IoT Security and Privacy

Create IoT devices with Raspberry Pi

Learning Outcomes

Upon completion of this unit:

1. Students will master the use of Raspberry Pi

2. Students will understand basic circuits interacting with Raspberry Pi

3. Students will master programming Raspberry Pi

Outline

- Overview
- Setup and configurations
- 10 Use of Raspberry Pi
- Breadboard
- GPIO
- Sample use: Control LED
- Sample use: Read PIR motion sensor

What is a Raspberry Pi?

- University of Cambridge’s Computer Laboratory
  - Decline in skill level
  - Designed for education
- A credit card sized PC
- Plugs into a TV or monitor
- Inexpensive <$40 each
- Capability:
  - Programming
  - Electronic Projects
  - Office
  - Play HD Videos

Different Versions

- Raspberry Pi 3 model B
- Raspberry Pi 2 model B
- Raspberry Pi model B+
- Raspberry Pi model A+
- Raspberry Pi Zero W
- Raspberry Pi Zero

Components

- Essential components
  - *Raspberry Pi 3 with WiFi (or USB WiFi dongle for old models)*
  - *Prepared Operating System SD Card*
  - USB keyboard
  - USB mouse
  - Display (HDMI, DVI, or composite input (TV cable), *DSI touch screen*)
  - *Power Supply*
- Highly suggested extras
  - Internet connectivity - LAN cable
  - *Case*
  - *Breadboard*
  - *Sensors*
  - *Wires*

