Materials and Prototyping DSL 732

CNC ROUTERS

HAND TOOLS

COMPUTER & SOFTWARE

VINYL CUTTER

LASER CUTTER

3D SCANNER 3D PRINTERS

ELECTRONICS WORKBENCH

SEWING MACHINE

VARIOUS MATERIALS
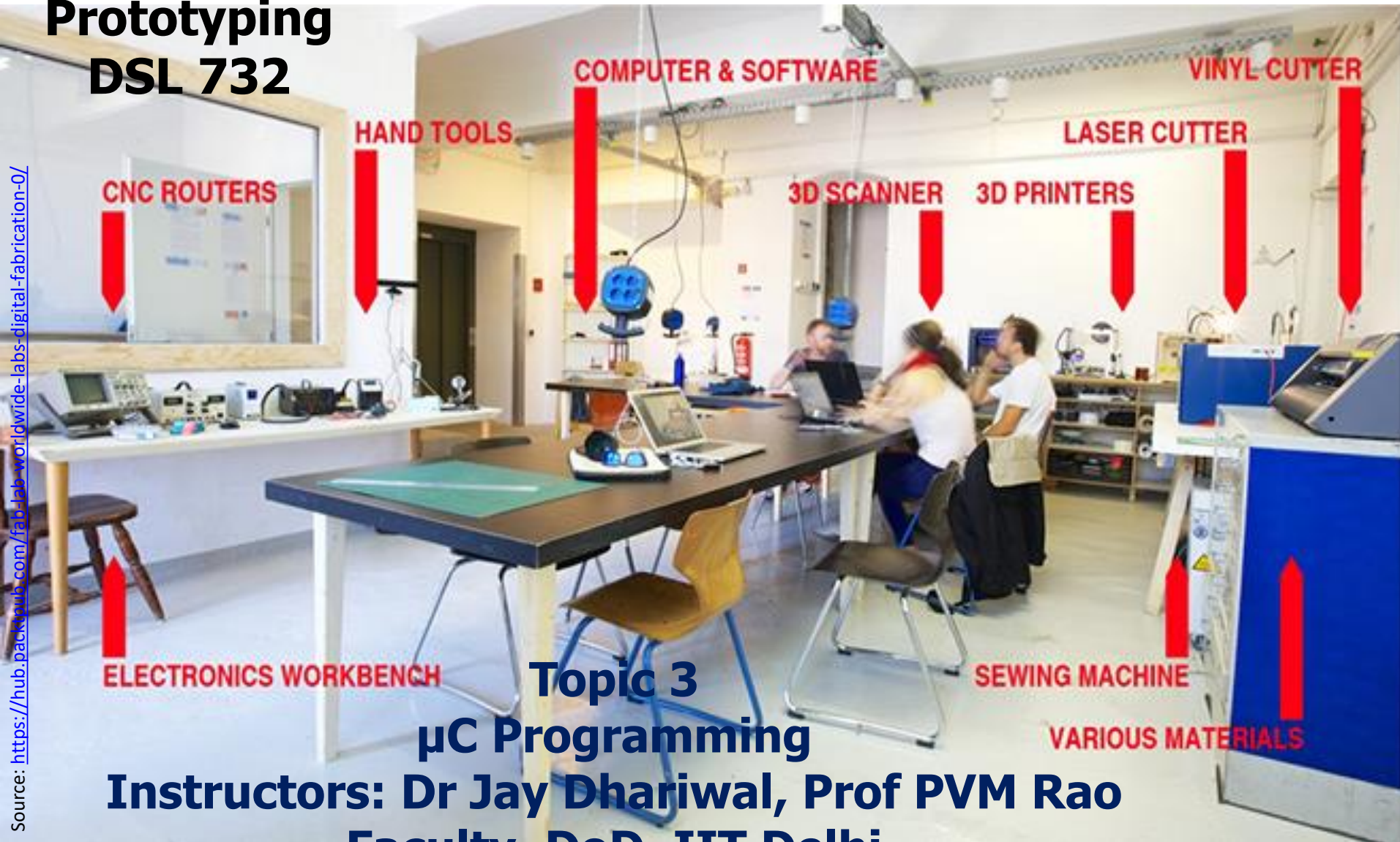
**Topic 3
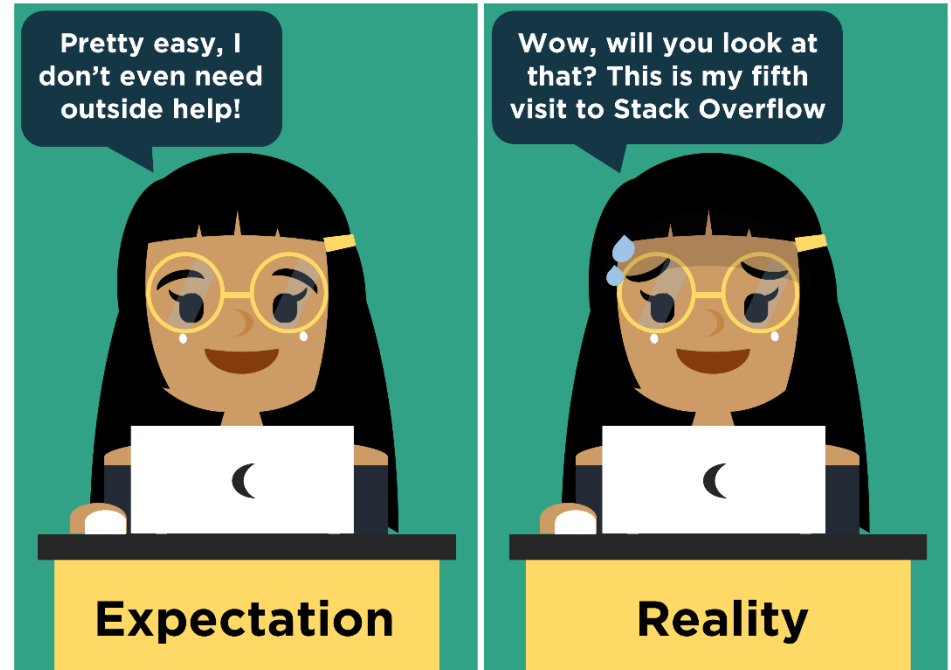μC Programming
Instructors: Dr Jay Dhariwal, Prof PVM Rao
Faculty, DoD, IIT Delhi
Dated: 25th February, 2021**

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"

Expectation — Pretty easy, I don't even need outside help!

Reality — Wow, will you look at that? This is my fifth visit to Stack Overflow
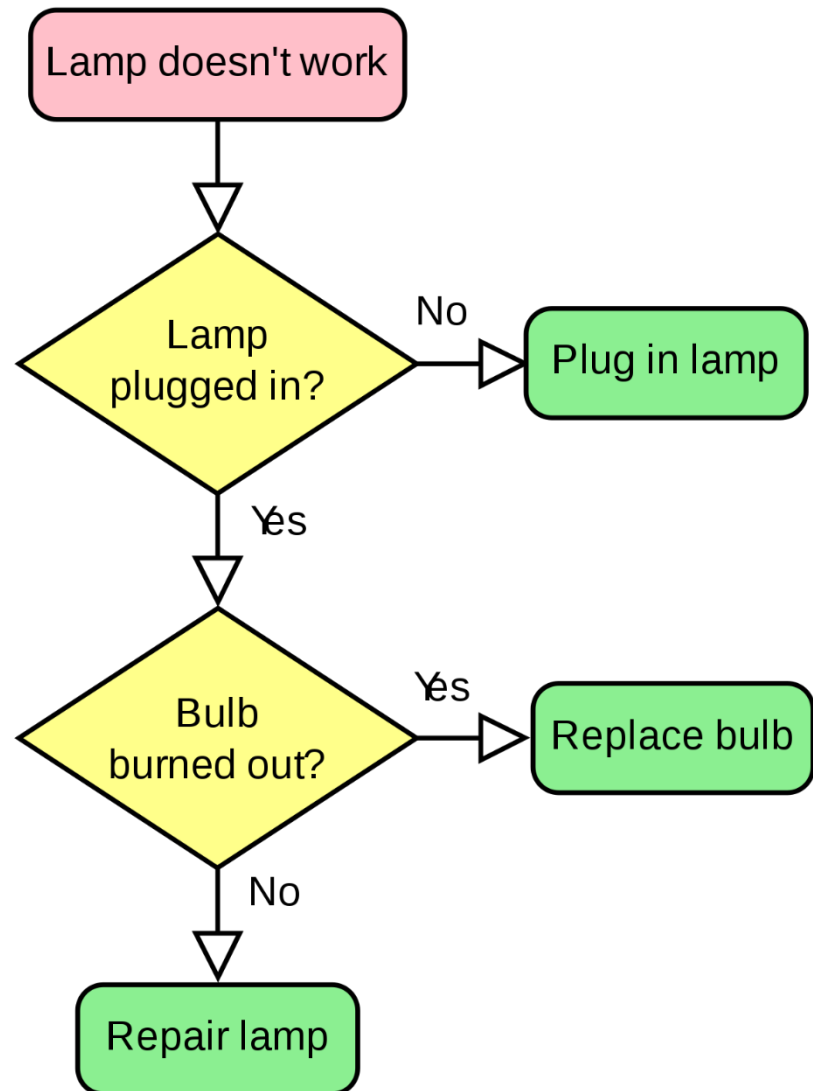
fb: Guen's Comics tw/ig: @guenscomics

