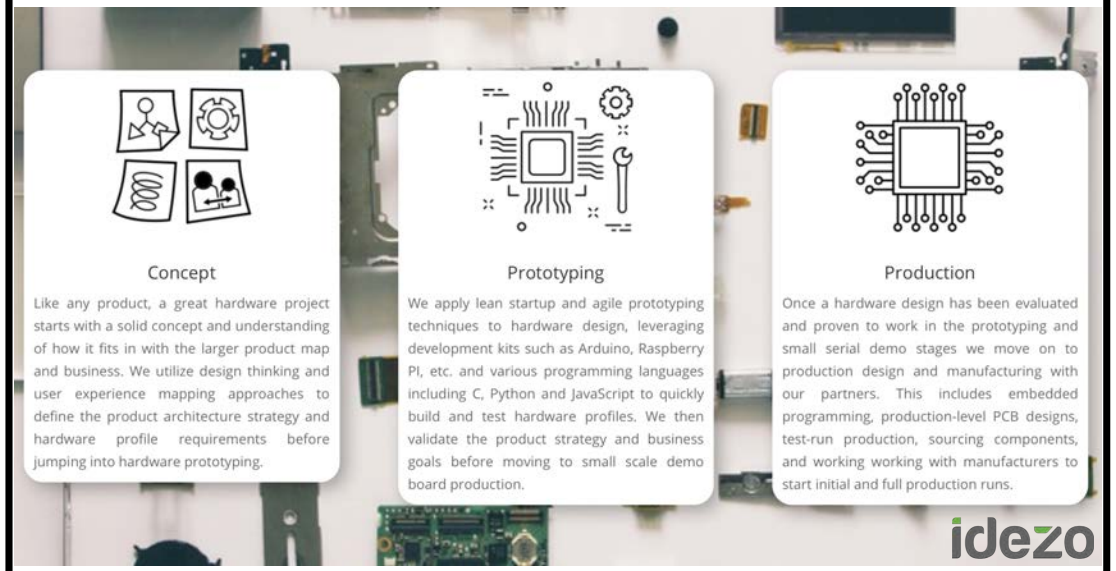
HANDS ON APPROACH TO

Data Science

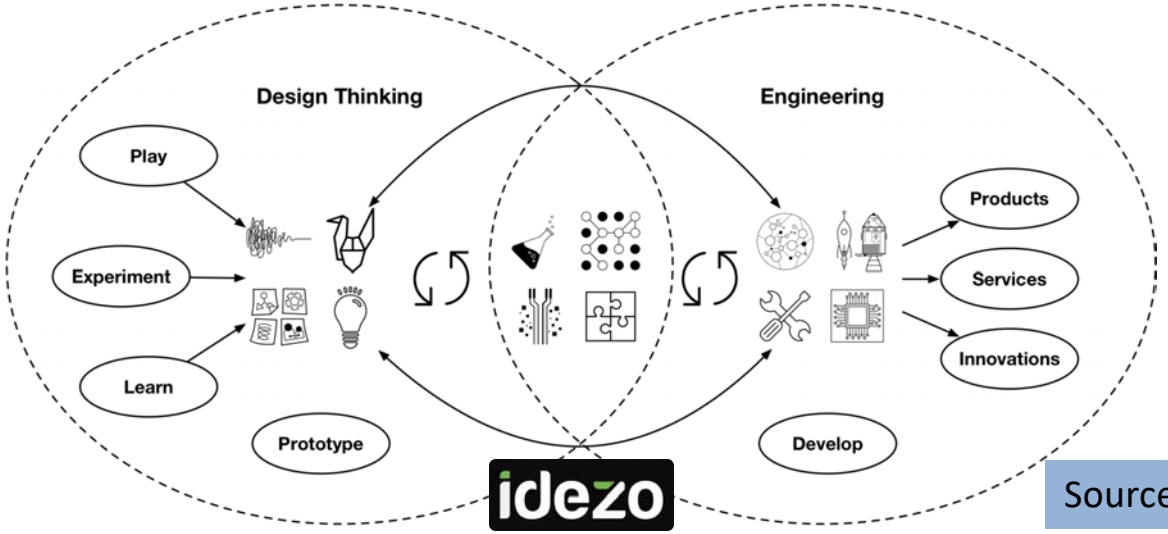
for (the)

IoT



Rob van der Willigen

HANDS ON APPROACH TO DATA SCIENCE for (the) IoT



Source: https://idezo.ch

This Data Science Course was developed for keuzevak- program of the School of Communication, Media and Information Technology (CMI, at the Hogeschool Rotterdam **(Rotterdam University of Applied Sciences, RUAS)**.
If you find errors or omissions, please contact the author, Rob van der Willigen, at r.f.van.der.willigen@hr.nl. Materials of this course and code examples used will become available at:
https://github.com/robvdw/CMIDAT01K-DATA-SCIENCE-for-IOT

Course Setup

Lesson 01:	**Discovering the IoT Data Science Domain**
Lesson 02:	**Defining project requirements**
	+ Cost calculation/estimate
Lesson 03	**Learn to write code + IoT Rapid Prototyping**
Lesson 04-05:	**Autonomous project work**
Lesson 06-07:	**Demonstrating working IoT prototype**
Lesson 08:	**Wrap-up**

Week 09/10: FEEDBACK + GRADING

lesson two

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LES: 02

Stetting up the hardware (Raspberry Pi)

Rapid prototyping basics

Preview Les 03

Write your first line of code (Python)

Setting up Raspberry Pi

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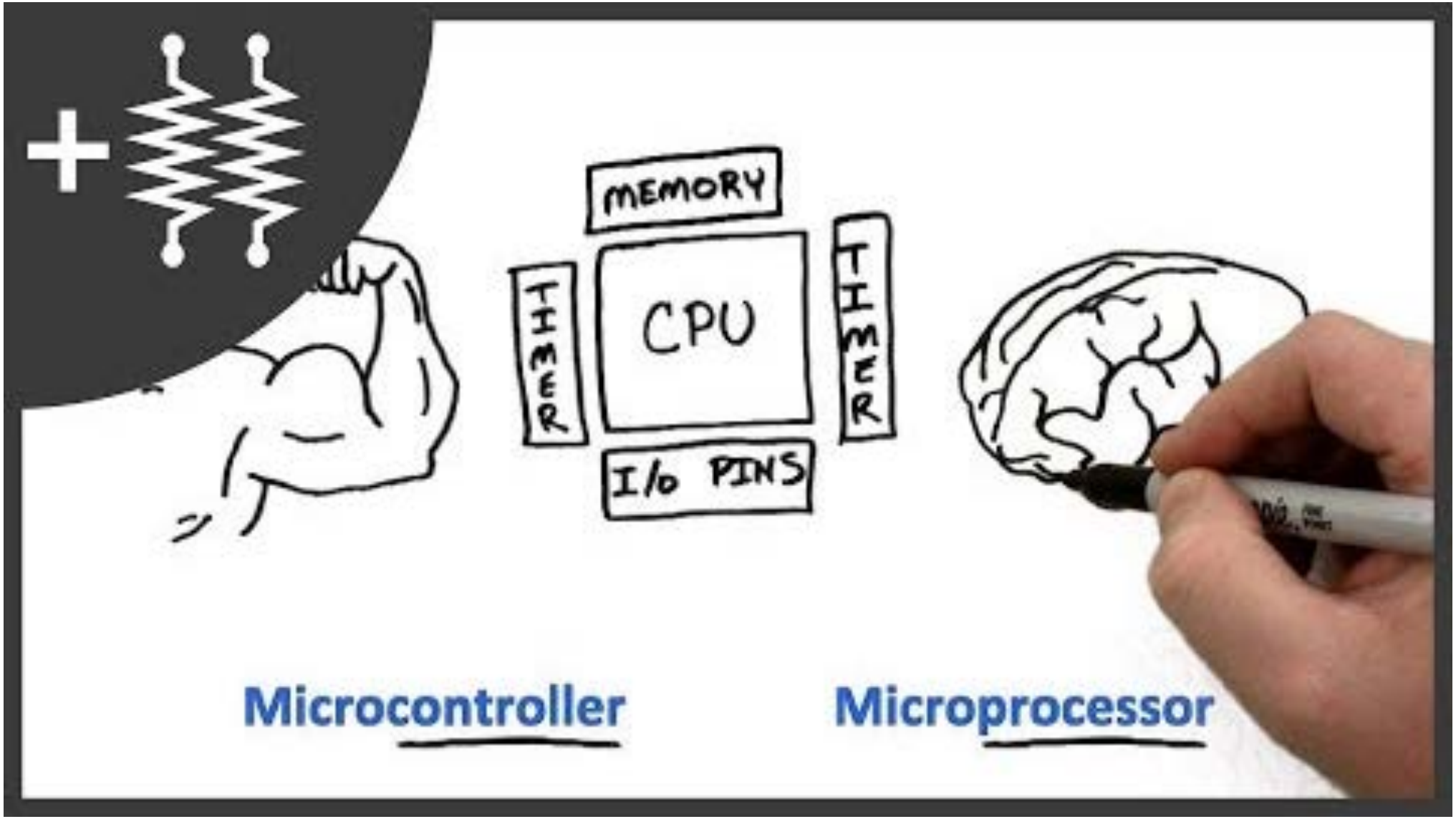
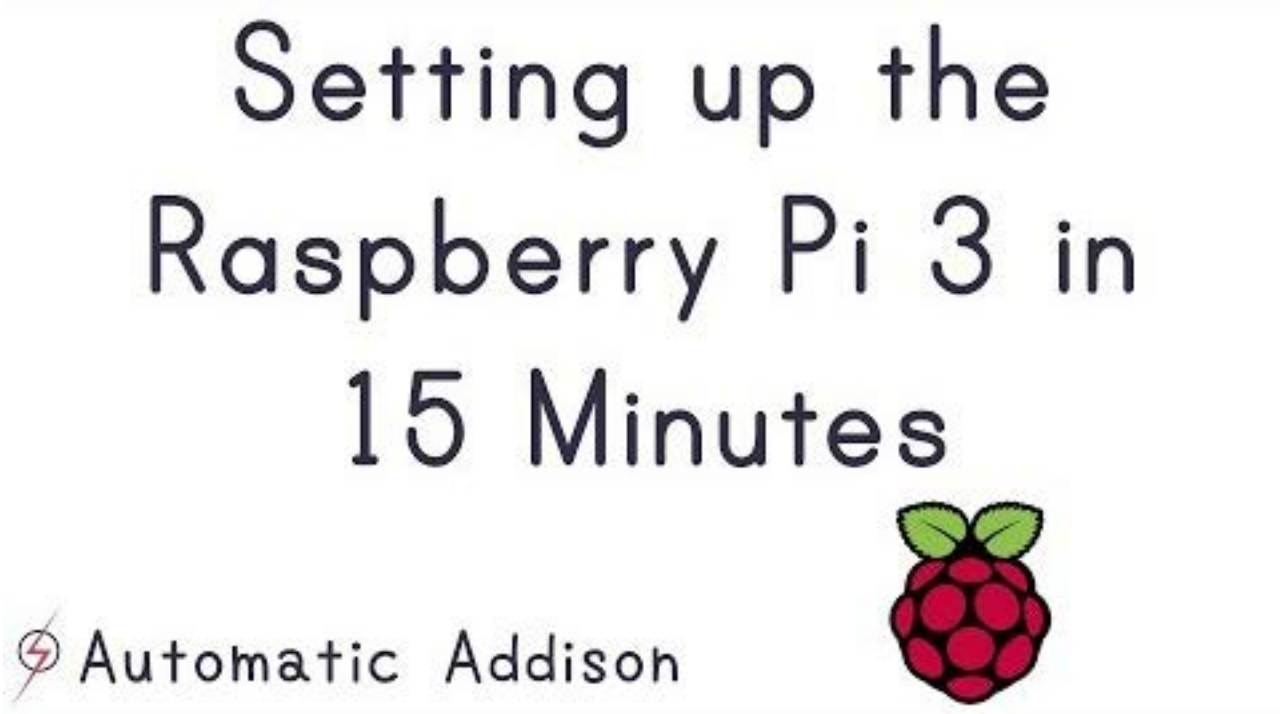
Arduino vs. Raspberry Pi?