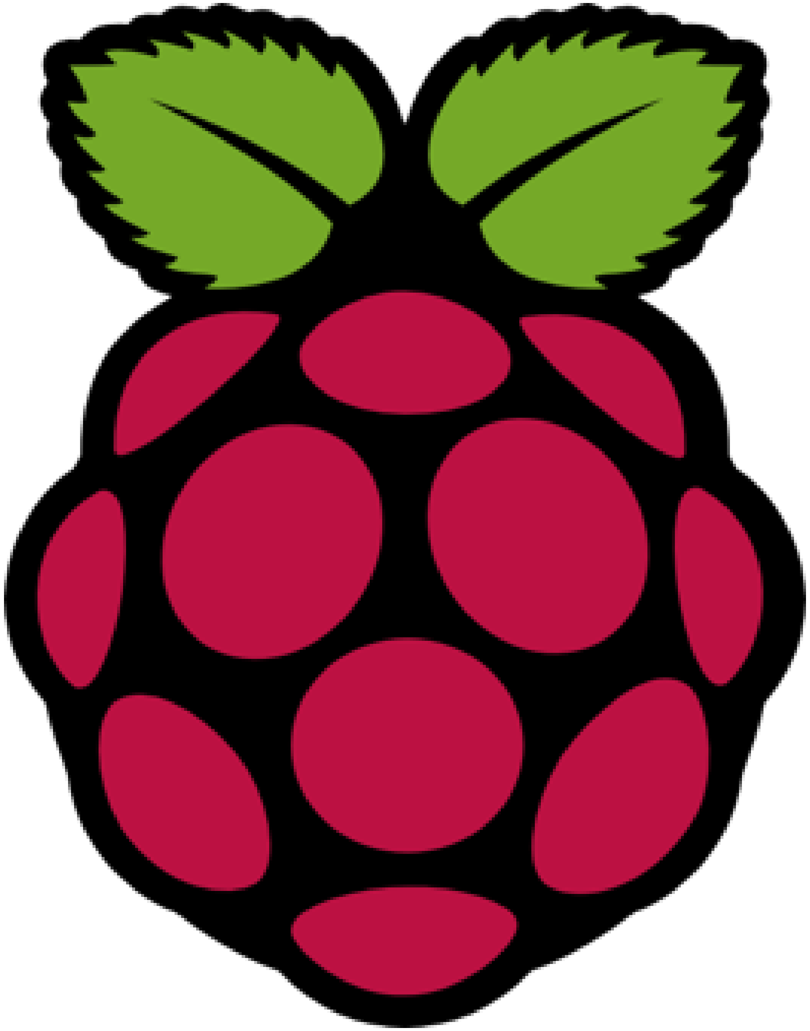
Programming Languages

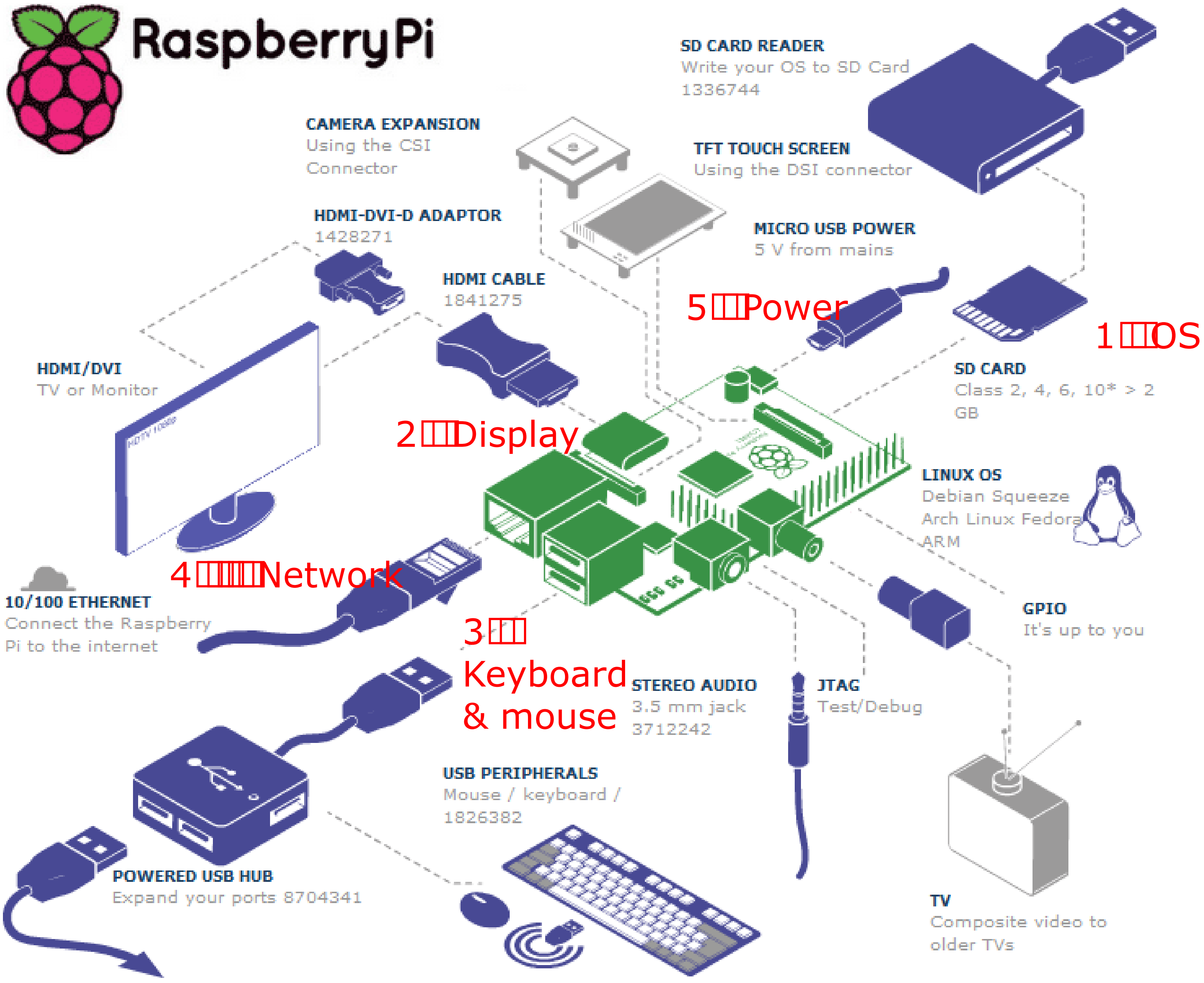
- Any language which will compile for the ARM chip used in the Pi
- Python
- C
- C++
- Java
- Scratch
- Ruby

Outline

- Overview
- Setup and configurations
- 10 Use of Raspberry Pi
- Breadboard
- GPIO
- Sample use: Control LED
- Sample use: Read PIR motion sensor