Algorithm for adding two numbers

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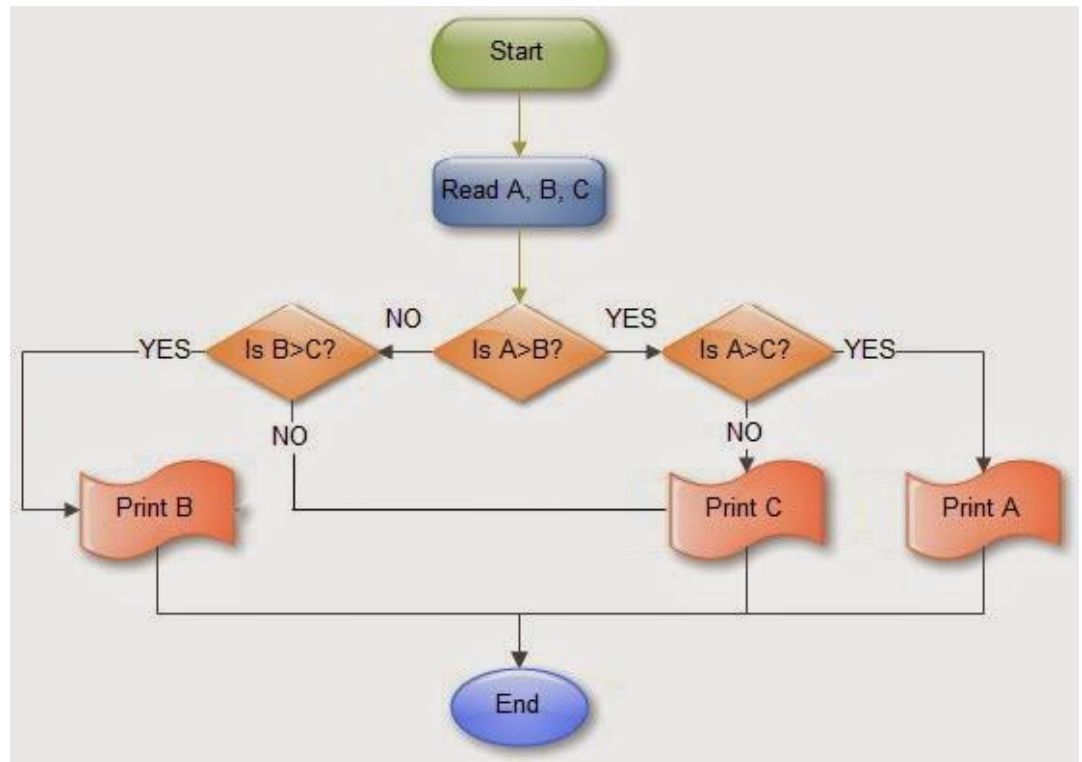- Add number1 and number 2
- Print the result.

Flowchart

- Languages have different syntax but are largely similar.
- Learn one language and you can learn others quickly.
- Flowchart/Algorithm is the key.