https://www.youtube.com/watch?v=7vhvnaWUZjE

Raspberry Pi B
setup from scratch



https://automaticaddison.com/how-to-blink-an-led-on-raspberry-pi-3-model-b/

Raspberry Pi 3 A+ (optimal for IoT) setup from scratch

https://youtu.be/ZdzdYE_MWTM

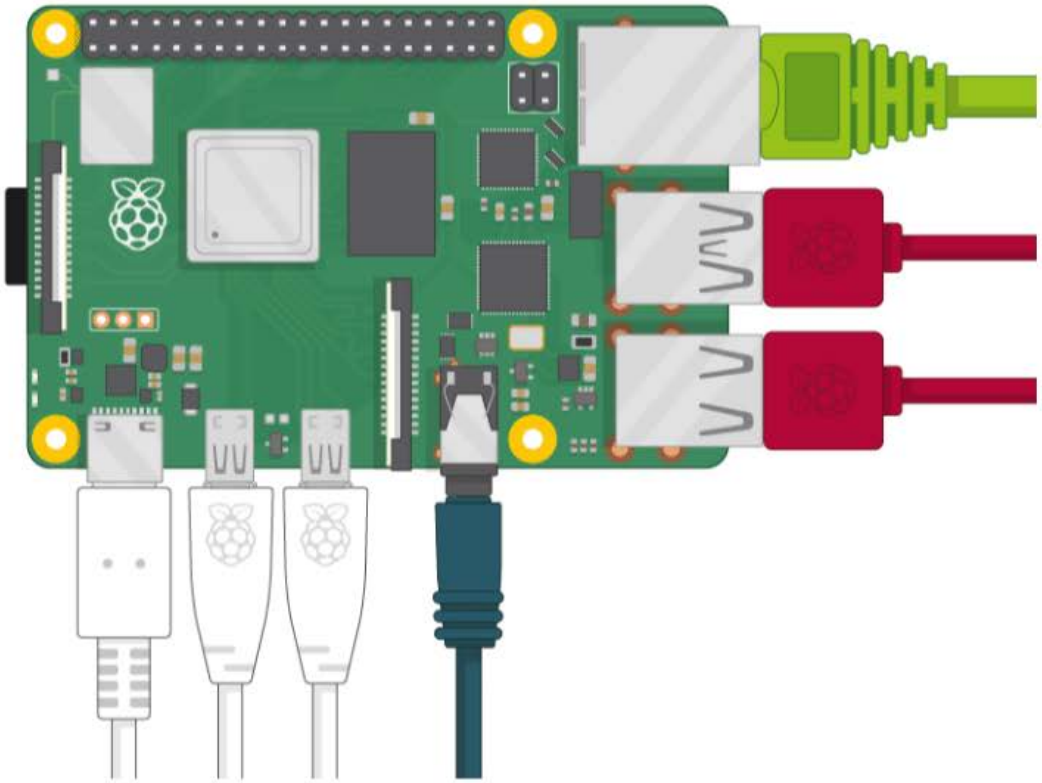
Raspberry Pi

https://projects.raspberrypi.org/en/projects/raspberry-pi-setting-up

- Introduction
- What you will need
- Set up your SD card
- Connect your Pi
- Start up your Pi
- Finish the setup
- Where to find help
- What next?

Introduction

Here you'll learn about your Raspberry Pi, what things you need to use it, and how to set it up.



What is a Raspberry Pi?

The Raspberry Pi is a low cost, **credit-card sized computer** that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.

What's more, the Raspberry Pi has the ability to interact with the outside world, and has been used in a wide array of digital maker projects, from music machines and parent detectors to weather stations and tweeting birdhouses with infra-red cameras. We want to see the Raspberry Pi being used by kids all over the world to learn to program and understand how computers work.

Keyboard + Mouse + HDMI

https://projects.raspberrypi.org/en/projects/raspberry-pi-setting-up

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A keyboard and a mouse

To start using your Raspberry Pi, you need a USB keyboard and a USB mouse.

Once you've set up your Raspberry Pi, you can use a Bluetooth keyboard and mouse, but you'll need a USB keyboard and mouse for the first setup.

A TV or computer screen

To view the Raspberry Pi OS desktop environment, you need a screen, and a cable to link the screen and your Raspberry Pi. The screen can be a TV or a computer monitor. If the screen has built-in speakers, Raspberry Pi is able to use these to play sound.

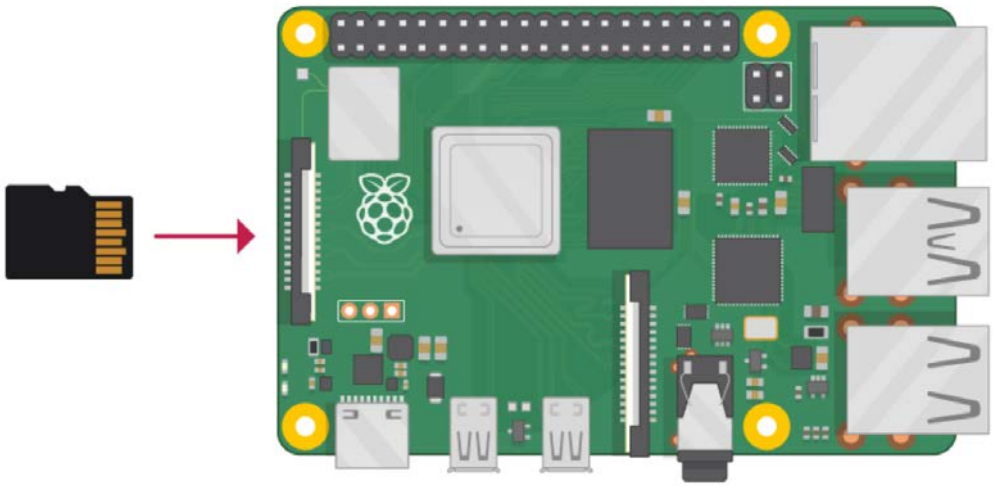
HDMI

Your Raspberry Pi has an HDMI output port that is compatible with the HDMI port of most modern TVs and computer monitors. Many computer monitors may also have DVI or VGA ports.

Micro SD Card

https://projects.raspberrypi.org/en/projects/raspberry-pi-setting-up

Your Raspberry Pi needs an SD card to store all its files and the Raspberry Pi OS operating system.



You need a microSD card with a capacity of **at least 8GB**.

If you have an SD card that doesn't have the Raspberry Pi OS operating system on it yet, or if you want to reset your Raspberry Pi, you can easily install Raspberry Pi OS yourself. To do so, you need a computer that has an SD card port — most laptop and desktop computers have one.

The Raspberry Pi OS operating system via the Raspberry Pi Imager

Using the Raspberry Pi Imager is the easiest way to install Raspberry Pi OS on your SD card.

Note: More advanced users looking to install a particular operating system should use this guide to **installing operating system images**.

Etching Raspbian onto a SD card

Set up your SD card

If you have an SD card that doesn't have the Raspbian operating system on it yet, or if you want to reset your Raspberry Pi, you can easily install Raspbian yourself. To do so, you need a computer that has an SD card port — most laptop and desktop computers have one.

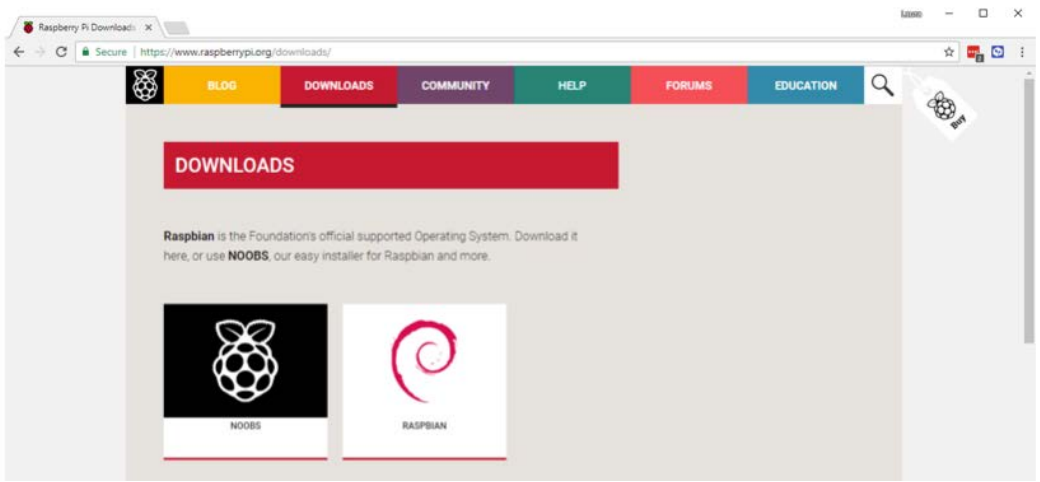
The Raspbian operating system via NOOBS

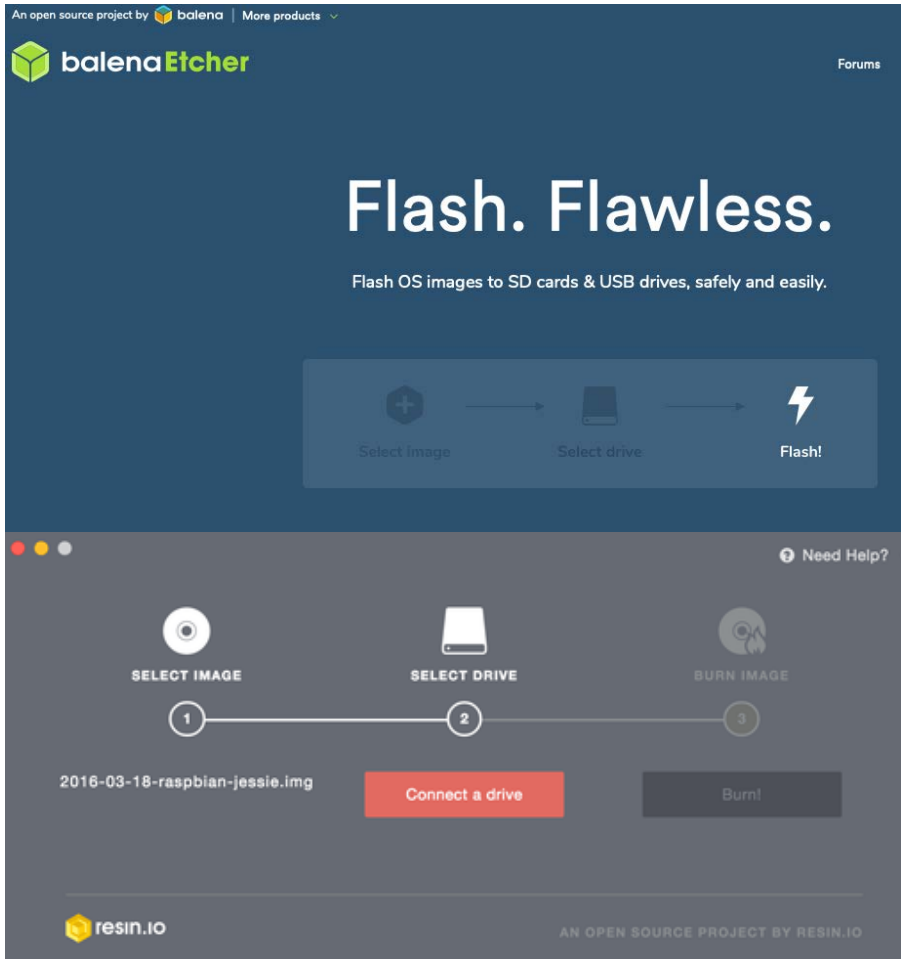
Using the NOOBS software is the easiest way to install Raspbian on your SD card.

Note: more advanced users looking to install a particular operating system should use this guide to installing operating system images.

Download NOOBS

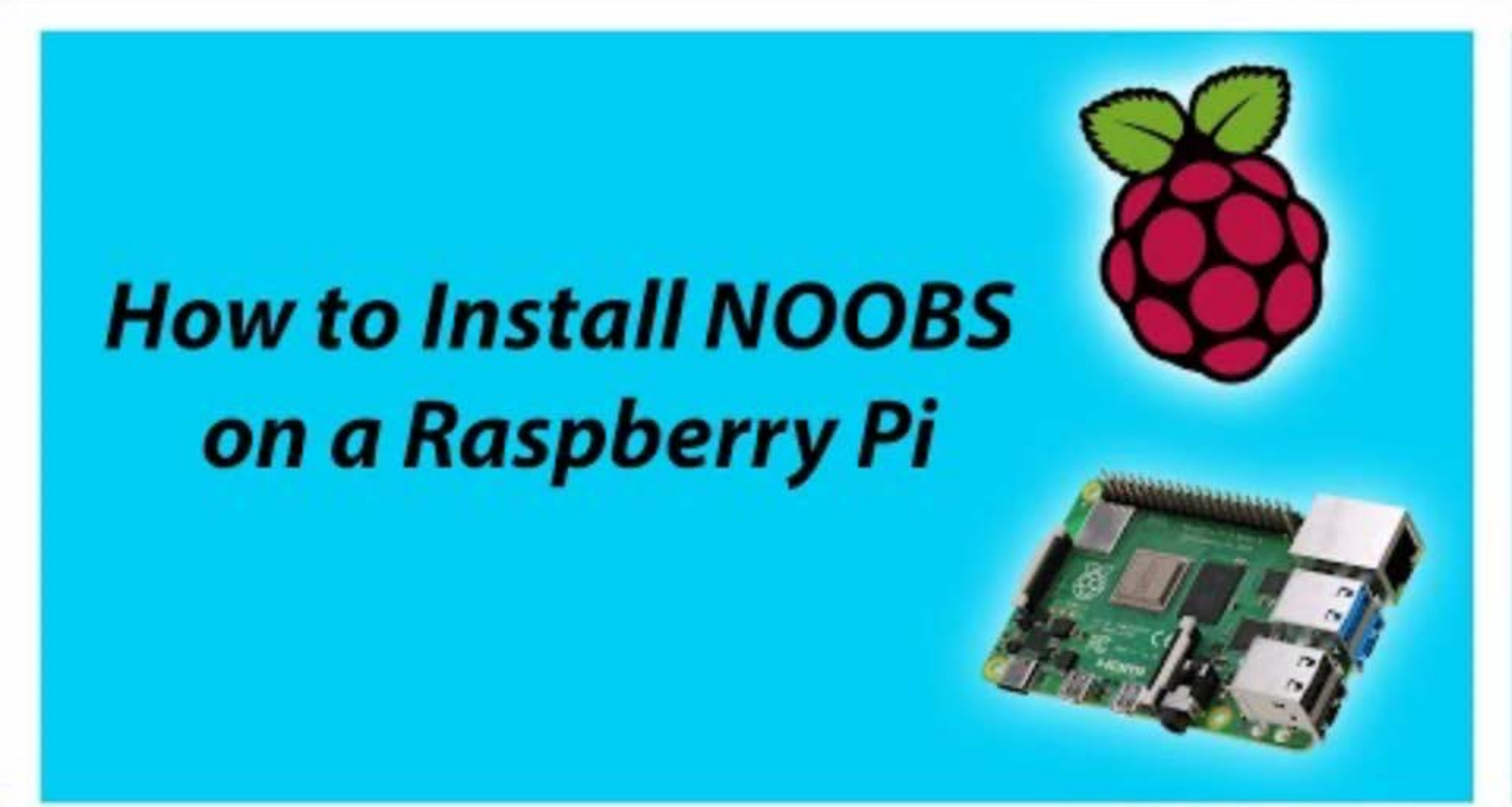
- Visit the Raspberry Pi downloads page.