Setup





RaspberryPi

SD CARD READER
Write your OS to SD Card
1336744

CAMERA EXPANSION
Using the CSI
Connector

TFT TOUCH SCREEN
Using the DSI connector

HDMI-DVI-D ADAPTOR
1428271

MICRO USB POWER
5 V from mains

HDMI CABLE
1841275

5□□Power

1□□OS

HDMI/DVI
TV or Monitor

SD CARD
Class 2, 4, 6, 10* > 2
GB

2□□Display

LINUX OS
Debian Squeeze
Arch Linux Fedora
ARM

4□□□□Network

10/100 ETHERNET
Connect the Raspberry
Pi to the internet

GPIO
It's up to you

3□□
Keyboard
& mouse

STEREO AUDIO
3.5 mm jack
3712242

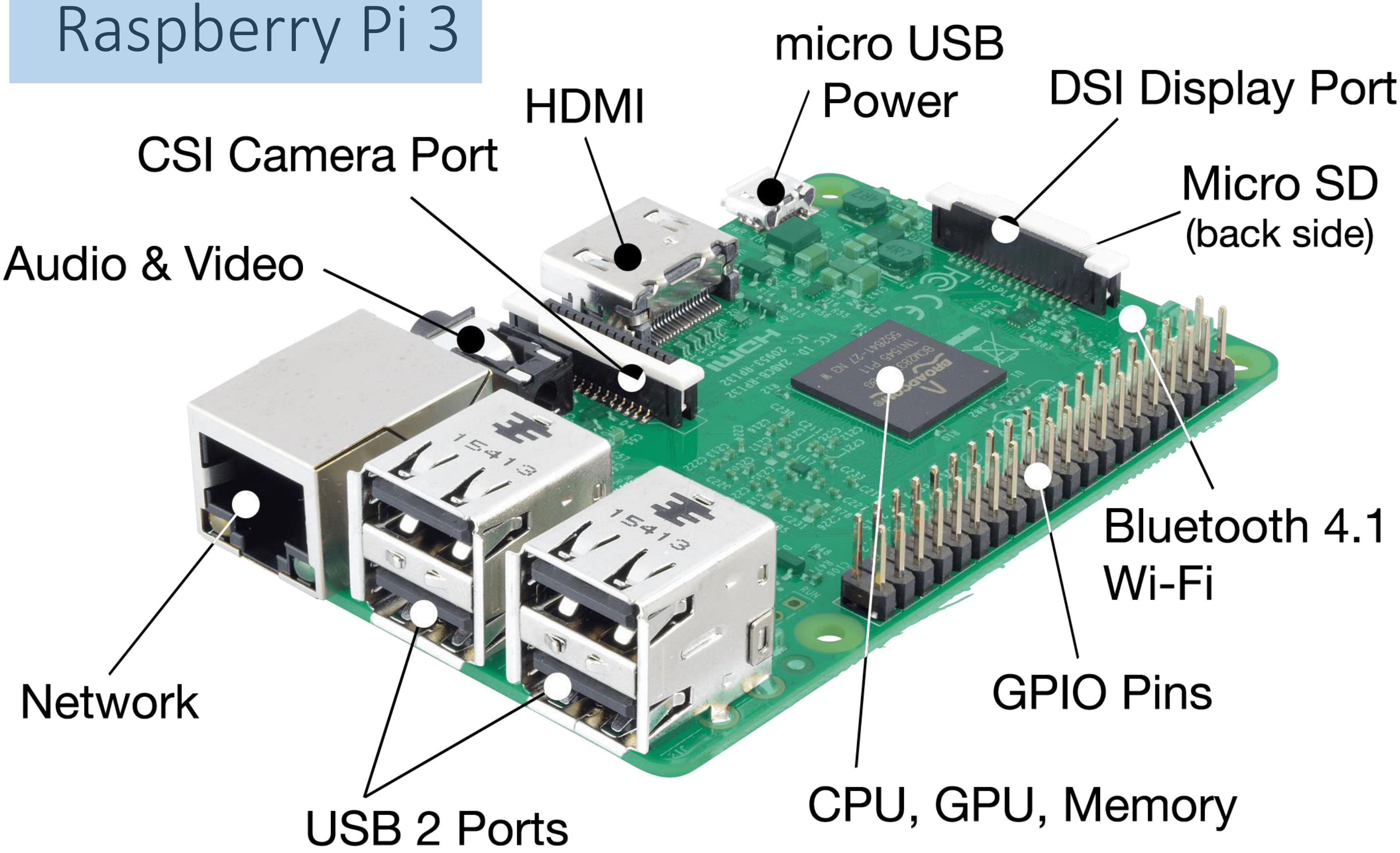
JTAG
Test/Debug

USB PERIPHERALS
Mouse / keyboard /
1826382

POWERED USB HUB
Expand your ports 8704341

TV
Composite video to
older TVs

Raspberry Pi 3



Configurations

- Booting Up for the First Time
  - Choose OS (Raspbian – recommended)
  - Configure to use the Whole SD Card
  - Change Timezone
  - Boot into Desktop
- Run the configuration later
  - *sudo raspi-config*
  - Or use the GUI
- Network setup
  - Using a Wired Network
  - USB WiFi Adapter/Onboard WiFi

Software Packages to Use I/O (Input/Output)

- GPIO setup: install Python library *Rpi.GPIO*
  1. *sudo apt-get update*
  2. *sudo apt-get install python-dev*
  3. *sudo apt-get install python-rpi.gpio*
- I2C: A standard for chips talking to each other
  - Multiple devices to Raspberry Pi through I2C bus
  - Unique address for each device through jumper settings
  - To use with Pi: Enable kernel support from rasp-config
- Install the i2c-tools utility.
  1. *sudo apt-get update*
  2. *sudo apt-get install python-smbus*
  3. *sudo apt-get install i2c-tools*
  - Test I2C devices: sudo i2cdetect -y 1

Sample Starter Kits

- CanaKit Raspberry Pi 2 Ultimate Starter Kit with WiFi $84.99

- Raspberry Pi 2 Model B Starter Pack - Includes a Raspberry Pi 2 $99.95

Outline

- Overview
- Setup and configurations
- 10 Use of Raspberry Pi
- Breadboard
- GPIO
- Sample use: Control LED
- Sample use: Read PIR motion sensor

Example Use

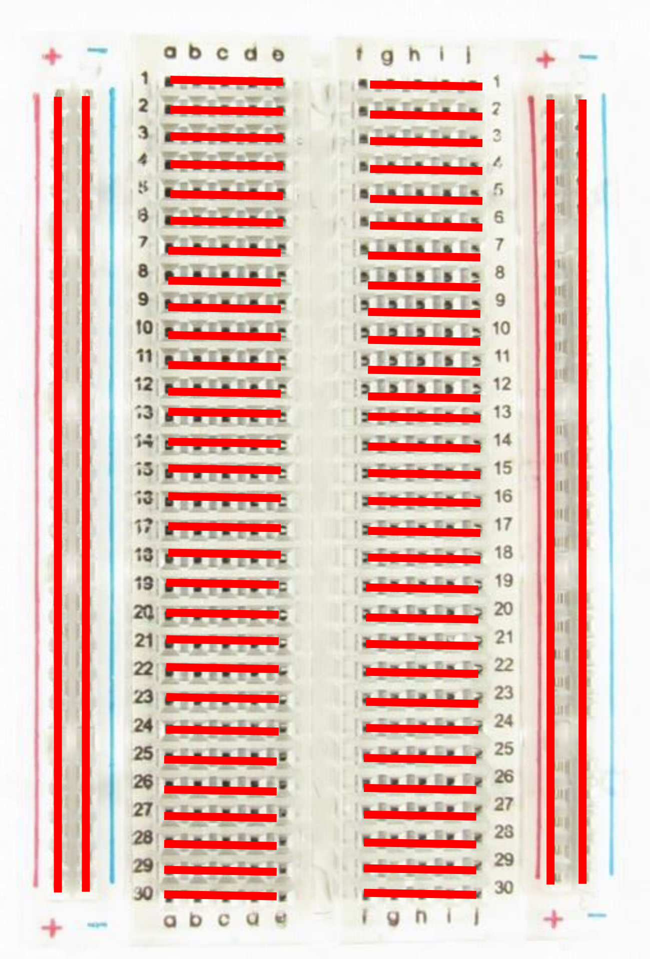
- Office: LibreOffice
- Programming: Python, Scratch
- Game console
- Web server: Apache
- Tor router
- HTPC - A home theater PC (HTPC) or media center computer
- Bird house
- Super computer
- Clock
- PiBot

