My first Raspberry Pi hands-on session

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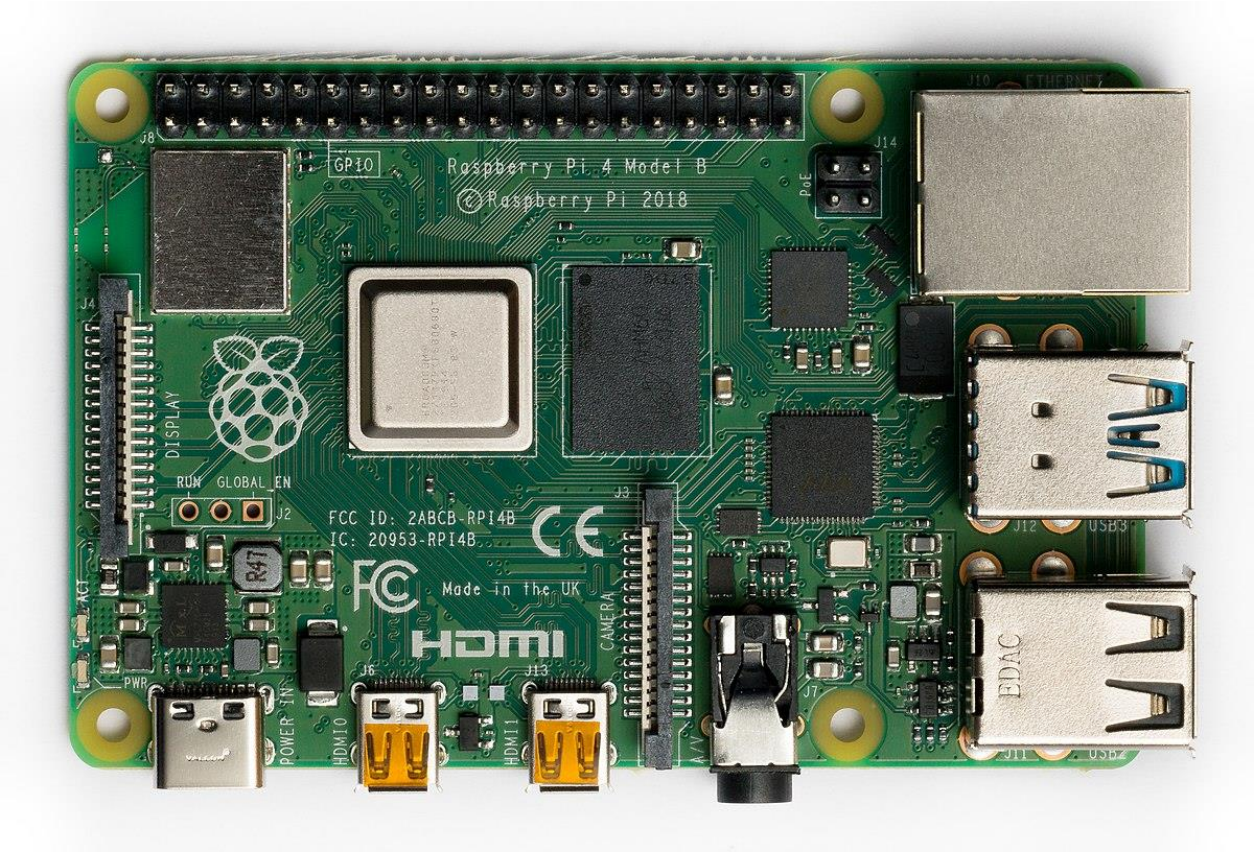
UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA
High Performance Real Time Lab

