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# Cyber-Physical Systems

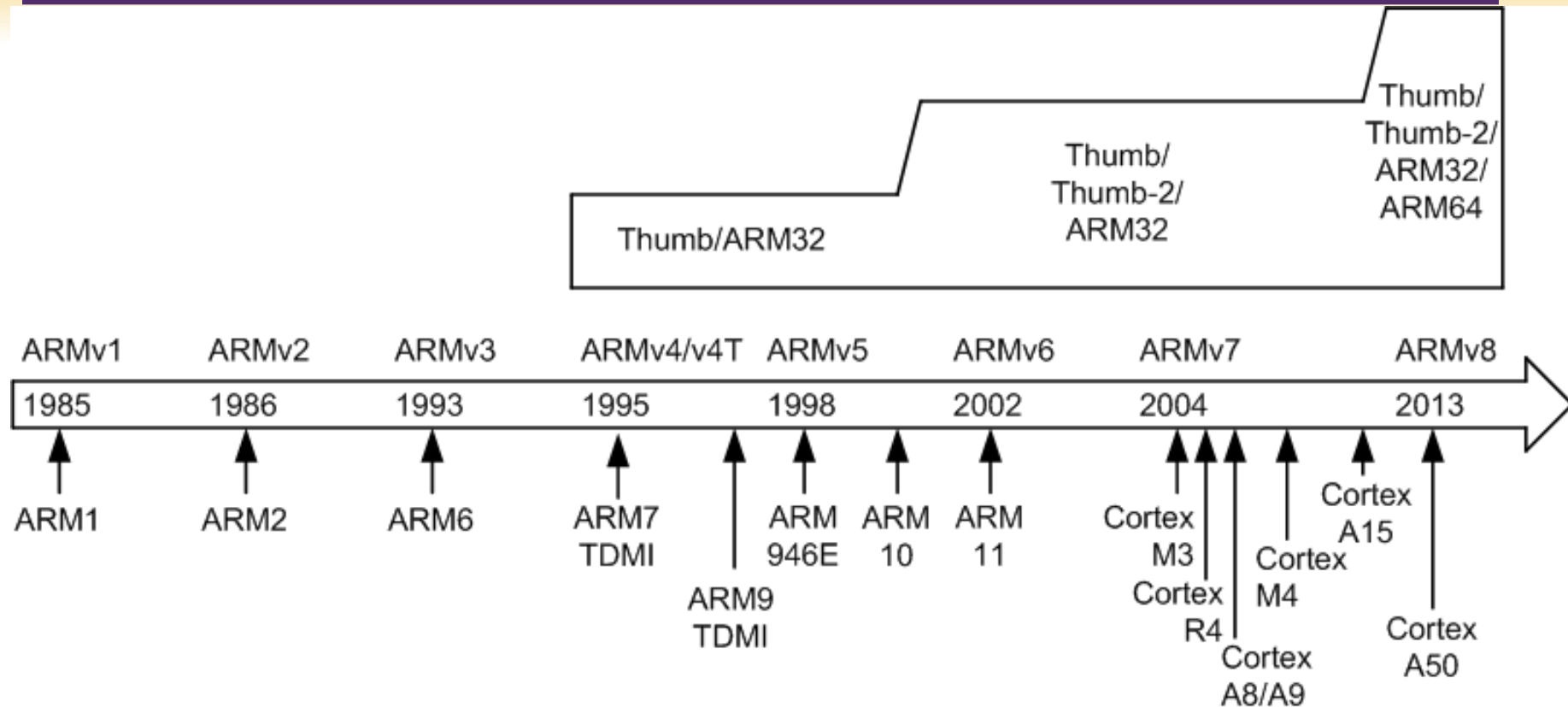
## Basic Electronics with RPi



ICEN 553/453 – Fall 2018

Prof. Dola Saha

# History of ARM Processor



# ARM Cortex Processors

ARM Cortex-**A** family:

**A**pplications processors

Support OS and high-performance applications

Such as Smartphones, Smart TV



ARM Cortex-**R** family:

**R**eal-time processors with high performance and high reliability

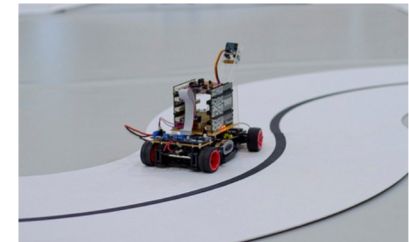
Support real-time processing and mission-critical control



ARM Cortex-**M** family:

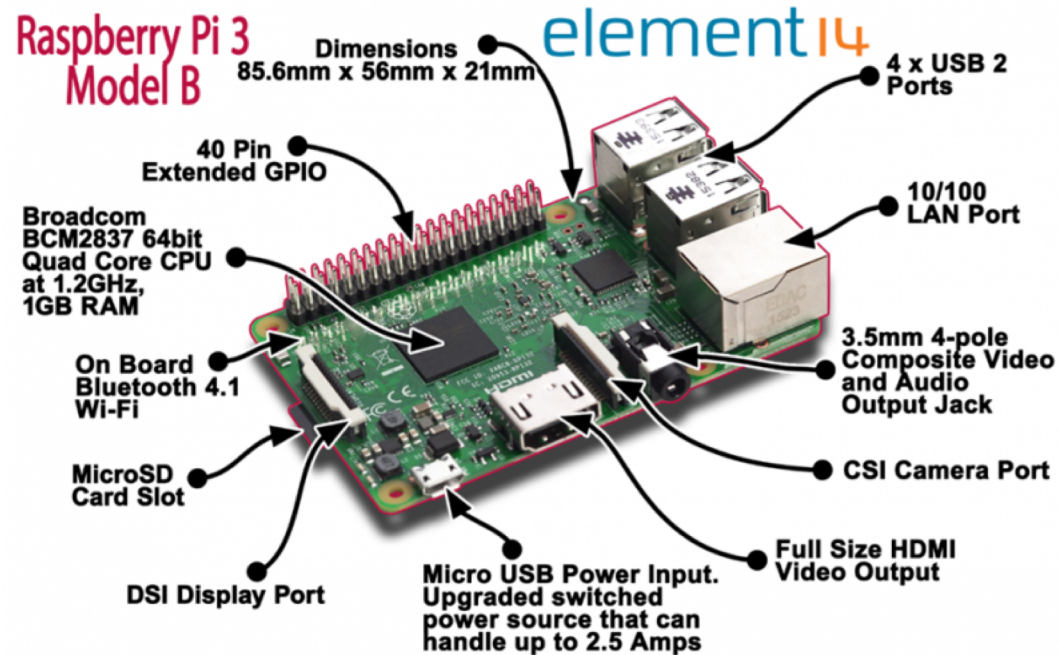
**M**icrocontroller

Cost-sensitive, support SoC



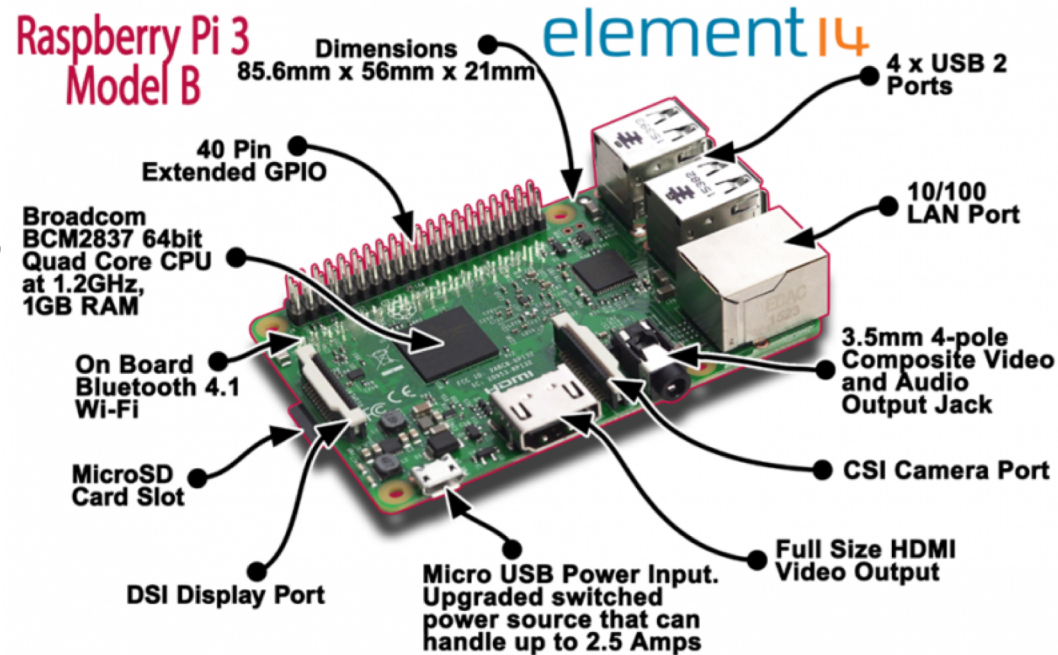
# Raspberry Pi – Know your board

- The Raspberry Pi 3 Model B+ is the latest product in Raspberry Pi range.
  - Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz
  - 1GB LPDDR2 SDRAM
  - 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE
  - Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps)
  - Extended 40-pin GPIO header
  - Full-size HDMI