https://www.balena.io/etcher/

How to Install NOOBS on Raspberry Pi

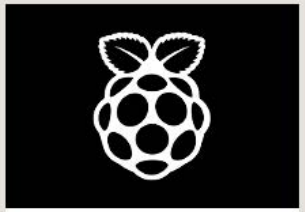


https://www.youtube.com/watch?v=TlQxaEdyBgM

Raspberry Pi Operating Systems

Downloads

Raspbian is our official operating system for **all** models of the Raspberry Pi. Download it here, or use **NOOBS**, our easy installer for Raspbian and more.



NOOBS

Raspbian

Raspberry Pi Desktop (for PC and Mac)

Debian with Raspberry Pi Desktop is the Foundation's operating system for PC and Mac. You can create a live disc, run it in a virtual machine, or even install it on your computer.

Raspberry Pi Desktop

Third Party Operating System Images

Third-party operating system images for Raspberry Pi are also available:

Ubuntu MATE

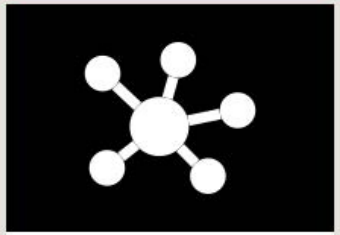
Ubuntu Core

Ubuntu Server

Windows 10 IoT Core

OSMC

LibreELEC



Mozilla WebThings

PiNet

Raspberry Pi Operating Systems

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01/25/2019 • 12 minutes to read

May 2017

Volume 32 Number 5

[Internet of Things]

Working with Raspberry Pi and Windows 10

By Bruno Sonnino

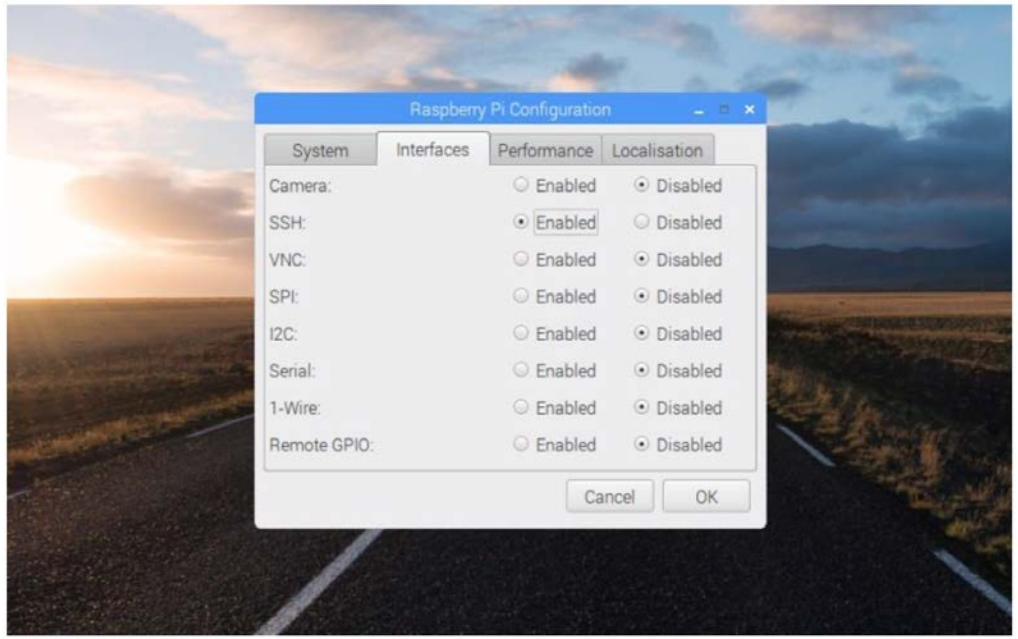
Although I've been working with software for a long time, I've never interacted directly with hardware. I've developed a lot of software that works near the hardware, but I've never worked with a physical board where I have complete control of what's being done. Therefore, when I had the opportunity to work with the Raspberry Pi, especially using Windows 10 and Visual Studio, I jumped at the opportunity.

The Raspberry Pi, in versions 2 and 3, can use Windows 10 as its OS (though it's not the full version, it lets you execute Universal Windows Platform [UWP] apps to control its devices). This is a cheap computer—you can get one for less than $35—and it's powerful. The Raspberry Pi 3 has a Quad-Core, 64-bit ARM processor, HDMI video, Ethernet and Wi-Fi networking, Bluetooth, and four USB ports. You can definitely do many things with it.

https://docs.microsoft.com/en-us/archive/msdn-magazine/2017/may/internet-of-things-working-with-raspberry-pi-and-windows-10

Raspberry Pi 3A+

Connect remotely



Remotely control your Raspberry Pi from a PC, Linux, or Mac computer and transfer files using SSH.

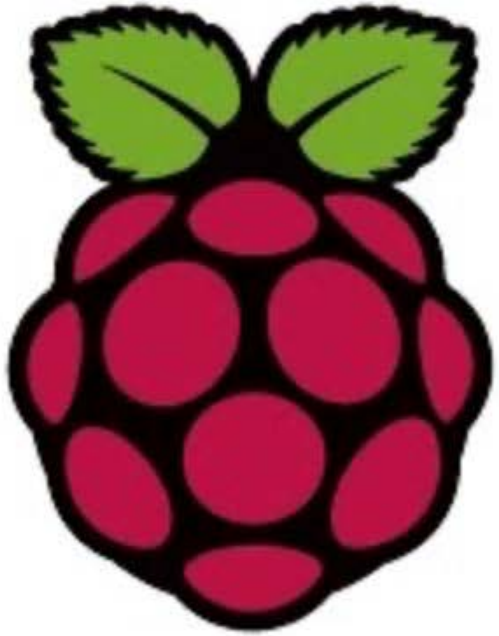
https://core-electronics.com.au/tutorials/how-to-connect-to-raspberry-pi-3A-plus-remotely-using-ssh.html

https://magpi.raspberrypi.org/articles/vnc-raspberry-pi

Raspberry Pi 3A+

Connect remotely

Raspberry Pi Tutorials



Part 3:
Remote
Access

https://www.youtube.com/watch?v=IDqQIDL3LKg

Rapid Prototyping

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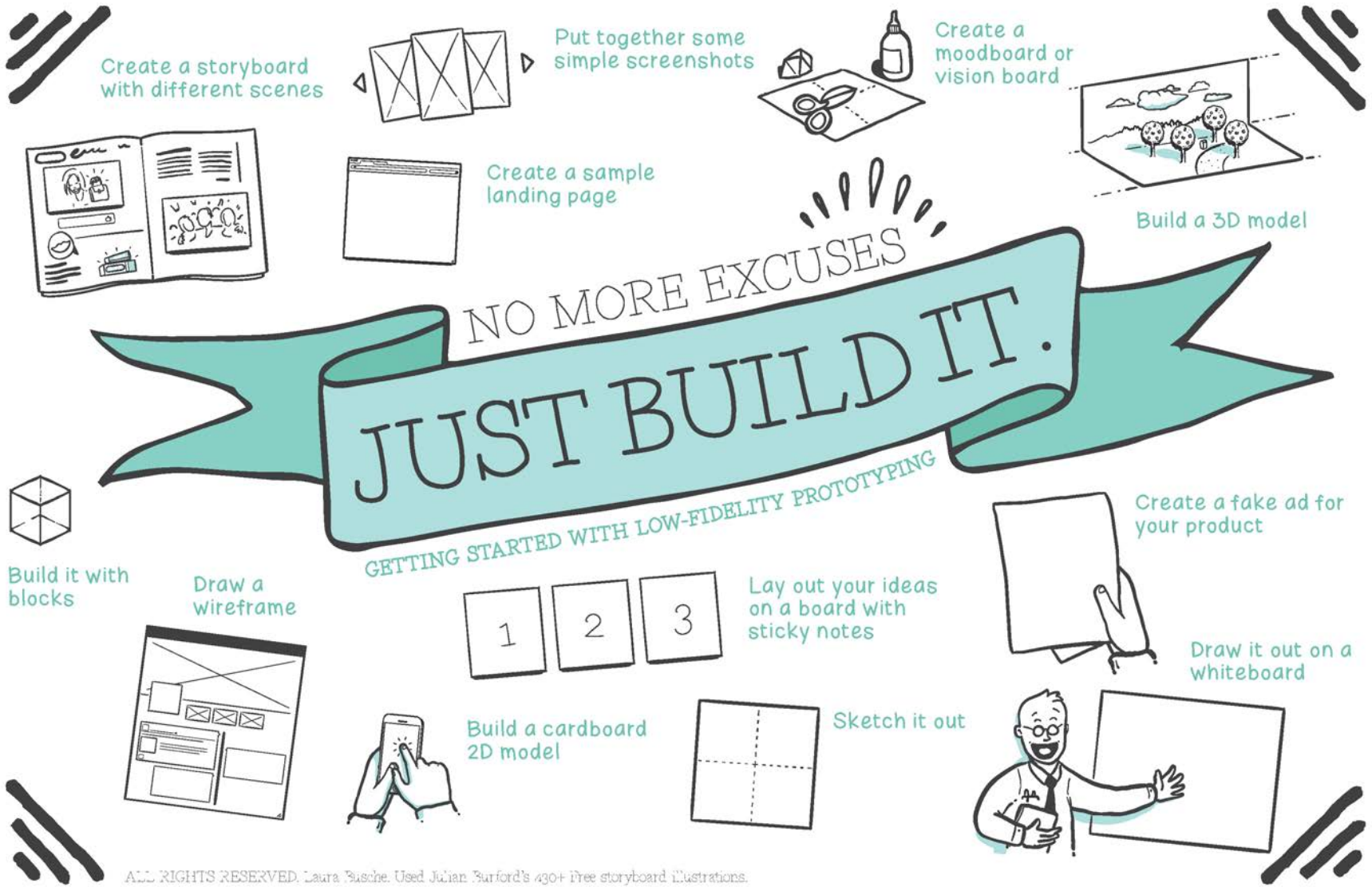
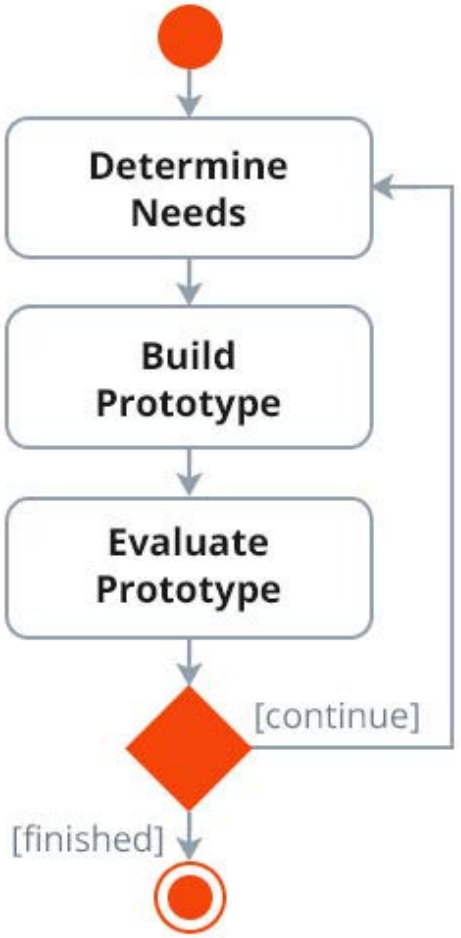

Create a storyboard with different scenes
Put together some simple screenshots
Create a moodboard or vision board
Create a sample landing page
Build a 3D model
NO MORE EXCUSES
JUST BUILD IT.
GETTING STARTED WITH LOW-FIDELITY PROTOTYPING
Build it with blocks
Draw a wireframe
1
2
3
Lay out your ideas on a board with sticky notes
Create a fake ad for your product
Draw it out on a whiteboard
Build a cardboard 2D model
Sketch it out
ALL RIGHTS RESERVED. Laura Busche. Used Julian Burford's 430+ Free storyboard Illustrations.