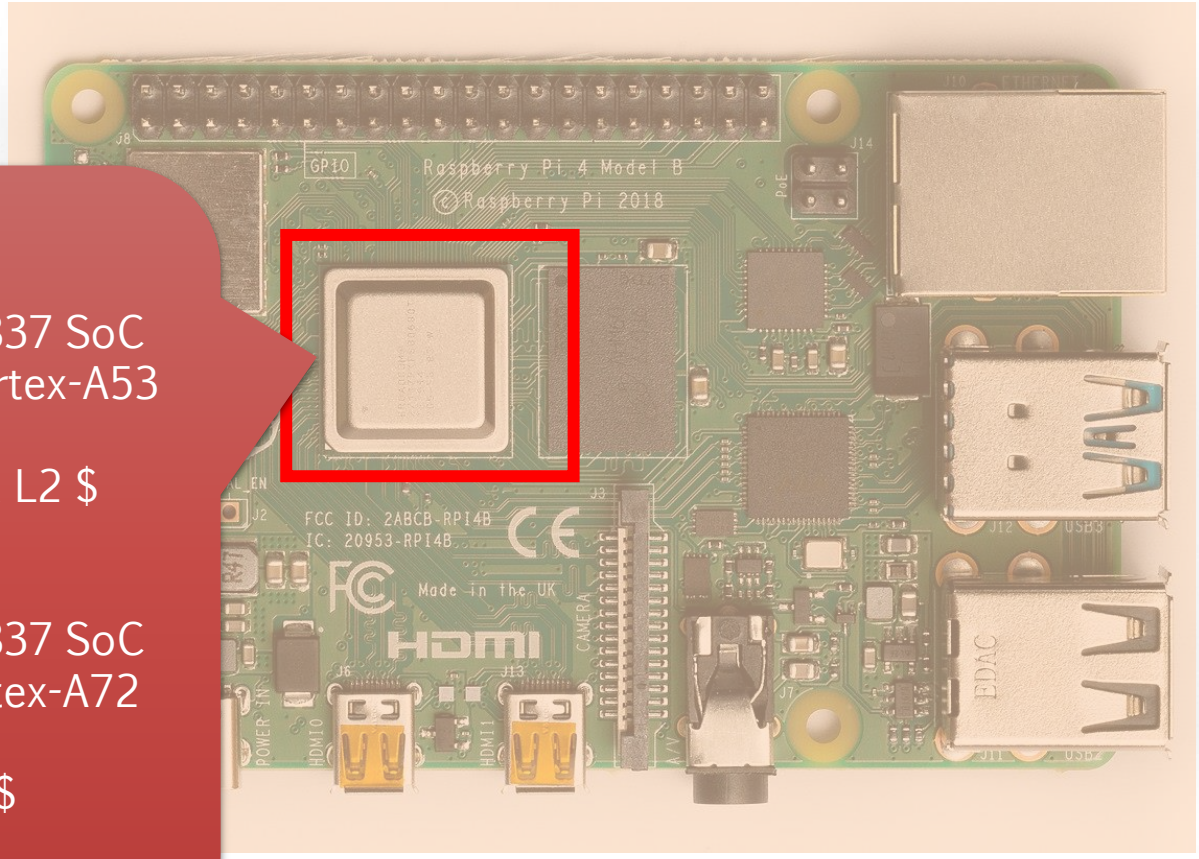
Programming is a skill best acquired by practice and example rather than from books.

ALAN TURING

Our guy (Pi4)


GPIO
Raspberry Pi 4 Model B
©Raspberry Pi 2018
DISPLAY
RUN GLOBAL_EN
FCC ID: 2ABCB-RPI4B
IC: 20953-RPI4B
Made in the UK
HDMI
POWER IN
HDMI0
HDMI1
CAMERA
PWR
ACT
PoE
USB3
USB2

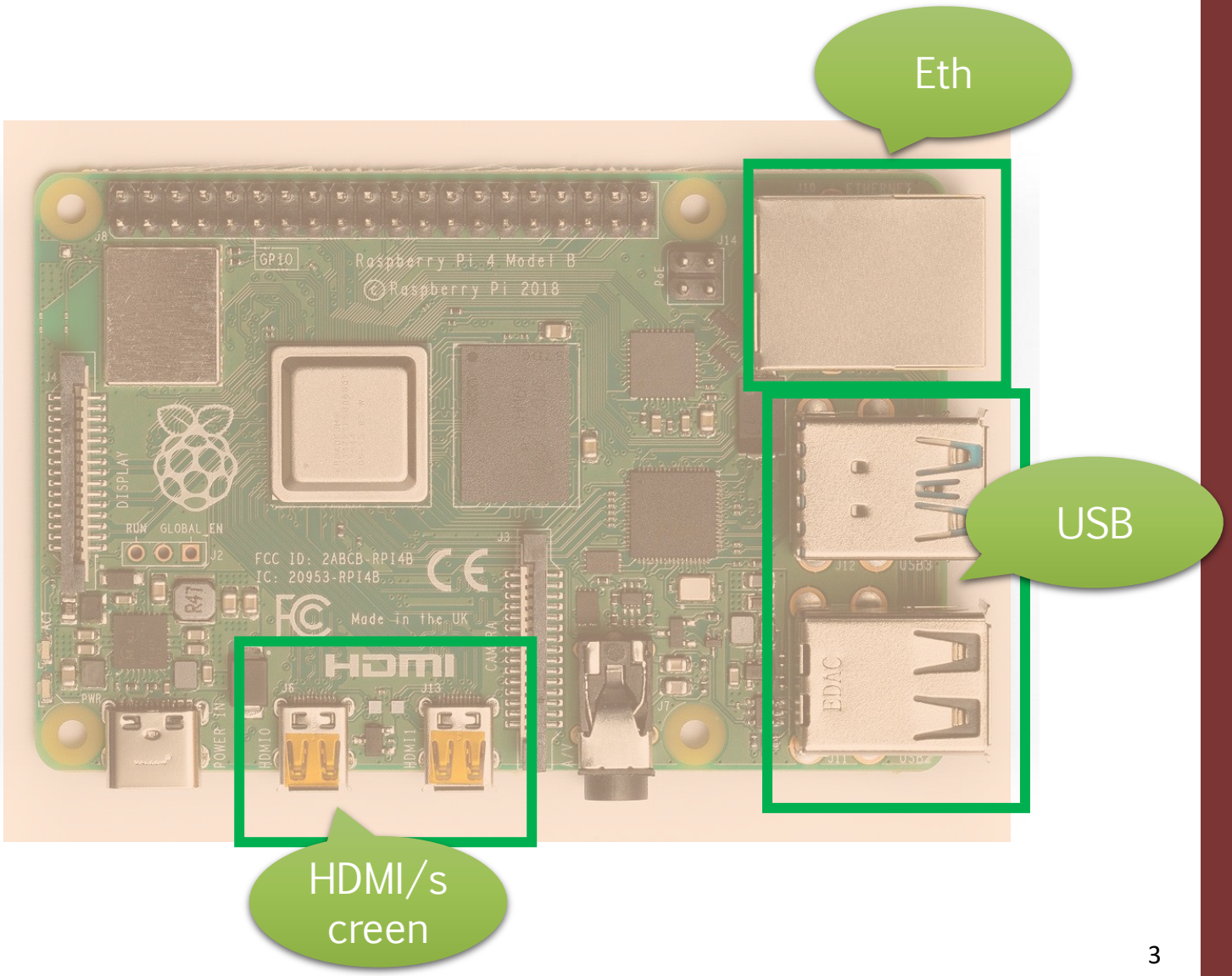
Our guy (Pi4)