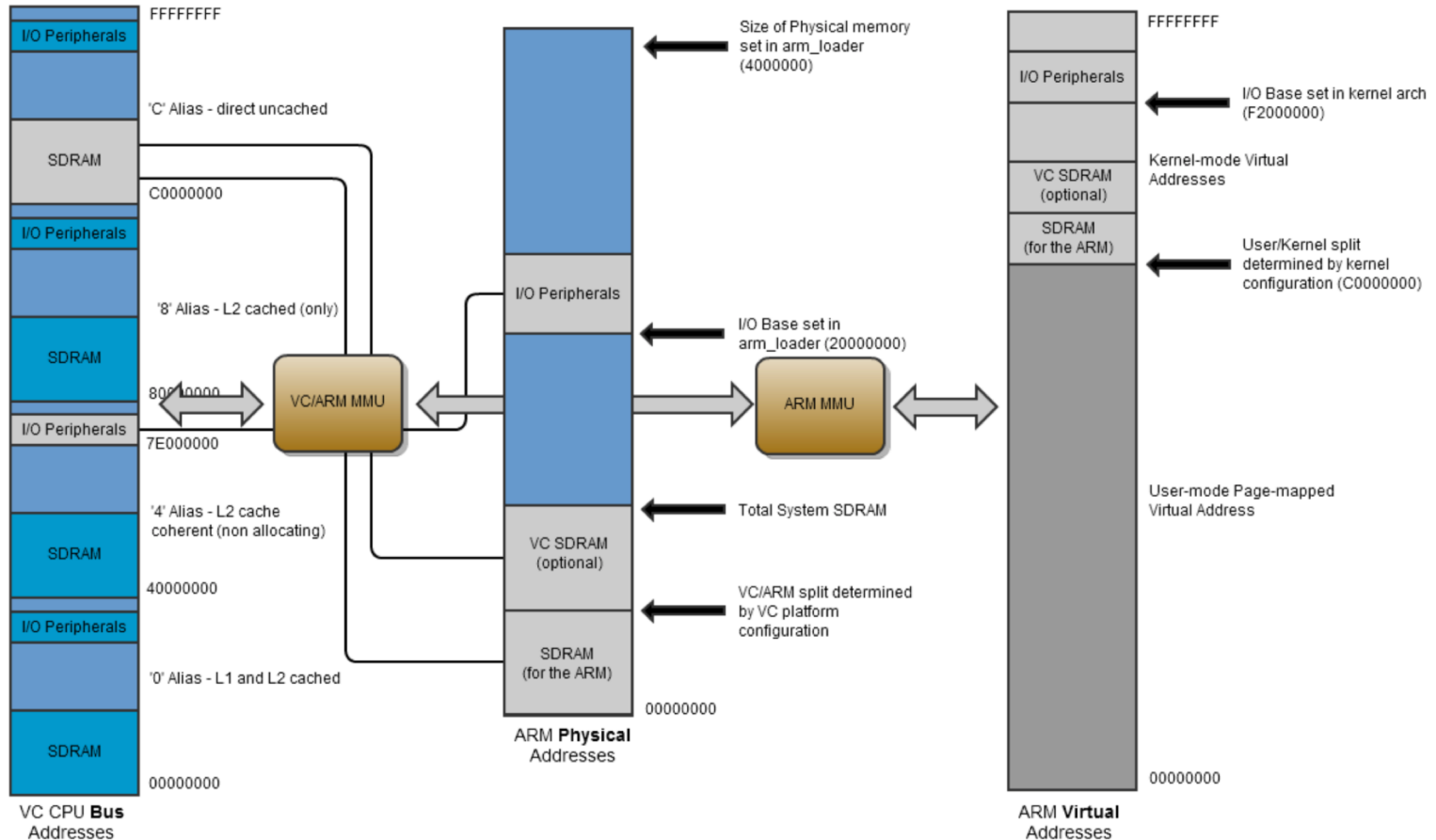


# Raspberry Pi – Know your board

- The Raspberry Pi 3 Model B+ is the latest product in Raspberry Pi range.
  - CSI camera port for connecting a Raspberry Pi camera
  - DSI display port for connecting a Raspberry Pi touchscreen display
  - 4-pole stereo output and composite video port
  - Micro SD port for loading your operating system and storing data
  - 5V/2.5A DC power input
  - Power-over-Ethernet (PoE) support (requires separate PoE HAT)