Outline

- Overview
- Setup and configurations
- 10 Use of Raspberry Pi
- Breadboard
- GPIO
- Sample use: Control LED
- Sample use: Read PIR motion sensor

How A Breadboard Works

- A grid of holes on a plastic board
- Internal metal strips underlining the holes as jumper wires
  - Connecting specific rows or columns of holes.
- Electric component leads and wires are inserted into the holes
  - Wires connect electric component leads
- Building circuits with a breadboard: stick components and wires into the holes.

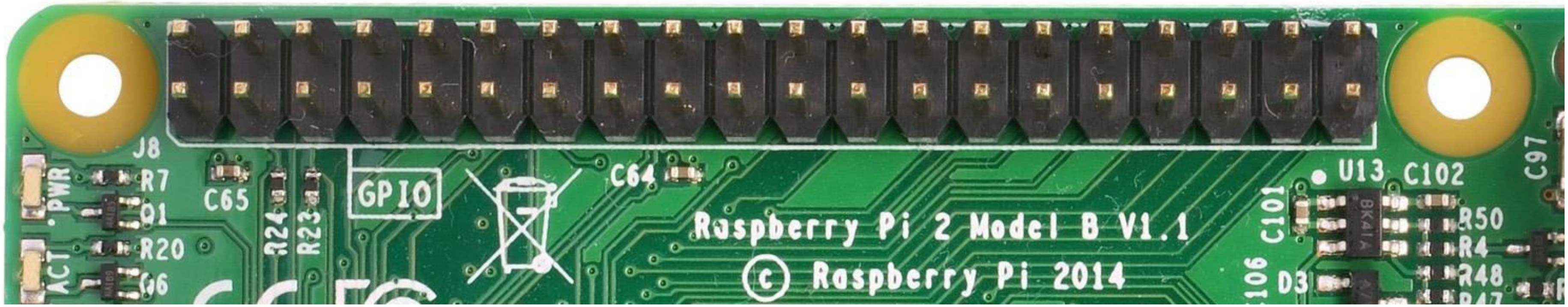


Outline

- Overview
- Setup and configurations
- 10 Use of Raspberry Pi
- Breadboard
- GPIO
- Sample use: Control LED
- Sample use: Read PIR motion sensor

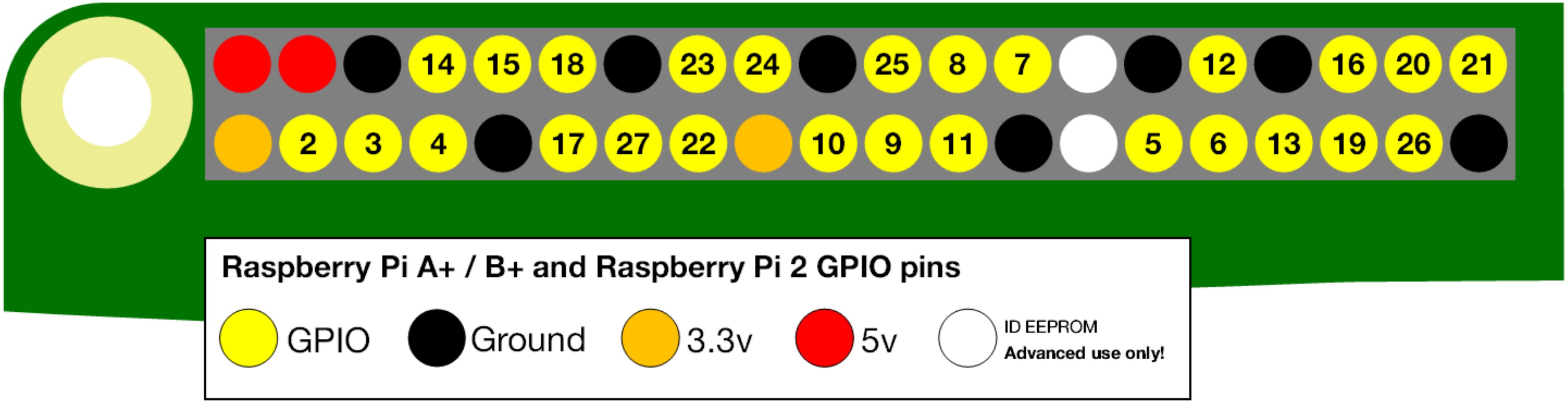
GPIO: MODELS A+, B+ AND RASPBERRY PI 2, 3

- Physical interface between the Pi and the outside world.
- Can be viewed as switches
  - that you can turn on or off (input)
  - or that the Pi can turn on or off (output).