Lamp doesn't work

Lamp plugged in? — No → Plug in lamp

Yes

Bulb burned out? — Yes → Replace bulb

No

Repair lamp

Flowchart for largest of three numbers

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

```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

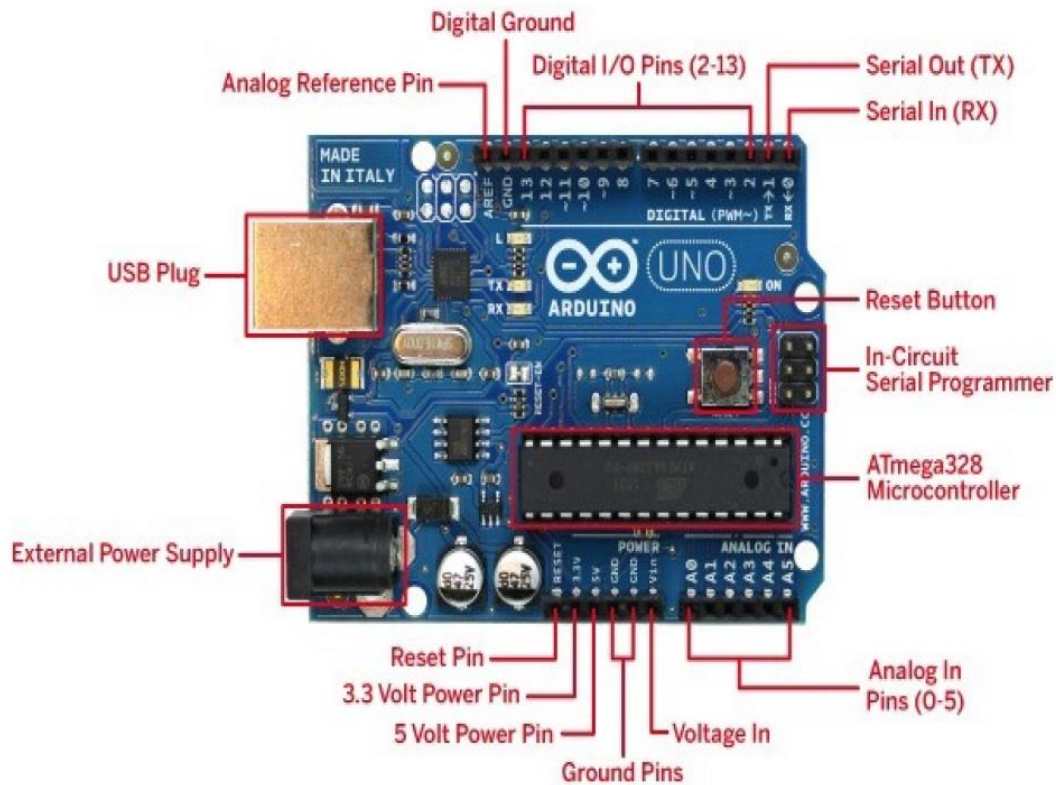Logical and Arithmetical Operators

If else conditions, Loops
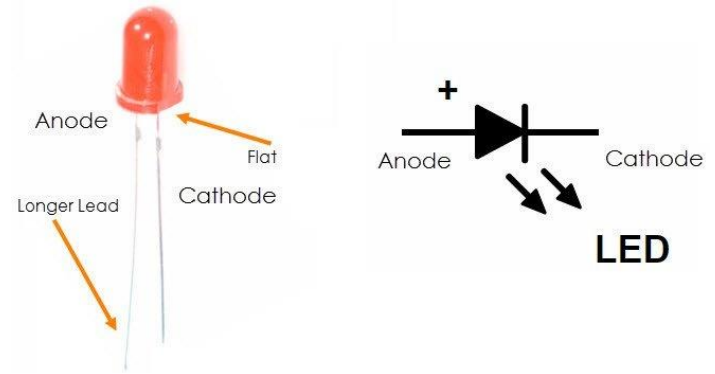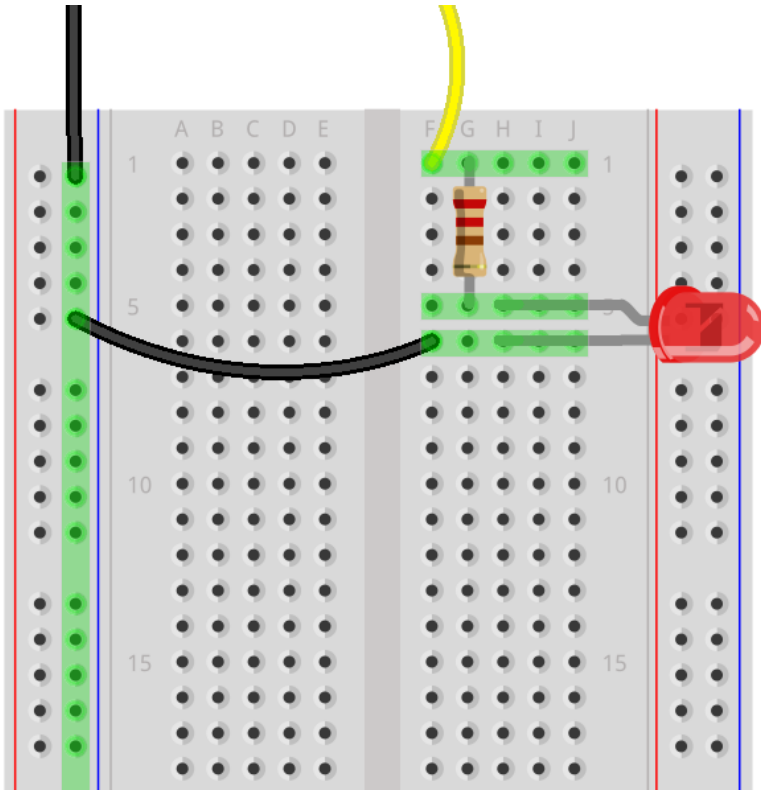
Functions

Comments, Indentation, Bottom up debugging

Microcontroller programming

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

Getting started with Arduino

- Download [Arduino IDE](#)
- [Arduino kit pdf](#) for instructions
- Lesson 0, 1 of Arduino Kit
- Open Arduino IDE
- Blink sketch with pin 13
- Blink sketch initialize pin 13
- Lesson 2 of Arduino Kit

Anode
Flat
Cathode
Longer Lead

+
Anode
Cathode
LED

Diode is like a one-way valve of electronics

Current
A   V ≡   Forward Bias

NO Current
B   V ≡   Reverse Bias
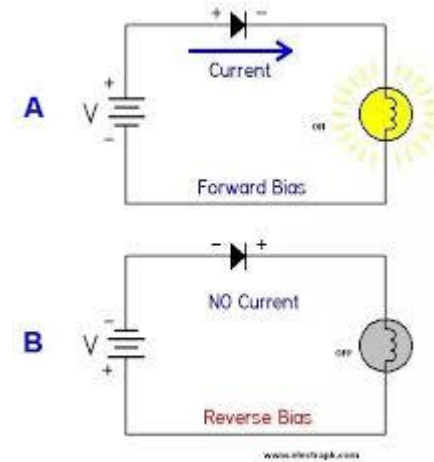
LED is a diode

- 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 3 of Arduino Kit

Lower pressure

Higher pressure