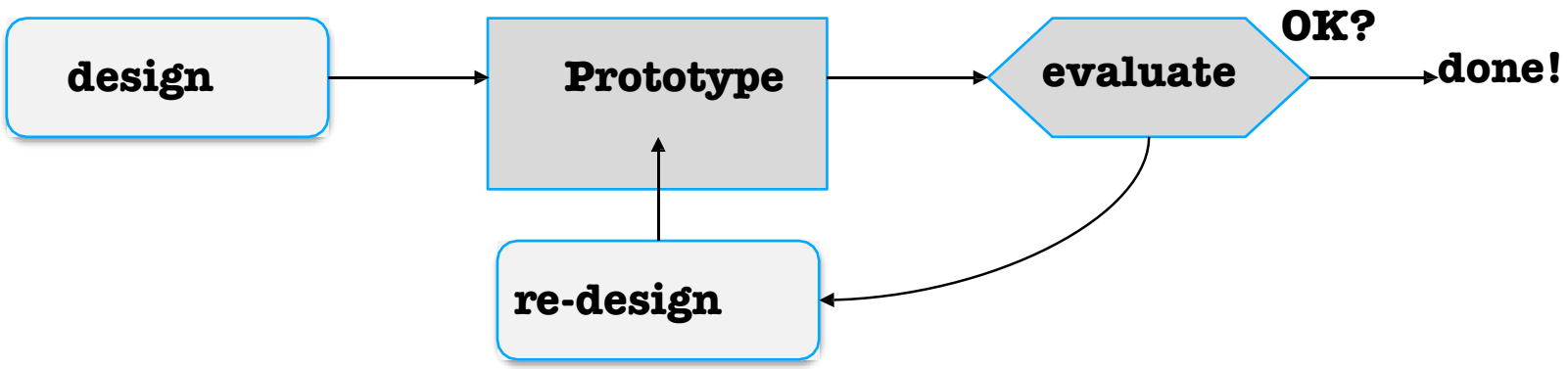
https://www.youtube.com/watch?v=JMjozqJS44M

Rapid Prototyping

- You never get it right first time
- If at first you don"t succeed ...

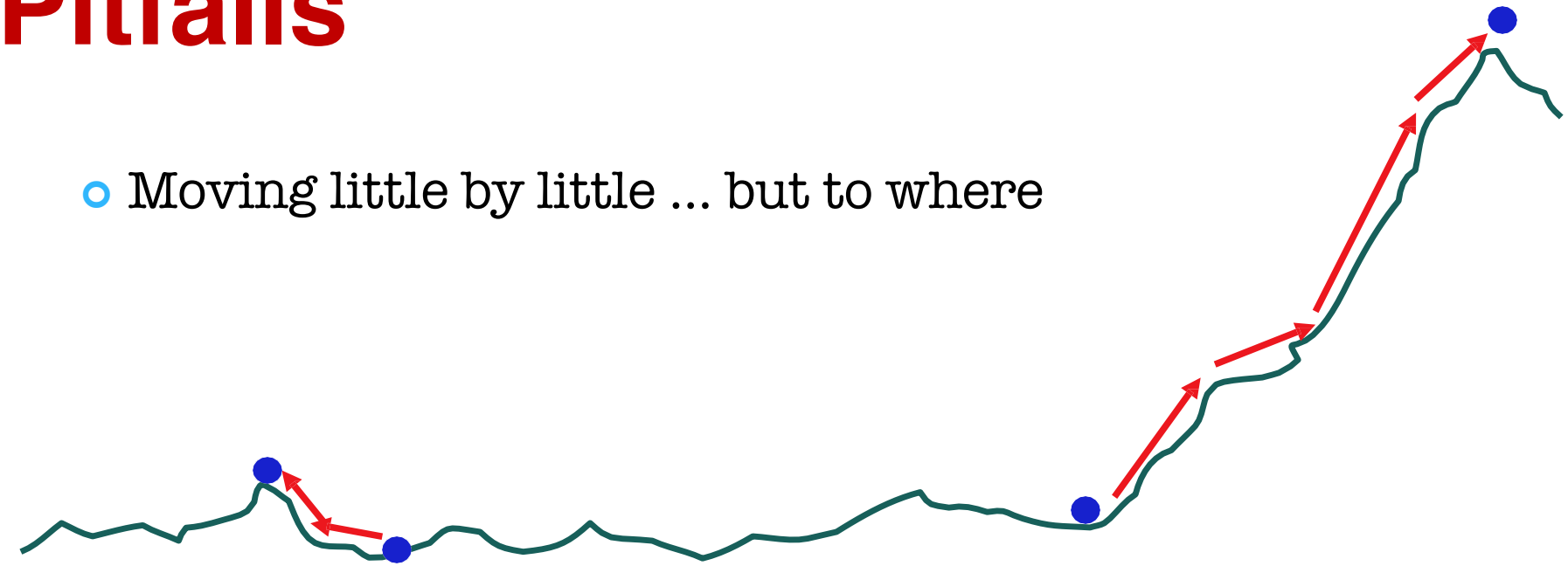


Rapid Prototyping



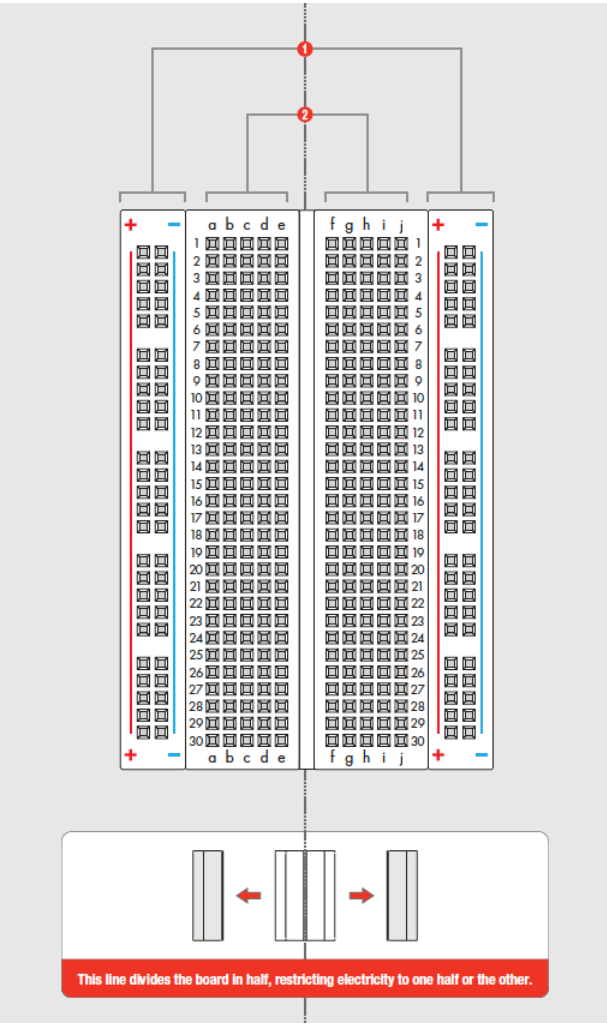
Rapid Prototyping Pitfalls

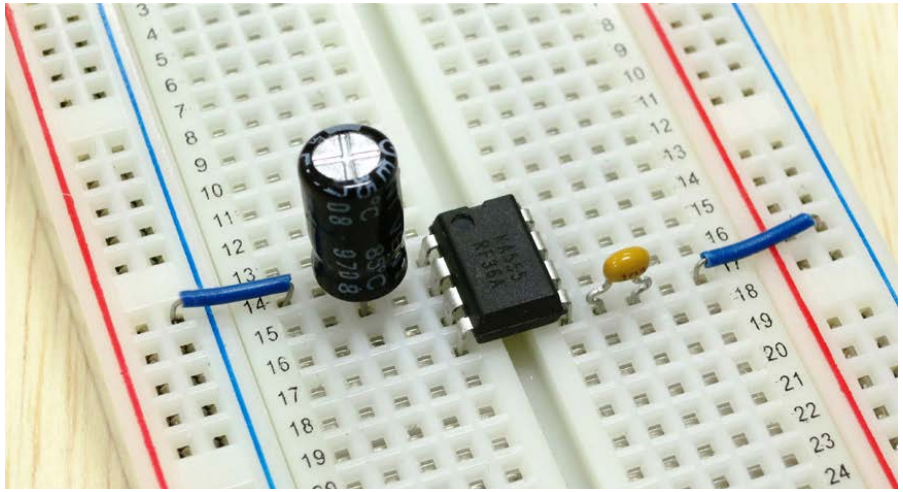
- Moving little by little … but to where