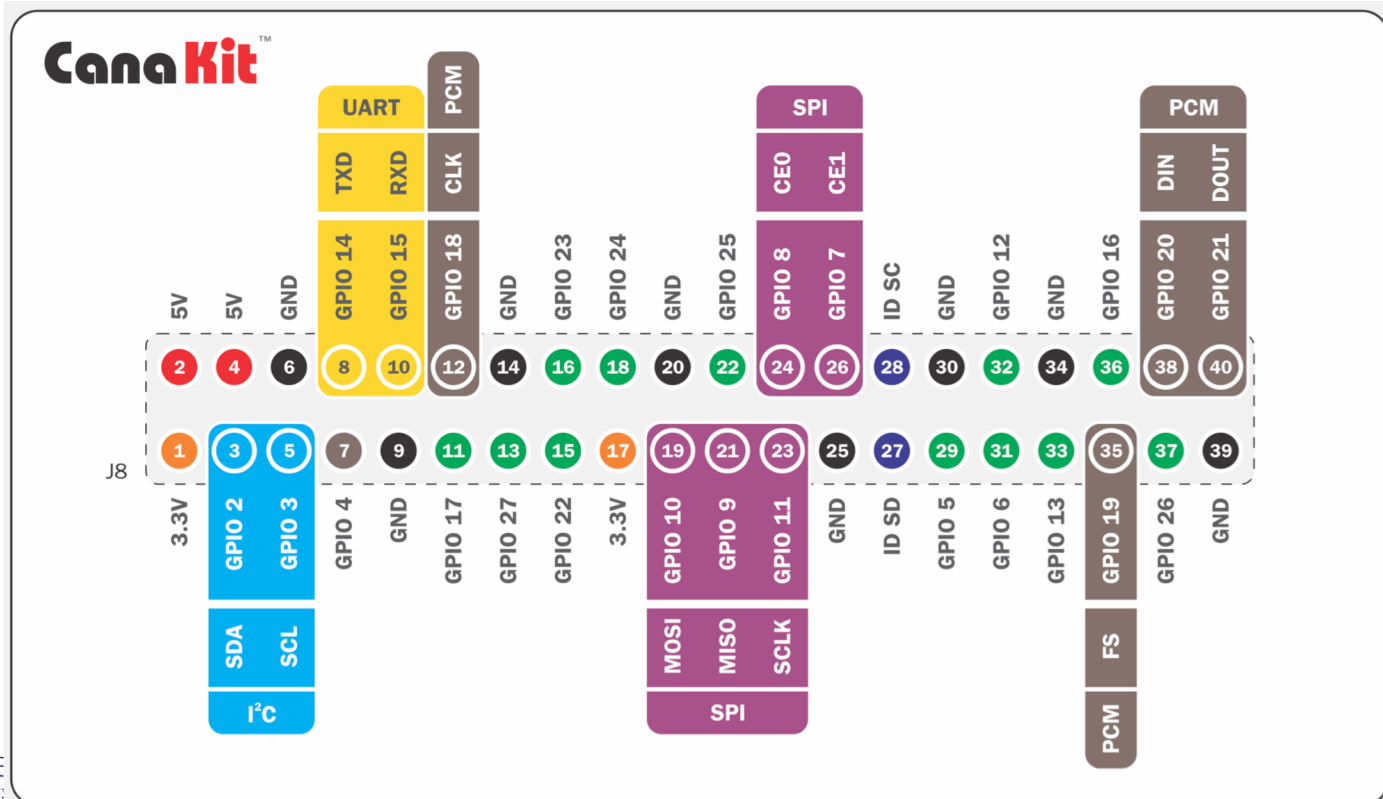


# ARM Peripherals

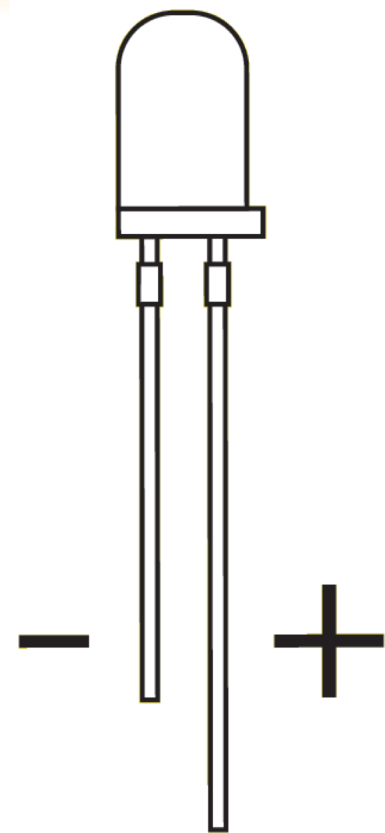
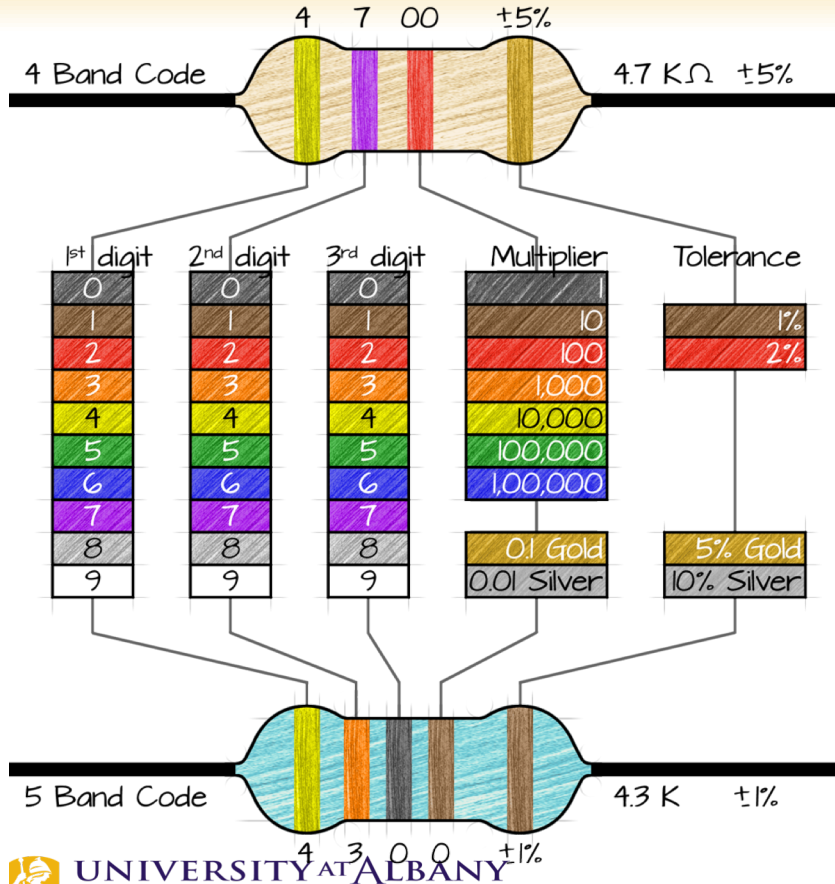