Hair in pipe

Small R

Same flow

Large R

Hydraulic analogy
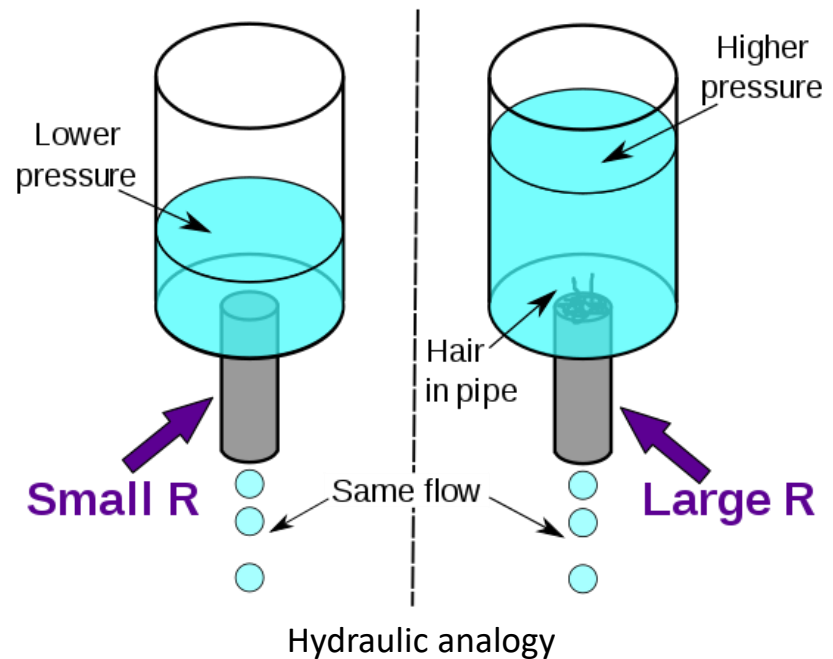
Ohm's Law, V=IR

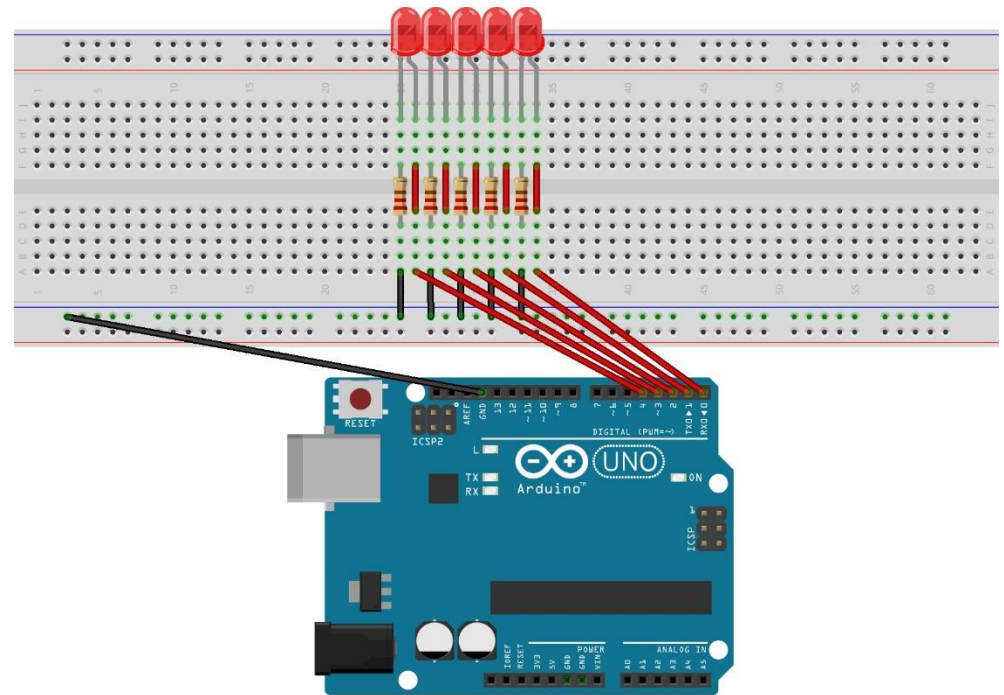V: Voltage, I: Current, R: Resistor

Thermal analogy, Q = dT/R , I = V/R
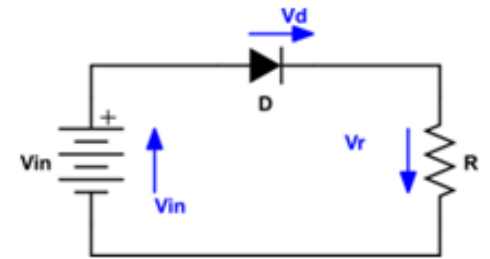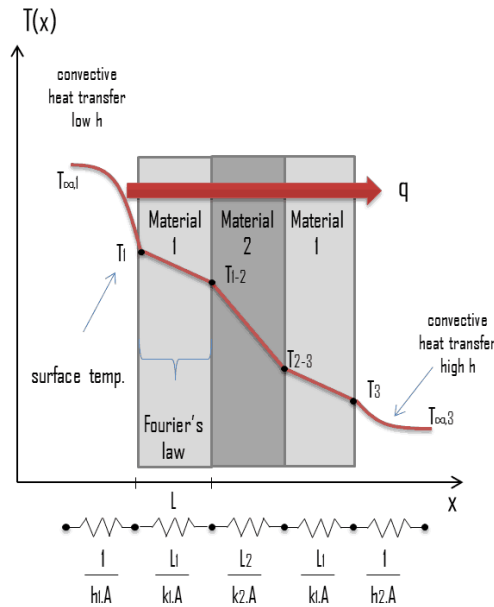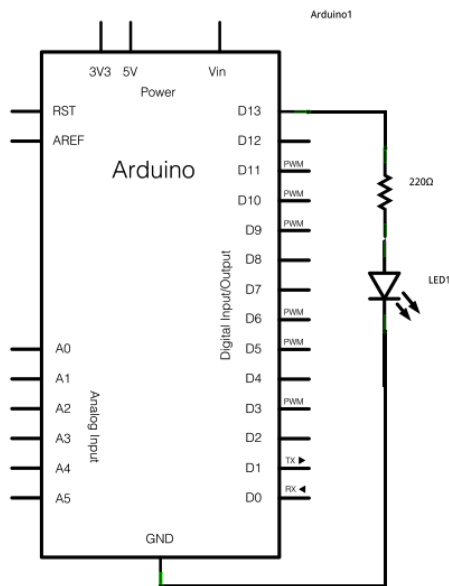
Kirchoff's Voltage Law

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](#)
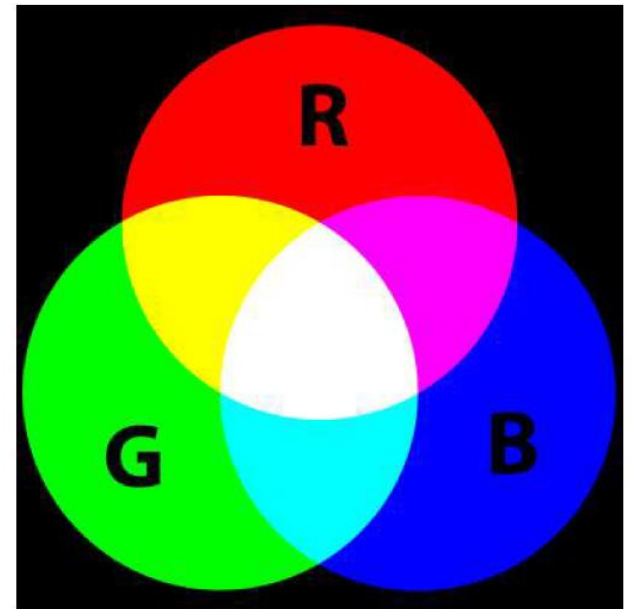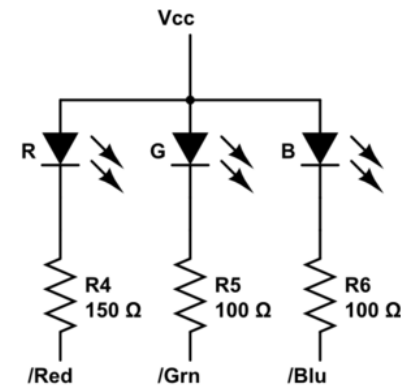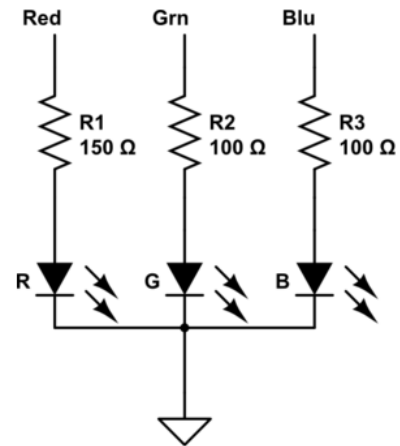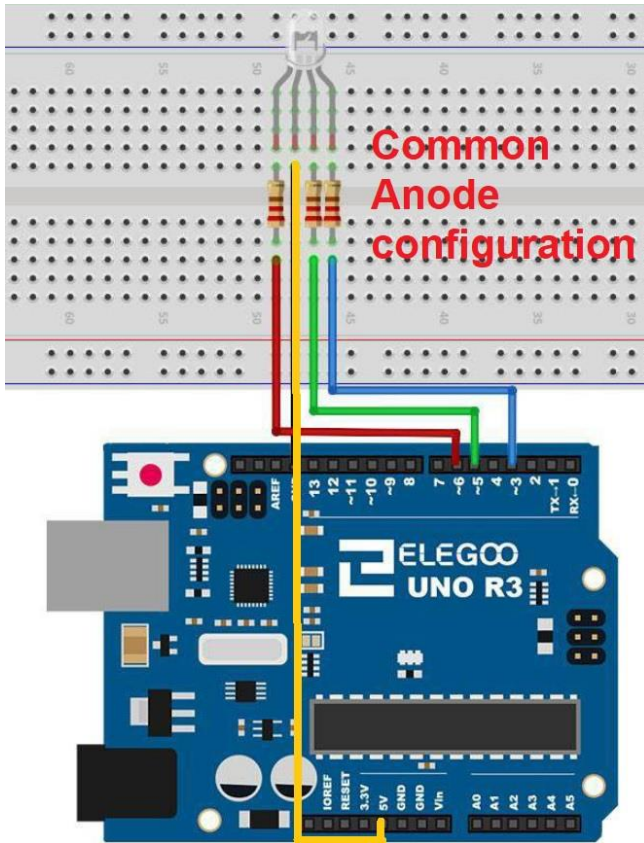

fritzing

RGB LED

- PWM with RGB LED with common anode (Lesson 4). NOTE: Longest leg of RGB LED goes to 5V pin.
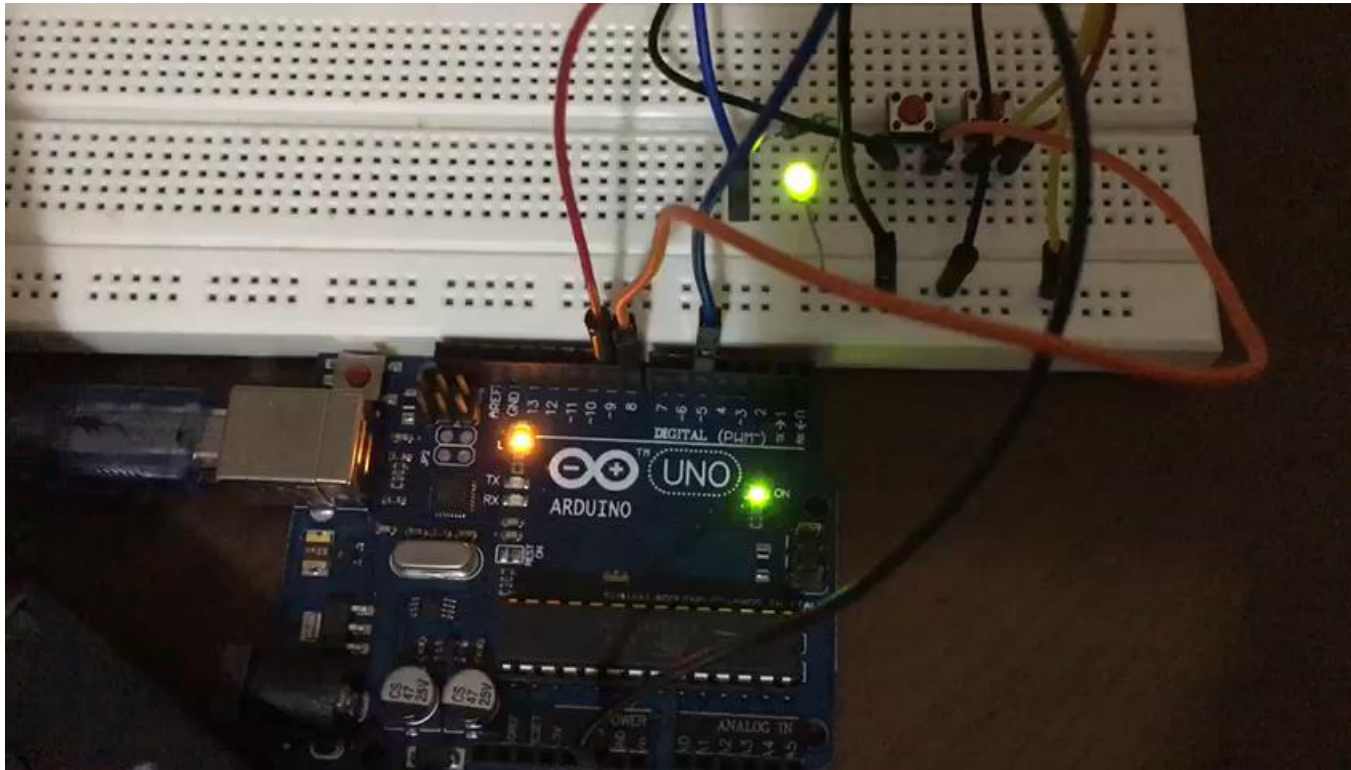- RGB code RGB_basic RGB_favorite_color
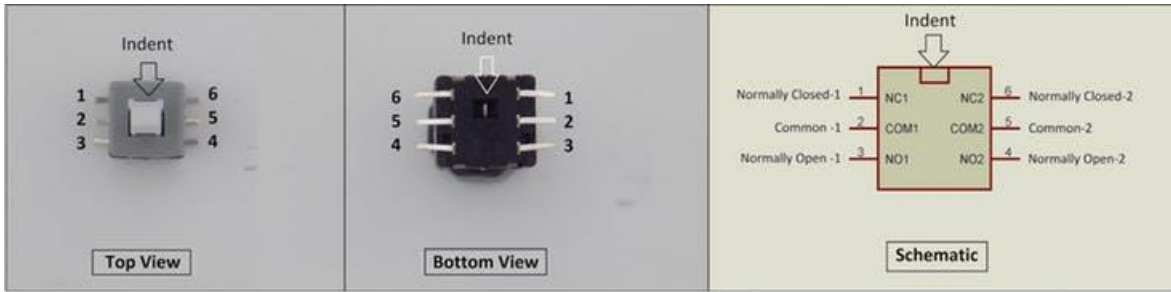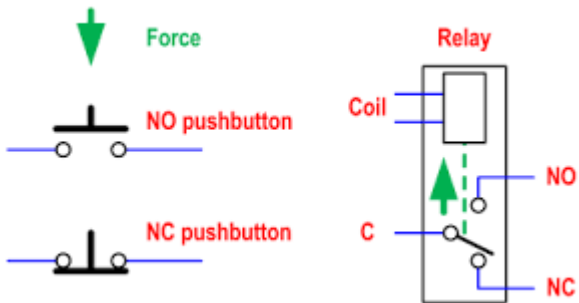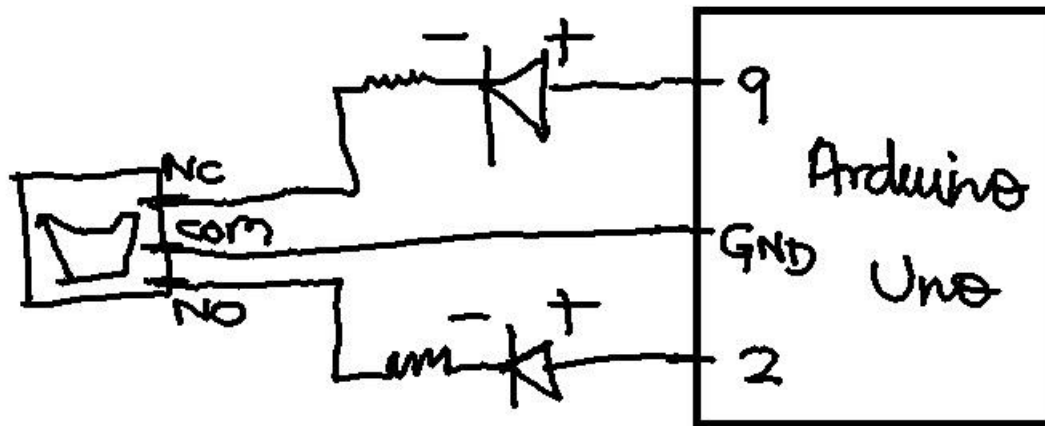
RGB LED circuit

Common Anode configuration

Push buttons (Input Pullup) – Lesson 5

- By default, input pullup pin is High, when push button pressed, it gets to Low. Video
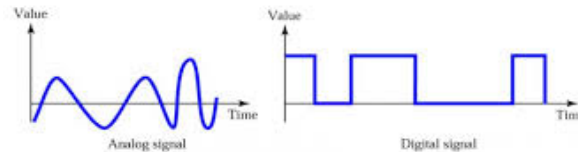
6 Pin Push Switch (Mini DPDT Push Switch) Pinout

