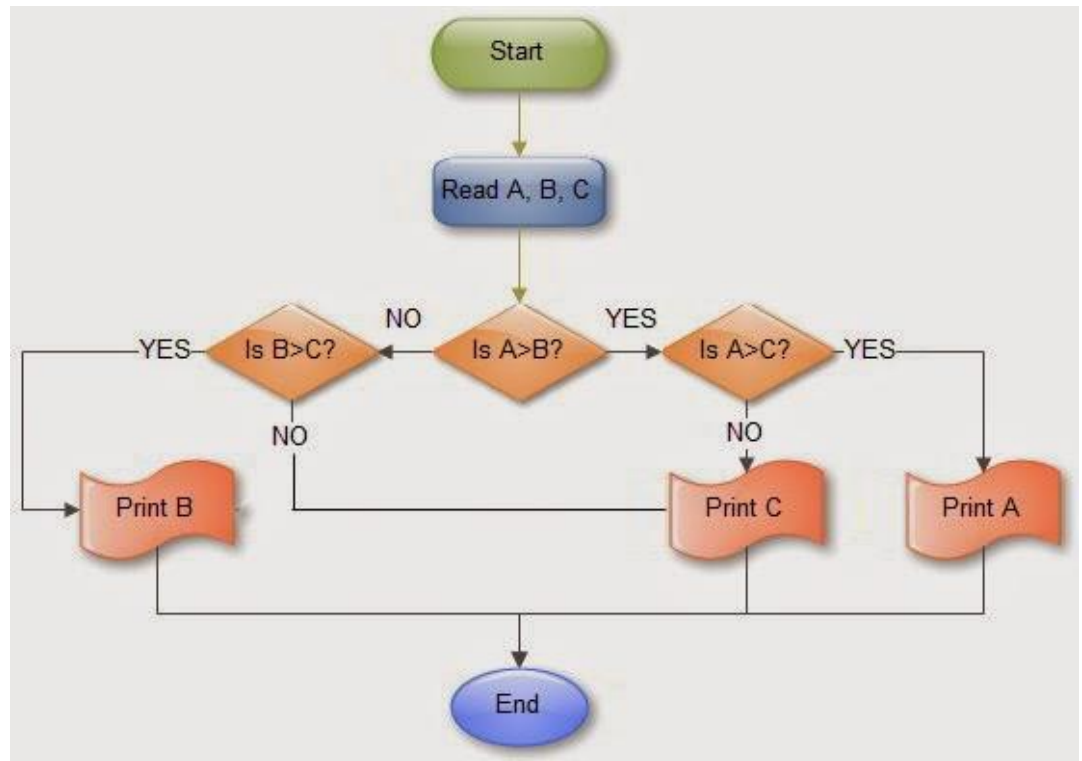
fb: Guen's Comics tw/ig: @guenscomics

Algorithm for adding two numbers

- Input number 1
- Input number 2
- Add number1 and number 2
- Print the result.

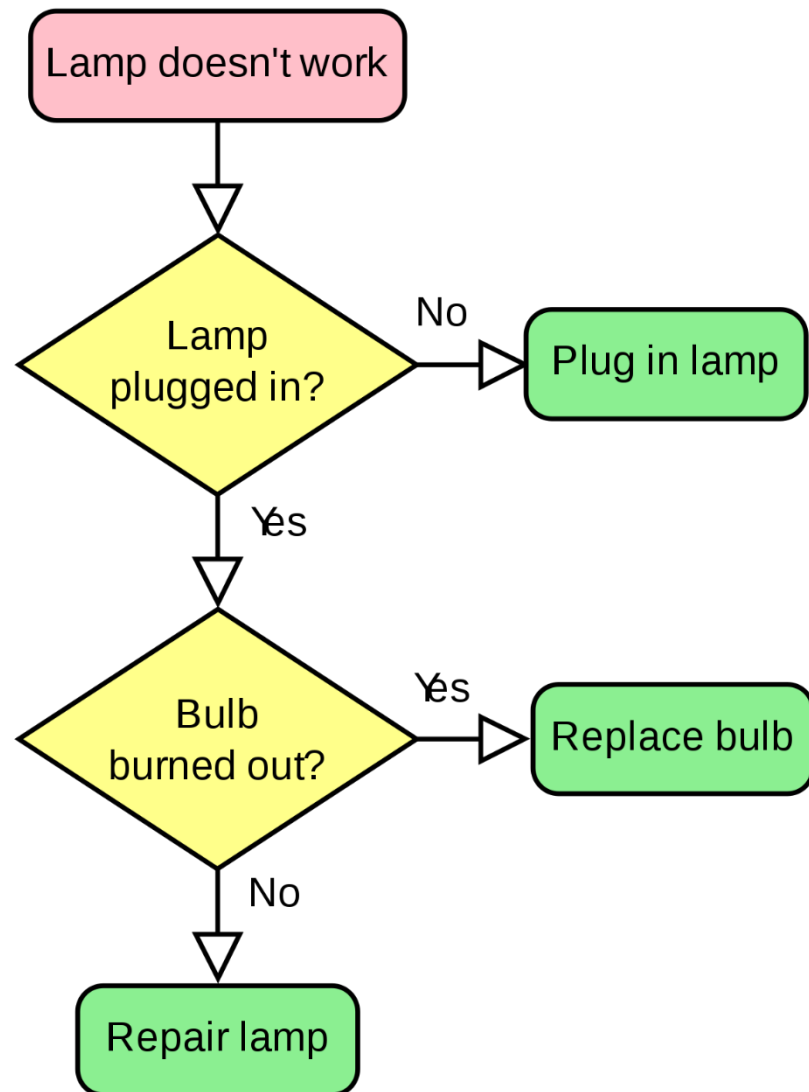


Flowchart for largest of three numbers



Flowchart

- Languages have different syntax but are largely similar.
- Learn one language and you can learn others quickly.
- Flowchart/Algorithm is the key.
- Flowchart to find out why the Lamp doesn't work?
- Your own projects?



Programming Language	Application
C	Microcontroller/ Embedded programming, Efficient at runtime. 95% embedded programming in C.
Python	One of the best to teach programming, Web applications, Data Science, Scientific computations, Raspberry Pi. Efficient in development times.
Javascript	Creating web pages. Run in browsers. HTML+CSS+Javascript
Scratch	Graphical language, flowchart based for children. MIT App Inventor related to it.
Processing	GUI for Arduino
Visual Basic	Windows based, Event based programming, Easy to build GUI, VBA in Excel.
.NET	Software framework from Microsoft

C programming

My first program in C

```
#include <stdio.h>
int main()
{
    printf("Hello World!");
    return 0;
}
```

- [Online compiler](#)
- [C for beginners](#)
- [Examples](#)