Pi3
Broadcom BCM2837 SoC
- 64-bit ARM Cortex-A53
- @1.2 GHz
- 512 KiB shared L2 $

Pi4
Broadcom BCM2837 SoC
- 64-bit ARM Cortex-A72
- @1.5 GHz
- 1MiB shared L2 $

Our guy (Pi4)


Eth
USB
HDMI/screen
Raspberry Pi 4 Model B
©Raspberry Pi 2018
FCC ID: 2ABCB-RPI4B
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Made in the UK
HDMI
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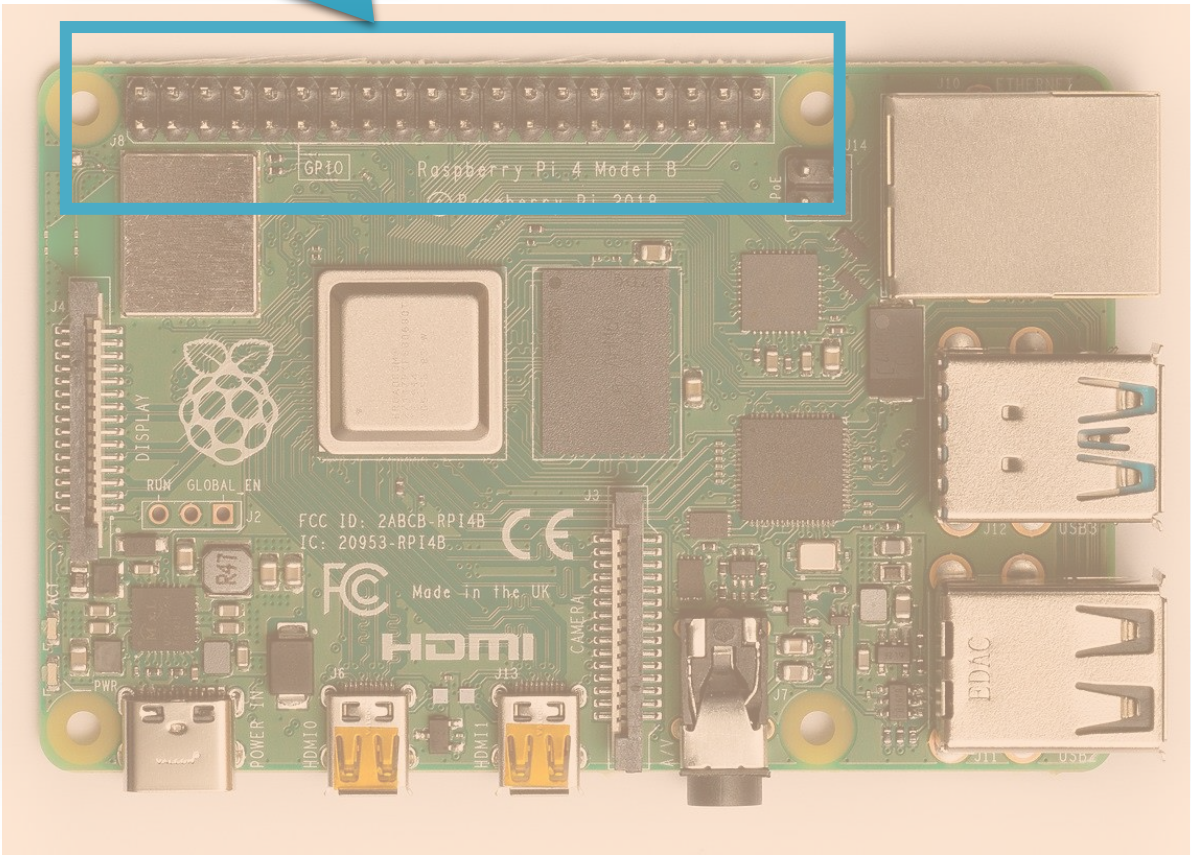
ETHERNET
PoE
USB3
USB2
EDAC

Our guy (Pi4)

