Special Topics in Design I
(Prototyping in IOT)
DSL 810
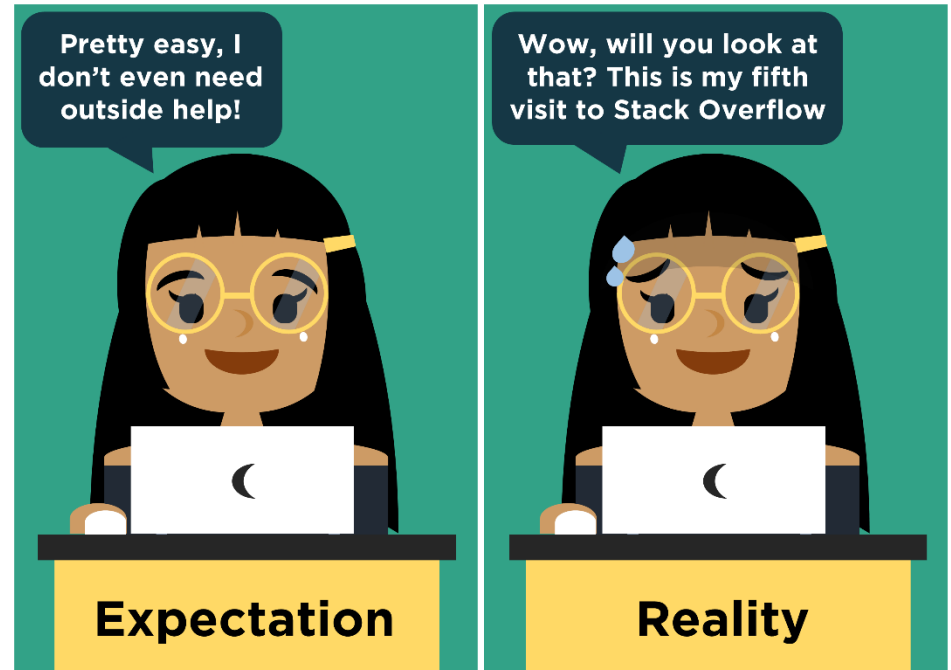
Topic 3
Microcontroller Programming
Instructor: Jay Dhariwal,
Asst. Prof., IIT Delhi

20th January 2020

Programming

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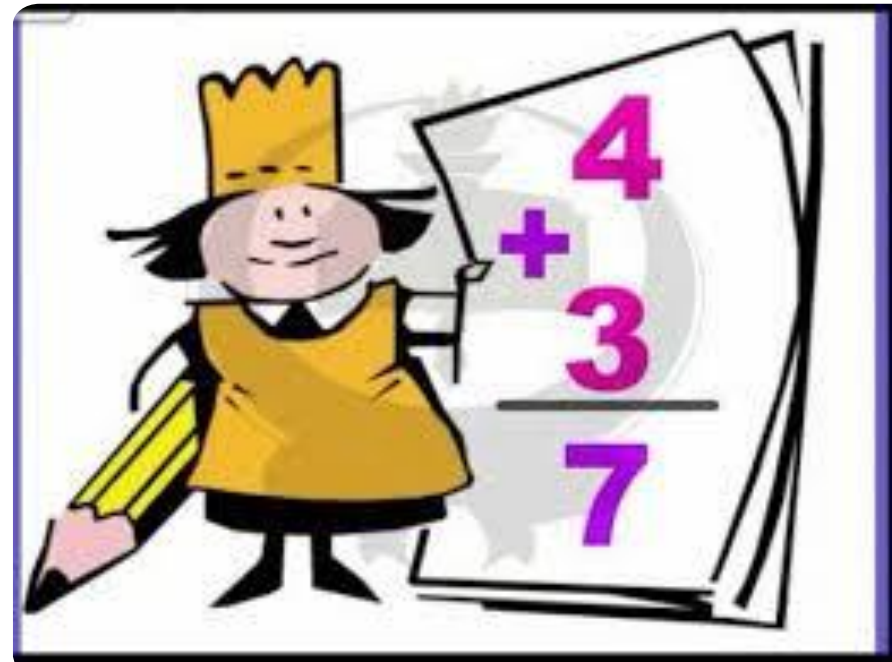- How would a calculator add two numbers?

"Programmers: Expectation VS Reality"