Basic
elements of
programming
language

Programming Environment

Data Types, Variables, Keywords

Input and Output Operations

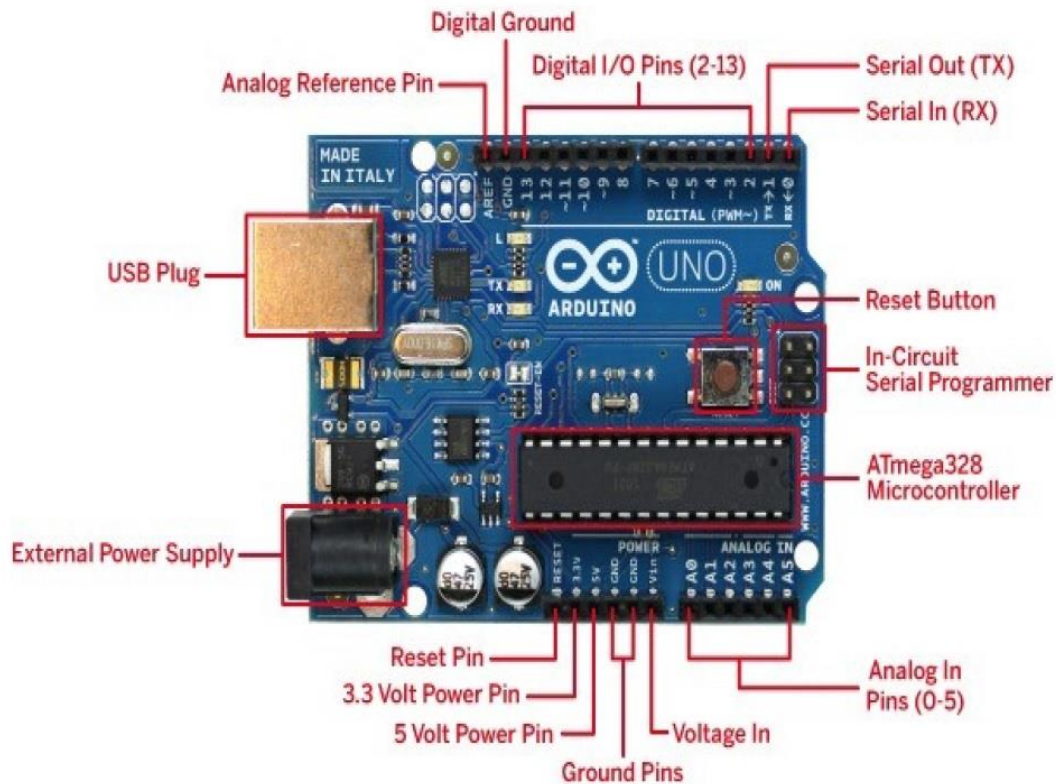
Logical and Arithmetical Operators

If else conditions, Loops

Functions

Comments, Indentation, Bottom up debugging

Microcontroller programming

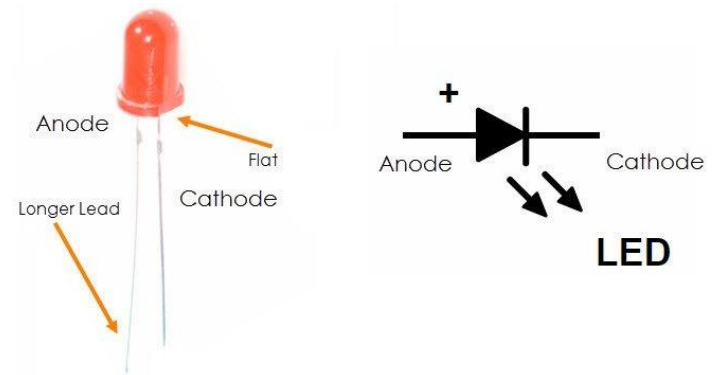
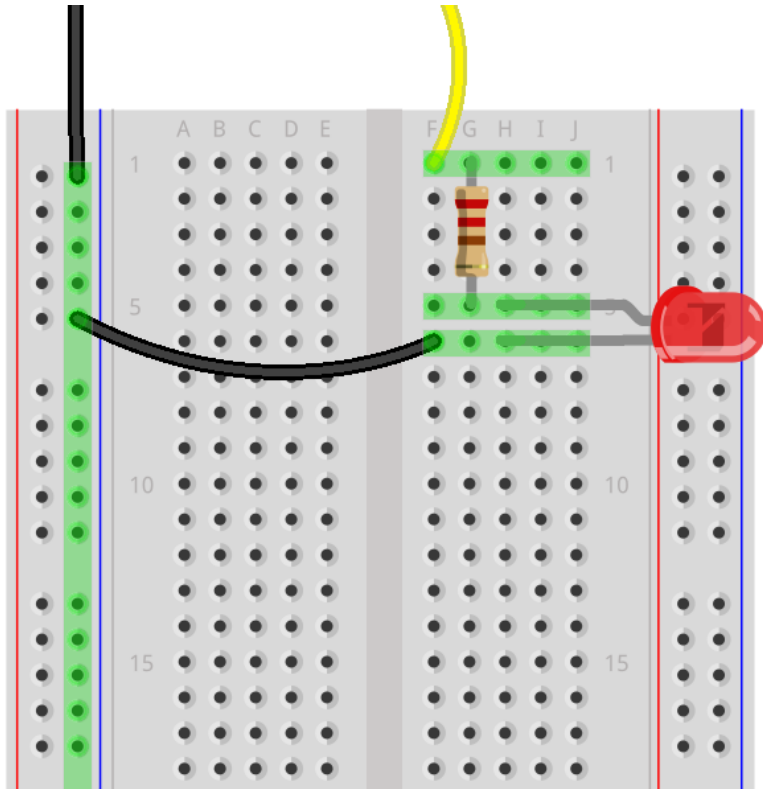


- [DIY devices](#)
- [Arduino](#) hardware
- Arduino IDE
- Arduino libraries

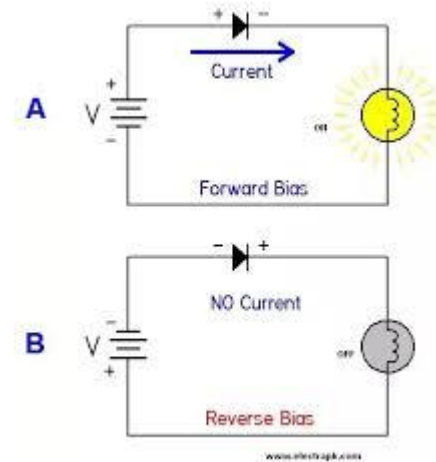
Getting started with Arduino

- [Arduino kit pdf](#) for instructions
- Download [Arduino IDE](#)
- Open Arduino IDE
- Blink sketch with pin 13
- Blink sketch initialize pin 13





Diode is like a one-way valve of electronics

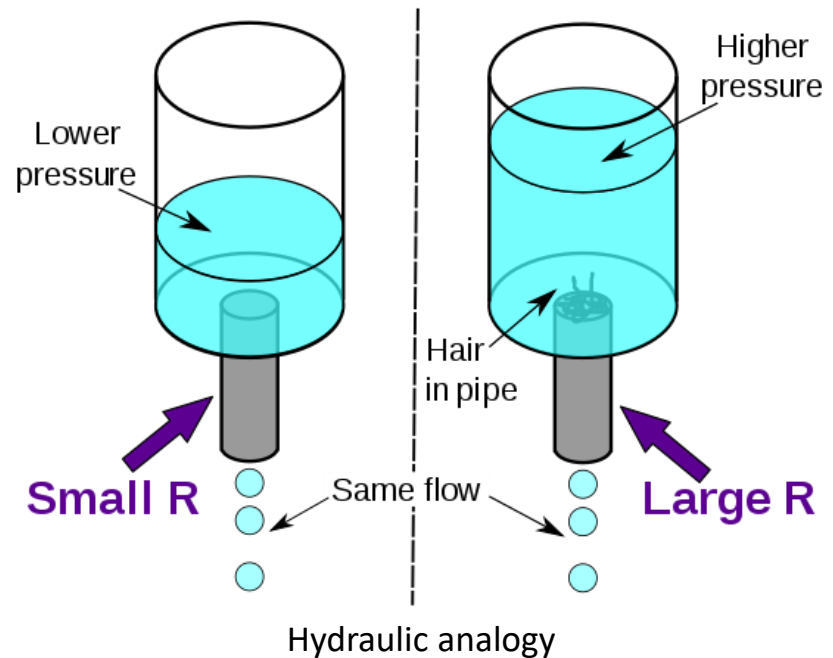


LED is a diode

- LED is a diode which makes the current flow only in one direction

Blinking LEDs

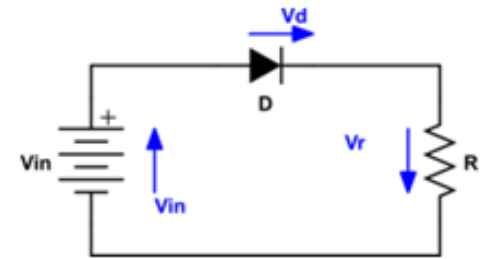
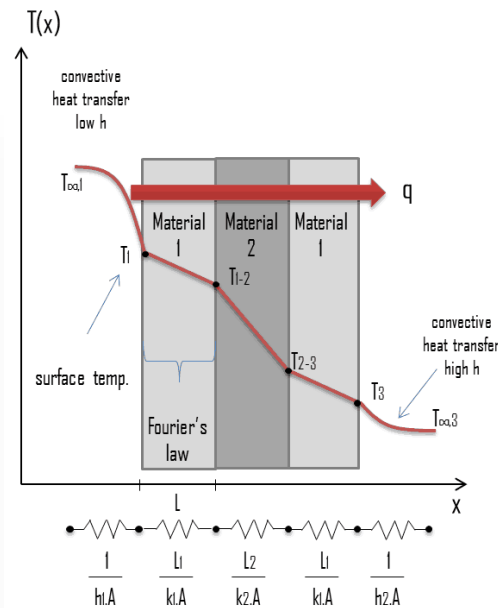
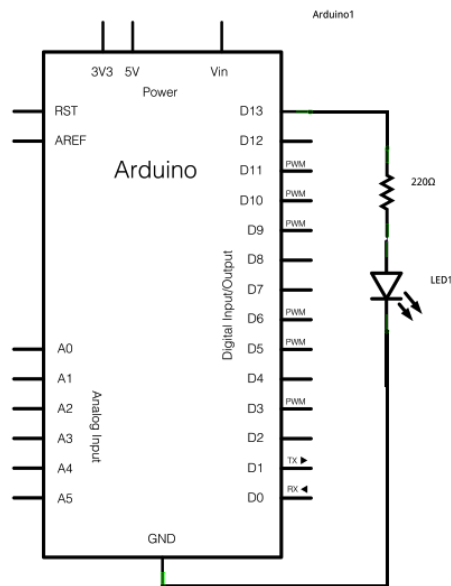
- Blink sketch (pin 12) with own LEDs and [resistors](#)
- Lesson 2.1 of Arduino Kit