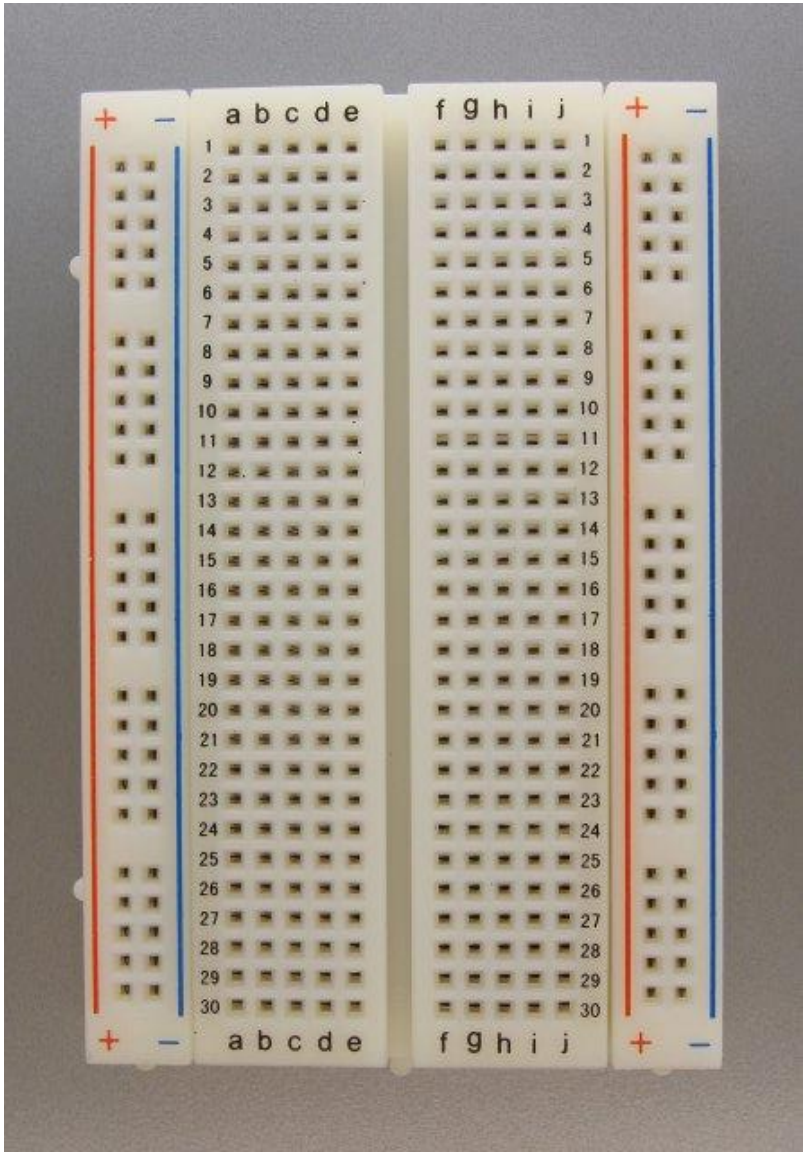
General Purpose I/O ports (GPIO)



Breadboard

Provides electrical connectivity

- Vertical vs. horizontal rails
- (Typically, power vs other)
- Can use jumper wires



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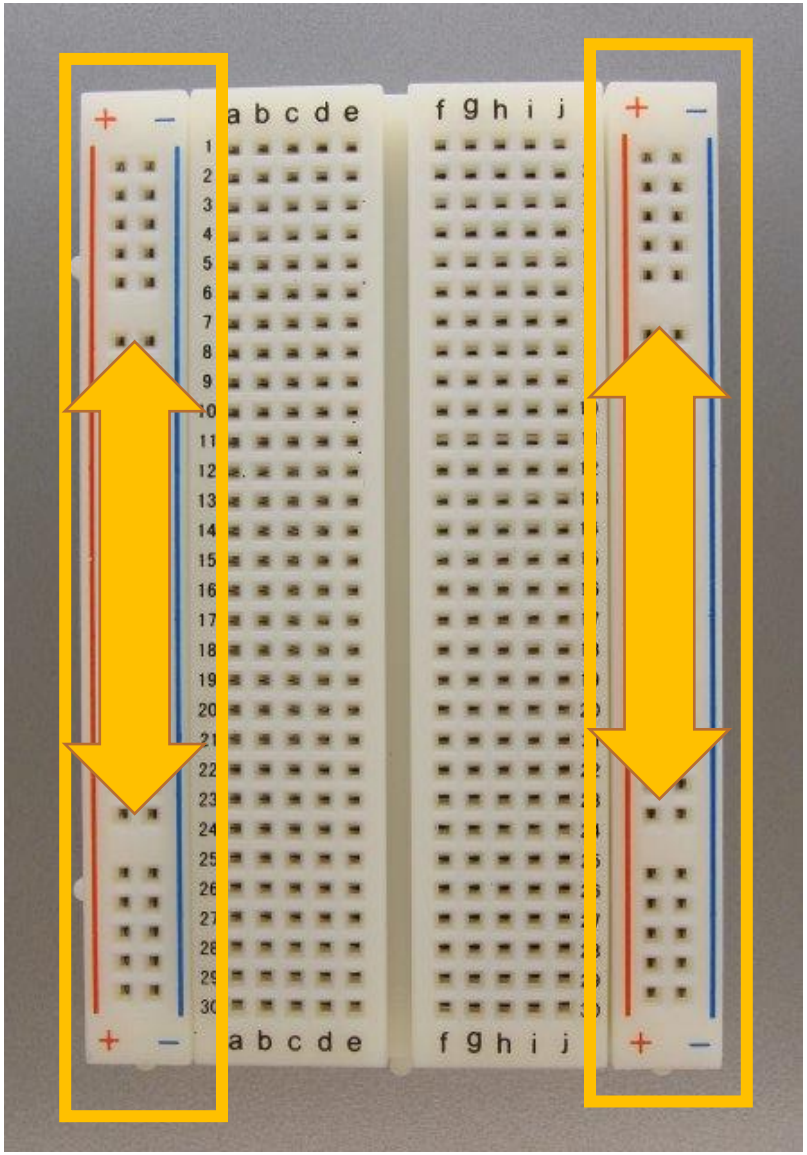