GPIO Pins

- 40 pins on the board
  - 26 GPIO pins
  - Others are power or ground pins



🟥	🟥	⚫	14	15	18	⚫	23	24	⚫	25	8	7	⚪	⚫	12	⚫	16	20	21
🟧	2	3	4	⚫	17	27	22	🟧	10	9	11	⚫	⚪	5	6	13	19	26	⚫

Raspberry Pi A+ / B+ and Raspberry Pi 2 GPIO pins

🟨 GPIO ⚫ Ground 🟧 3.3v 🟥 5v ⚪ ID EEPROM **Advanced use only!**

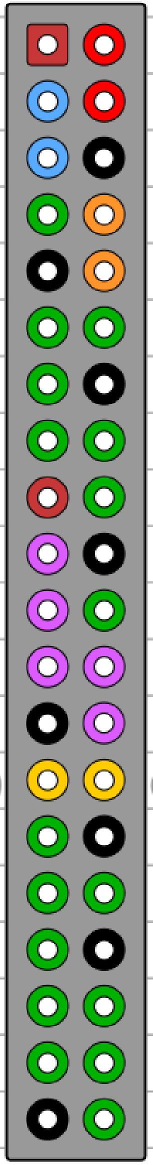
Use of GPIO Pins

- Program the pins to interact in various ways
- Input to a pin from a sensor, another computer or device
  - For example, from a motion sensor
- Output from a pin can do
  - Turn on an LED
  - Send a signal or data to another device.
- A networked Raspberry Pi
  - Remote control of attached physical devices
  - Receiving data from those devices

Pin Numbering

- GPIO NUMBERING
  - Seen by the onboard computer
- PHYSICAL NUMBERING
  - Counting across and down from pin 1 at the top left

Raspberry Pi 3 GPIO Header



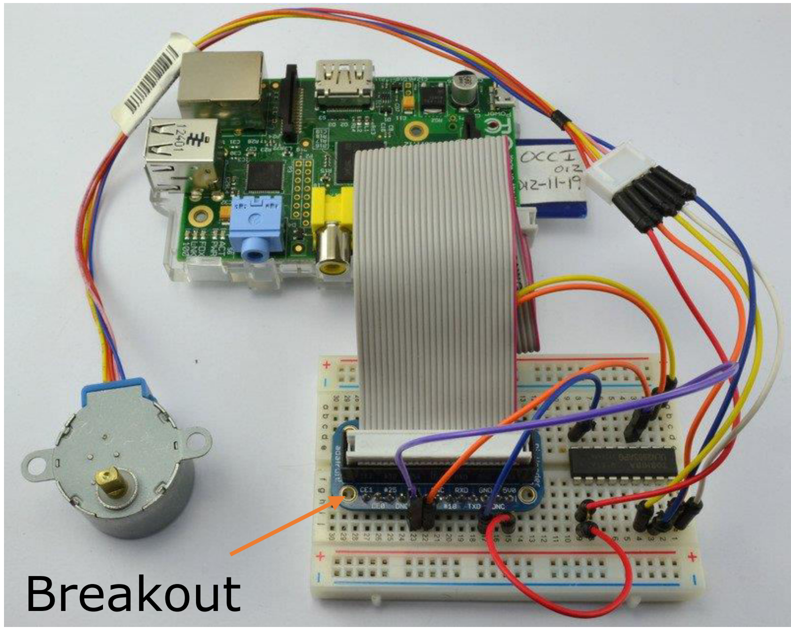
Pin#	NAME	NAME	Pin#
01	3.3v DC Power	DC Power 5v	02
03	GPIO02 (SDA1 , I^{2}C)	DC Power 5v	04
05	GPIO03 (SCL1 , I^{2}C)	Ground	06
07	GPIO04 (GPIO_GCLK)	(TXD0) GPIO14	08
09	Ground	(RXD0) GPIO15	10
11	GPIO17 (GPIO_GEN0)	(GPIO_GEN1) GPIO18	12
13	GPIO27 (GPIO_GEN2)	Ground	14
15	GPIO22 (GPIO_GEN3)	(GPIO_GEN4) GPIO23	16
17	3.3v DC Power	(GPIO_GEN5) GPIO24	18
19	GPIO10 (SPI_MOSI)	Ground	20
21	GPIO09 (SPI_MISO)	(GPIO_GEN6) GPIO25	22
23	GPIO11 (SPI_CLK)	(SPI_CE0_N) GPIO08	24
25	Ground	(SPI_CE1_N) GPIO07	26
27	ID_SD (I^{2}C ID EEPROM)	(I^{2}C ID EEPROM) ID_SC	28
29	GPIO05	Ground	30
31	GPIO06	GPIO12	32
33	GPIO13	Ground	34
35	GPIO19	GPIO16	36
37	GPIO26	GPIO20	38
39	Ground	GPIO21	40