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

Wow, will you look at that? This is my fifth visit to Stack Overflow

Expectation

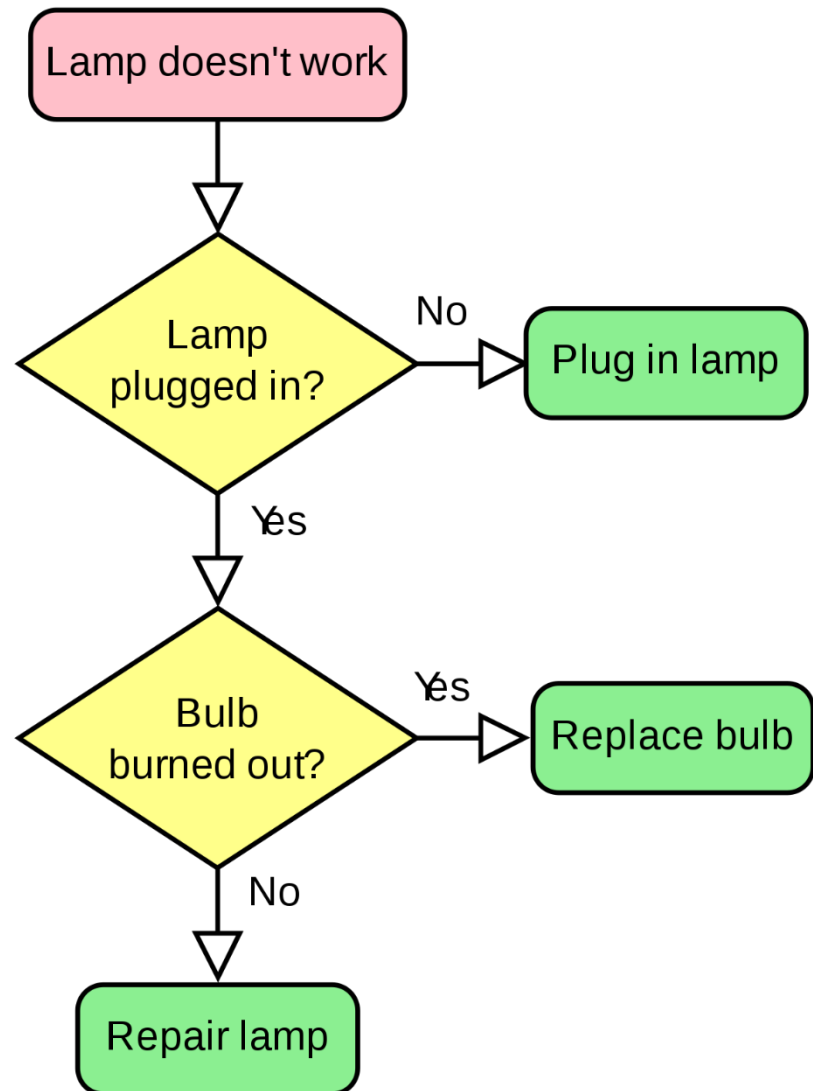**Reality**

fb: Guen's Comics tw/ig: @guenscomics
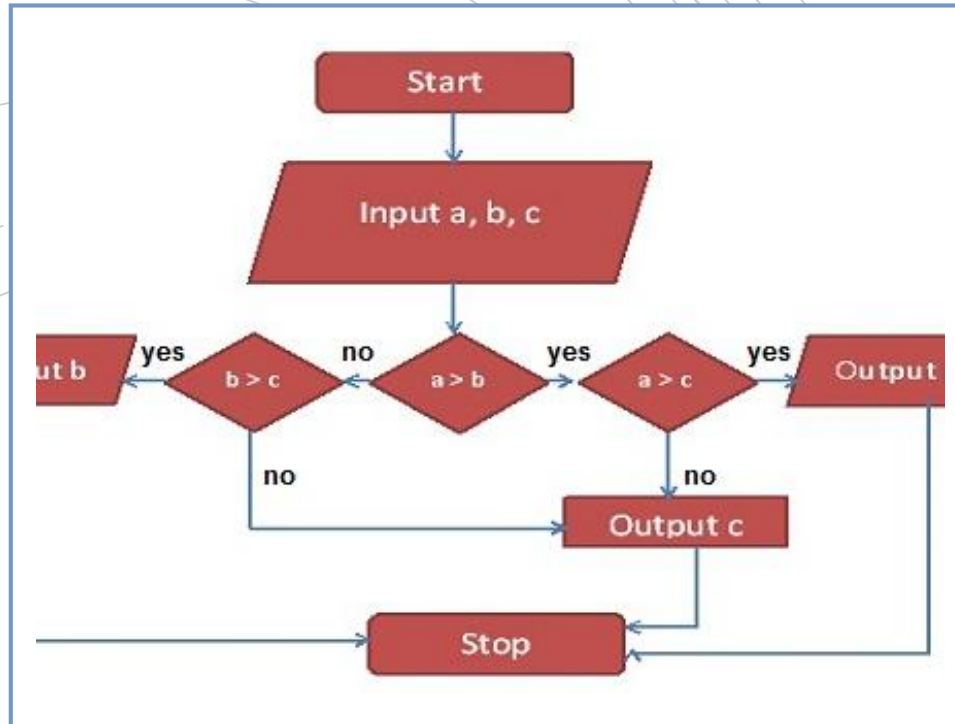
Algorithm for adding two numbers

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

Flowchart

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

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, 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 Operationss

Logical and Arithmetical Operators

If else conditions, Loops

Functions

Comments, Indentation, Bottom up debugging

Python

Python Advantages & Disadvantages

ADVANTAGES
- Data Science Library
- Embeddable
- IOT Opportunities
- Object-Oriented
- Extensible
- Improved Productivity
- Readable
- Portable, Free and Open-Source

DISADVANTAGES
- Speed Limitations
- Weak in Mobile Computing
- Design Restrictions
- Underdeveloped DB Layers

- [Python basics](#) from Sanju Ahuja
- [Python interpreter](#)
- [Python examples](#)
- [Fab Academy tutorial on python](#)

Scratch

- [Scratch animations](#)
- Scratch games
- Arduino with Scratch

Processing IDE

- [Graphical programming language](#) –visual design, images, creative applications

- [Youtube tutorials](#)

- Extendable through libraries (written in Java)

- Use for creating GUI for Arduino projects. For visualizing the output from sensors.

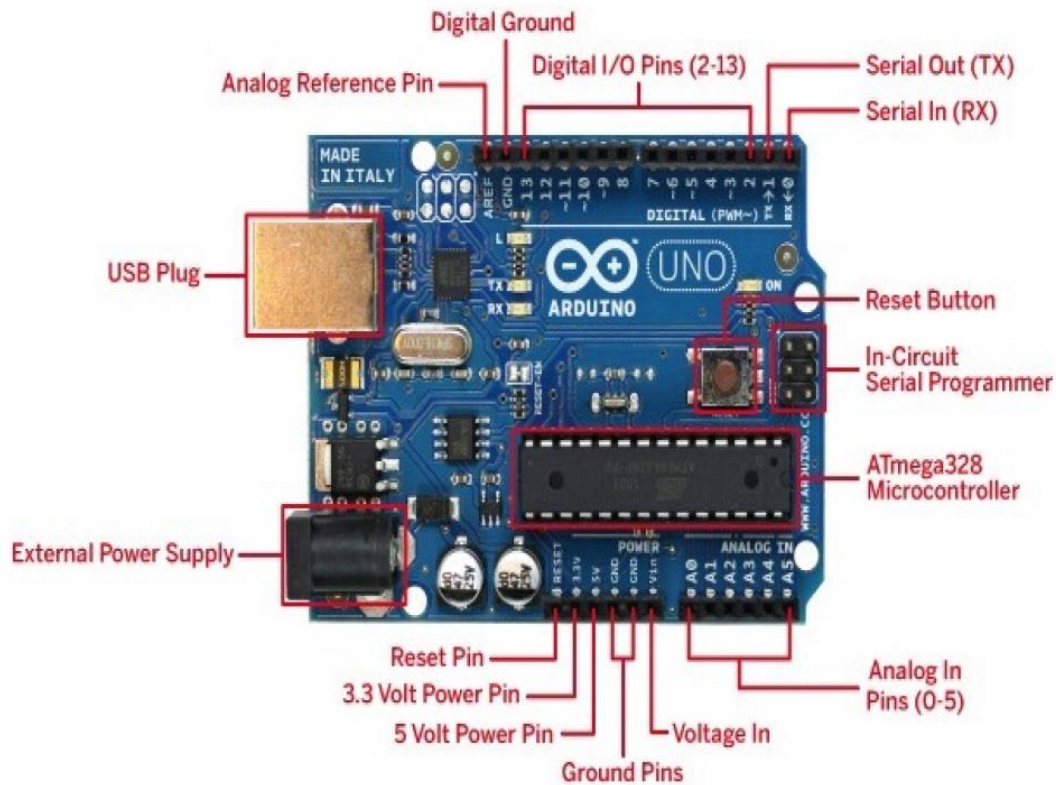- [Other applications](#): Motion graphics, Data visualization, [Music visualization](#)