# GPIO Pins

➤ <https://pinout.xyz>

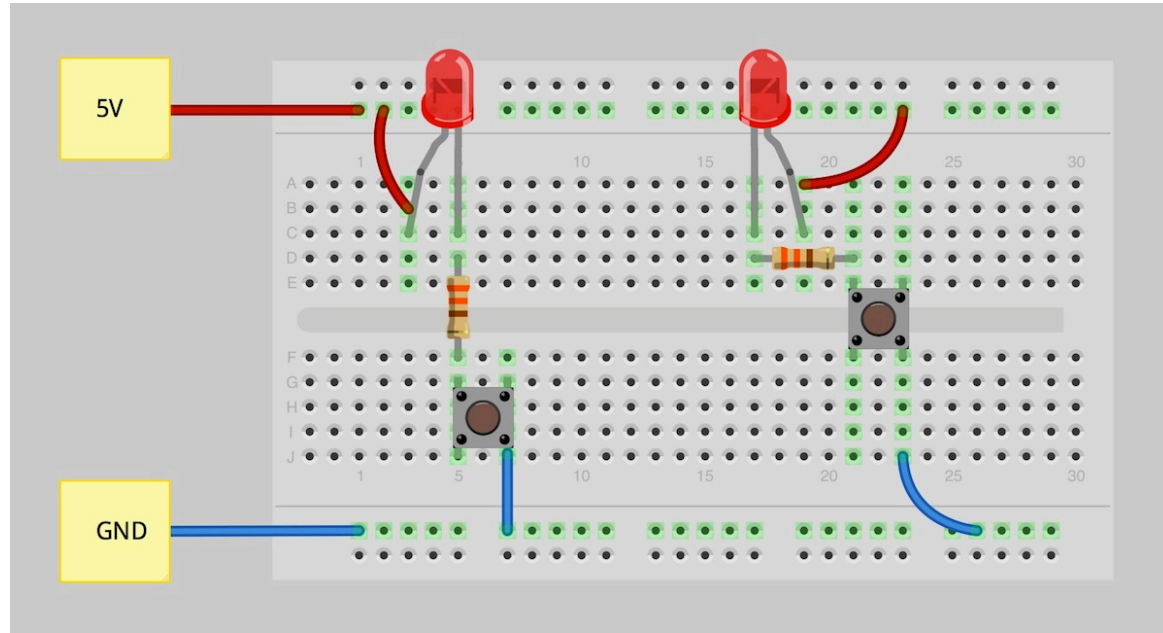
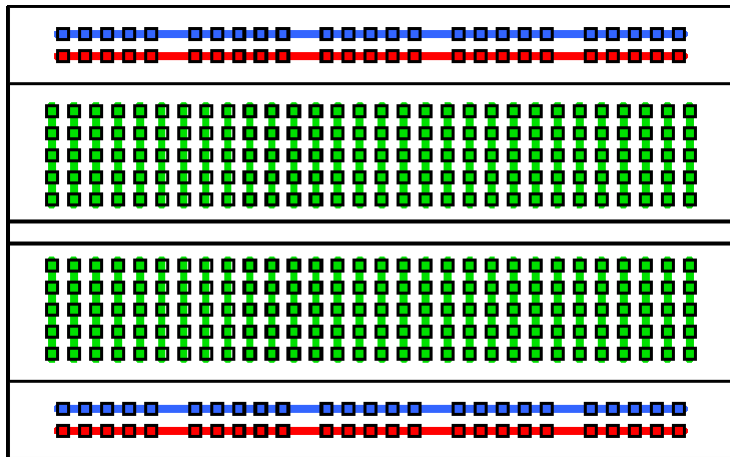