Rev. 2
29/02/2016

www.element14.com/RaspberryPi

Warning

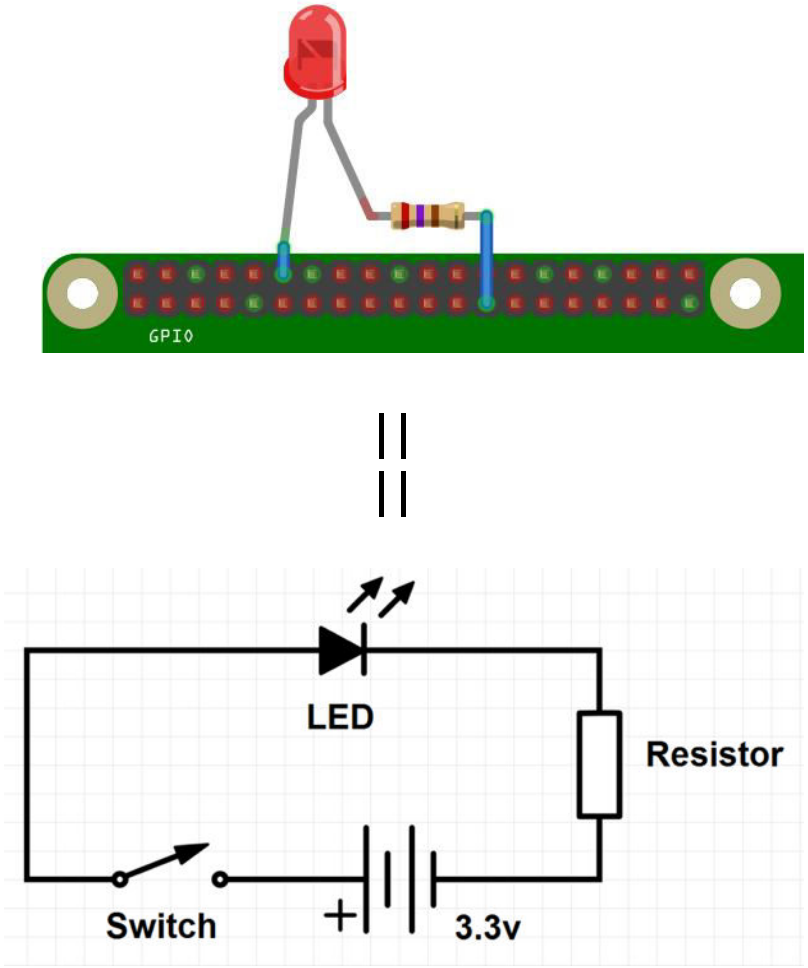
- **Unknowingly plugging wires and power sources may damage Pi** when connecting power hungry things to a Pi
  - LEDs are fine,
  - motors are not.
- For caution and ease of use, use a breakout board like Pibrella Until you become familiar with Pi
  - Labeled pins (otherwise needs a diagram)
  - Maybe protection circuit



Breakout board

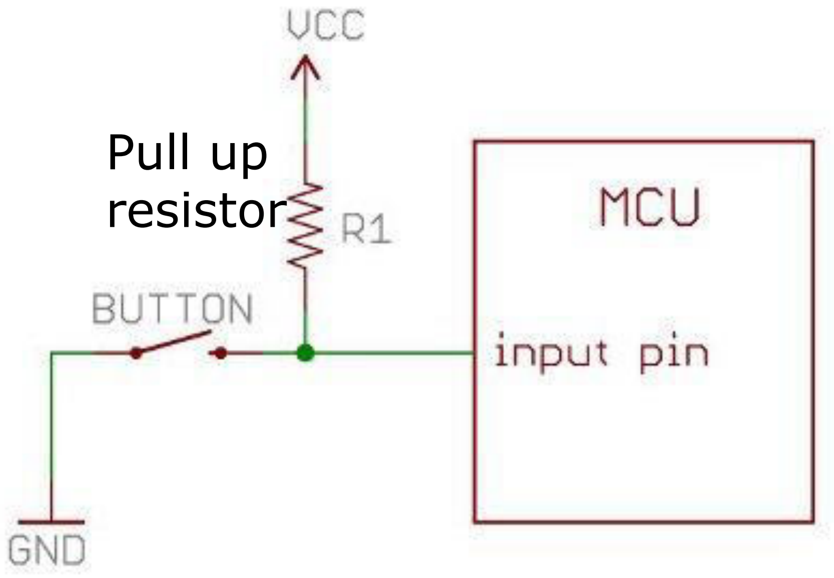
Output

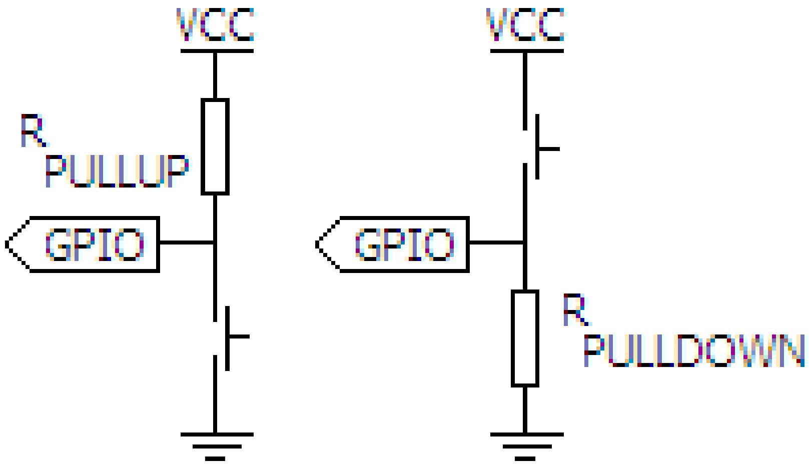
- GPIO pin **outputs** are 3v3 or 0v
  - Can be called **on** or **off**, **HIGH** or **LOW**
  - Each pin can turn on or off
- Example use
  - Raspberry Pi as **the switch and the battery** in the left diagram.