- [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.

Pulse Width Modulation

0% Duty Cycle – analogWrite(0)

25% Duty Cycle – analogWrite(64)

50% Duty Cycle – analogWrite(127)

75% Duty Cycle – analogWrite(191)

100% Duty Cycle – analogWrite(255)

Value

Time

Analog signal

Value

Time

Digital signal
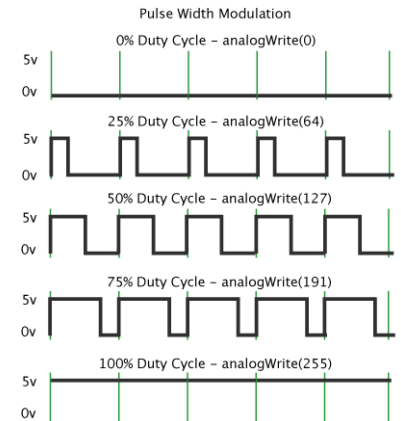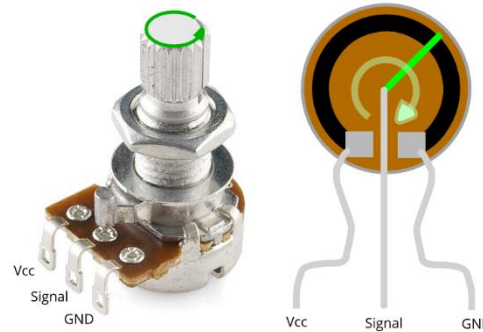
Arduino features
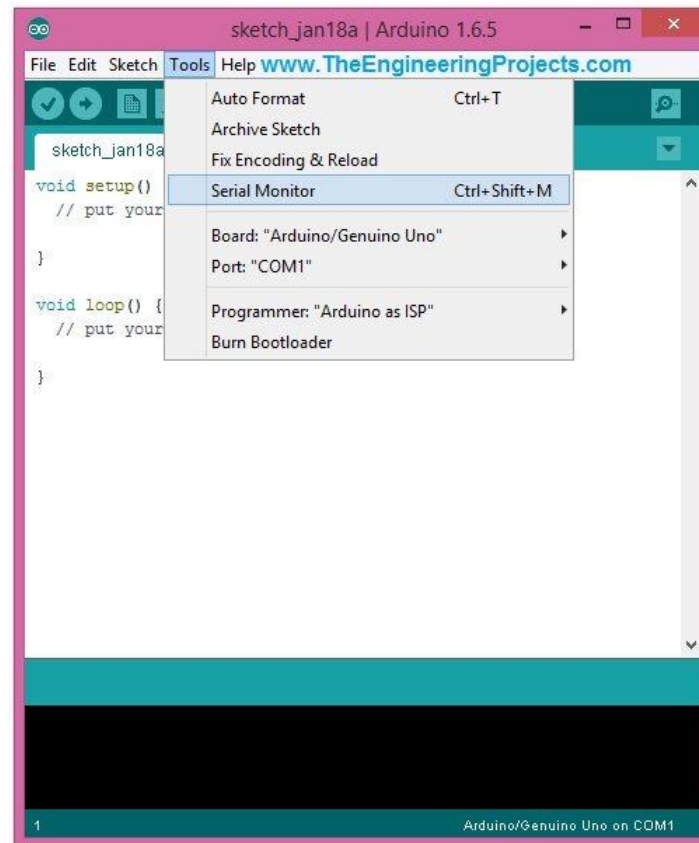
- If then else
- function, for loop, serial communication, serial monitor
- interfacing Arduino with Processing
- Arduino examples
- Arduino codes

Summary so far

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

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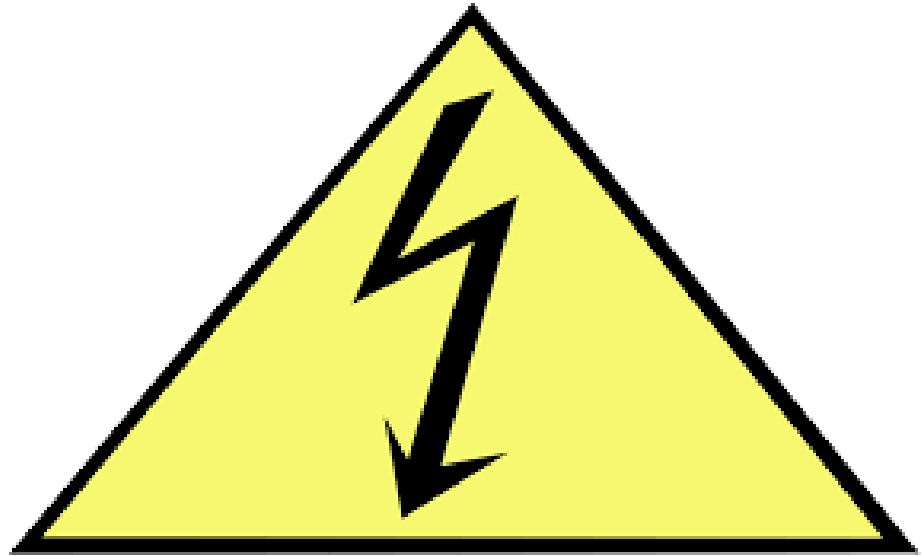
- [Video](#) (1:30 - 4:00 minutes)
- Take utmost care of the electronics. Shouldn't be exposed to water. Keep in Ziploc bags. Delicate stuff.

Electrical Safety

~1 mA: fine

~10 mA: shock, contraction

~100 mA: fibrillation
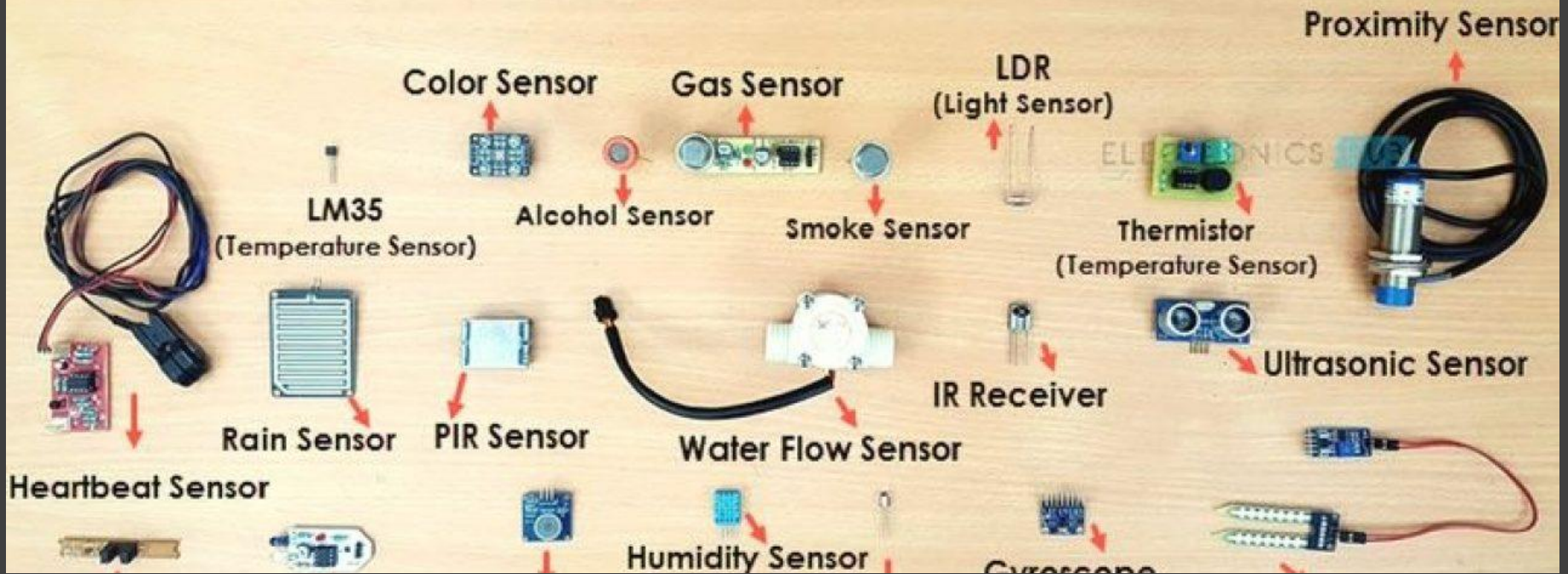
- body: M ohm external, k ohm internal

"Don't touch him! He's a conductor."

DIFFERENT TYPES OF SENSORS