Breadboard

Provides electrical connectivity

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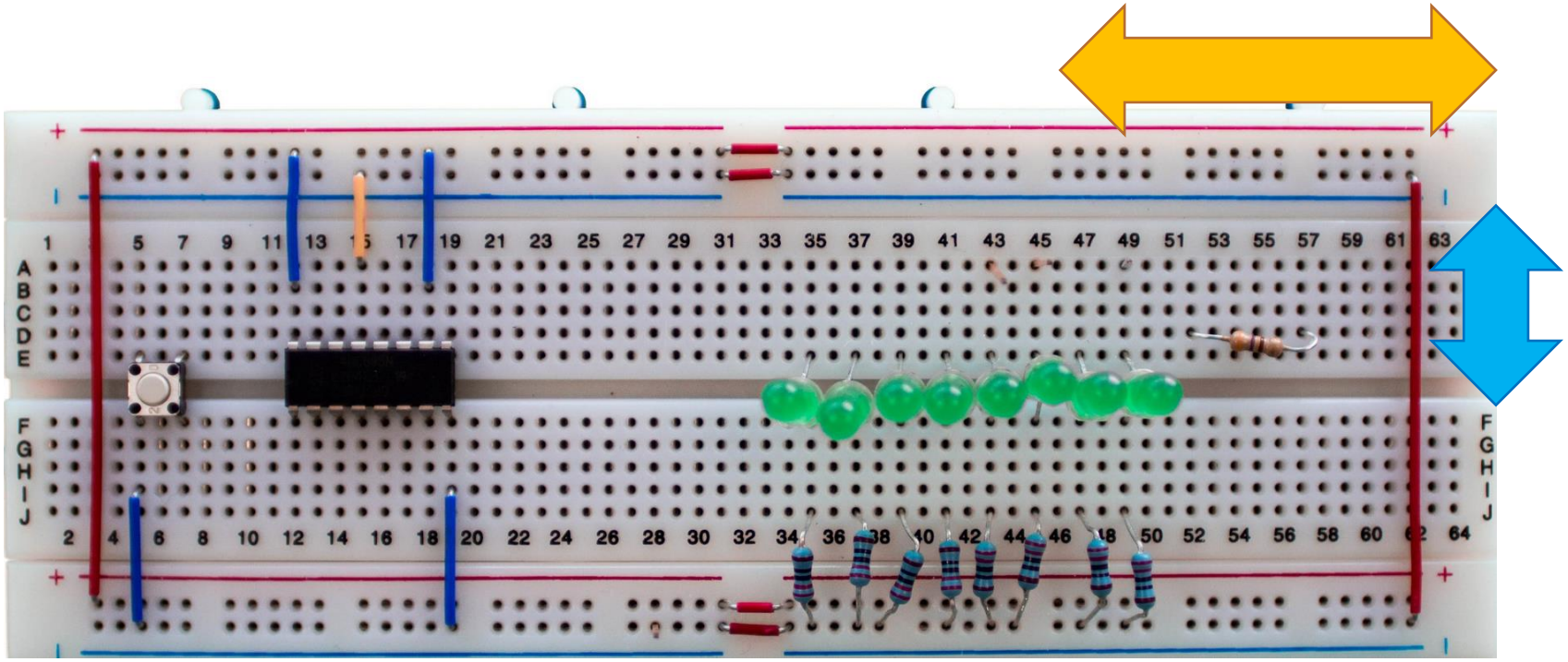
Breadboard

The two sides of the + and - rails are wired together

› Typically, used for power/GND

Brought to the internal rails with jumper wires

› Where core/chip and other stuff reside



Finally…LEDs

Light Emitting Diodes

- You feed with electrons; they light up
- They have a side!!!!
- They need a resistance to lower the charge

