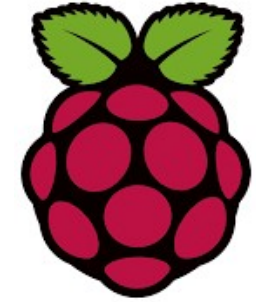


# ENPM 809T

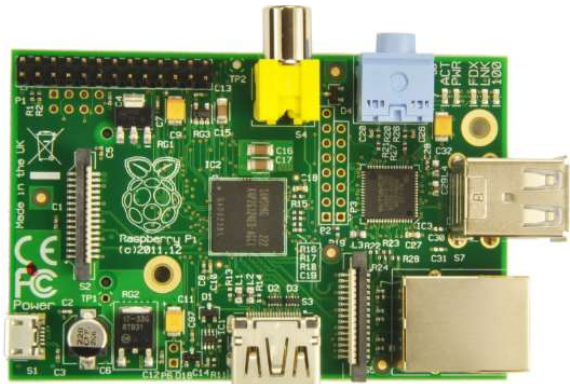
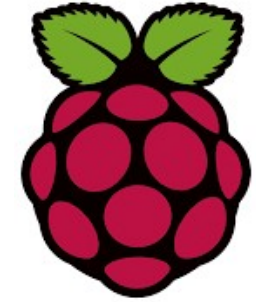
UMCP, Mitchell

# Raspberry Pi



- Eben Upton 2006
  - Google widely used
  - Facebook accessible to everyone
  - Twitter's first tweet
- 2009 Raspberry Pi Foundation
  - Registered educational charity foundation based in UK
  - Goal: help students learn to program at low cost (\$30)
- 2012 first release of Raspberry Pi to the public