Processing examples

- [Writing simple programs](#)
- [Processing functions reference](#)
- [Examples](#), import libraries
- [Creative, Fun programming](#)
- Setup, draw, events, random, other functions, [rendering a processing sketch](#)
- [Processing for Android](#)
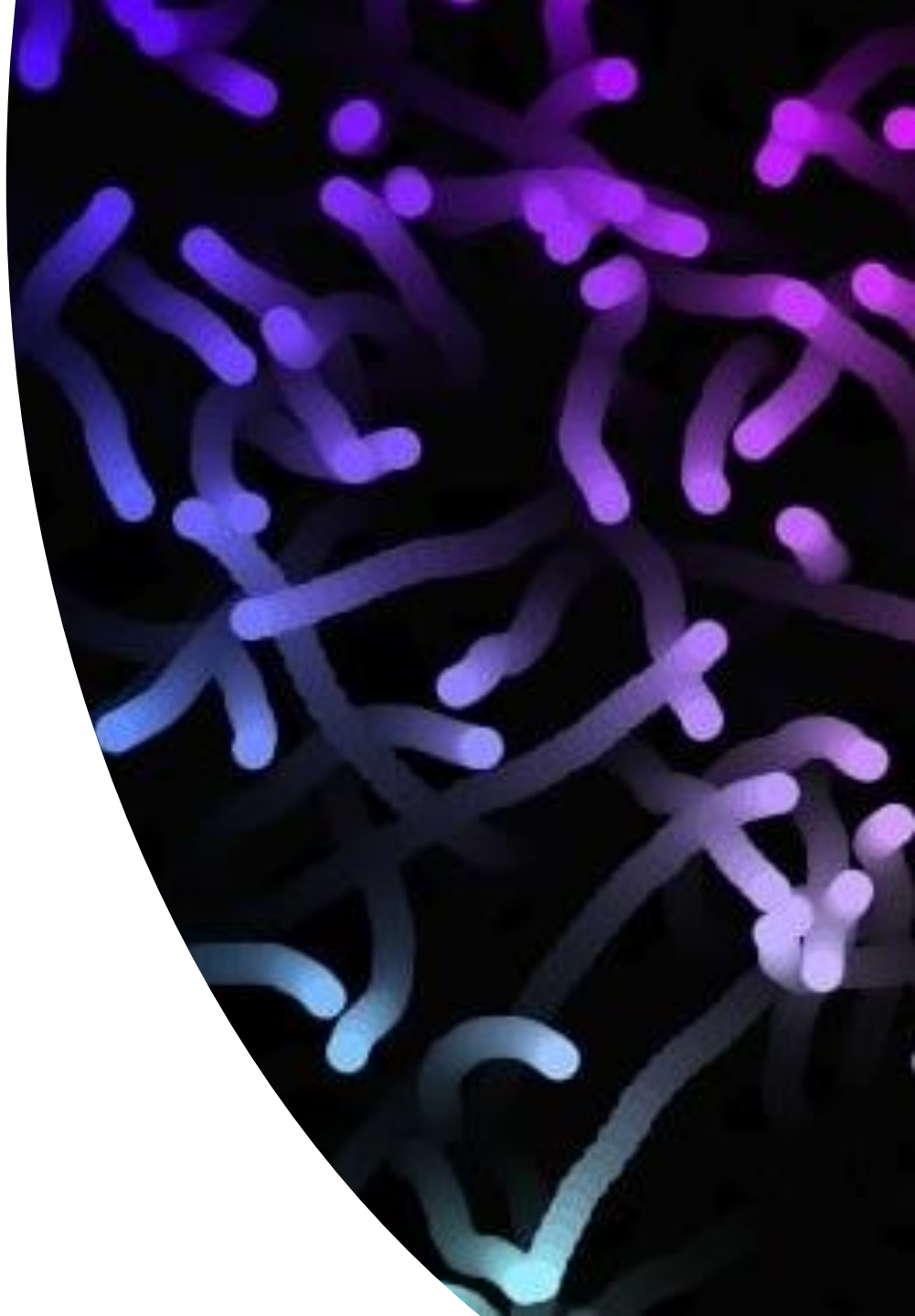
Microcontroller programming

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

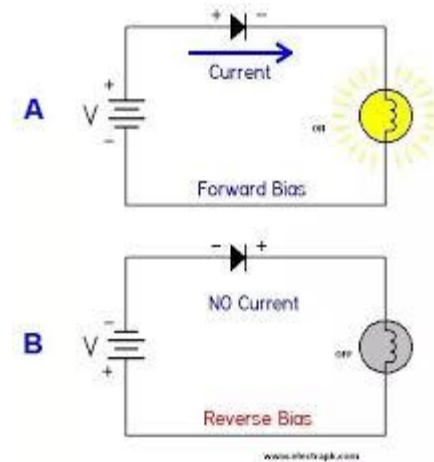| uP	uC
Pentium, i3, i5, etc.	AVR, ARM, PIC
CPU only	Computer on a single chip
Unspecific tasks like software development, document editing	Specific tasks like washing machine, watches, etc.
More expensive, clock speed = 1GHz or more.	Cheaper, clock speed ~ few MHz