Ohm's Law, $V=IR$

V: Voltage, I: Current, R: Resistor

Thermal analogy, $Q = dT/R$, $I = V/R$

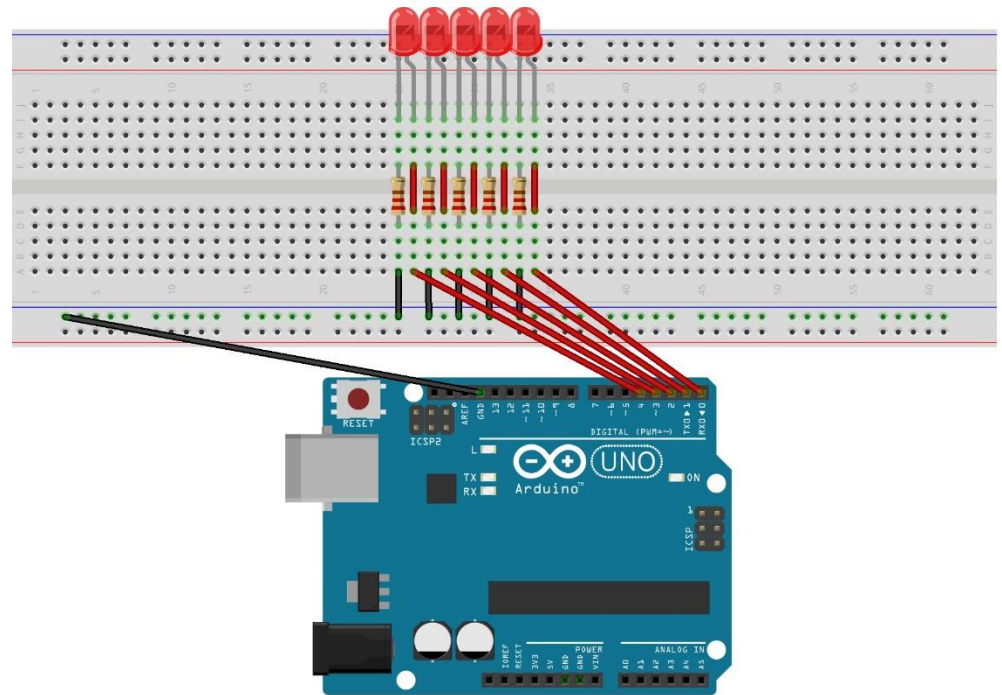


$$\sum_{k=1}^n V_k = 0$$

Kirchoff's Voltage Law

Blinking LEDs

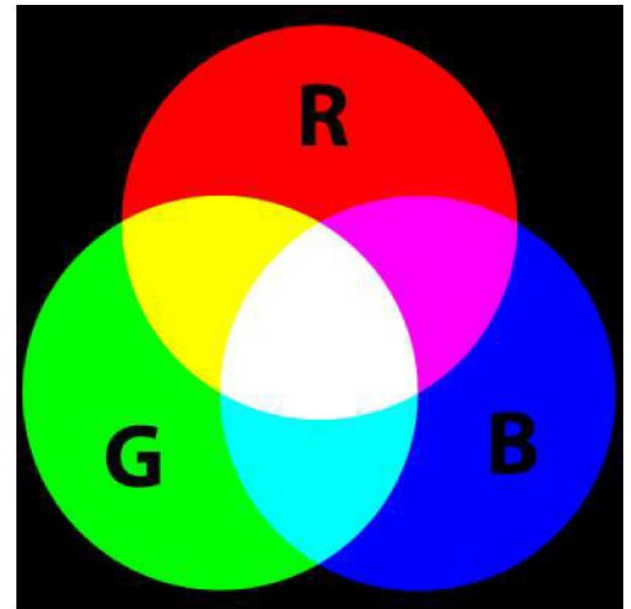
- [TINKERCAD circuits video tutorials](#)
- Blink sketch (pin 12) with own LEDs and resistors
- Blink sketch (pin 12) with own LEDs and resistors and pin 13. (Sequentially on and off vs. Both on and Both off.) [Arduino code](#)



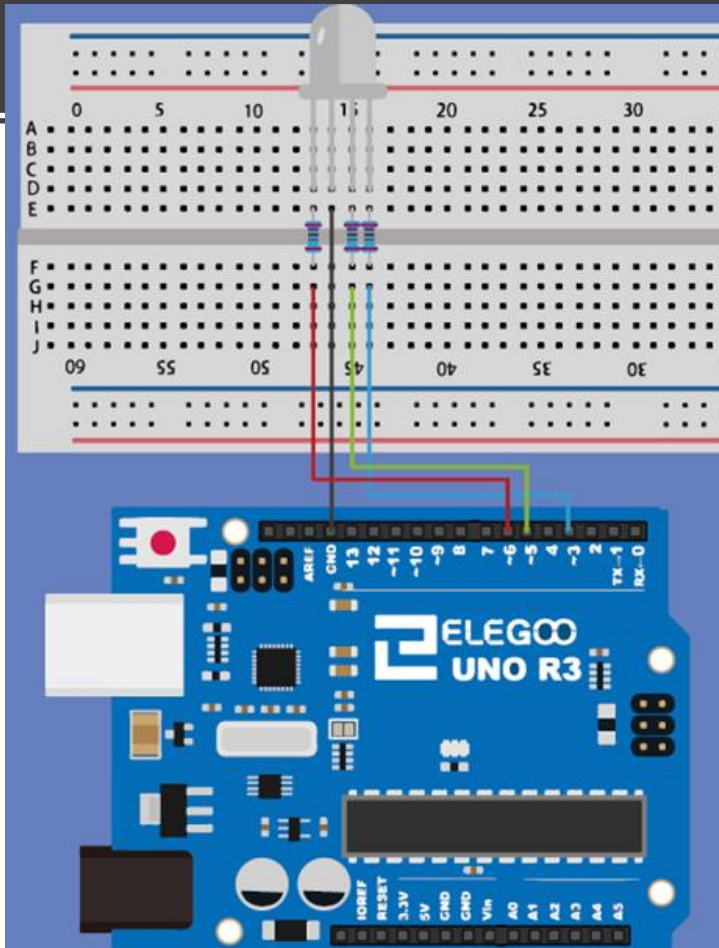
fritzing

RGB LED

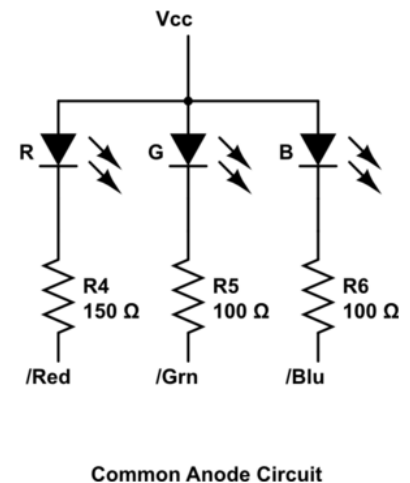
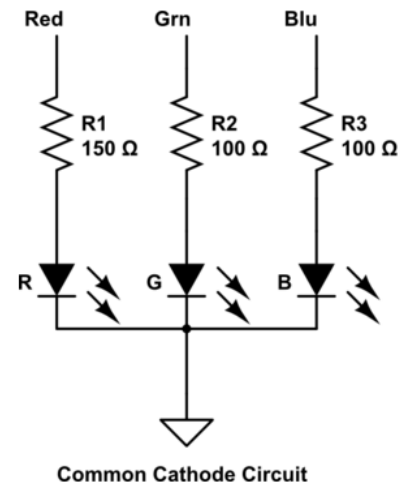
- PWM with RGB LED with common anode (Lesson 2.2). NOTE: Longest leg of RGB LED goes to GND pin for common cathode.
- RGB code [RGB basic](#)
[RGB favorite color](#)