# Resistors and LEDs

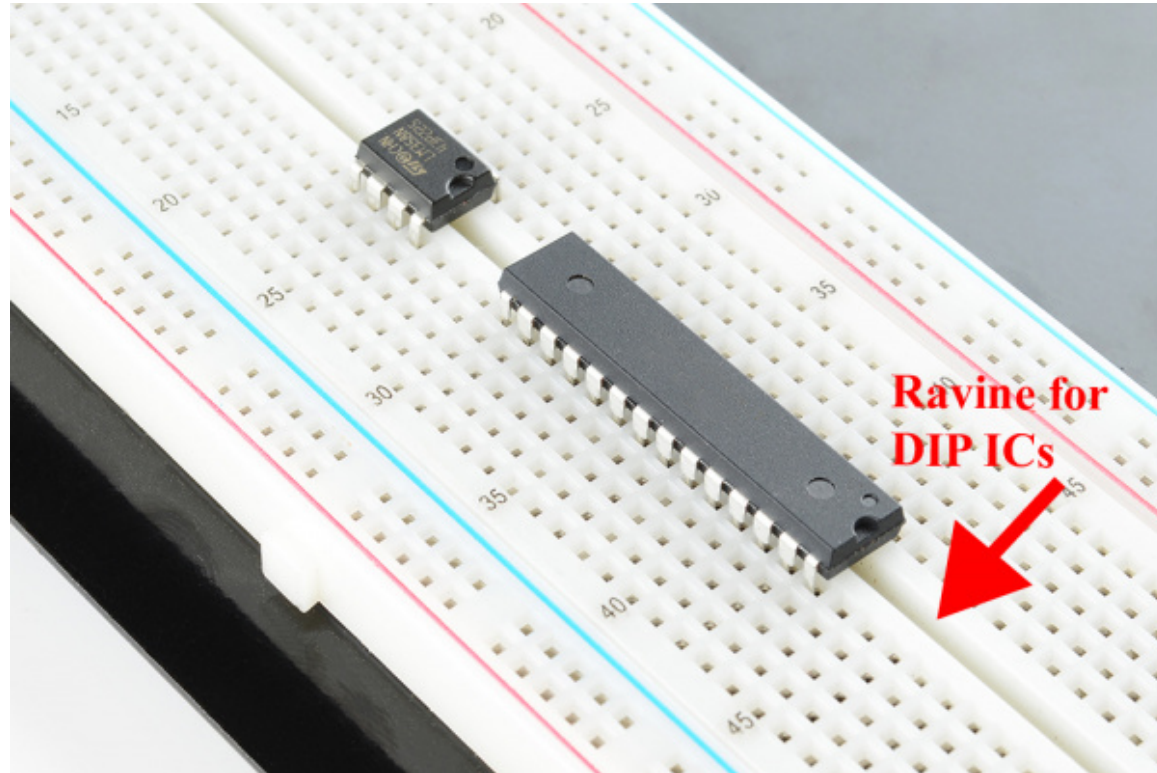




# Breadboard Connections



# Dual In-Line Package or DIP

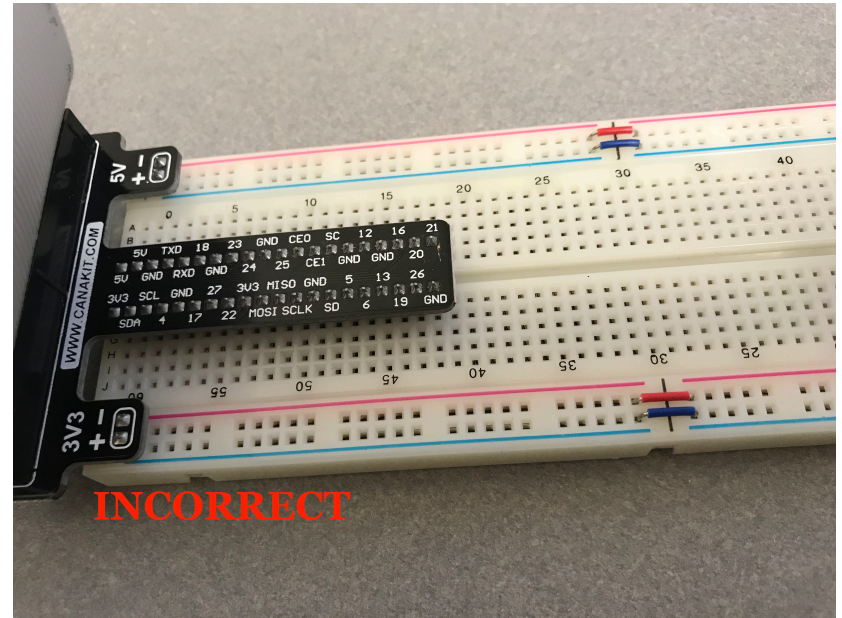
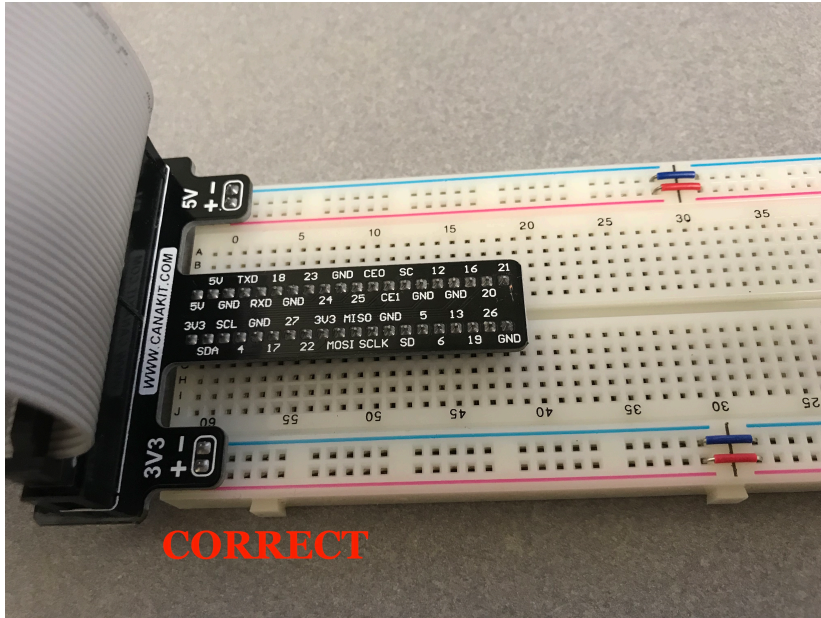