Microprocesser: CPU
and several supporting chips.
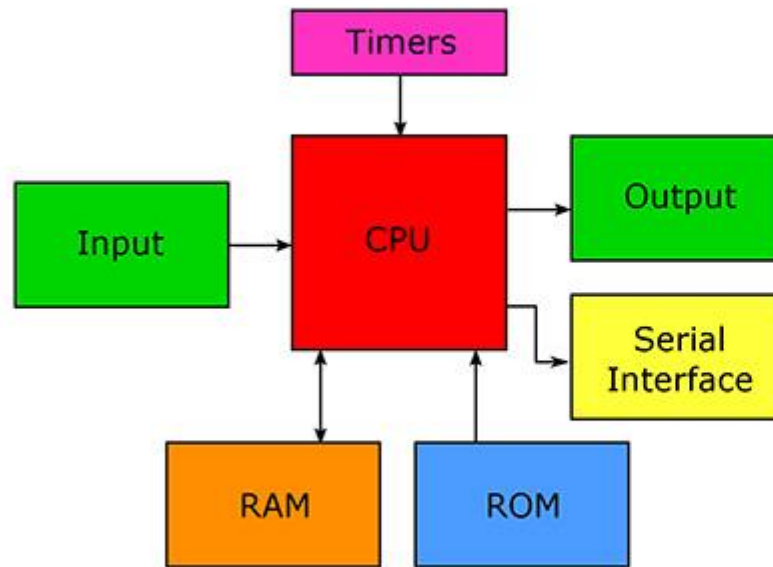
Microcontroller: CPU
on a single chip.
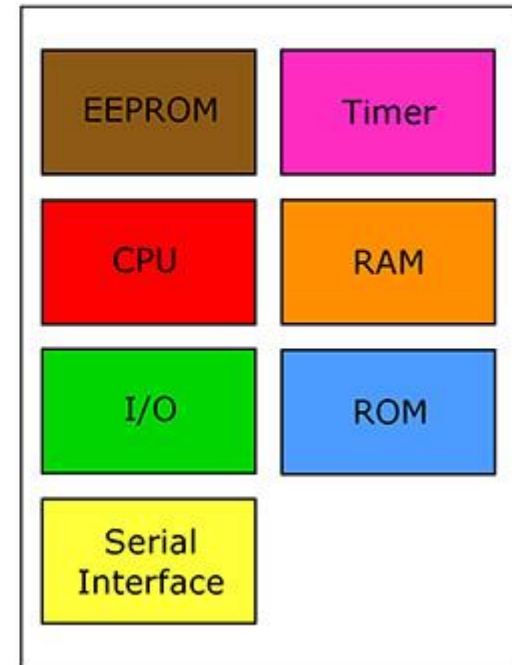
Getting started with Arduino

- 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
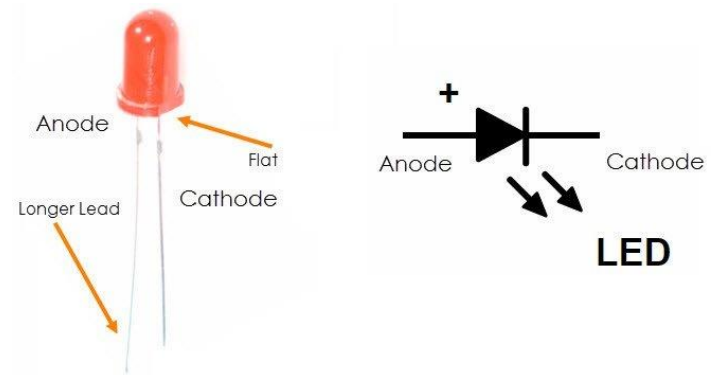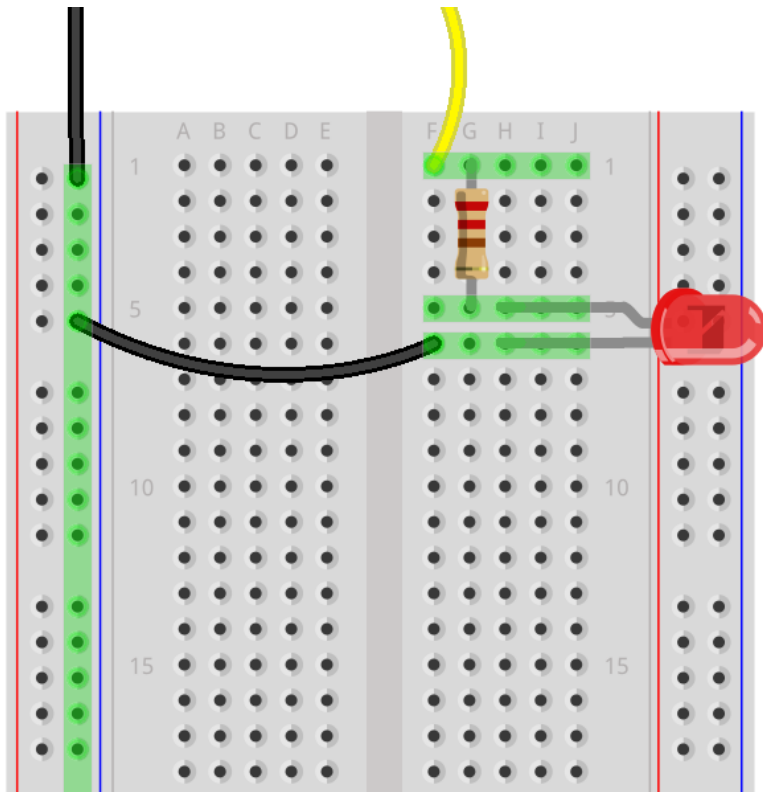
Diode is like a one-way valve of electronics