RGB LED circuit

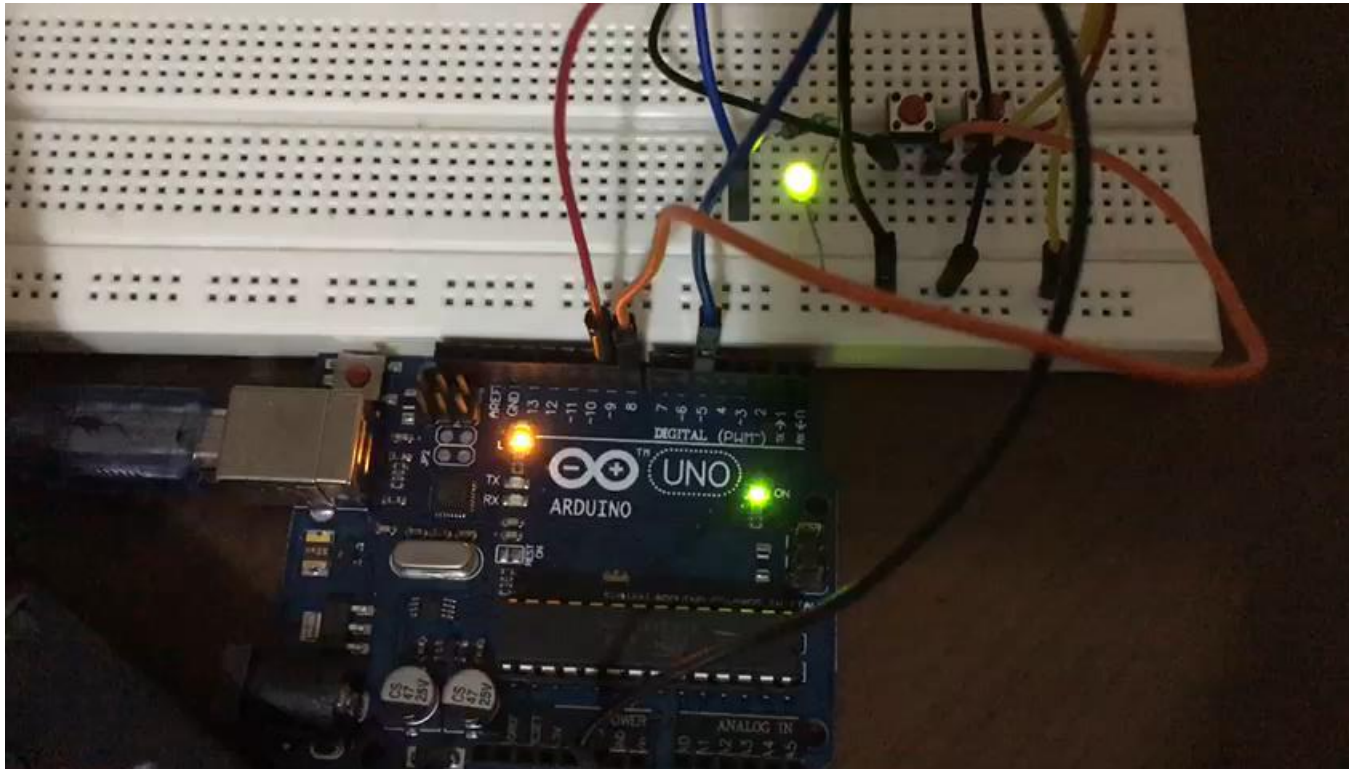


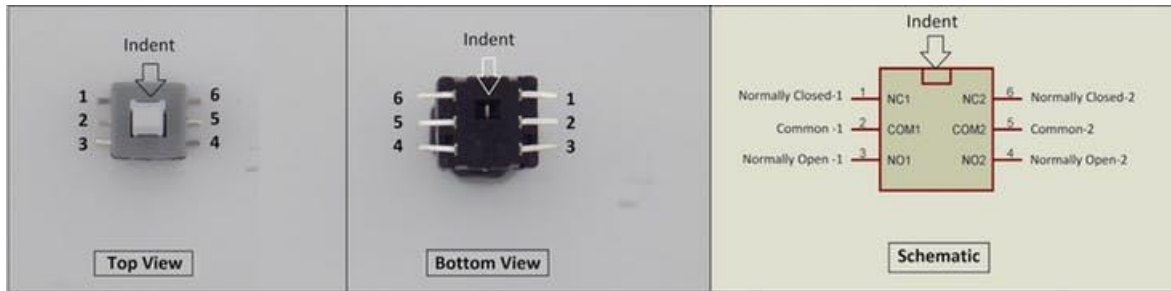
Common cathode configuration



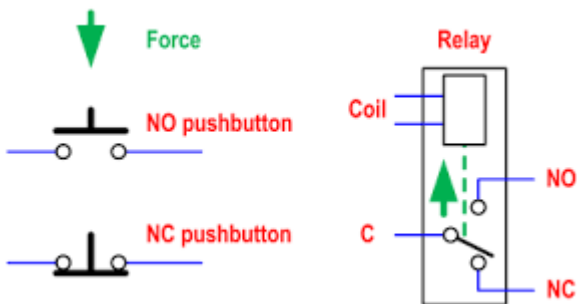
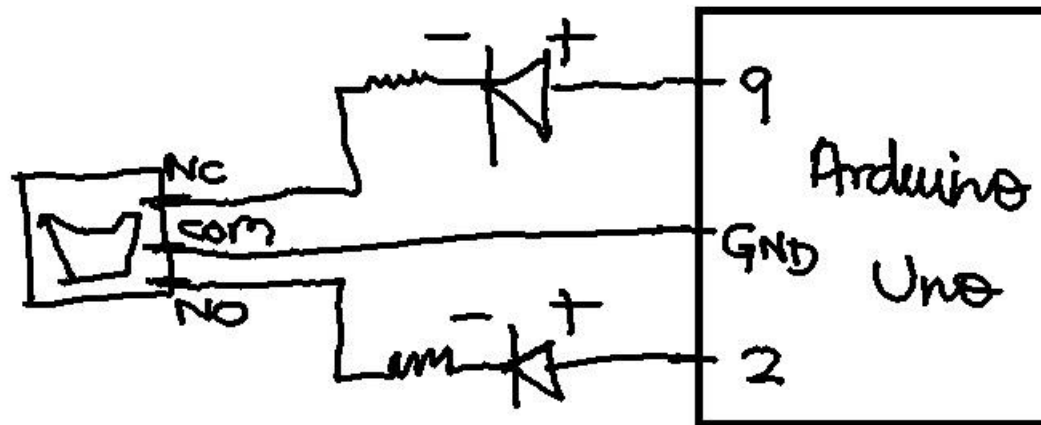
Push buttons (Input Pullup) – Lesson 2.3

- By default, input pullup pin is High, when push button pressed, it gets to Low. [Video](#)





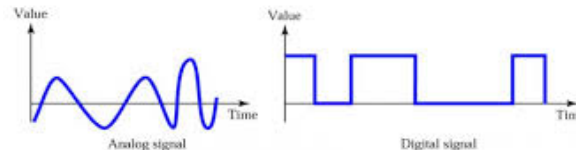
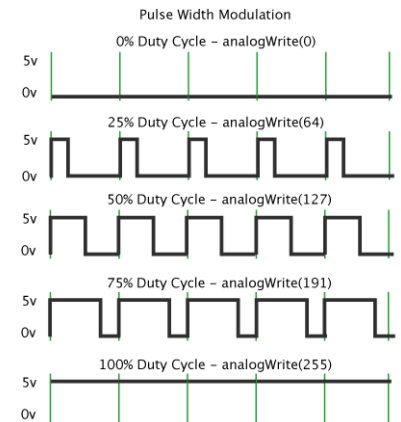
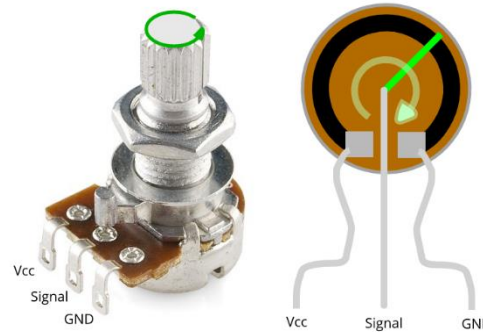
6 Pin Push Switch (Mini DPDT Push Switch) Pinout