Wrong wiring => you burn them…

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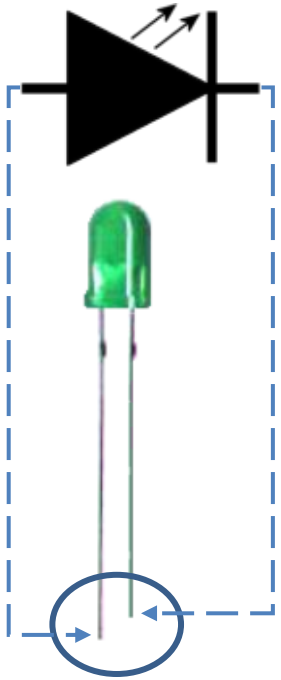

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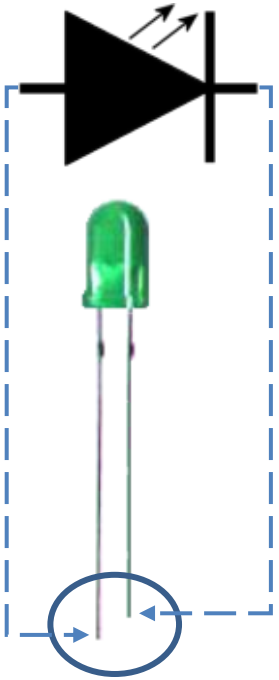

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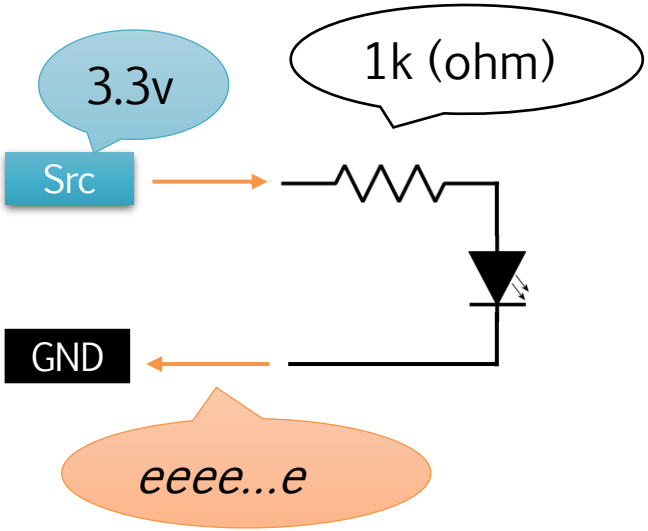

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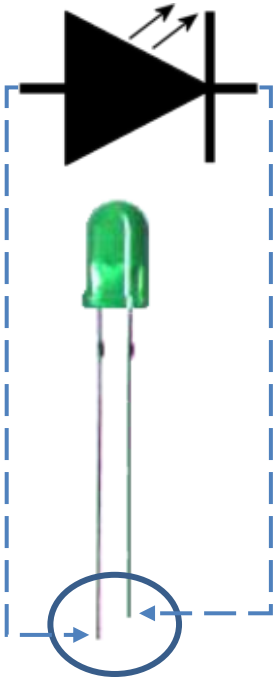

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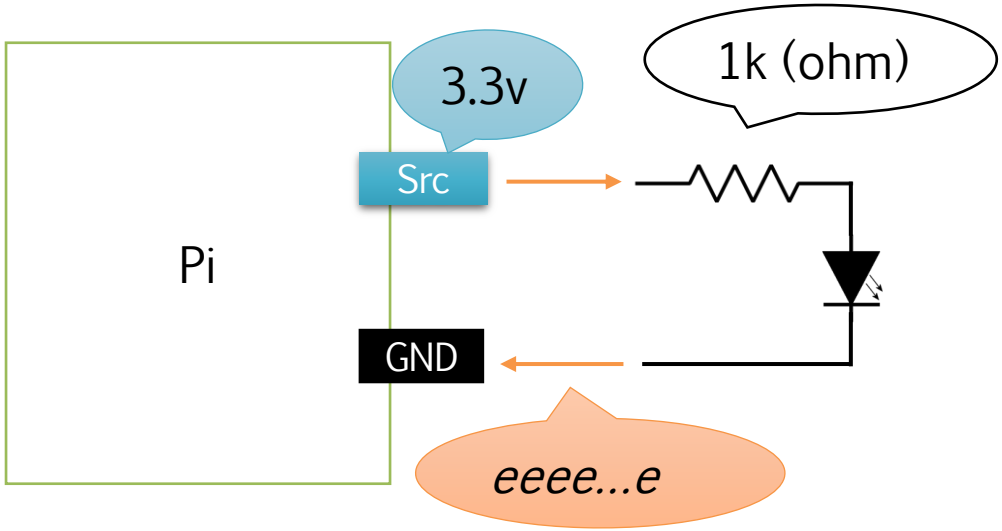