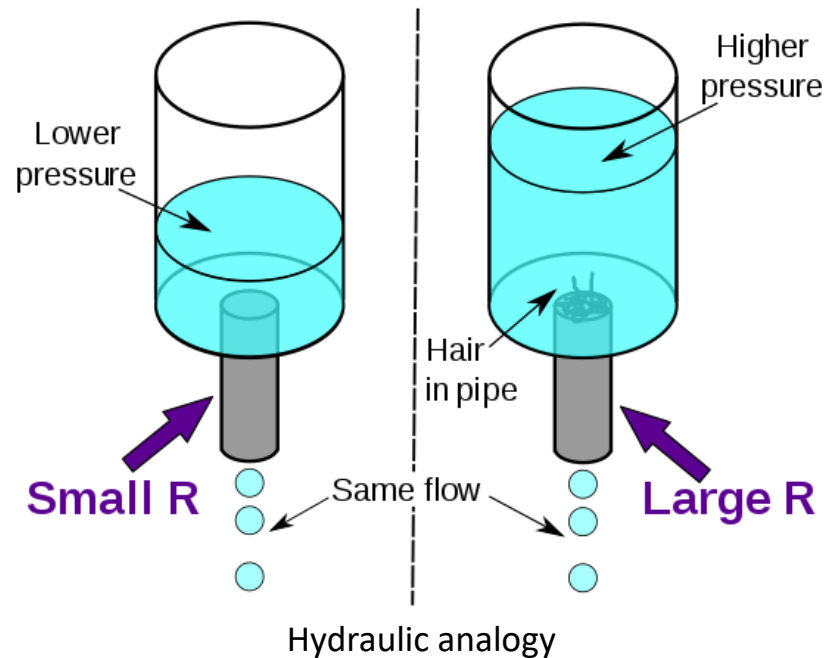A V

Current

Forward Bias

on

B V

NO Current

Reverse Bias

off

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

Higher pressure

Lower pressure

Small R

Large R

Hair in pipe

Same flow

Hydraulic analogy

Ohm's Law, V=IR

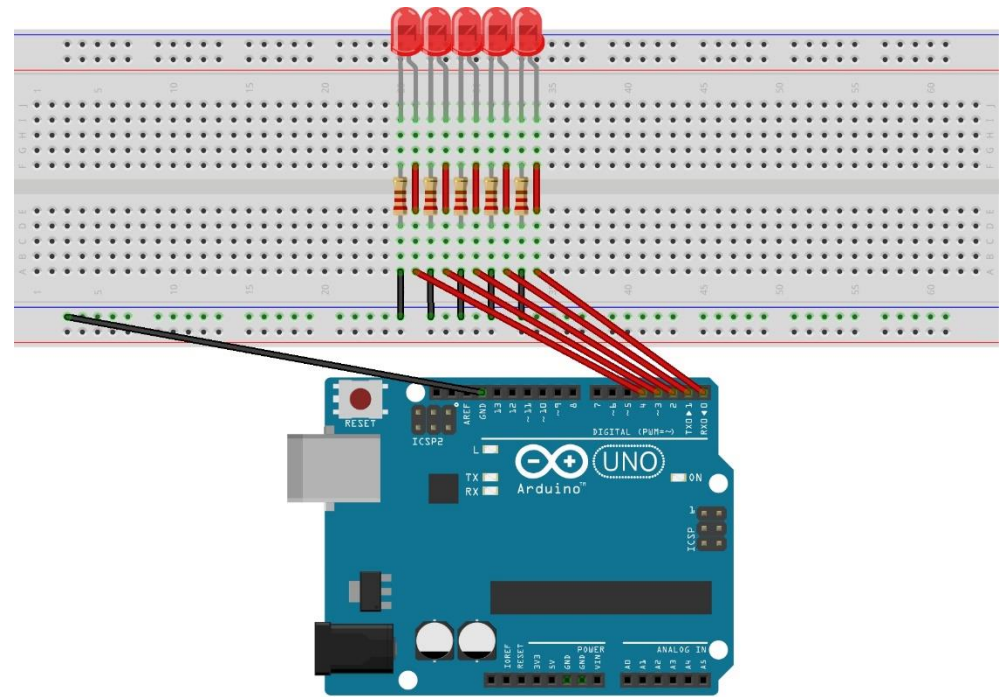# Thermal analogy, Q = dT/R , I = V/R
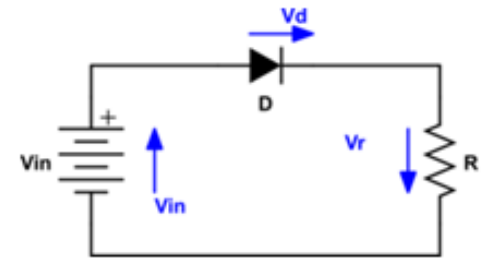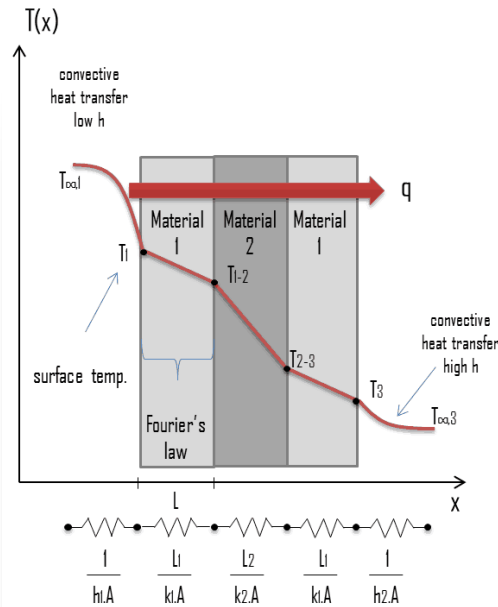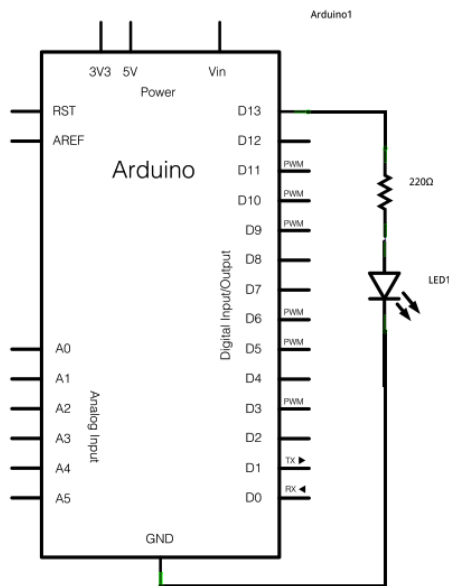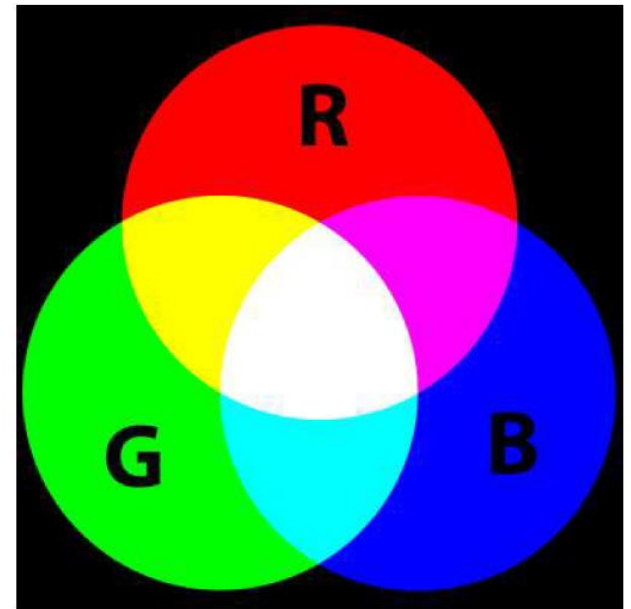