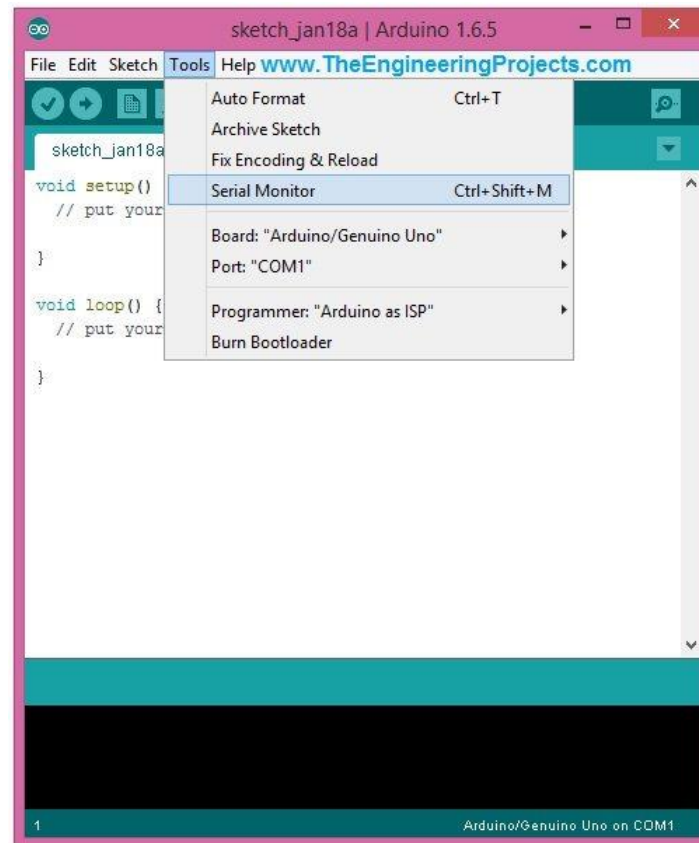
- [DPDT switch video](#)

Digital vs. Analog signal

- digital output = Blink sketch
- digital input_pullup = push button example, Lesson 5
- analog output = Fade example, PWM pins (~)
- Analog input = AnalogInOutSerial (potentiometer)
- Multimeter = voltages, resistors, diodes, continuity.



Arduino features



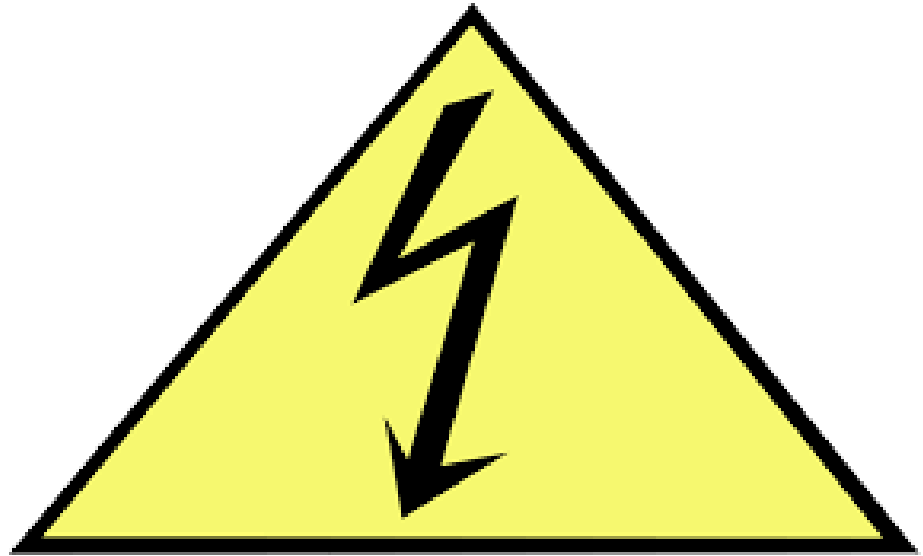
- If then else
- [function, for loop, serial communication, serial monitor](#)
- interfacing Arduino with Processing
- Arduino examples
- [Arduino codes](#)



Summary so far

- Algorithm, Flowchart, Programming in C,
- Arduino based programming
- LEDs, buttons, buzzer
- Analog and Digital signals (read and write)
- Serial communication

Electrical Safety and handling



- [Video](#) (1:30 - 4:00 minutes)
- Take utmost care of the electronics. Shouldn't be exposed to water. Keep in Ziploc bags. Delicate stuff.

Electrical Safety

~1 mA: fine

~10 mA: shock,
contraction

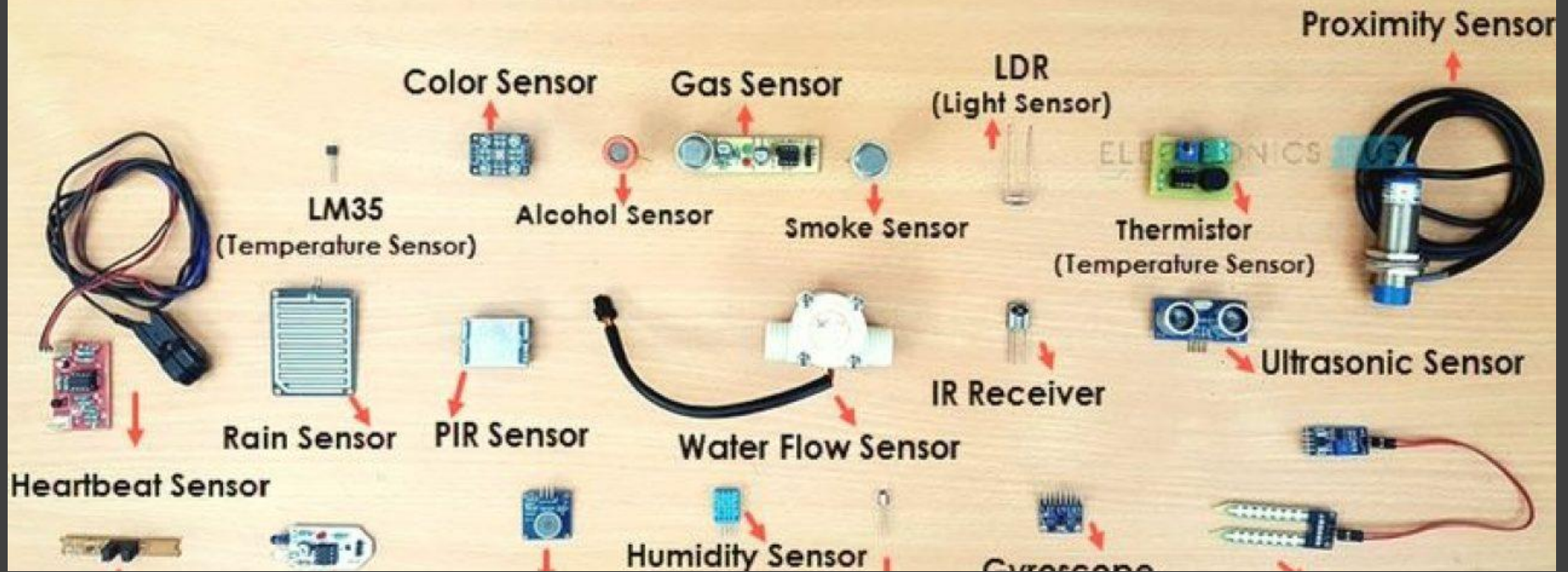
~100 mA:
fibrillation

- body: M ohm
external, k
ohm internal



“Don’t touch him! He’s a conductor.”

DIFFERENT TYPES OF SENSORS



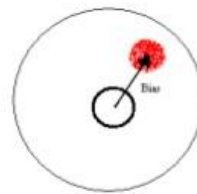
Input Devices

- [Sensors](#)
- [Different types of sensors](#) to measure temperature (thermistor), distance (ultrasonic sensor), force (strain gauge), light, sound
- [What makes your smart phone so smart? Arduino Science Journal](#)

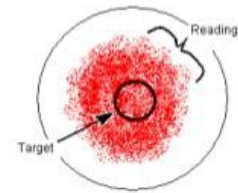
Sensor features

- Sensor vs transducer
- Sensor resolution, range, speed of response, cost, reliability (datasheet)
- Sensor calibration

Accuracy vs. Precision



Precision without accuracy



Accuracy without precision

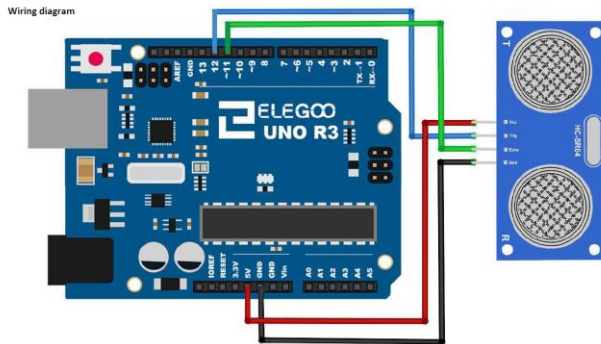


Precision and accuracy

Distance Measurement



- Ultrasonic sensor module (Lesson 2.9)
- Read datasheet (2 cm- 400 cm range)
- Lesson 1.5 (install library)
- Reading library
- Smart cane, other applications