General Purpose I/O Ports

Our interface towards the external world

- https://pinout.xyz/pinout/#
- BCM vs. Standard Wiring

Raspberry Pi Pinout

3v3 Power	1	2	5v Power
GPIO 2 (I2C1 SDA)	3	4	5v Power
GPIO 3 (I2C1 SCL)	5	6	Ground
GPIO 4 (GPCLK0)	7	8	GPIO 14 (UART TX)
Ground	9	10	GPIO 15 (UART RX)
GPIO 17	11	12	GPIO 18 (PCM CLK)
GPIO 27	13	14	Ground
GPIO 22	15	16	GPIO 23
3v3 Power	17	18	GPIO 24
GPIO 10 (SPI0 MOSI)	19	20	Ground
GPIO 9 (SPI0 MISO)	21	22	GPIO 25
GPIO 11 (SPI0 SCLK)	23	24	GPIO 8 (SPI0 CE0)
Ground	25	26	GPIO 7 (SPI0 CE1)
GPIO 0 (EEPROM SDA)	27	28	GPIO 1 (EEPROM SCL)
GPIO 5	29	30	Ground
GPIO 6	31	32	GPIO 12 (PWM0)
GPIO 13 (PWM1)	33	34	Ground
GPIO 19 (PCM FS)	35	36	GPIO 16
GPIO 26	37	38	GPIO 20 (PCM DIN)
Ground	39	40	GPIO 21 (PCM DOUT)

Software

Operative system

- Debian-based GNU/Linux Distro called **Raspberry Pi OS**
  - Aka *Raspbian*
- Also Ubuntu and Win10 IoT are supported
- (and many more…)

(A number of) dev environments

- **Standard GCC toolchain**
- Arduino IDE (micro-kernel)
- Google's TensorFlow for AI ;)
- ….

WiringPi

- Library to interact with I/O
- Uses “progressive” wiring

Raspberry Pi GPIO Header

BCM	WiringPi	Name	Physical		Name	WiringPi	BCM
		3.3v	1	2	5v		
2	8	SDA.1	3	4	5V		
3	9	SCL.1	5	6	0v		
4	7	1-Wire	7	8	TxD	15	14
		0v	9	10	RxD	16	15
17	0	GPIO. 0	11	12	GPIO. 1	1	18
27	2	GPIO. 2	13	14	0v		
22	3	GPIO. 3	15	16	GPIO. 4	4	23
		3.3v	17	18	GPIO. 5	5	24
10	12	MOSI	19	20	0v		
9	13	MISO	21	22	GPIO. 6	6	25
11	14	SCLK	23	24	CE0	10	8
		0v	25	26	CE1	11	7
0	30	SDA.0	27	28	SCL.0	31	1
5	21	GPIO.21	29	30	0v		
6	22	GPIO.22	31	32	GPIO.26	26	12
13	23	GPIO.23	33	34	0v		
19	24	GPIO.24	35	36	GPIO.27	27	16
26	25	GPIO.25	37	38	GPIO.28	28	20
		0v	39	40	GPIO.29	29	21
BCM	WiringPi	Name	Physical		Name	WiringPi	BCM

WiringPi API

Include library header

```
#include <wiringPi.h>
```

(In desktop environments doesn't exist, so you shall use macro to remove this code, e.g., `NO_PI`)

Init library, and **every** GPio port

```
wiringPiSetup(); // Init lib
pinMode(0, OUTPUT); // GPio 0 is output port
```

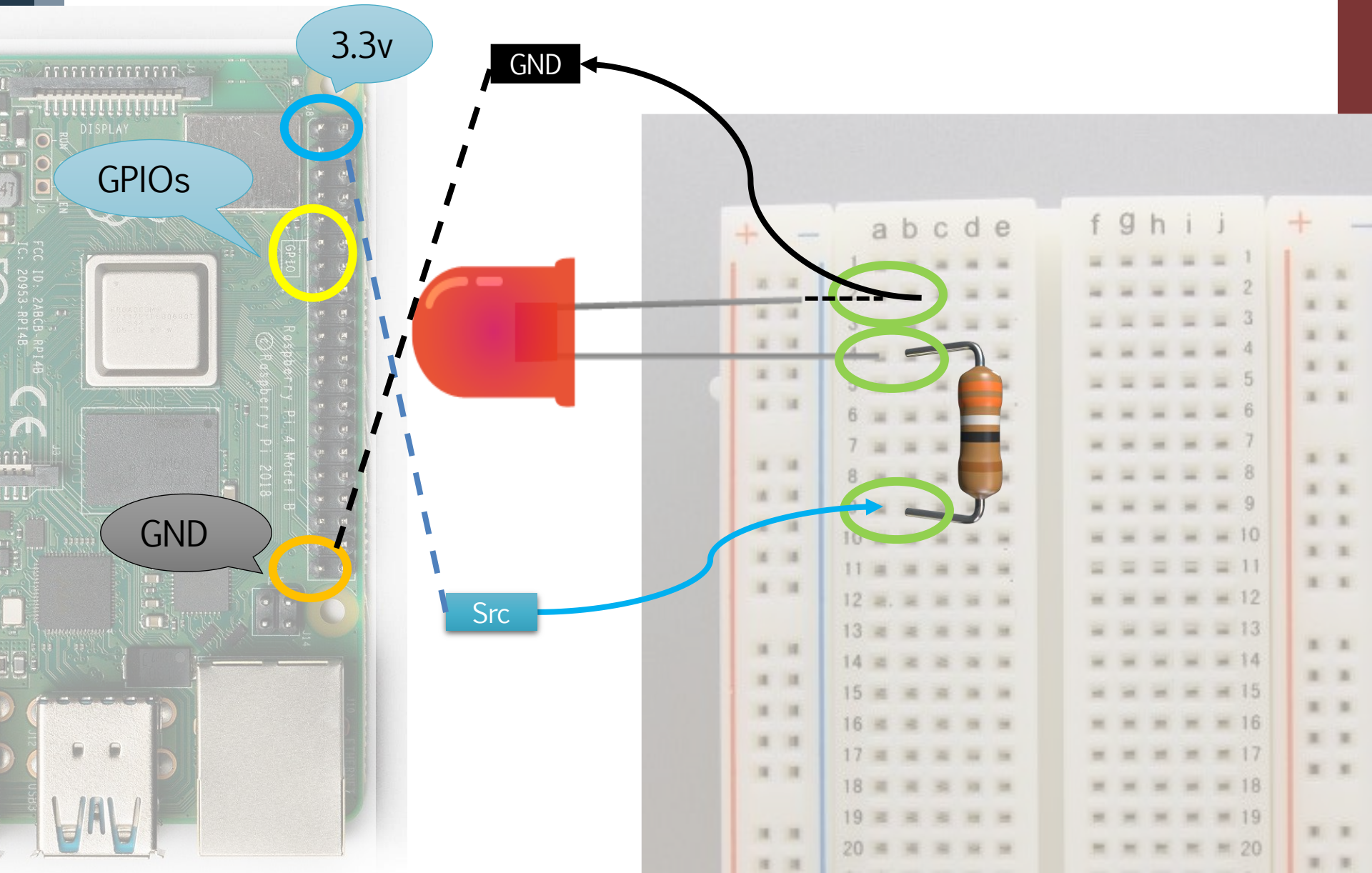
Write to port

```
digitalWrite(0, true); // Set port 0
```