Color Sensor
Gas Sensor
LDR (Light Sensor)
Proximity Sensor
LM35 (Temperature Sensor)
Alcohol Sensor
Smoke Sensor
Thermistor (Temperature Sensor)
Heartbeat Sensor
Rain Sensor
PIR Sensor
Water Flow Sensor
IR Receiver
Ultrasonic Sensor
Humidity Sensor
Gyroscope

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
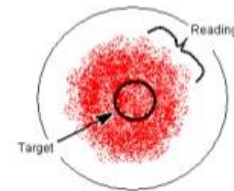
Sensor features

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

Accuracy vs. Precision
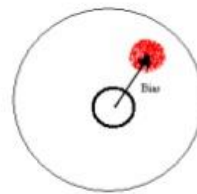
Precision without accuracy
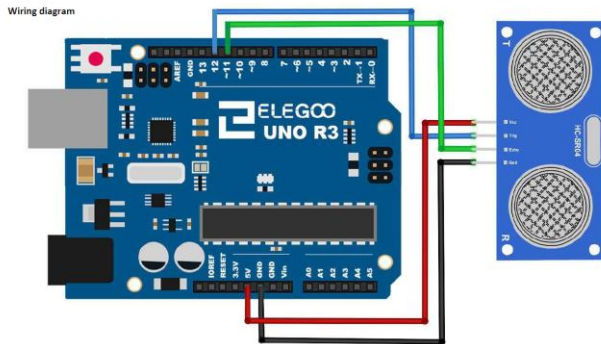
Accuracy without precision

Precision and accuracy

Distance Measurement

- Ultrasonic sensor module (Lesson 10)

- Read datasheet (2 cm- 400 cm range)

- Lesson 1 (install library)

- Reading library

- Smart cane, other applications

4X4 Keypad module

- Lesson 11
- 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
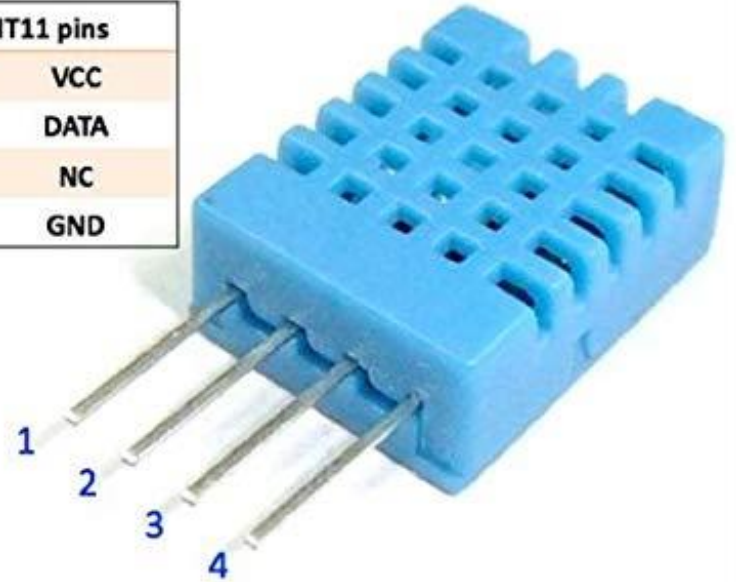
Temperature, RH measurement

- DHT11 sensor (Lesson 12)
- DHT22 sensor Another library
- Datasheet

Input Devices Summary
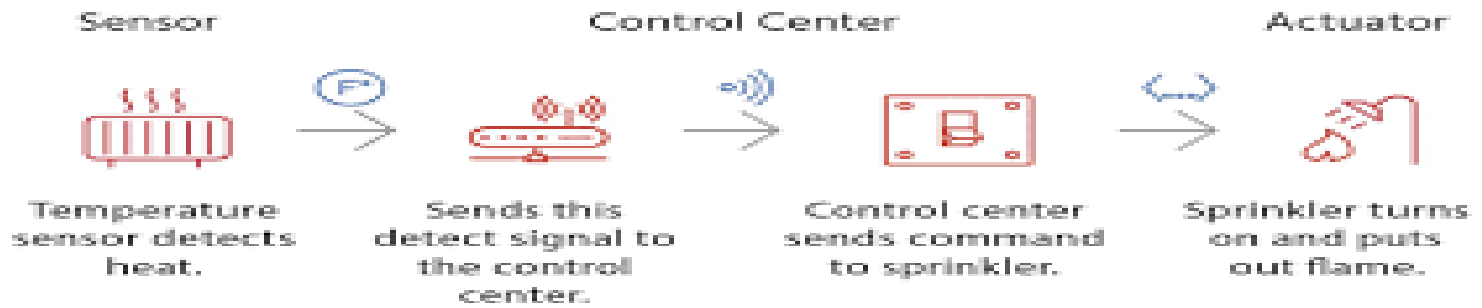
Smart phone sensors

Sensor characteristics