4X4 Keypad module



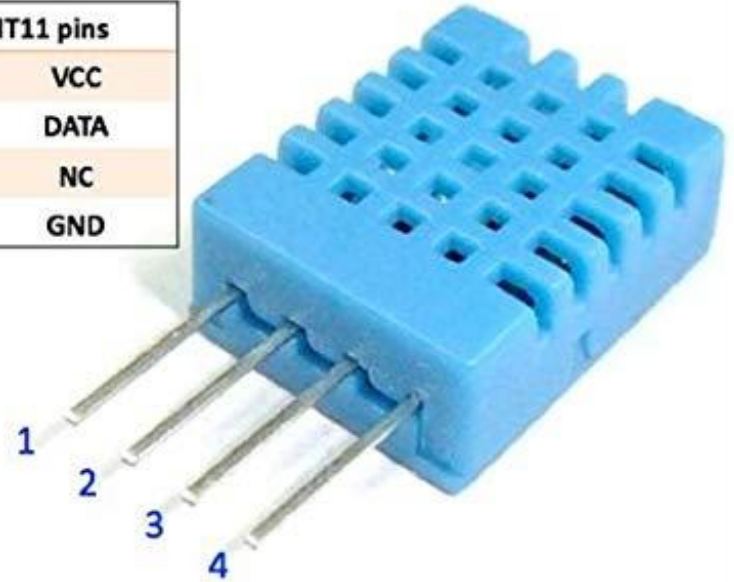
- Lesson 2.10
- Applications: cell phones, ovens, door locks, keyboards



DHT22 pins	
1	VCC
2	DATA
3	NC
4	GND



DHT11 pins	
1	VCC
2	DATA
3	NC
4	GND



Temperature, RH measurement

- DHT11 sensor (Lesson 2.11)
- DHT22 sensor [Another library](#)
- Datasheet

Input Devices Summary



Smart phone sensors



Sensor characteristics



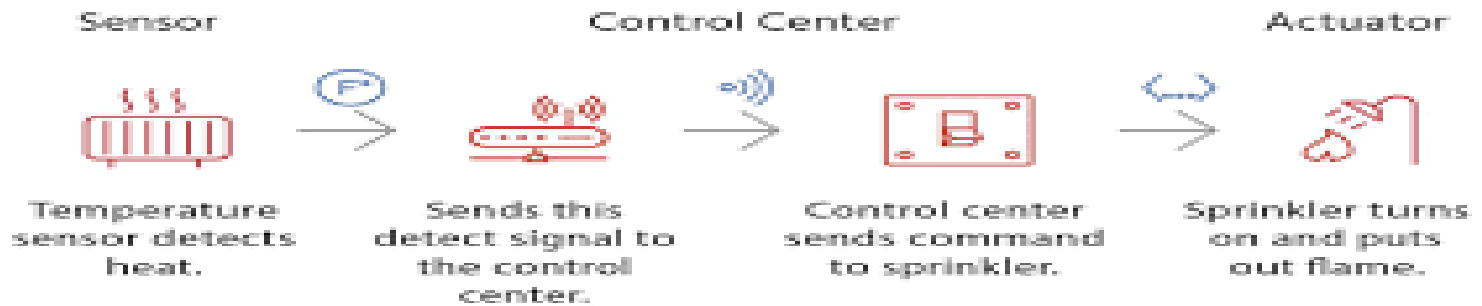
Examples: Ultrasonic sensor, Keypad module, Temp/RH. Other sensors similar procedure.



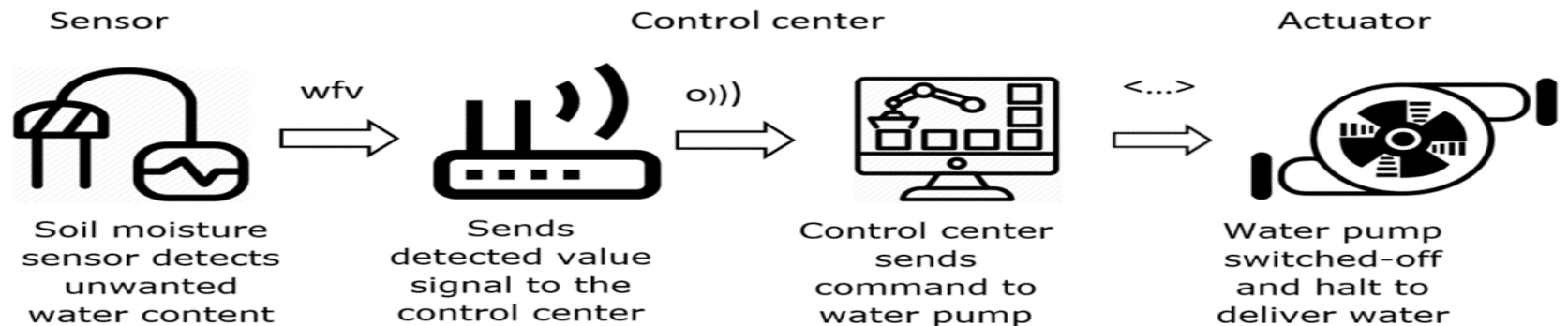
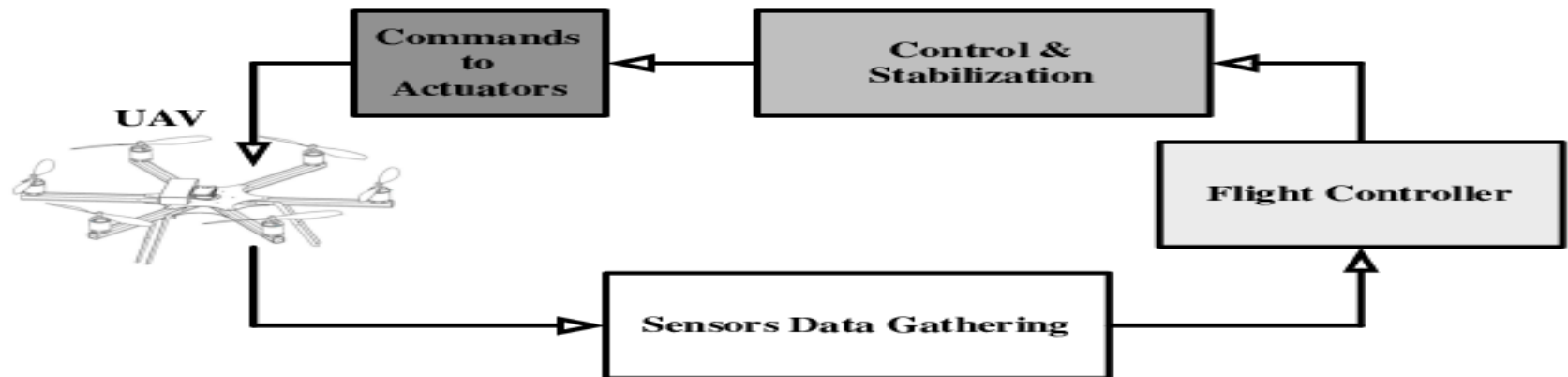
Fab Academy [webpage](#) [video](#)