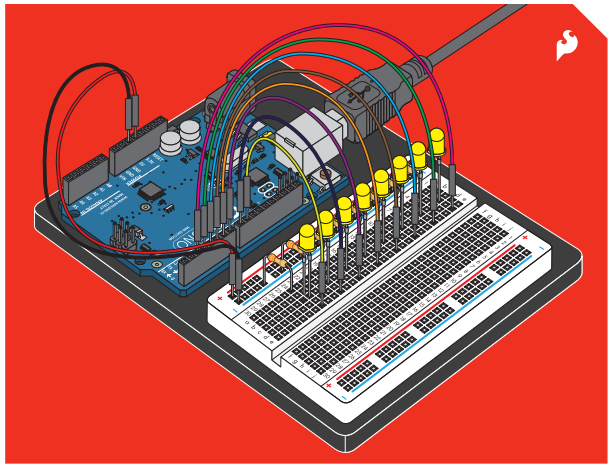


1. need a good start point
2. need to understand what is wrong

Breadboard

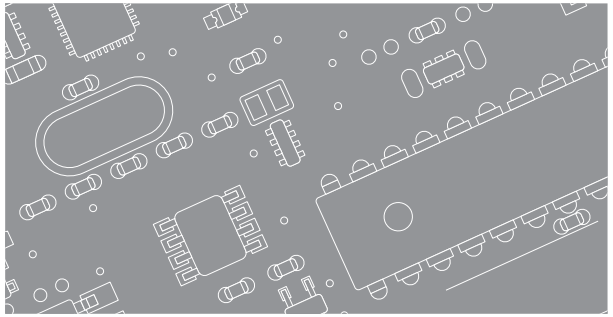






SIK GUIDE

Your Guide to the SparkFun Inventor's Kit for Arduino

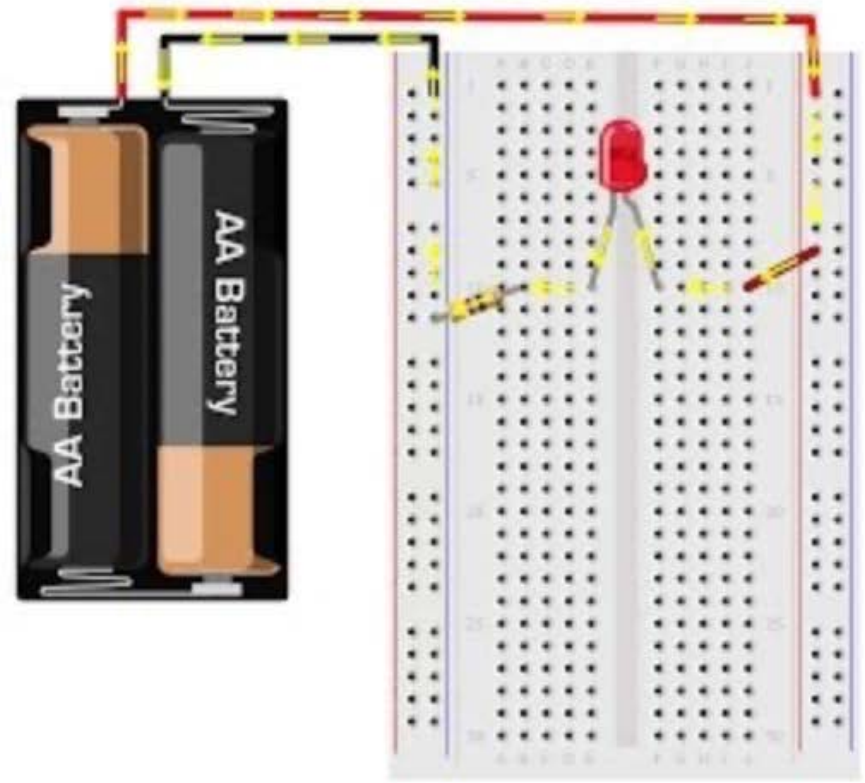


https://cdn.sparkfun.com/datasheets/Kits/RedBoard_SIK_3.2.pdf

https://learn.sparkfun.com/tutorials/how-to-use-a-breadboard/

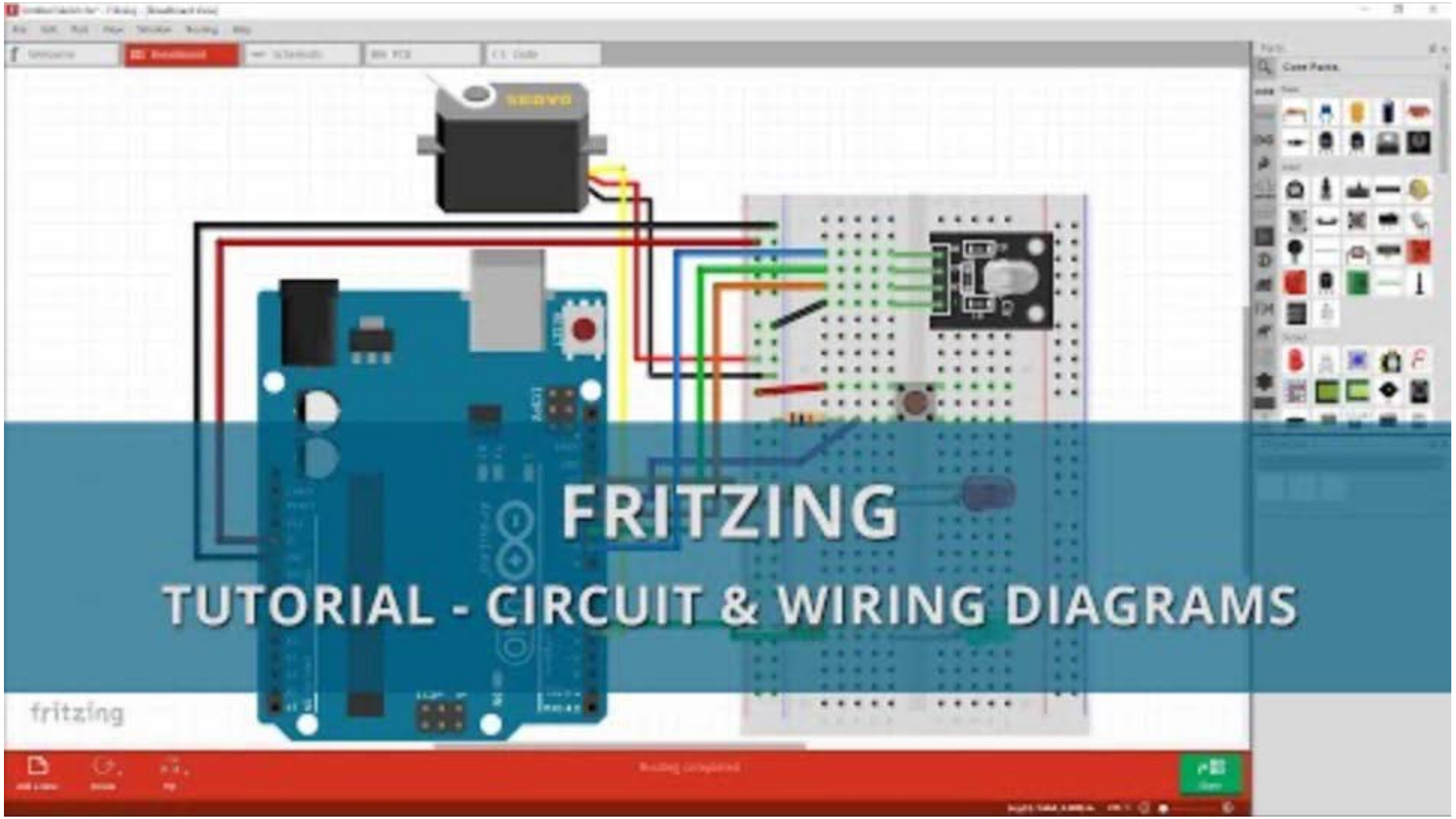
Breadboard

How to use it for Rapid Prototyping



https://www.youtube.com/watch?v=6WReFkfrUIk

Fritzing beginners guide

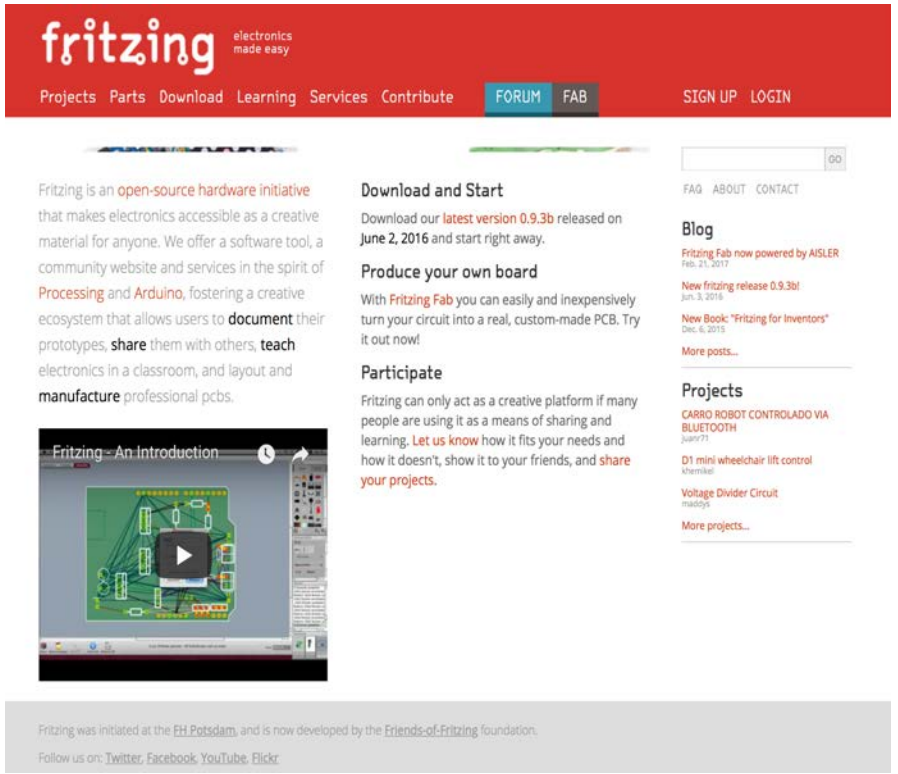


https://www.youtube.com/watch?v=-saXw1EipX0

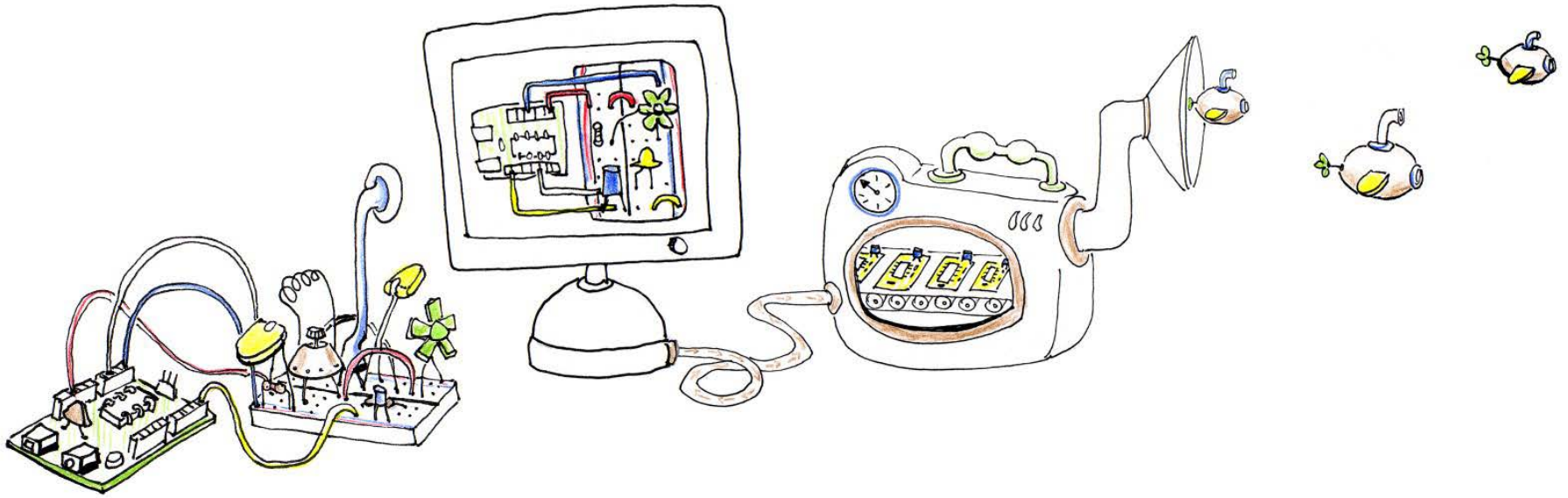
Fritzing

A tool for advancing
electronic prototyping for designers

Today a growing community of DIY-practitioners, artists and designers are using microcontroller-based toolkits to express their concepts for digital artifacts by building them.

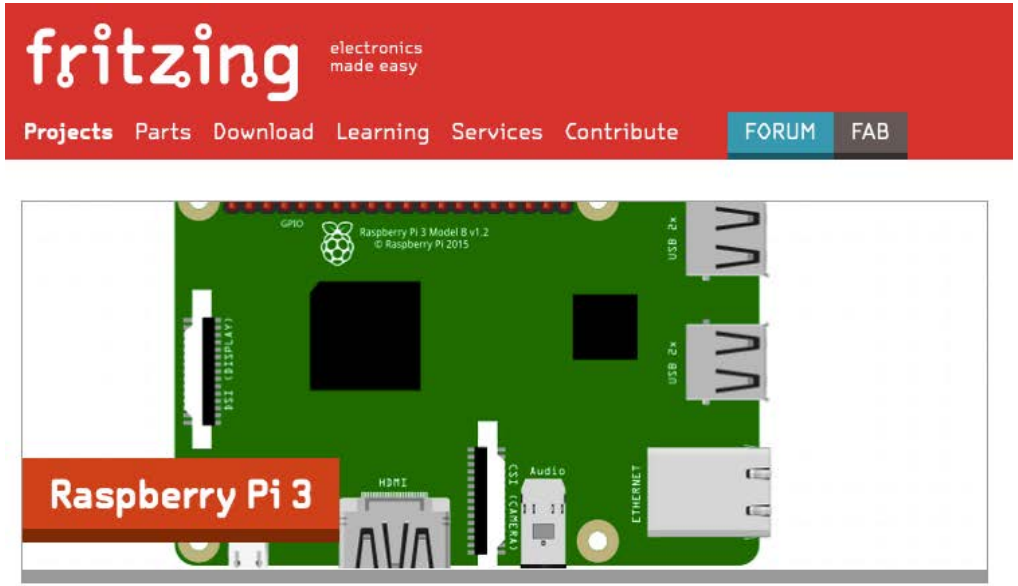


Concept of Fritzing

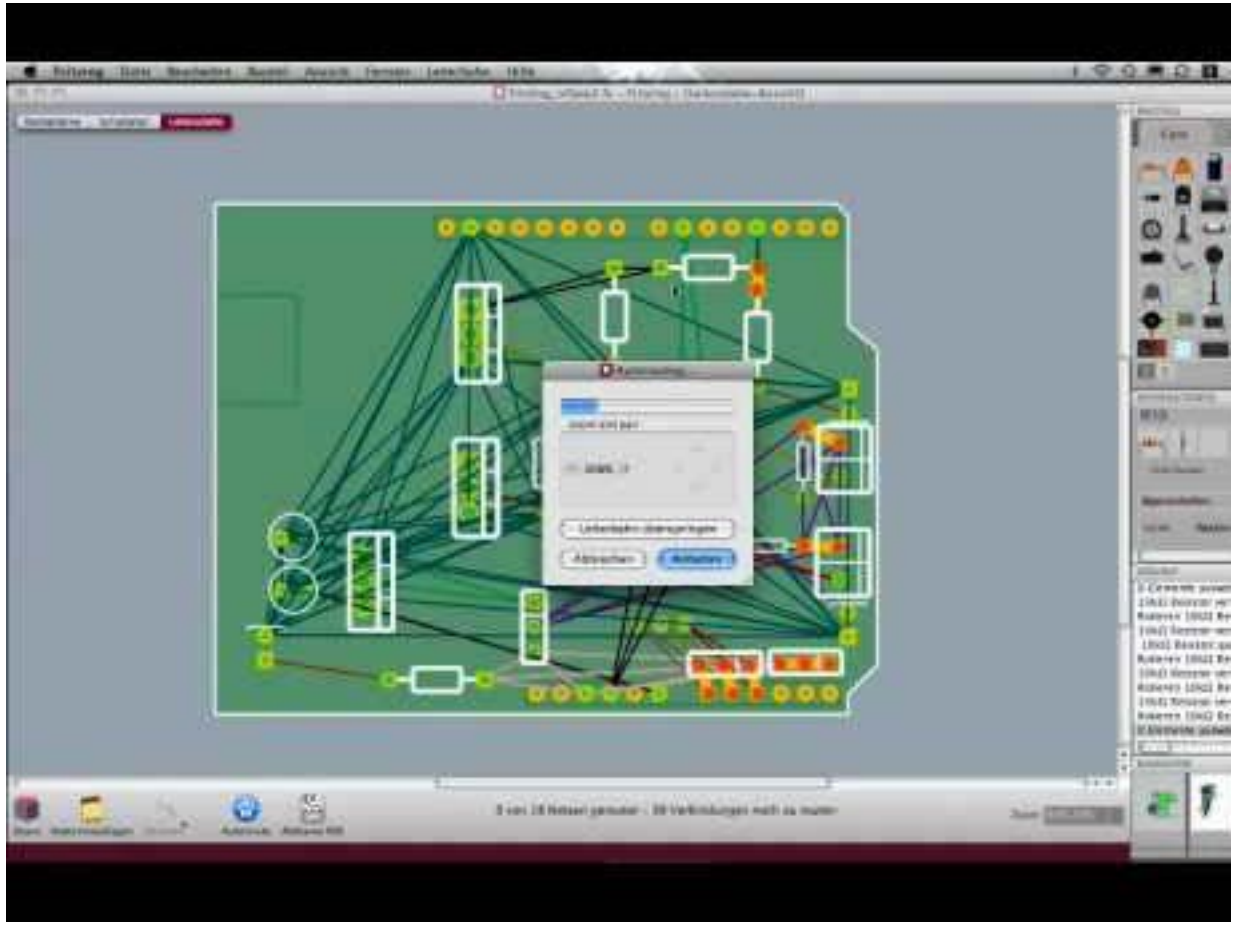


The recreation of their breadboard prototype in the Fritzing software enables designers to produce professional PCBs and also to share their designs.