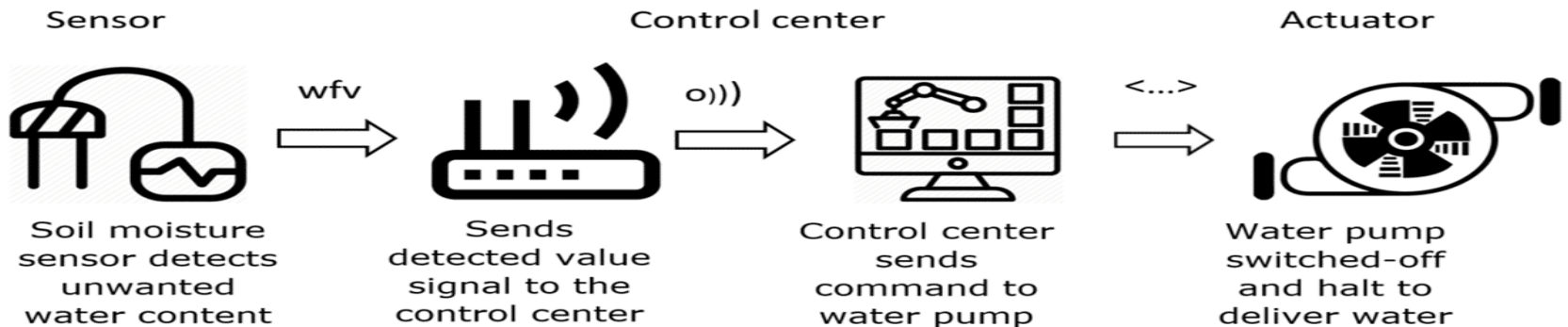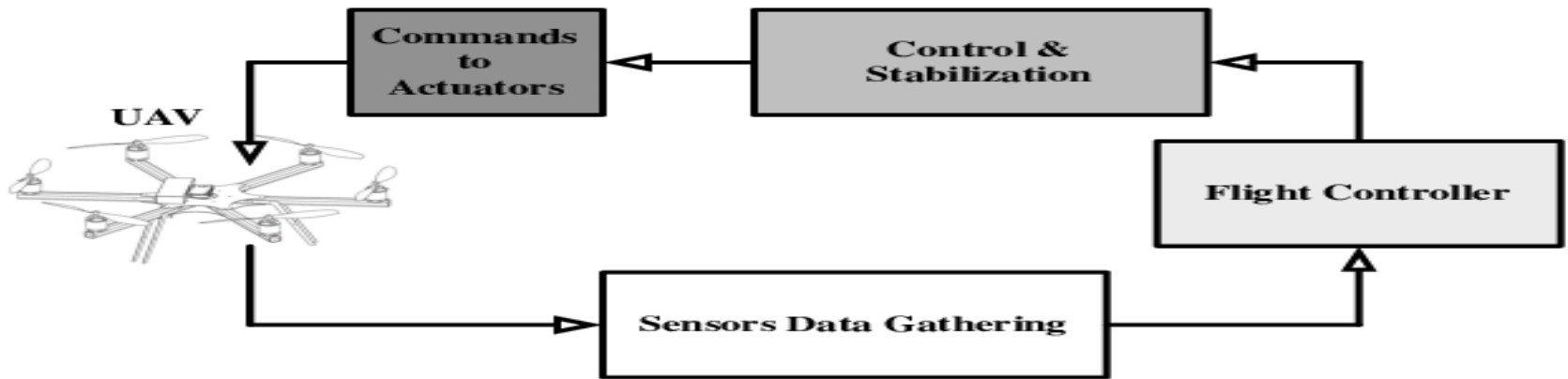Examples: Ultrasonic sensor, Keypad module, Temp/RH. Other sensors similar procedure.

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

Think of applications as a design student

Sensor

Temperature sensor detects heat.

Sends this detect signal to the control center.

Control Center

Control center sends command to sprinkler.

Actuator

Sprinkler turns on and puts out flame.

Sensor to **Actuator** Flow

Commands to Actuators

Control & Stabilization

UAV

Flight Controller

Sensors Data Gathering

Sensor

Soil moisture sensor detects unwanted water content

wfv

Sends detected value signal to the control center

o)))

Control center

Control center sends command to water pump

<...>

Actuator

Water pump switched-off and halt to deliver water
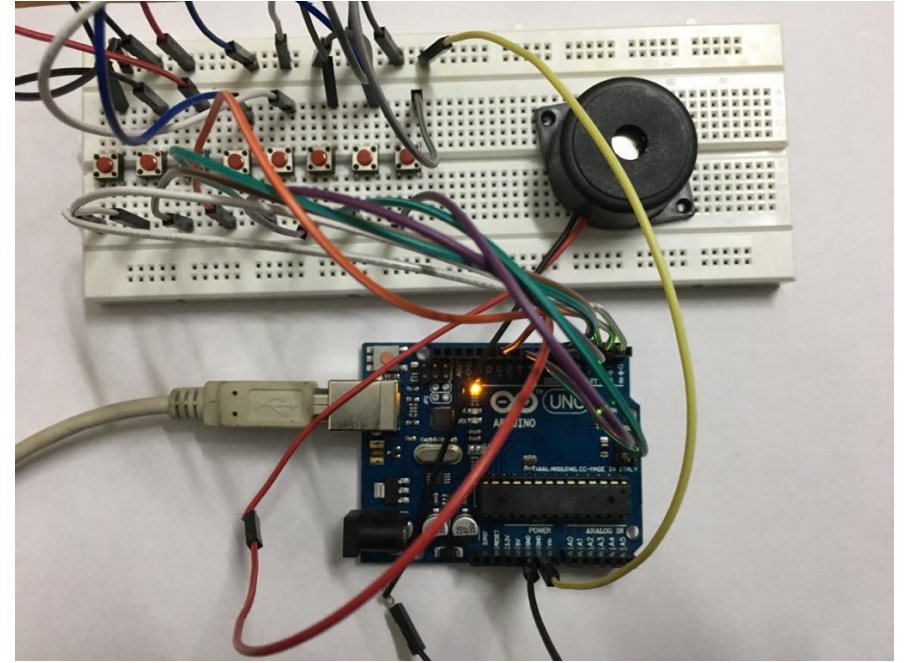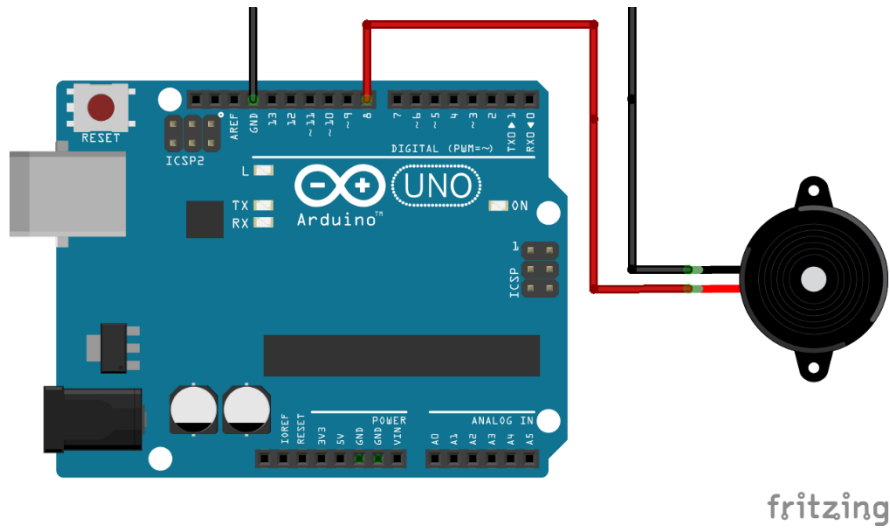
Output Devices

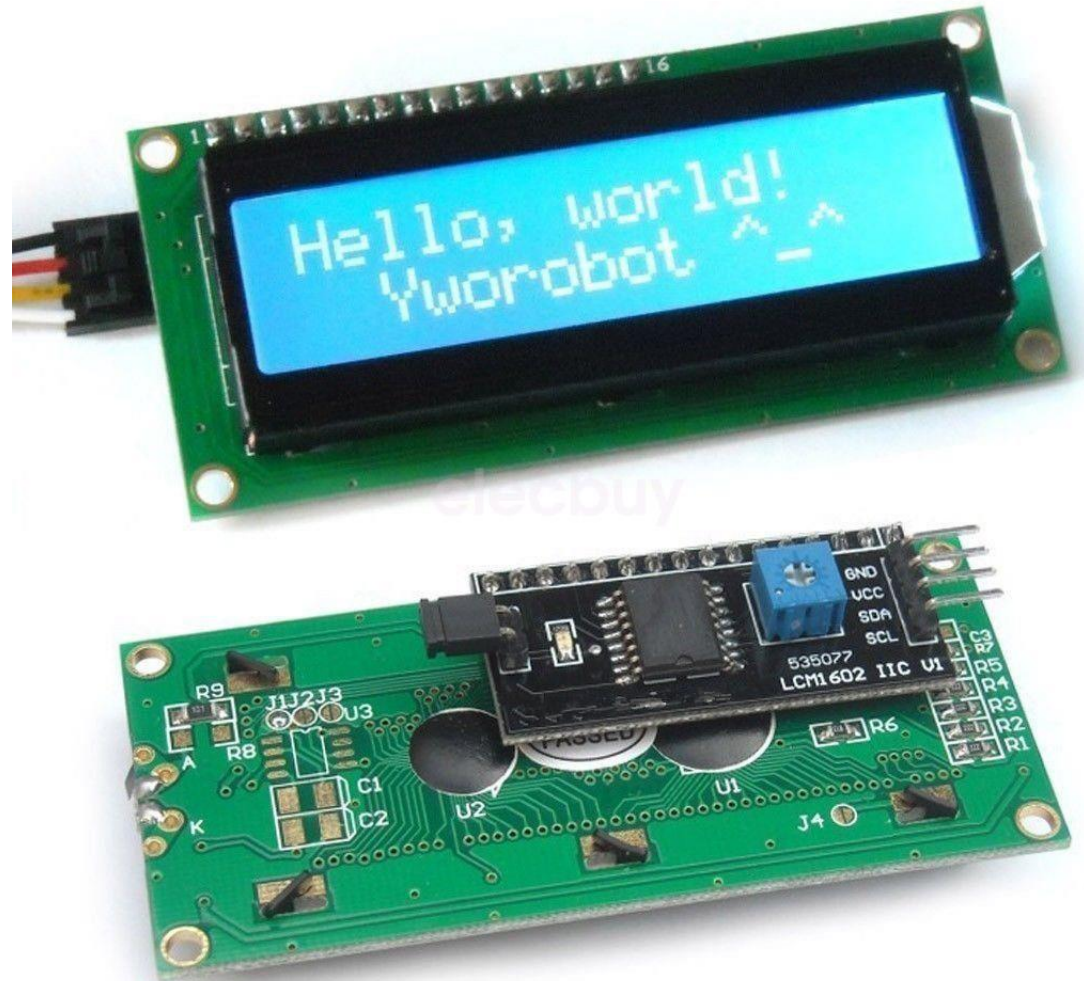- LEDs, Displays, Speakers/ Buzzers, DC/Servo/Stepper Motors, Relays, Dataloggers

[Basic musical instrument](#)

Piezo buzzer (Lesson 7)

LCD display

- Lesson 22 (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 31, Examples