# GPIO

- GPIO to Breadboard Interface Board
- GPIO Ribbon Cable
- Breadboard

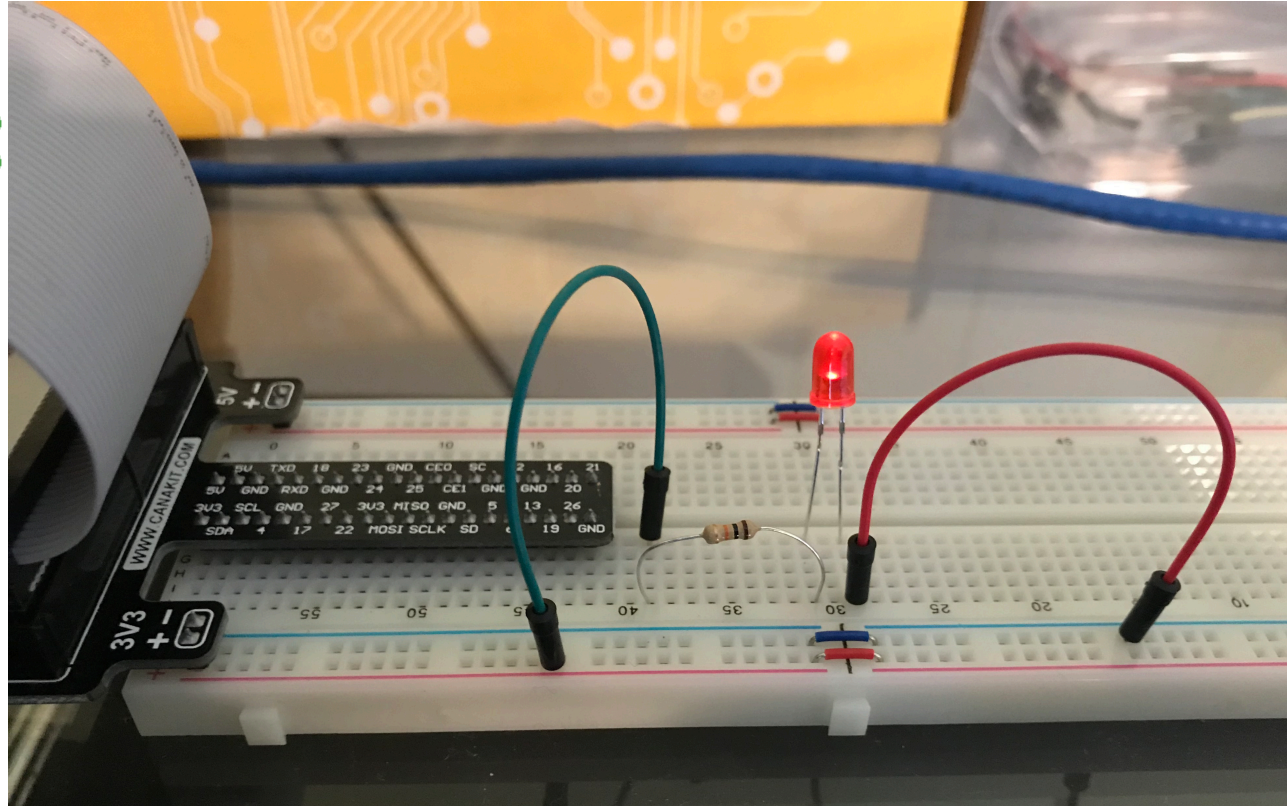
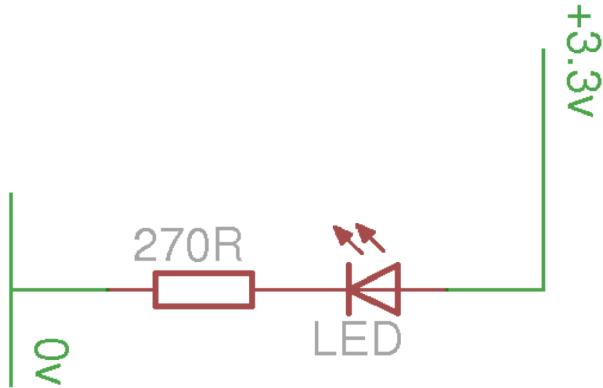