INPUT

- GPIO pins are the simplest I/O on microcontrollers
- "pull up" and "pull down" circuits give an input pin a reference
  - In a case that the switch is off
  - To differentiate noise from signal
- **The input mode of a GPIO pin has high impedance**





Outline

- Overview
- Setup and configurations
- 10 Use of Raspberry Pi
- Breadboard
- GPIO
- Sample use: Control LED
- Sample use: Read PIR motion sensor

Program with Python to Control LED

- Open **Terminal** application
  - Click the terminal icon on the taskbar or
  - **Main Menu** -> **Accessories** -> **Terminal**.
- Open editor **idle3**: sudo idle3 & and press
- Create a Python file within idle3
  - **File** -> **new window**.
  - *File -> New Window*.
  - *File -> Save As* **reaction.py**
  - Type the code
  - Save the file: *File -> Save*.
- Run the code: **Run** -> **Run Module** or by pressing F5

Run Python File from the Command Line

- Run Python 2
  - python reaction.py

- Run python3
  - Python3 reaction.py

Python [7]

- Hello world
  - print("Hello world")
- Indentation
  - Indicate a block of code
  - 4 blank spaces in tradition
- Variables
  - Assignment like c with no need of type definition
  - Type can be changed
- Comments
  - Single line #
  - Multi-line: triple quotes “”” comments “””

Python [7] (Cont’d)

- Lists (like array)
  - Mylist=[7, 8, 9]

- Iteration
  - for

```
N= [1, 2, 3]
for n in N:
    print(n)
```

- Range

```
for i in range(5):
    print(i)
```

- if statement

```
name = "Joe"
if len(name) > 3:
    print("Nice name,")
    print(name)
else:
    print("That's a short name,")
    print(name)
```

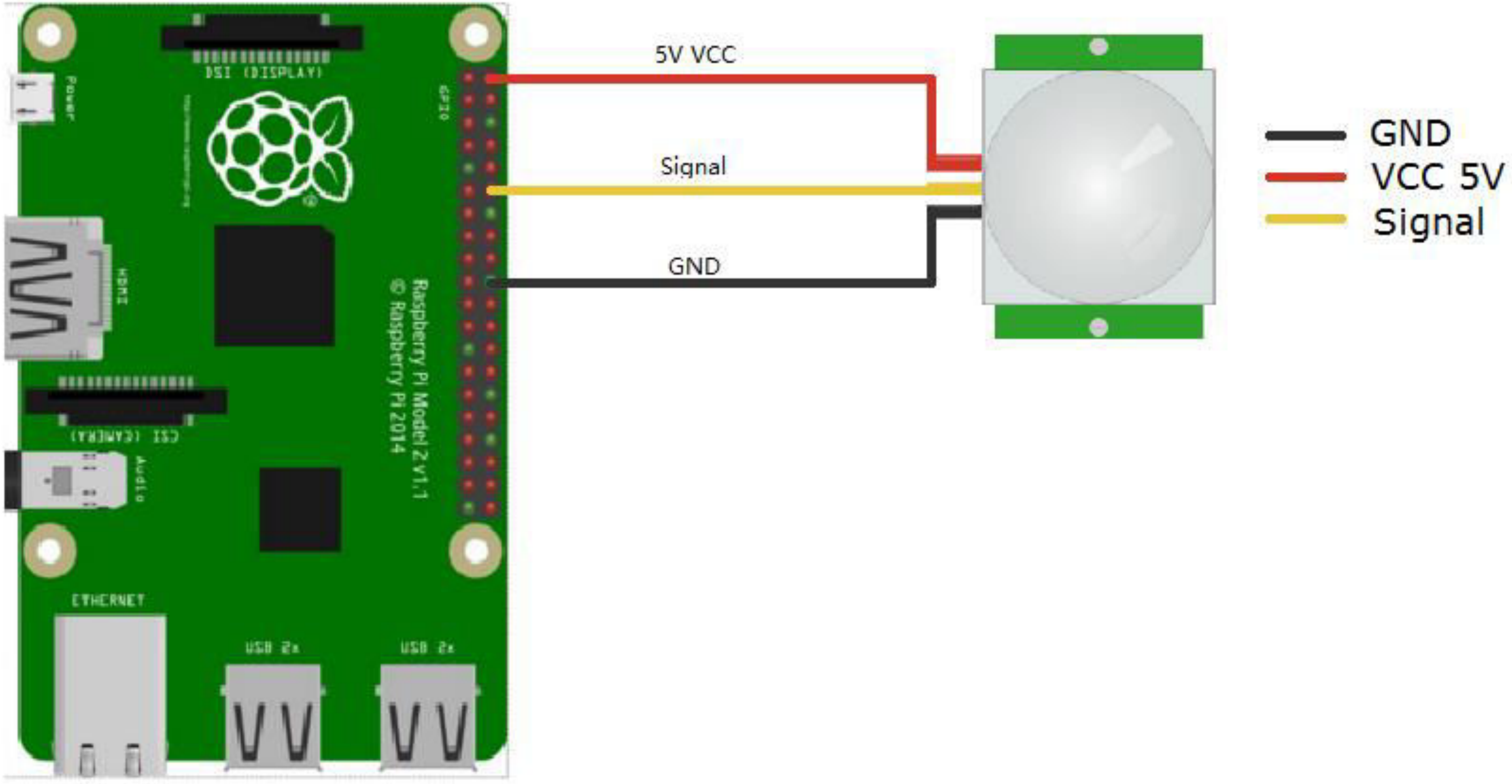
Code

```
import RPi.GPIO as GPIO  # Import GPIO library
import time # Import time library

GPIO.setmode(GPIO.BCM) #Use BCM pin numbering
GPIO.setwarnings(False) #Ignore GPIO warning messages
led = 4 # Assign 4 to variable led
GPIO.setup(led, GPIO.OUT) # Set pin 4 for outputting information
GPIO.output(led, 1) # Turns the GPIO pin ‘on’ ( i.e., outputs 3.3v)
time.sleep(5) # Pause the prorgam for 5 second
GPIO.output(led, 0) # Turns the GPIO pin ‘off’ ( i.e., outputs 0v)
# Clean up all the used ports in the program. Resets any ports you have used in this program back to input mode
GPIO.cleanup()
```