Installing Fritzing



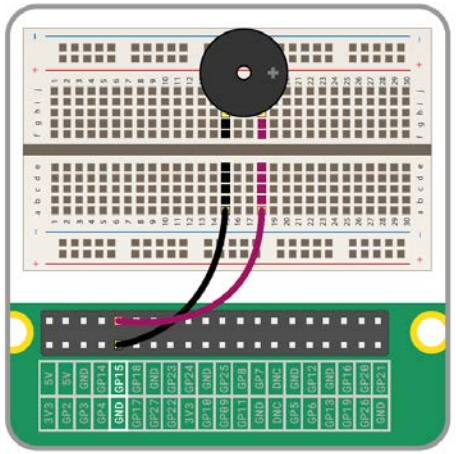
https://fritzing.org/projects/raspberry-pi-3

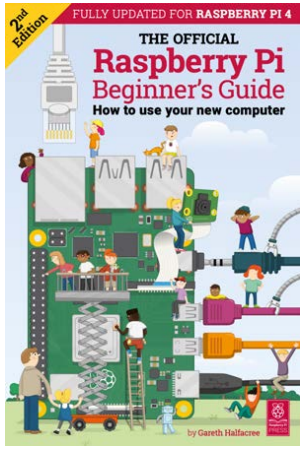


Rapid Prototyping
with Raspberry Pi

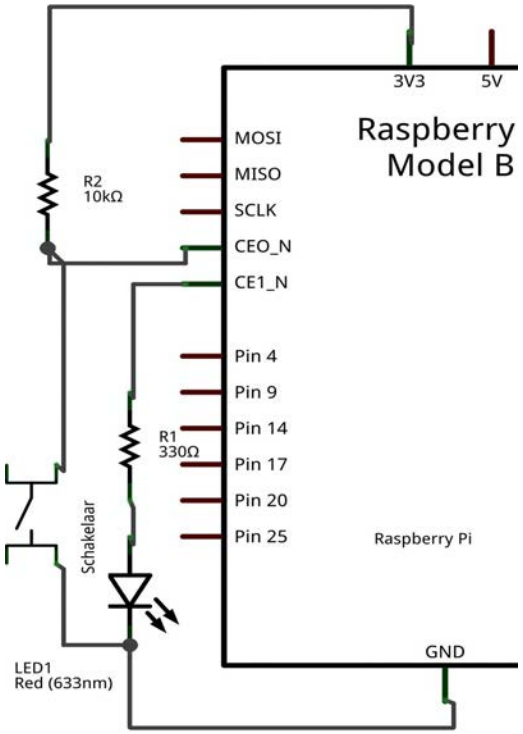
How It Works:

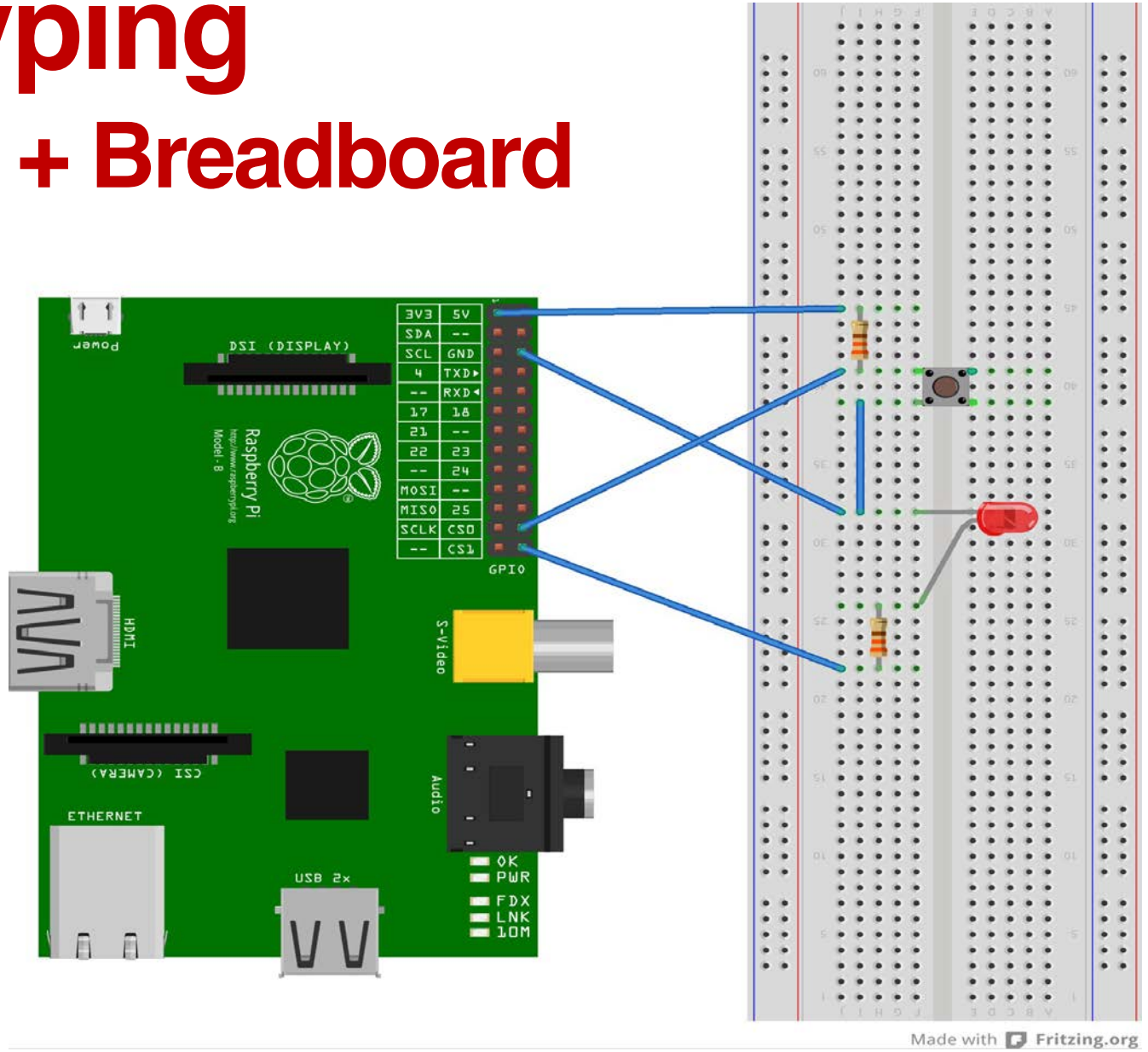
1 ASSEMBLE **2 WRITE** **3 UPLOAD**



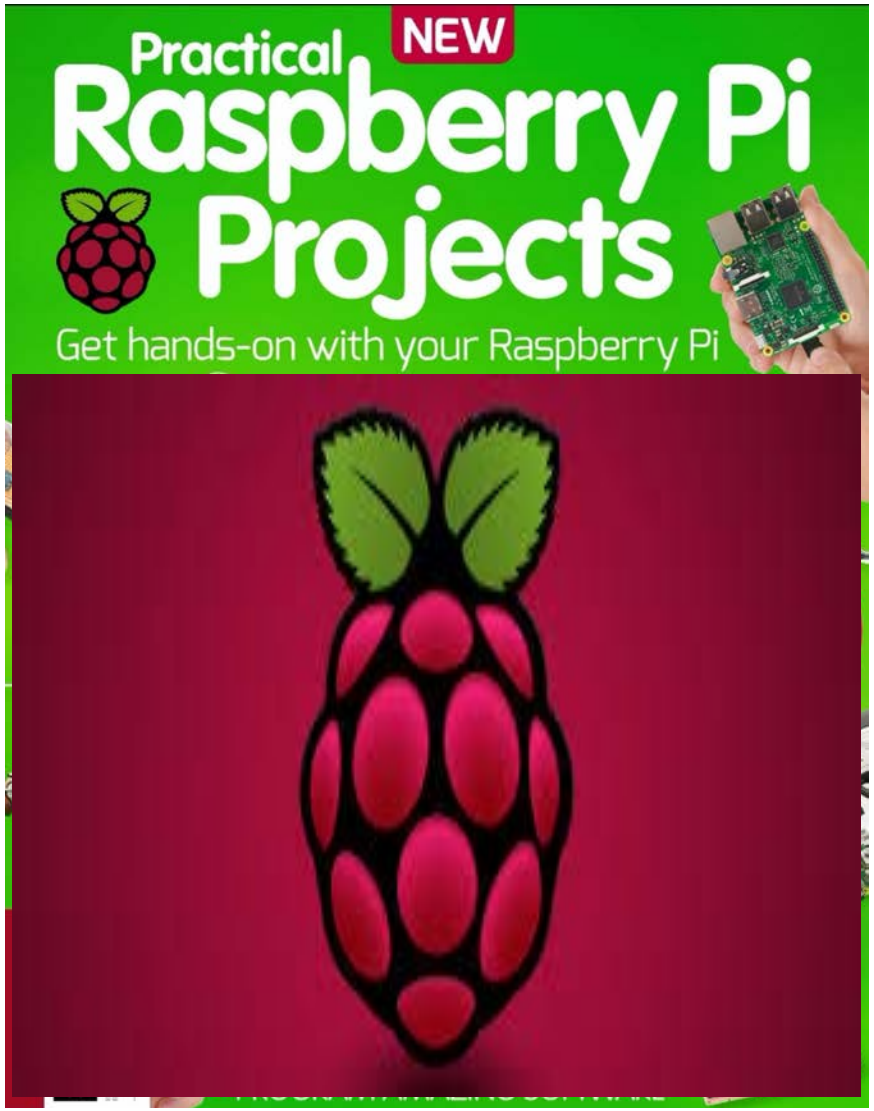


Rapid Prototyping
with Raspberry Pi + Breadboard





Raspberry Pi



Get interactive with Scratch

Experiment with physical computing by using Scratch to interact with buttons and lights on your Pi

What you'll need

- Breadboard
- LEDs
- Buttons
- Resistors
- Jumper wires
- ScratchGPIO3

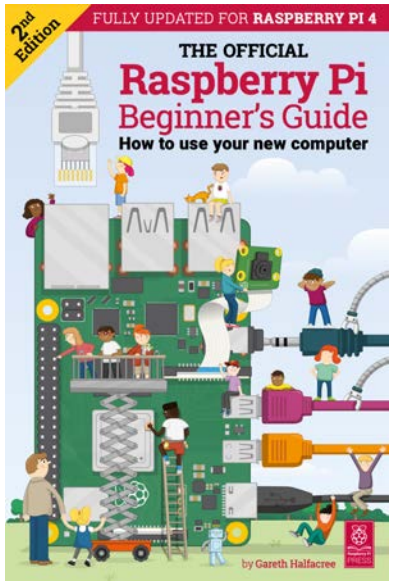
Scratch is a very simple visual programming language, commonly used to teach basic programming concepts to learners of any age. In this project we'll learn how to light up an LED when a button is pressed in Scratch, and then change a character's colour when a physical button is pressed. With these techniques you can make all manner of fun and engaging projects, from musical keyboards to controllers for your Scratch games and animations.