Servo Motor

- Rotate 180 degrees
- SG90, Datasheet
- Lesson 9
- Applications: pen lift mechanism for XY plotter
- Potentiometer example – [Gouri's project](#)
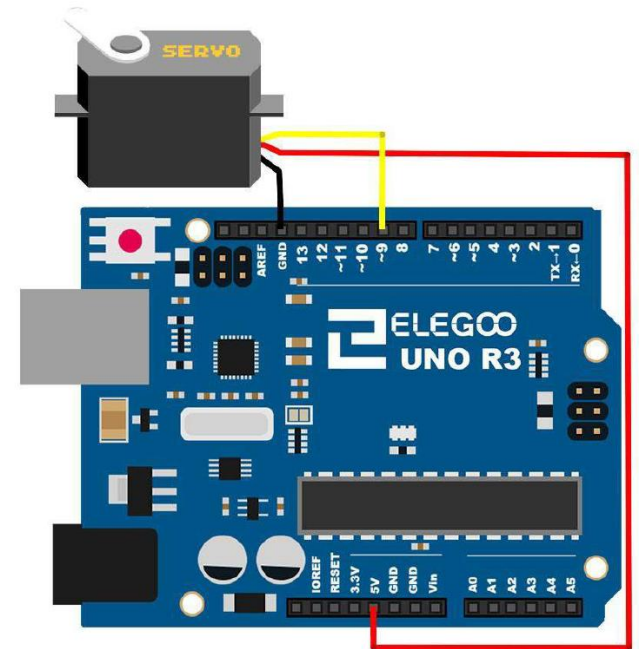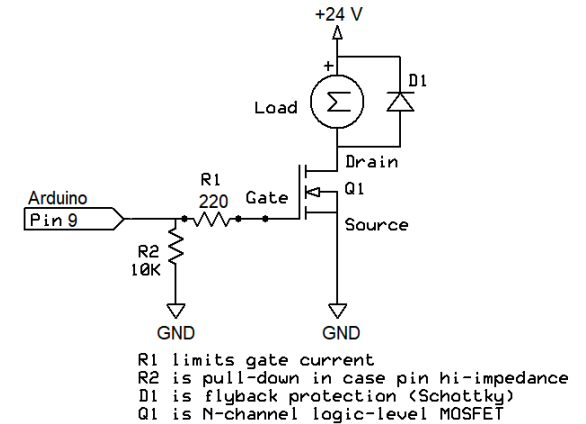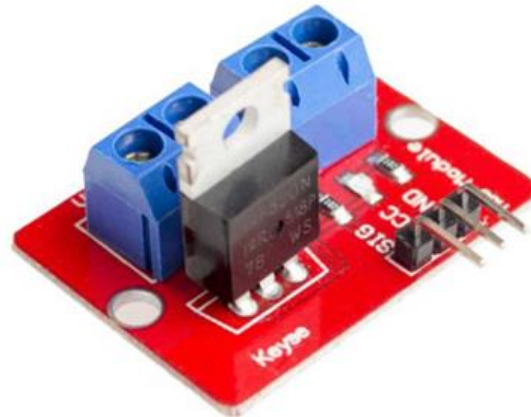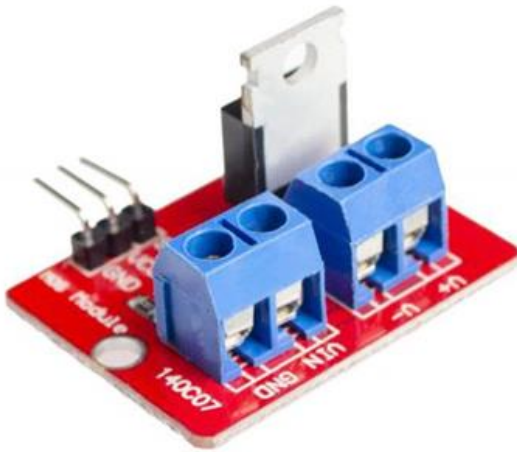
[3-6 V DC Motor](#)

DC motor control

- Lesson 29
- L293D datasheet, Motor drivers
- PWM (speed control), potentiometer control
- Direction control
- DC power supply for higher current

+24 V

R1 limits gate current
R2 is pull-down in case pin hi-impedance
D1 is flyback protection (Schottky)
Q1 is N-channel logic-level MOSFET

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

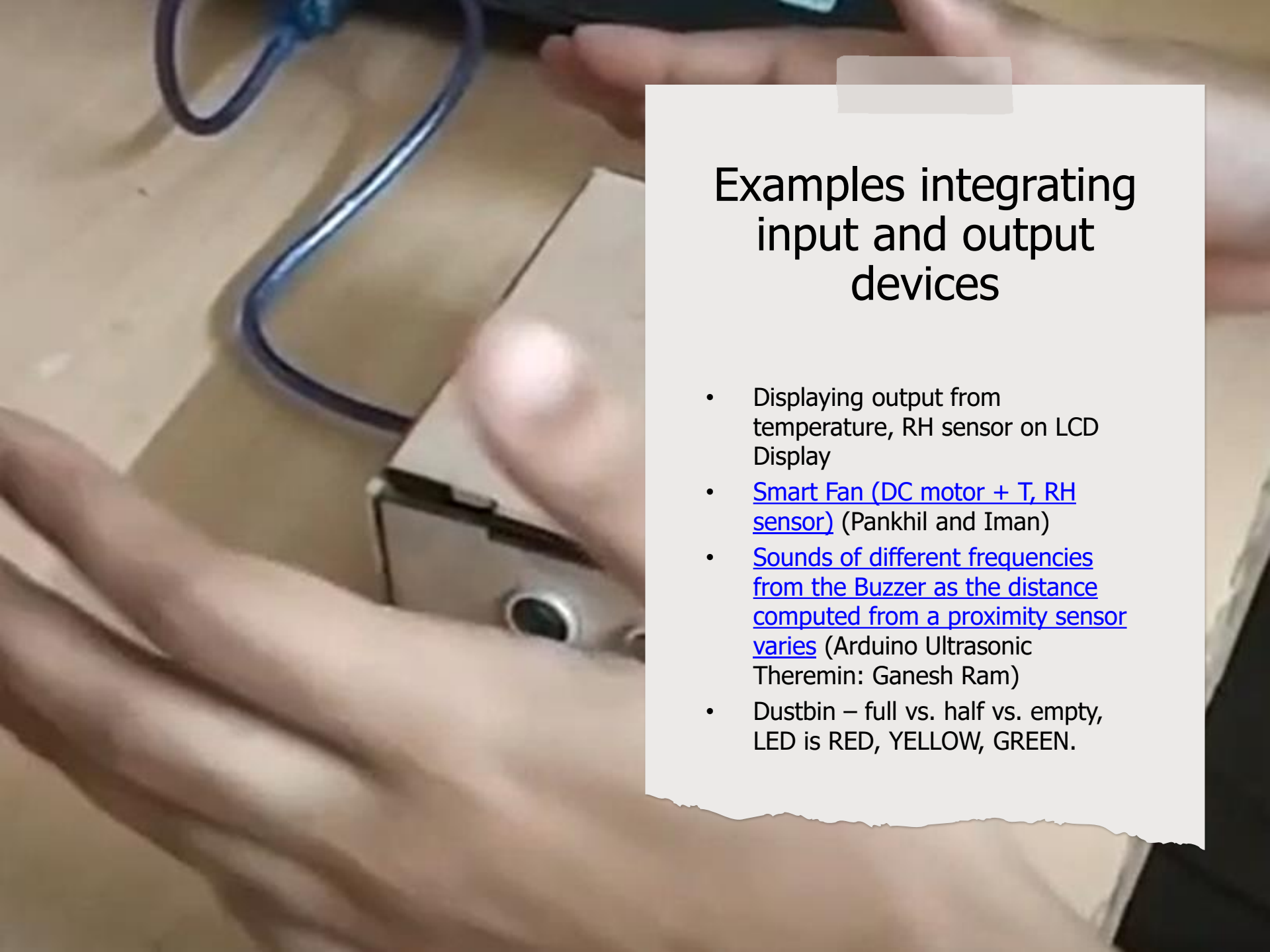Examples: LCD display, RGB LED, Motors, Buzzer

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 Ram)

- 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 March 27th.

Announcements

- Please keep updating your project in the final project page. [Example](#)
- Assignment 1 is Project Proposal so update it at both places.
- 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.