Link library

```
$ gcc ..... -l wiringPi
```

E/E system



Exercise

Let's code!

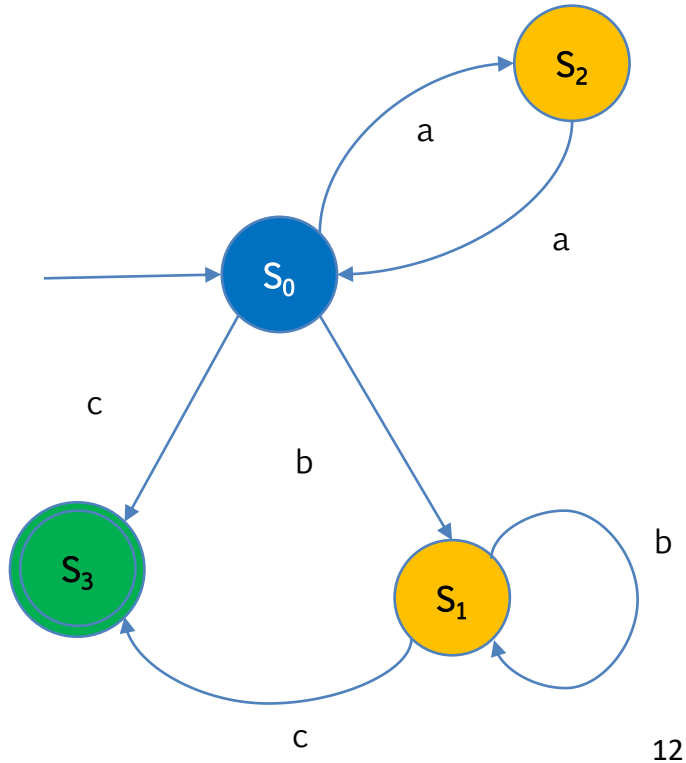
› Implement the Moore machine of the FSM that understands whether a words is from L

"Identify even sequences of a (even empty),

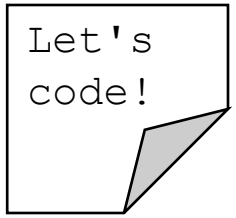
followed by one, or more, or no, b, ended by c"

› ..and turns on the corresponding led color

- **Blue** => GPIO 0
- **Red (error state)** => GPIO 1
- **Yellow** => GPIO 2
- **Green** => GPIO 3



How to run the examples



- Find them in `Code/` folder from the course website

For C++: compile

- `$ gcc code.cpp [-DNO_PI] -o code -Wall -l stdc++ -l wiringPi`

Run (Unix/Linux)

```
$ ./code
```

Run (Win/Cygwin)

```
$ ./code.exe
```

References

Course website

- http://hipert.unimore.it/people/paolob/pub/Industrial_Informatics/index.html

My contacts

- paolo.burgio@unimore.it
- http://hipert.mat.unimore.it/people/paolob/

Resources

- Programmazione I course @FIM UNIMORE
  - https://algogroup.unimore.it/people/paolo/courses/programmazione_I/
- Practice, practice, practice
- A "small blog"
  - http://www.google.com