01 Installing the required software

Log into the Raspbian system with the username **Pi** and the password **raspberry**. Start the LXDE desktop environment using the command **startx**. Then open LXTerminal and type the following commands:

```
wget http://liamfraser.co.uk/lud/install_scratchgpio3.sh
chmod +x install_scratchgpio3.sh
sudo bash install_scratchgpio3.sh
```

This will create a special version of Scratch on your desktop called ScratchGPIO3. This is a normal version of Scratch with a Python script that handles communications between Scratch and the GPIO. ScratchGPIO was created by simplesi (cymplecy.wordpress.com).



Scratch can be used to do Internet Of Things projects with a few tweaks

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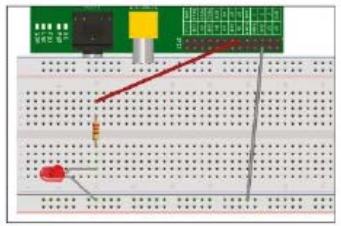


02 Connecting the breadboard

Power off your Pi and disconnect the power cable. Get your breadboard, an LED, a 330-ohm resistor and two GPIO cables ready. You'll want to connect the 3.3V pin (top-right pin, closest to the SD card) to one end of the 330-ohm resistor, and then connect the positive terminal of the LED (the longer leg is positive) to the other end. The resistor is used to limit the amount of current that can flow to the LED.

Then put the negative terminal of the LED into the negative rail of the breadboard. Connect one of the GROUND pins (for example, the third pin from the right on the bottom row of pins) to the negative lane. Now connect the power to your Pi. The LED should light up. If it doesn't, then it's likely that you've got it the wrong way round, so disconnect the power, swap the legs around and then try again.

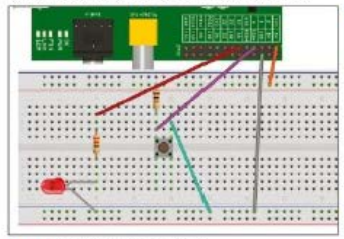
03 Switching the LED on and off

At the moment, the LED is connected to a pin that constantly provides 3.3V. This isn't very useful if we want to be able to turn it on and off, so let's connect it to GPIO 17, which we can turn on and off. GPIO 17 is the sixth pin from the right, on the top row of pins. Power the Pi back on. We can turn the LED on by exporting the GPIO pin, setting it to an output pin and then setting its value to 1. Setting the value to 0 turns the LED back off:

```
echo 17 > /sys/class/gpio/export
echo out > /sys/class/gpio/gpio17/direction
echo 1 > /sys/class/gpio/gpio17/value
echo 0 > /sys/class/gpio/gpio17/value
```

04 Controlling the LED from Scratch

Start the LXDE desktop environment and open ScratchGPIO3. Go to the control section and create a simple script that broadcasts **pin11on** when Sprite1 is clicked. Then click the sprite. The LED should light up. Then add to the script to wait 1 second and then broadcast **pin11off**. If you click the sprite again, the LED will come on for a second and then go off. ScratchGPIO3 uses pin numbers rather than GPIO numbers to identify pins. The top-right pin (the 3.3V we first connected our LED to) is pin number 1, the pin underneath that is pin number 2, and so on.



05 Wiring up our push button

Power off the Pi again. This circuit is a little bit more complicated than the LED one we created previously. The first thing we need to do is connect 3.3V (the top-right pin we used to test our LED) to the positive rail of the breadboard. Then we need to connect a 10Kohm resistor to the positive rail, and the other end to an empty track on the breadboard. Then on the same track, add a wire that has one end connected to GPIO 4. This is two pins to the right of GPIO 17. Then, on the same track again, connect one pin of the push button. Finally, connect the other pin of the push button to ground by adding a wire that is connected to the same negative rails that ground is connected to.

When the button is not pressed, GPIO 4 will be receiving 3.3V. However, when the button is pressed, the circuit to ground will be completed and GPIO 4 will be receiving 0V (and have a value of 0), because there is much less resistance on the path to ground.

We can see this in action by watching the pin's value and then pressing the button to make it change:

```
echo 4 > /sys/class/gpio/export
echo in > /sys/class/gpio/gpio4/direction
watch -n 0.5 cat /sys/class/gpio/gpio4/value
```

06 Let there be light!

Boot up the Pi and start ScratchGPIO3 as before. Go to the control section and add **when green flag clicked**, then attach a **forever** loop, and inside that an **if else** statement. Go to the operators section and add an **if [] = []** operator to the **if** statement. Then go to the sensing section and add a value sensor to the left side of the equality statement, and set the value to pin7. On the right side of the equality statement, enter **0**. Broadcast **pin11on** if the sensor value is 0, and broadcast **pin11off** otherwise. Click the green flag. If you push the button, the LED will light up!

You'll learn...

1. Simple circuits
While these are very simple circuits, you'll get a great feel of how the Raspberry Pi interfaces with basic prototyping kit. If you need to buy the bits and pieces, we recommend you check out: shop.pimoroni.com

2. Coding principles
If you're new to programming, Scratch is the perfect place to learn the same programming principles employed by all programming languages.

3. Physical computing
There's nothing more magical than taking code from your computer screen and turning it into a real-life effect. Your first project might just turn a light on and off, but with that skill banked, the sky is the limit.

Things you should Do

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To Do's

DIY Blinking an LED on the Raspberry Pi

https://embeddedcode.wordpress.com/2017/01/18/blinking-an-led-on-the-raspberry-pi/

Do it yourself (DIY) : Make a LED blinking

Raspberry Pi, Power Supply,

microSD Card with Raspbian Installed and Setup,

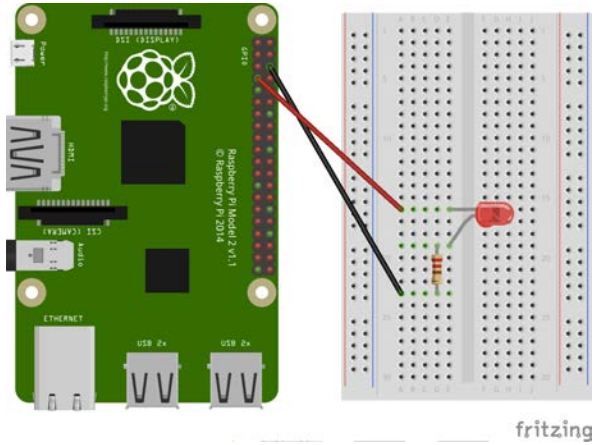
Internet connectivity (Optional),

Bread board,

connecting wires,

an LED 5mm of preferred colour

and a resistor of 220Ohms



LEARNING OBJECTIVES

In this Rapid prototyping experiment,
You will learn the essentials of Raspberry Pi GPIO control by toggling an LED at predefined intervals of time.

KEY WORDS, CONCEPTS, & PRACTICES

+ LED
+ Resistor
+ GPIO
+ Rapid Prototyping
+ Coding (Python)

Reminder lesson 01

1st STEP Managing Data Science for IoT Projects

➔➔➔Getting started with GitHub➔➔➔

A Computational Thinking culture has an intellectual dimension, engaging with a set of creative concepts and practices. It has a physical dimension, encouraging interactions with others through the placement of desks, chairs, and computers. Most importantly, it has an affective dimension, cultivating a sense of confidence and fearlessness.

LEARNING OBJECTIVES

Students will:

+ be introduced to the concept of computational Thinking, in the context of GitHub
+ be able to imagine possibilities for their own GitHub-based computational thinking
+ become familiar with resources that support their computational thinking
+ prepare for creating GitHub projects by establishing a GitHub account, exploring GitHub, creating design journals

KEY WORDS, CONCEPTS, & PRACTICES

+ GitHub
+ Computational Thinking

Preview
lesson Three

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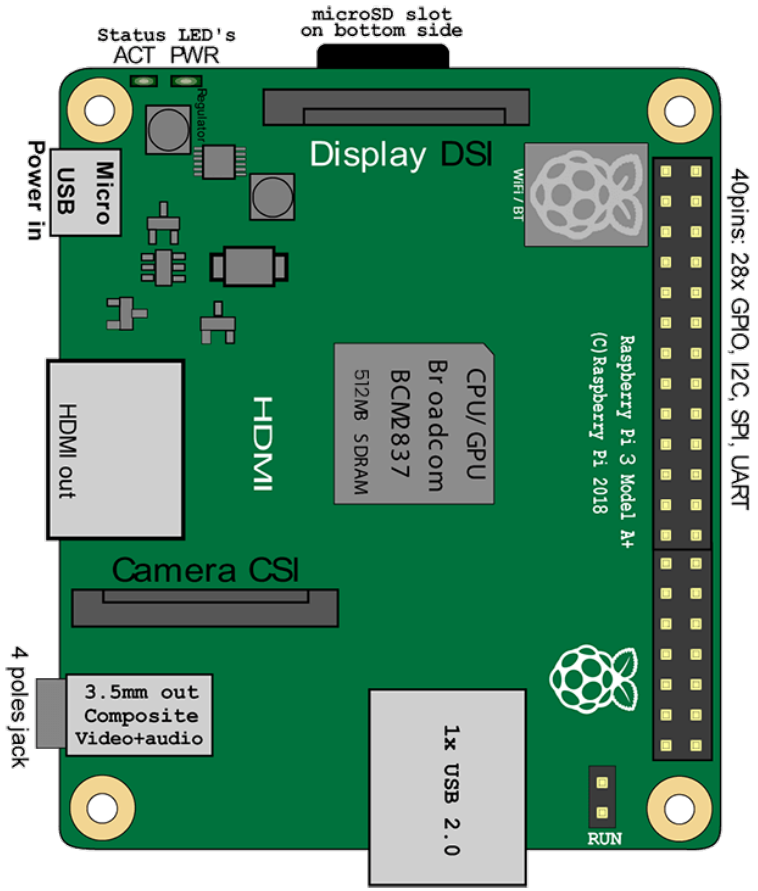
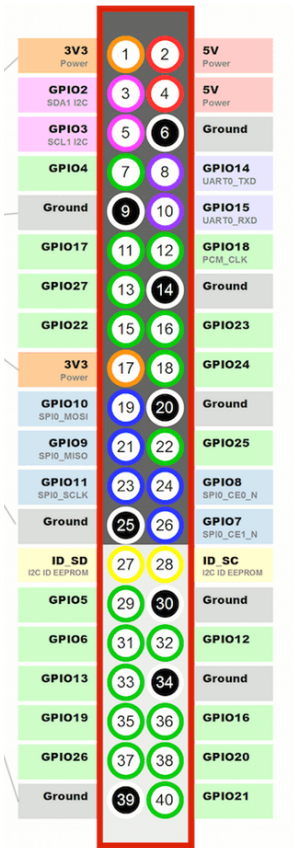
Raspberry Py 3A+



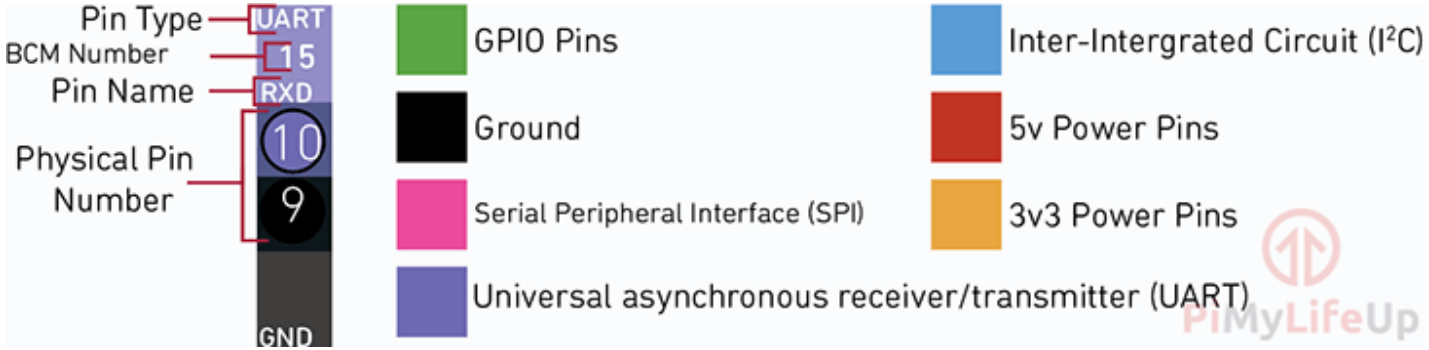


Here we have included some schematics of the Raspberry Pi 3 A Plus hardware.
These schematics show the general positioning of all the vital circuitry on the board.
The Raspberry Pi 3 A+ is a cut down version of the Pi 3B. As you can tell by its diagram, it features a single USB 2.0 Port. It's only means of network connectivity is the inbuilt Wi-Fi.