$$\sum_{k=1}^{n} V_k = 0$$

Kirchoff's Voltage Law

Blinking LEDs

- 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
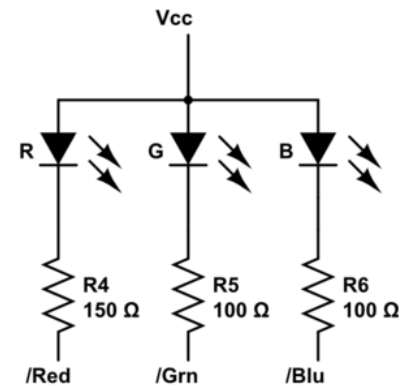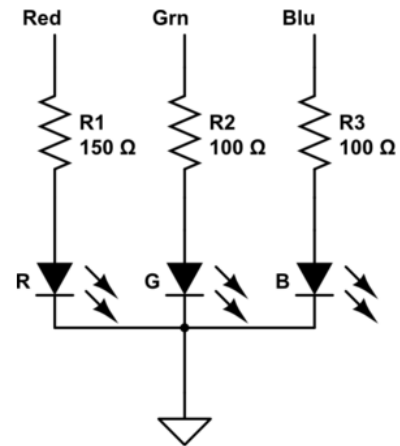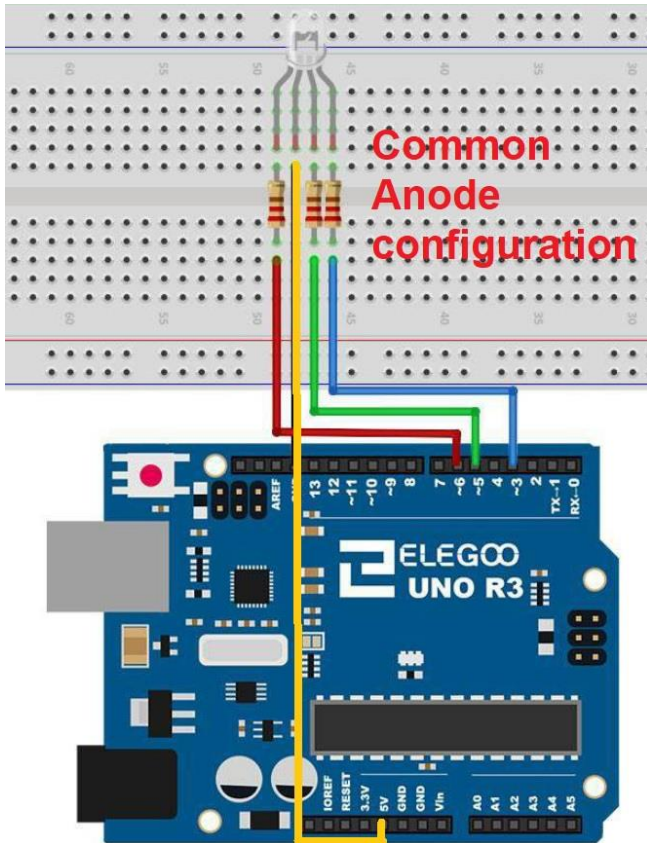