Outline

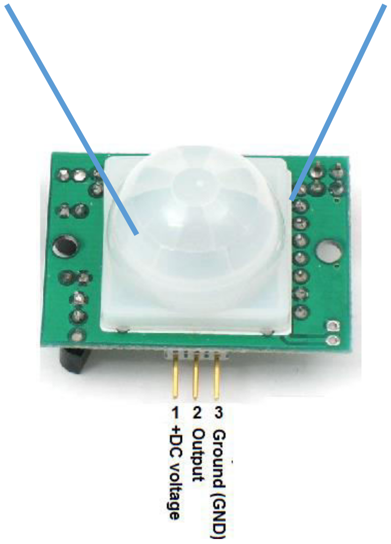
- Overview
- Setup and configurations
- 10 Use of Raspberry Pi
- Sample starter kit
- GPIO
- Sample use: Control LED
- Sample use: Read PIR motion sensor

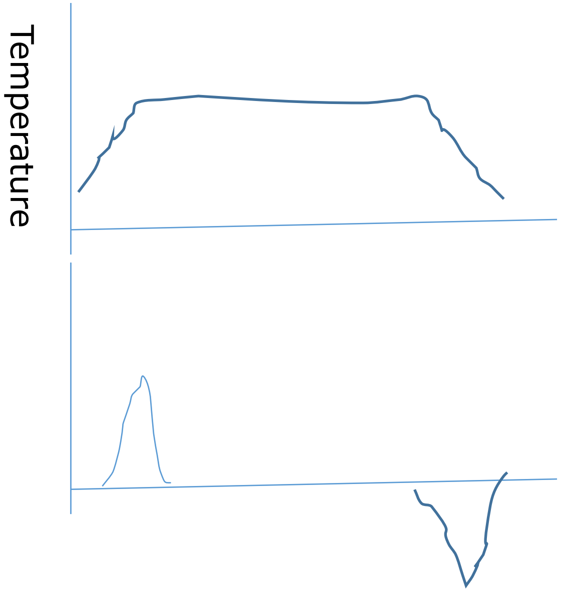
Demo – Motion Sensor



PIR Sensor Principle

- The PIR sensor is made of IR sensitive material
- The lens over the sensor can change
  - breadth, range, sensing pattern
- An idle sensor detect the same amount of IR from the environment.
- Motion detection
  - A warm entity entering the sensing zone causes a *positive differential* change
  - The warm entity leaving the sensing zone generates a negative differential change



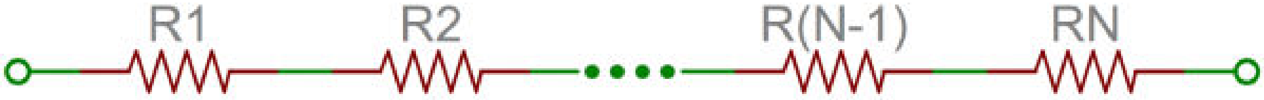


PIR Sensor Code Example

```
import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BCM)
pir= 7
GPIO.setup(pir, GPIO.IN)

try:
    print “PIR Module Test (CTRL+C to exit)”
    time.sleep(10)
    print “Ready”
    while True:
    # read status of pin pir
        if GPIO.input(pir): #
            print “Motion Detected!”
        time.sleep(1)

except KeyboardInterrupt:
    print “ Quit”

GPIO.cleanup()
```

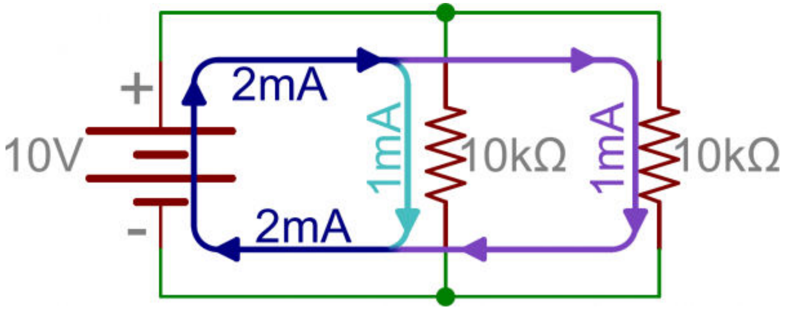
Circuits

- Equivalent Resistances in Series Circuits



- Equivalent Resistances in Parallel Circuits

$$R_{tot} = R_1 + R_2 + ... + R_{N-1} + R_N$$



$$\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_{N-1}} + \frac{1}{R_N}$$

References

[1] CTAYLOR, Voltage, Current, Resistance, and Ohm's Law, 2016

[2] Smon Monk, LEARN RASPBERRY PI 13 GUIDES, 2015

[3] Mtaylor, Raspberry gPIo, 2016

[4] How PIRs work, 2015

[5] PETE-O, Series and Parallel Circuits, 2016

[6] RPi.GPIO basics 6 – Using inputs and outputs together with RPi.GPIO – pull-ups and pull-downs, Jul 172013

[7] Python, 2017