# Convention



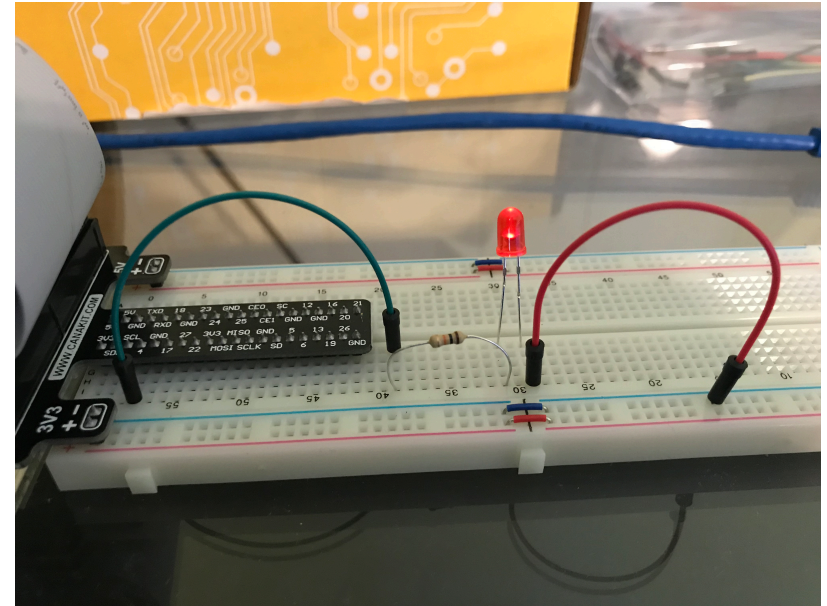
# Circuit to Breadboard

➤ Use 3V



# Circuit to Breadboard

- Use GPIO pin



# sysfs - a filesystem for exporting kernel objects

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- The **sysfs** filesystem is a pseudo-filesystem which provides an interface to kernel data structures.
- The files under **sysfs** provide information about devices, kernel modules, filesystems, and other kernel components.

# Exporting GPIO control to userspace

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## ➤ "export"

- Userspace may ask the kernel to export control of a GPIO to userspace by writing its number to this file.
- Example: "echo 19 > export" will create a "gpio19" node for GPIO #19, if that's not requested by kernel code.

## ➤ "unexport"

- Reverses the effect of exporting to userspace.
- Example: "echo 19 > unexport" will remove a "gpio19" node exported using the "export" file.



# Control GPIO with Linux

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- Become the Sudo user
  - dsaha@sahaPi:~ \$ sudo su
- Go to the GPIO folder and list the contents
  - root@sahaPi:/home/dsaha# cd /sys/class/gpio/
  - root@sahaPi:/sys/class/gpio# ls
  - export gpiochip0 gpiochip128 unexport
- Export gpio 4
  - root@sahaPi:/sys/class/gpio# echo 4 > export
  - root@sahaPi:/sys/class/gpio# ls
  - export gpio4 gpiochip0 gpiochip128 unexport

# Control GPIO with Linux

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- Go to the gpio4 folder and list contents
  - `root@sahaPi:/sys/class/gpio# cd gpio4/`
  - `root@sahaPi:/sys/class/gpio/gpio4# ls`
  - `active_low device direction edge power subsystem uevent value`
- Set direction (in or out) of pin
  - `root@sahaPi:/sys/class/gpio/gpio4# echo out > direction`
- Set value to be 1 to turn on the LED
  - `root@sahaPi:/sys/class/gpio/gpio4# echo 1 > value`

# Control GPIO with Linux

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- Set value to be 0 to turn off the LED
  - `root@sahaPi:/sys/class/gpio/gpio4# echo 0 > value`
- Check the status (direction and value) of the pin
  - `root@sahaPi:/sys/class/gpio/gpio4# cat direction`
  - `out`
  - `root@sahaPi:/sys/class/gpio/gpio4# cat value`
  - `0`

# Control GPIO with Linux

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- Ready to give up the control? Get out of gpio4 folder and list contents, which shows gpio4 folder
  - `root@sahaPi:/sys/class/gpio/gpio4# cd ../`
  - `root@sahaPi:/sys/class/gpio# ls`
  - `export gpio4 gpiochip0 gpiochip128 unexport`
- Unexport gpio 4 and list contents showing removal of gpio4 folder
  - `root@sahaPi:/sys/class/gpio# echo 4 > unexport`
  - `root@sahaPi:/sys/class/gpio# ls`
  - `export gpiochip0 gpiochip128 unexport`

# Bash Script

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➤ `exploringrpi/chp05/bashLED/bashLED`

# Python

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➤ [exploringrpi/chp05/pythonLED/python2LED.py](#)

# C code

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➤ `exploringrpi/chp05/makeLED/makeLED.c`

# Use Rpi Library

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- <https://sourceforge.net/projects/raspberry-gpio-python/>
- Note: Current release does not support SPI, I2C, 1-wire or serial functionality on the RPi yet



# Use gpiozero Library

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➤ <https://gpiozero.readthedocs.io/en/stable/>