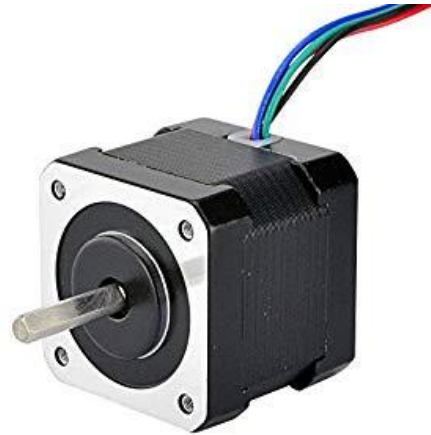


Think of applications as a design student



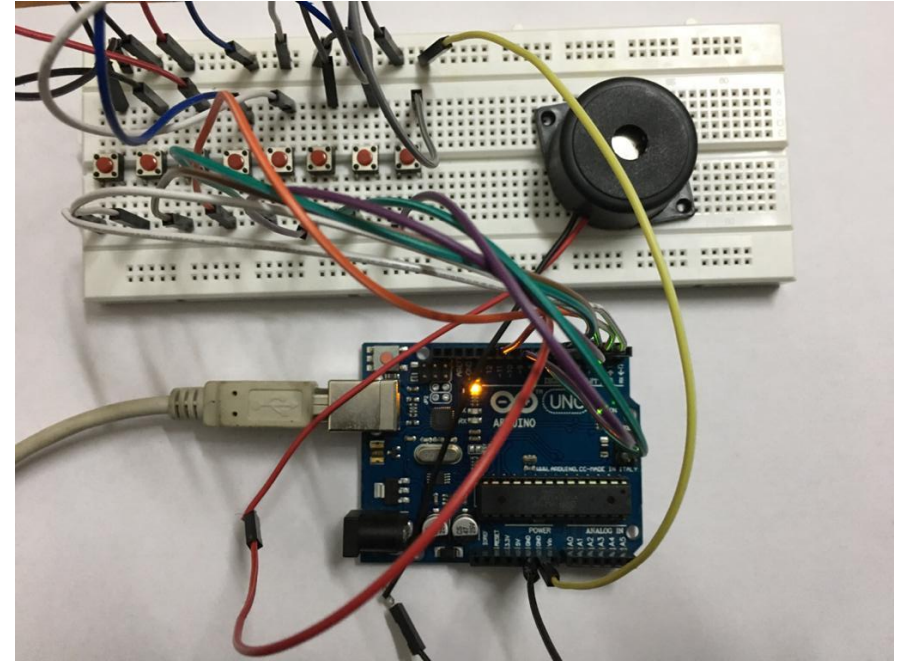
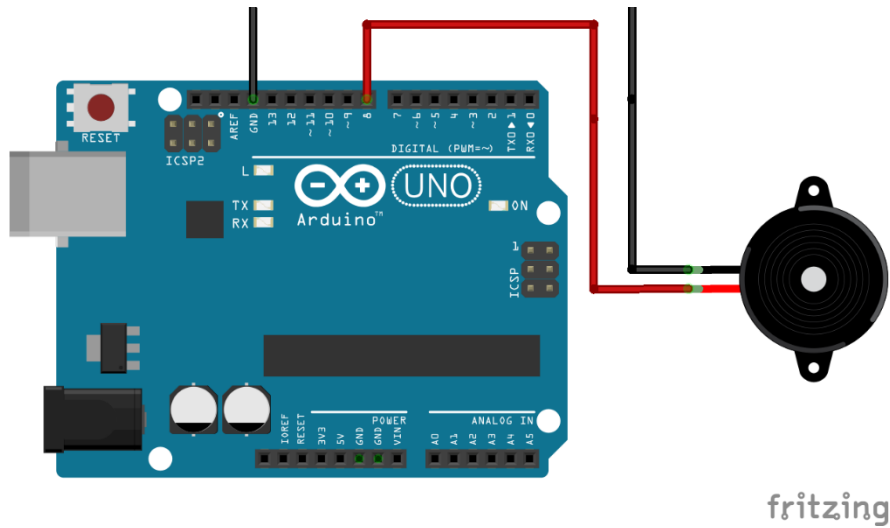
Sensor to **Actuator** Flow





Output Devices

- LEDs, Displays, Speakers/ Buzzers, DC/Servo/Stepper Motors, Relays, Dataloggers

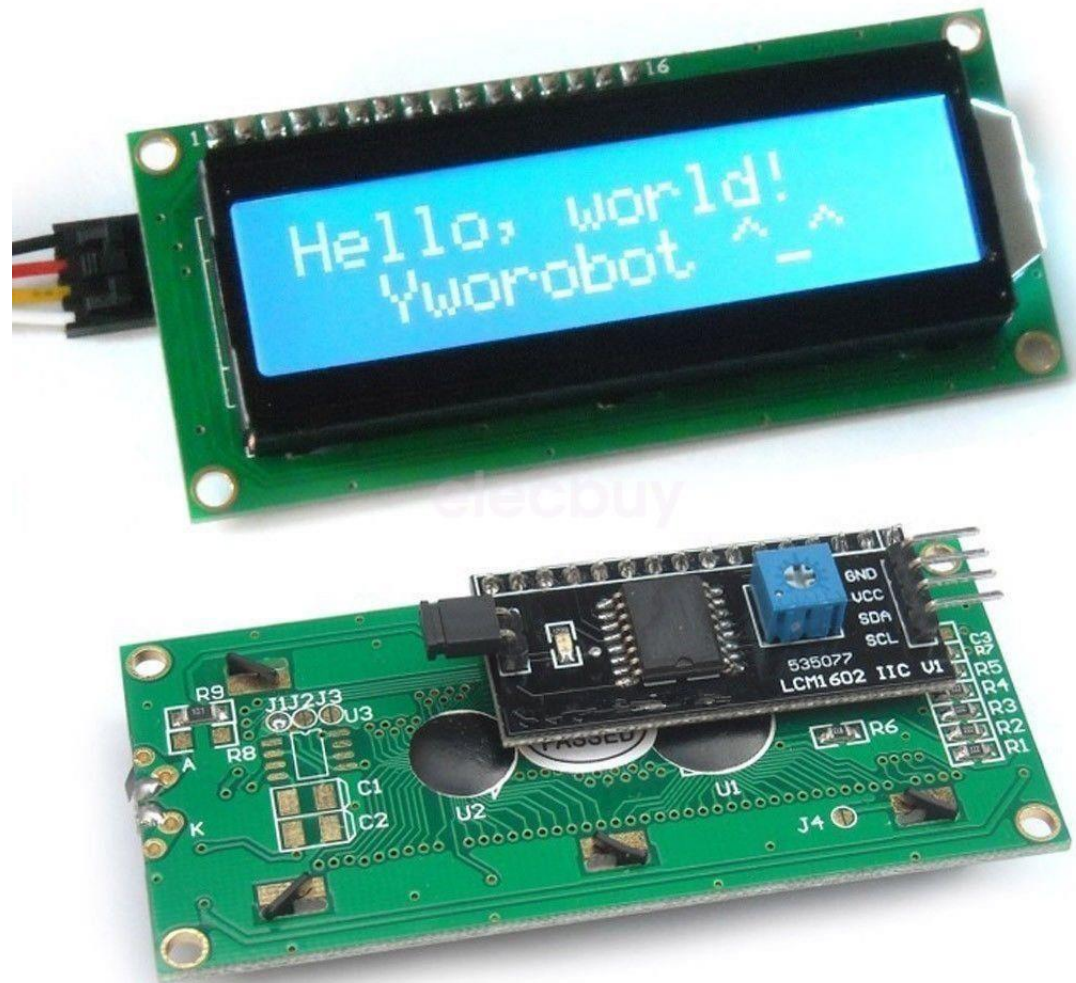


Basic musical instrument
Piezo buzzer RGB Led sync

Piezo buzzer (Lesson 2.6)

LCD display

- Lesson 2.21 (i2c)
 - Adjusting contrast with a screwdriver.
 - Connections:
SDA pin to A4 (Uno)
SCL pin to A5 (Uno)
- [Arduino code](#)
- Other examples



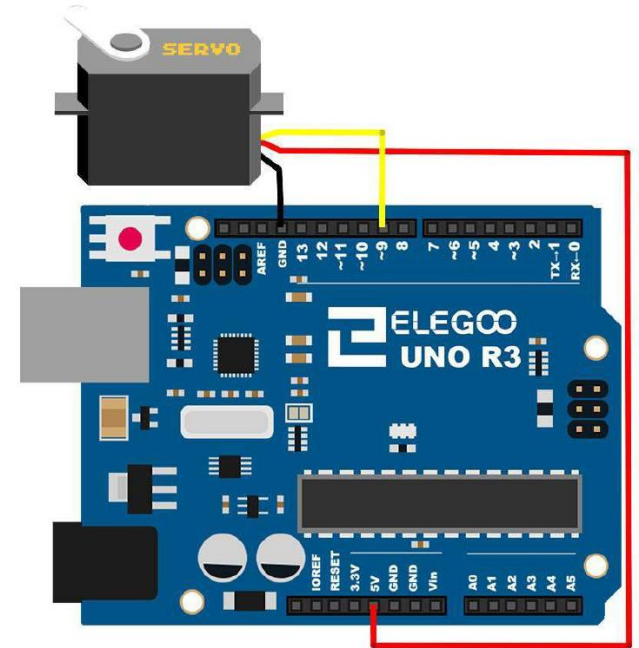
Stepper Motor



- [Stepper motor rotates in steps](#), open loop position control
- Basis for many machines (motion control)
- XY plotter, 3D printer, Laser cutter, CNC router
- 28BYJ-48 stepper motor, ULN2003 Driver Board
- Lesson 2.24, Examples

Servo Motor

- Rotate 180 degrees
- SG90, Datasheet
- Lesson 2.8
- Applications: [pen lift mechanism for XY plotter](#)
- Potentiometer example – [Gouri's project](#)