fritzing

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

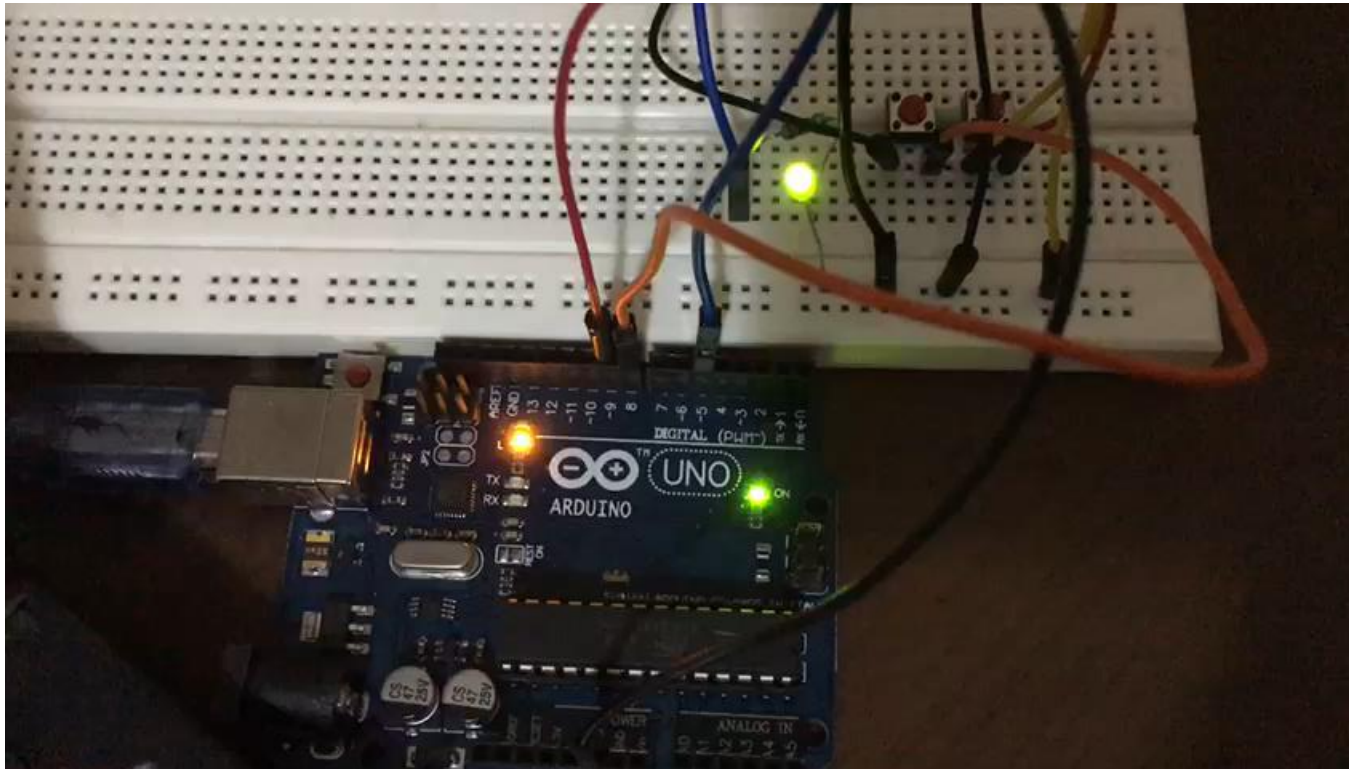# RGB LED circuit

Common Anode configuration

Red   Grn   Blu

R1 150 Ω   R2 100 Ω   R3 100 Ω

R   G   B

Common Cathode Circuit

Vcc

R   G   B

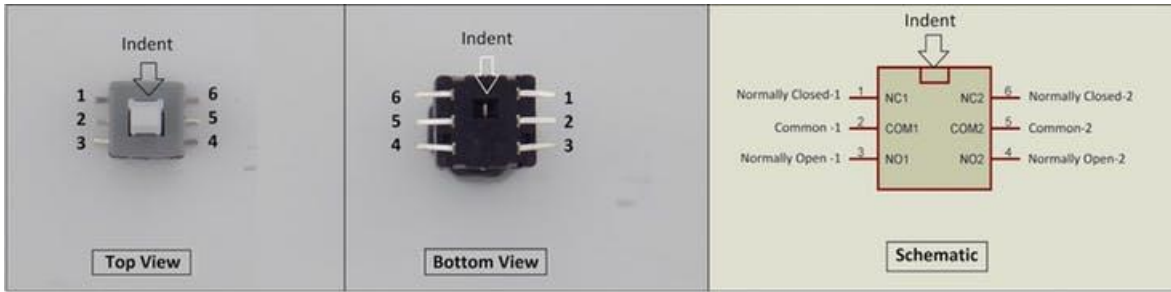R4 150 Ω   R5 100 Ω   R6 100 Ω

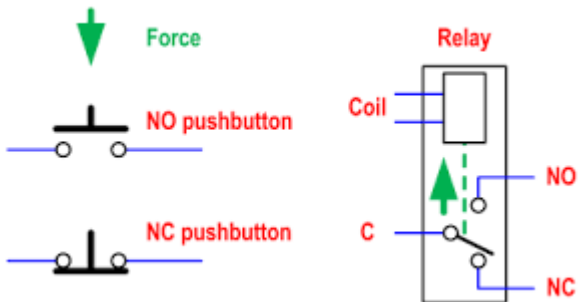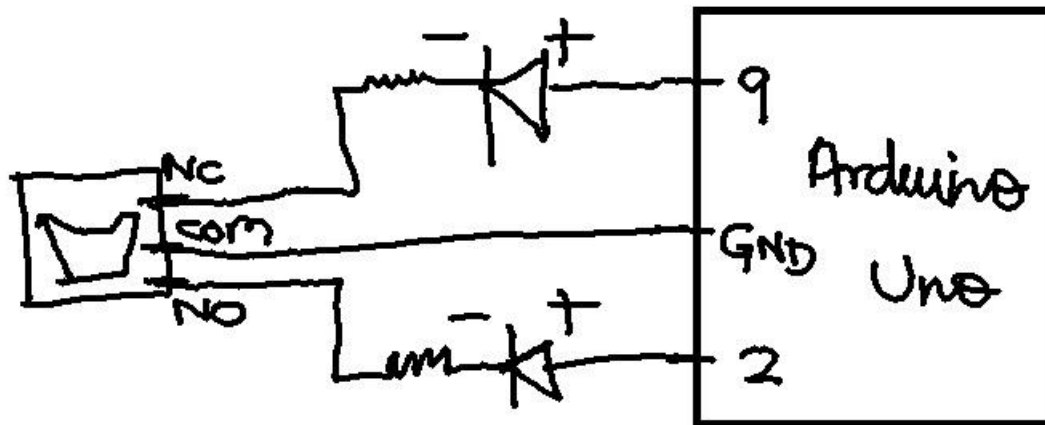/Red   /Grn   /Blu

Common Anode Circuit

Push buttons (Input Pullup) – Lesson 5

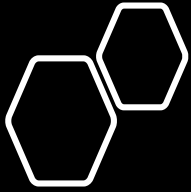- By default, input pullup pin is High, when push button pressed, it gets to Low. [Video](#)
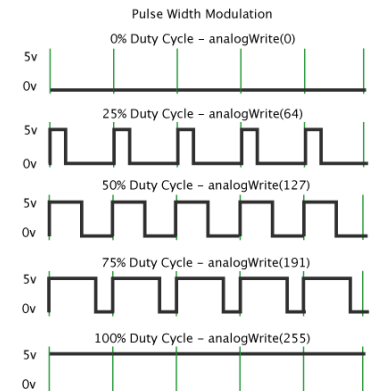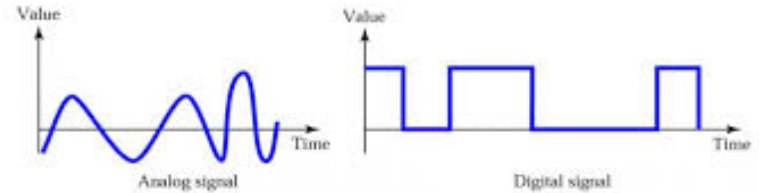
6 Pin Push Switch (Mini DPDT Push Switch) Pinout

NC
com
NO

Arduino Uno

9
GND
2

Force

NO pushbutton

NC pushbutton

Relay

Coil

C

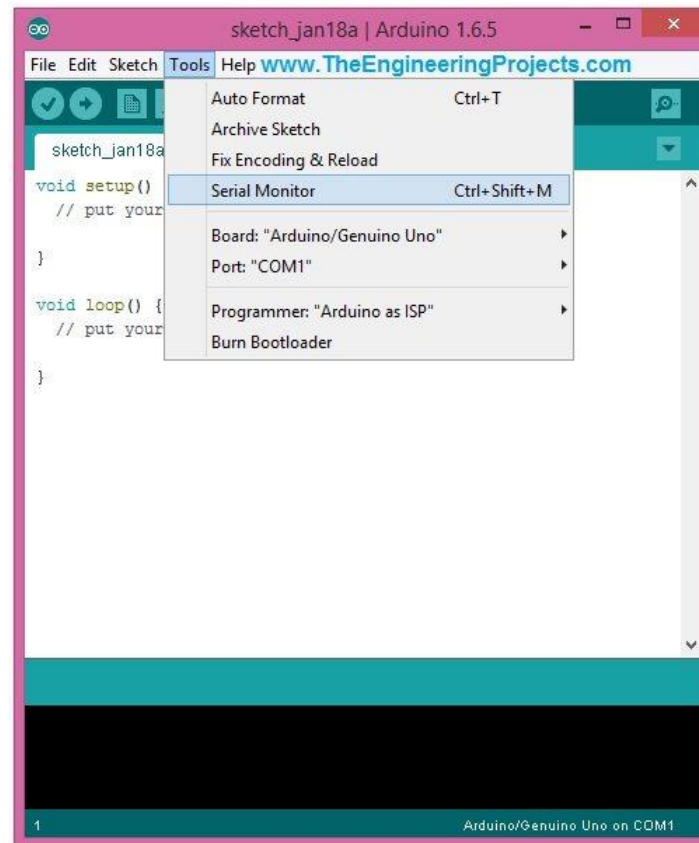NO

NC

- [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.