CPU: 1.4 GHz quad core ARM Cortex-A53
GPU: 250MHz Broadcom VideoCore IV
RAM: 512mb (Shared with GPU)
Storage: Micro SD
USB 2.0 Ports: 1
USB 3.0 Ports: 0
Networking: 802.11b/g/n/ac dual band 2.4/5 GHz wireless, Bluetooth 4.2 LS BLE
Video Input: 15-pin MIPI camera interface (CSI) connector
Video Ouputs: HDMI 1.3, MIPI display interface, DSI
Audio Inputs: Audio over I2S
Audio Outputs: 3.5mm phone jack, Digital Audio via HDMI
Low-Level peripherals: 17 x GPIO, +3.3v, +5v, ground, Plus the following that can be used as GPIO: UART, I2C Bus, SPI bus with two chip select, I2S audio
Power Source: 5v via MicroUSB or GPIO header
Size: 65.00mm x 56.50mm x 17mm
Weight: 23 g (0.81 oz)

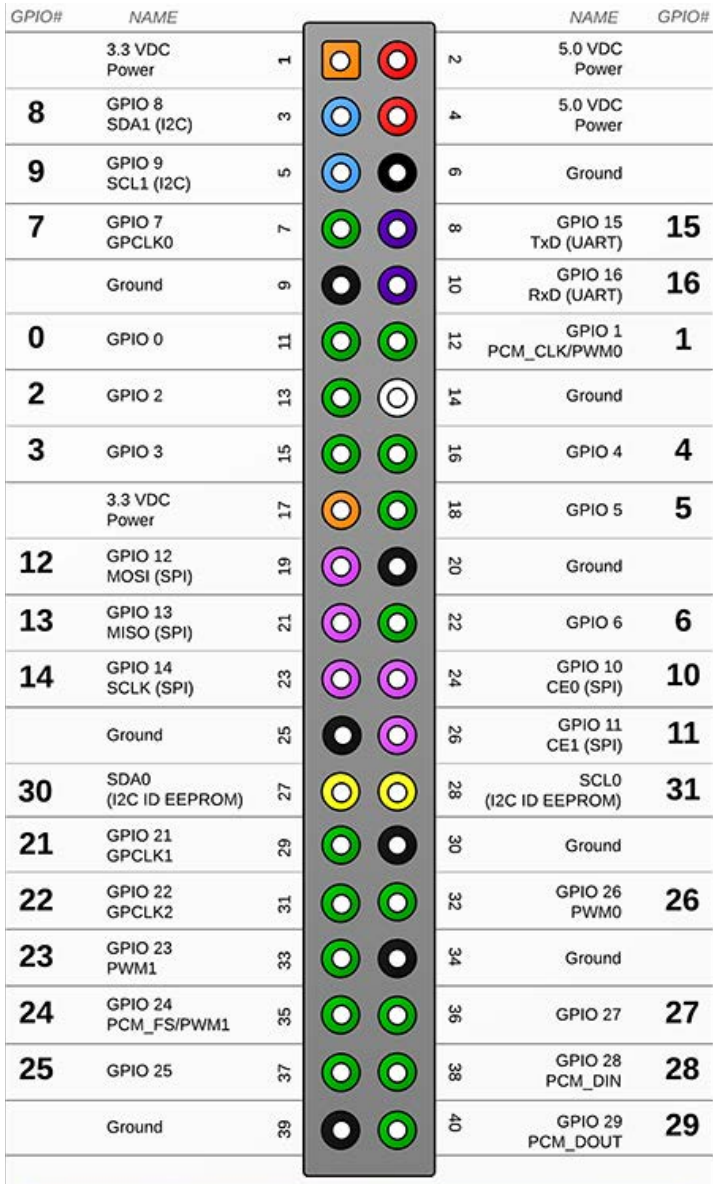
GPIO (general-purpose input/output)

connecting to the outside world



https://pimylifeup.com/raspberry-pi-3-a-plus/

GPIO pins groups on the Raspberry 3



GPIO#	NAME				NAME	GPIO#
	3.3 VDC Power	1	2		5.0 VDC Power	
8	GPIO 8 SDA1 (I2C)	3	4		5.0 VDC Power	
9	GPIO 9 SCL1 (I2C)	5	6		Ground	
7	GPIO 7 GPCLK0	7	8		GPIO 15 TxD (UART)	15
	Ground	9	10		GPIO 16 RxD (UART)	16
0	GPIO 0	11	12		GPIO 1 PCM_CLK/PWM0	1
2	GPIO 2	13	14		Ground	
3	GPIO 3	15	16		GPIO 4	4
	3.3 VDC Power	17	18		GPIO 5	5
12	GPIO 12 MOSI (SPI)	19	20		Ground	
13	GPIO 13 MISO (SPI)	21	22		GPIO 6	6
14	GPIO 14 SCLK (SPI)	23	24		GPIO 10 CE0 (SPI)	10
	Ground	25	26		GPIO 11 CE1 (SPI)	11
30	SDA0 (I2C ID EEPROM)	27	28		SCL0 (I2C ID EEPROM)	31
21	GPIO 21 GPCLK1	29	30		Ground	
22	GPIO 22 GPCLK2	31	32		GPIO 26 PWM0	26
23	GPIO 23 PWM1	33	34		Ground	
24	GPIO 24 PCM_FS/PWM1	35	36		GPIO 27	27
25	GPIO 25	37	38		GPIO 28 PCM_DIN	28
	Ground	39	40		GPIO 29 PCM_DOUT	29

https://pi4j.com/1.1/pins/model-3b-rev1.html

•**Power:** Pins that are labeled 5.0v supply 5 volts of power and those labeled 3V3 supply 3.3 volts of power. There are two 5V pins and two 3V3 pins.
•**GND:** These are the ground pins. There are eight ground pins.

•**Input/Outputpins**: These are the pins labeled with the # sign, for example, #17, #27, #22, etc. These pins can be used for input or output.

•**I2C:** I2C is a serial protocol for a two-wire interface to connect low-speed devices like microcontrollers, EEPROMs, A/D and D/A converters, I/O interfaces, and other similar peripherals in embedded systems. These pins are labeled **SDA** and **SCL**.

•**UART:** The **Universal Asynchronous Receiver/Transmitter** allows your Raspberry Pi to be connected to serial peripherals. The UART pins are labeled **TXD**and **RXD**.

•**SPI:** The **Serial Peripheral Interface** is a synchronous serial communication interface specification used for short distance communication, primarily in embedded systems. The SPI pins are labeled **MOSI**, **MISO**, **SCLK**, **CE0**, and **CE1**.

•**ID EEPROM:Electrically Erasable Programmable Read-Only Memory** is a user-modifiable read-only memory that can be erased and written to repeatedly through the application of higher than normal electrical voltage. The two EEPROM pins on the Raspberry Pi (**EED** and **EEC**) are also secondary I2C ports that primarily facilitate the identification of Pi Plates (e.g., Raspberry Pi Shields/Add-On Boards) that are directly attached to the Raspberry Pi.

GPIO general purpose IO

Voorgedefinieerde pennen

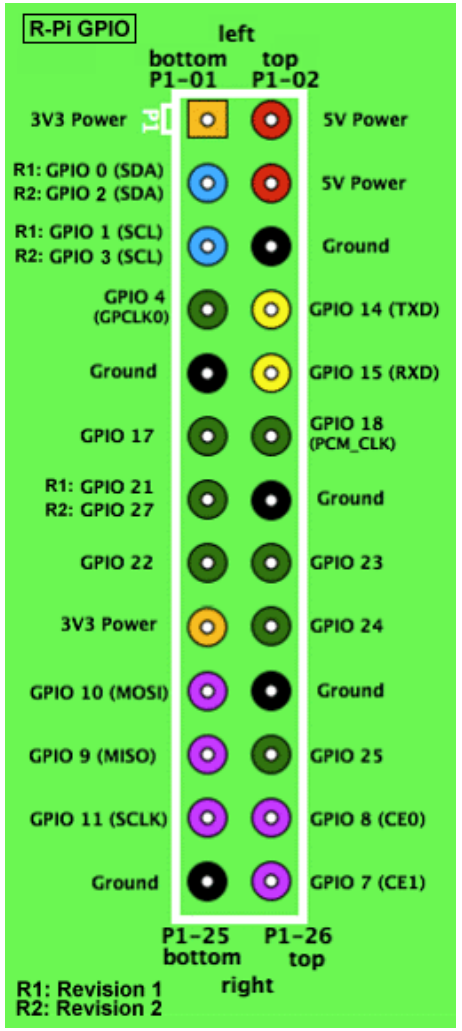
- 0V, 3.3V, 5V, Transmit, Receive
- I2C, 1-Wire

Vrijbeschikbare pennen

- GPIO 4, 17, 18, 8, 7

Naamgeving

- Pinnummer van connector P1
- Broadcom documentatie van de SoC (System on Chip)



GPIO

Voordat je iets aansluit

- input maximaal 3.3V
  - let met name op de 5V van pin 2 en 4
- output maximaal 16 mA
  - LED over 330 Ω weerstand mag
  - motortje heeft een buffer nodig (ULN2003)
- totale output maximaal 50 mA

Programmeren

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Schrijven (led laten knipperen)

- Eerst: GPIO pennetje definieren als output
- Dan: herhaaldelijk schrijven

Pennetje 26 = GPIO 7

Lezen (schakelaar uitlezen)

- Eerst: GPIO pennetje definieren als input
- Dan: herhaaldelijk lezen

Pennetje 24 = GPIO 8

Programmeren (bash)

- bash is de Linux command line interpreter
- als root in directory /sys/class/gpio werken
- GPIO 7 voor uitvoer

```
echo "7" >/sys/class/gpio/export
echo "out" >/sys/class/gpio/gpio7/direction
```

- led aan (1), led uit (0)

```
echo   "1"      > /sys/class/gpio/gpio7/value
echo   "0"      > /sys/class/gpio/gpio7/value
```

Programmeren (bash)

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Knipperen

```
while sleep 0.5
do echo "1" > /sys/class/gpio/gpio7/value  sleep  0.5
   echo "0" > /sys/class/gpio/gpio7/value  done
```

GPIO 8 voor invoer

```
echo "8" > /sys/class/gpio/export
echo "in" > /sys/class/gpio/gpio8/direction
```

eenmalig lezen

```
cat /sys/class/gpio/gpio8/value
```

Programmeren (bash)

herhaald lezen

```
while sleep 0.1
do cat /sys/class/gpio/gpio8/value
done
```

opruimen

```
echo "7"      > /sys/class/gpio/unexport
echo "8"      > /sys/class/gpio/unexport
```

Programmeren (python)

Pi in Raspberry Pi staat voor Python

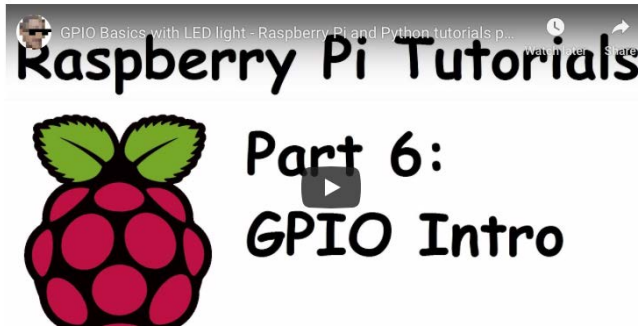
Standaard modules en bibliotheken

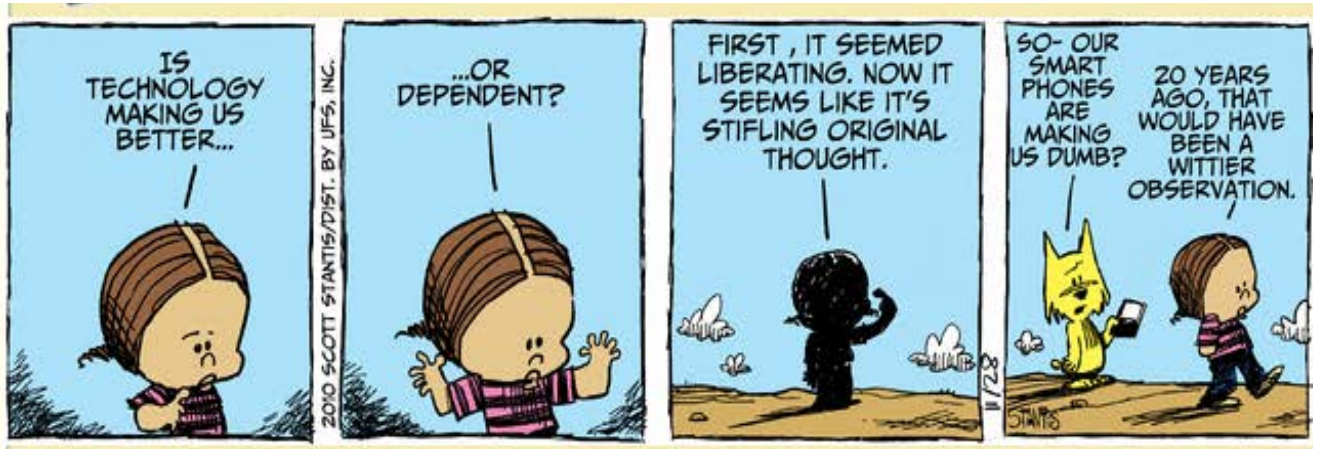
- keuze in naamgeving pennetjes / meer functies
- https://pythonprogramming.net/gpio-raspberry-pi-tutorials/

RPi.GPIO

- standaard onderdeel van Raspbian
- https://pypi.org/project/RPi.GPI

GPIO (General Purpose Input Output) Pins - Raspberry Pi tutorial





This lesson was developed by:
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NOV 2019

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