3-6 V DC Motor

DC motor control

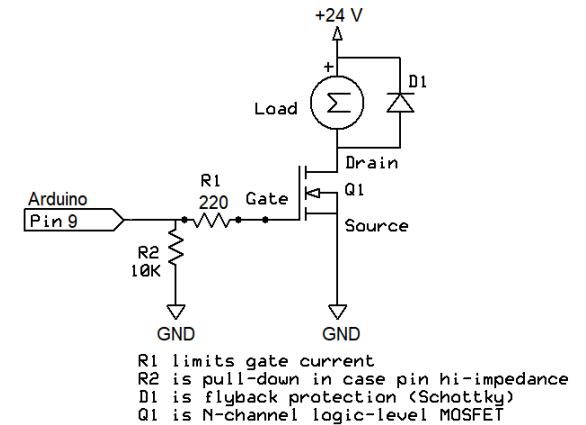
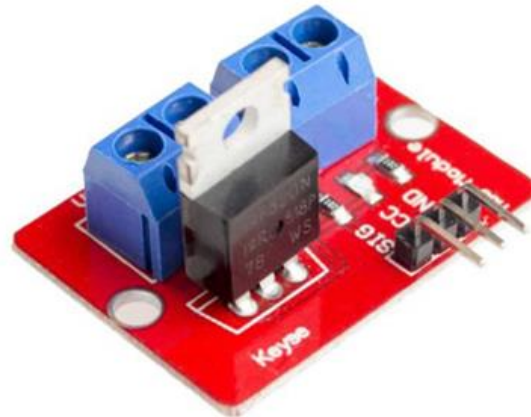
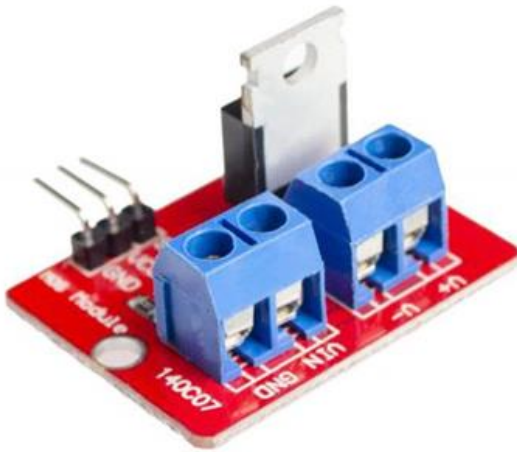
L293D

M1 PWM	1	16	Battery +ve
M1 direction 0/1	2	15	M2 direction 0/1
M1 +ve	3	14	M2 +ve
GND	4	13	GND
GND	5	12	GND
M1 -ve	6	11	M2 -ve
M1 direction 1/0	7	10	M2 direction 1/0
Battery +ve	8	9	M2 PWM

Motor 1

Motor 2

- Lesson 2.23
- L293D datasheet, Motor drivers
- PWM (speed control), potentiometer control
- Direction control
- DC power supply for higher current



MOSFET module

High Power DC Loads

- Controlling a high power DC load with a microcontroller
- MOSFET GATE acts as a switch for high power DC loads, Fade Arduino code
- IRF520 MOSFET datasheet
- LED strip, DC fan, DC motors, etc.
- [AC light dimmer module](#) (dangerous!) for AC loads

Output Devices Summary



Output devices



Examples: LCD display, RGB LED, Motors, Buzzer



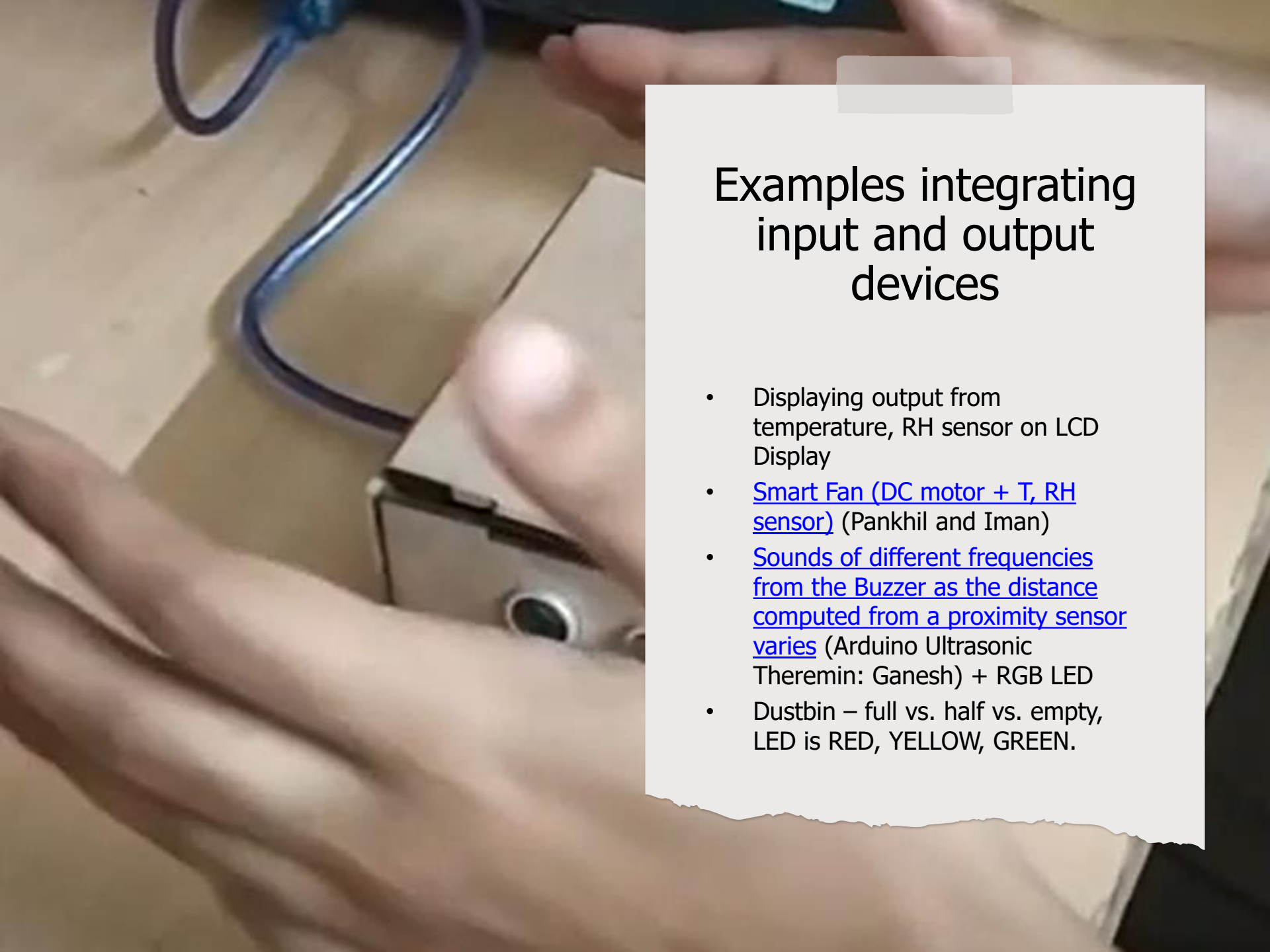
Fab Academy [webpage](#)
[video](#)



Think of applications as a design student



Explore other input and output devices



Examples integrating input and output devices

- Displaying output from temperature, RH sensor on LCD Display
- [Smart Fan \(DC motor + T, RH sensor\)](#) (Pankhil and Iman)
- [Sounds of different frequencies from the Buzzer as the distance computed from a proximity sensor varies](#) (Arduino Ultrasonic Theremin: Ganesh) + RGB LED
- Dustbin – full vs. half vs. empty, LED is RED, YELLOW, GREEN.

Assignment 3:

μC

Programming

Combine an input and output device together and collect data for an activity connected to you. Analyze that data and make sense of it. e.g. some examples could be displaying output from temperature/RH sensor on LCD Display to find the thermal comfort in your room, sounds of different frequencies from the Buzzer as the distance computed from a proximity sensor varies, Dustbin (full vs. half vs. empty) shows LED to be RED, YELLOW, GREEN. Please documents the steps and create a [video](#)/screenshots showing the interaction between the input and the output devices. Please also upload the codes used.

Assignment due on April 3th.

Announcements



- Please keep updating your project in the final project page. [Example](#)
- Please take good care of the electronics so that they are in working condition for the students learning this content later. Thanks!

Announcements



- Assignments are skills learnt in the class
- We would give you a chance to resubmit your assignment for re-evaluation once after we evaluate your assignment.