Analog signal

Digital signal

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)

Arduino features

- If then else
- function, for loop, serial communication, serial monitor
- interfacing Arduino with Processing
- Arduino examples
- Arduino codes
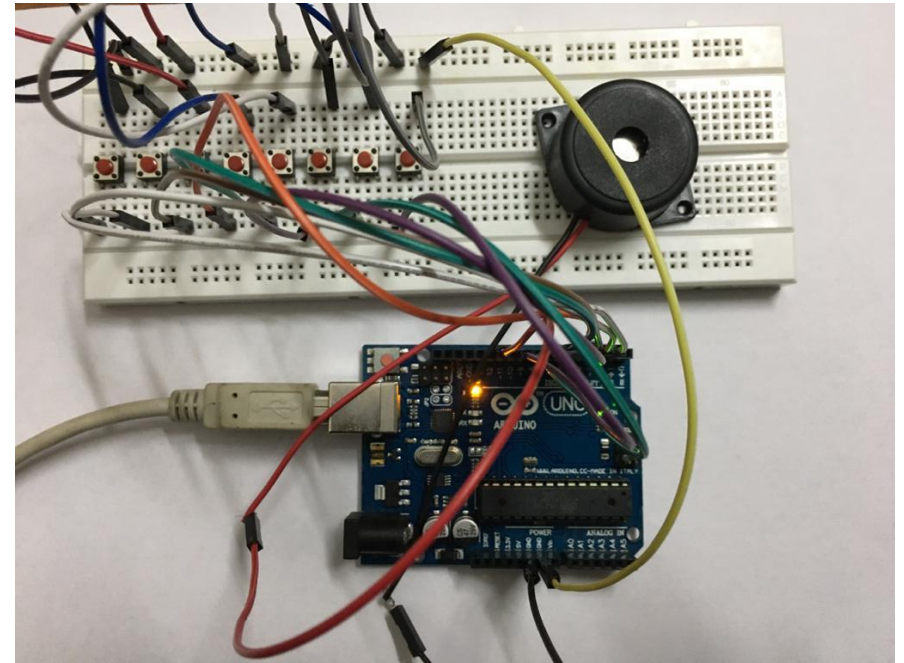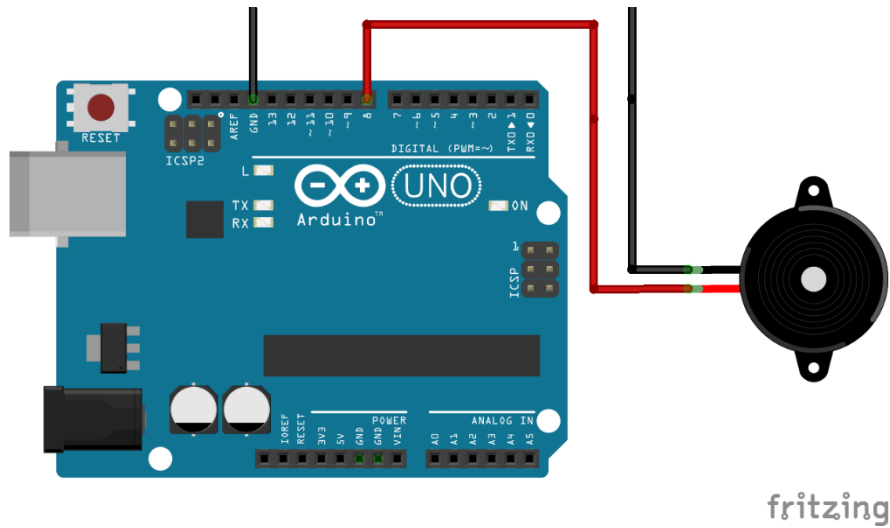
[Basic musical instrument](#) [Music Player with Processing Interface](#)
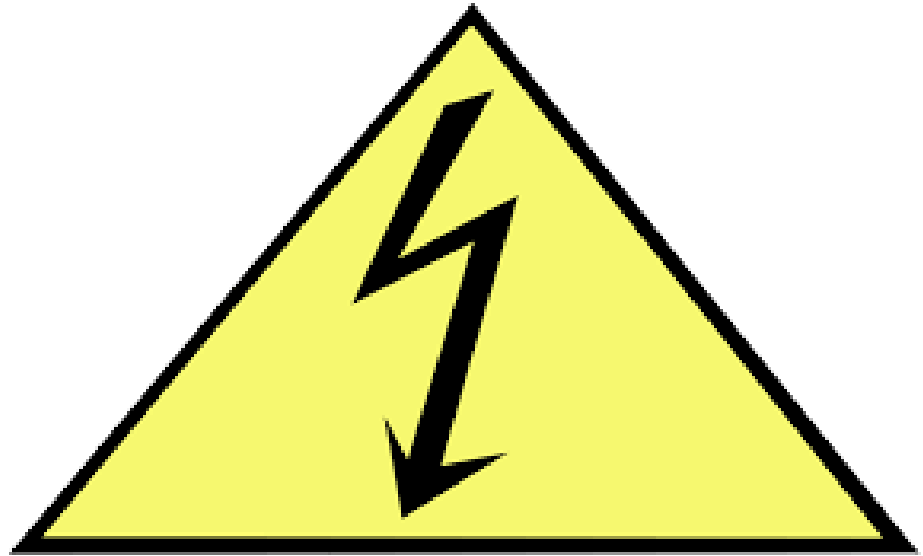
Piezo buzzer (Lesson 7)

Assignment 4

Summary

- Algorithm, Flowchart, Programming in C, Python, Processing
- Arduino based programming
- LEDs, buttons, serial communication, buzzer
- Arduino Processing interfacing
- Analog and Digital signals

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.

Announcements

- 26th Feb: 6:30 pm to 8 pm?
- Project development till minor test1 date (10 Feb)
- 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.