# Raspberry Pi



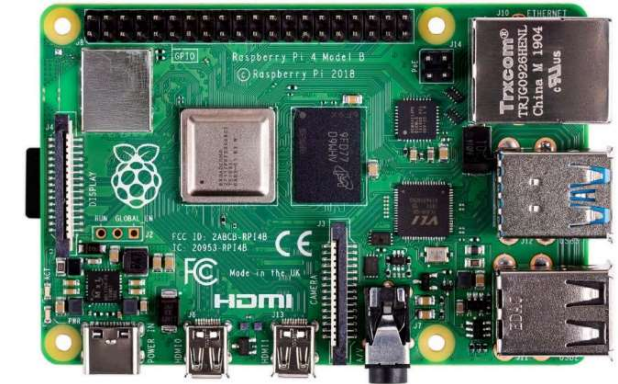
**B: 2012 \$35**



**Zero W: 2017 \$10**



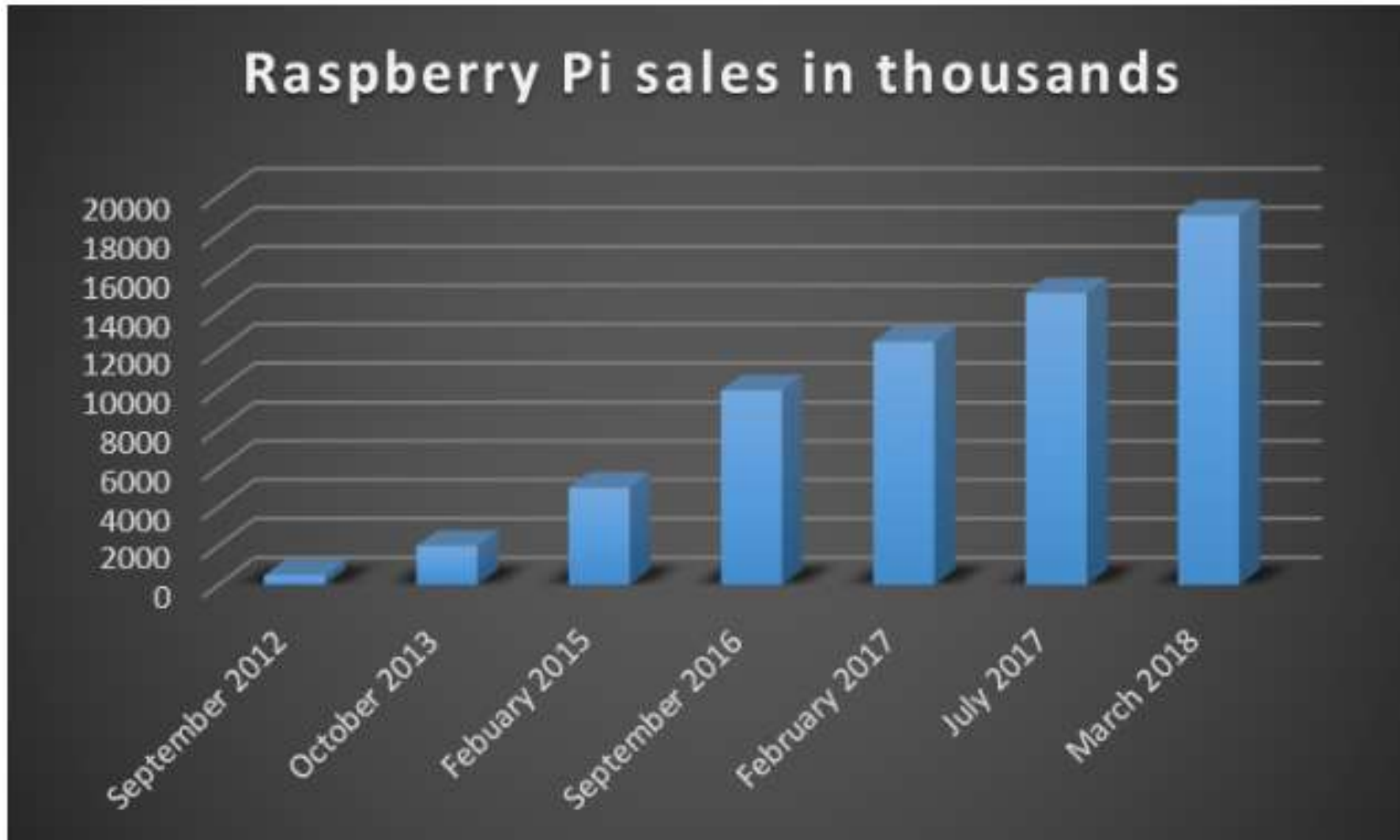
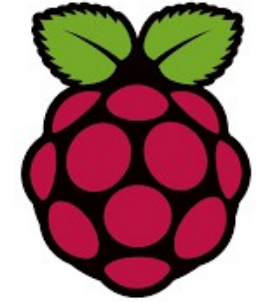
**3 B+: 2018 \$35**



**4 B: 2019 \$35-\$55**

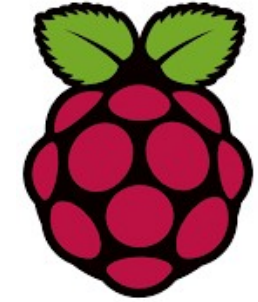
<http://socialcompare.com/en/comparison/raspberrypi-models-comparison>

# Raspberry Pi





# Raspberry Pi



| Pin No. |       |
|---------|-------|
| 3.3V    | 1 2   |
| GPIO2   | 3 4   |
| GPIO3   | 5 6   |
| GPIO4   | 7 8   |
| GND     | 9 10  |
| GPIO17  | 11 12 |
| GPIO27  | 13 14 |
| GPIO22  | 15 16 |
| 3.3V    | 17 18 |
| GPIO10  | 19 20 |
| GPIO9   | 21 22 |
| GPIO11  | 23 24 |
| GND     | 25 26 |
| DNC     | 27 28 |
| GPIO5   | 29 30 |
| GPIO6   | 31 32 |
| GPIO13  | 33 34 |
| GPIO19  | 35 36 |
| GPIO26  | 37 38 |
| GND     | 39 40 |
| 5V      |       |
| 5V      |       |
| GND     |       |
| GPIO14  |       |
| GPIO15  |       |
| GPIO18  |       |
| GND     |       |
| GPIO23  |       |
| GPIO24  |       |
| GND     |       |
| GPIO25  |       |
| GPIO8   |       |
| GPIO7   |       |
| DNC     |       |
| GND     |       |
| GPIO12  |       |
| GND     |       |
| GPIO16  |       |
| GPIO20  |       |
| GPIO21  |       |

# Setup

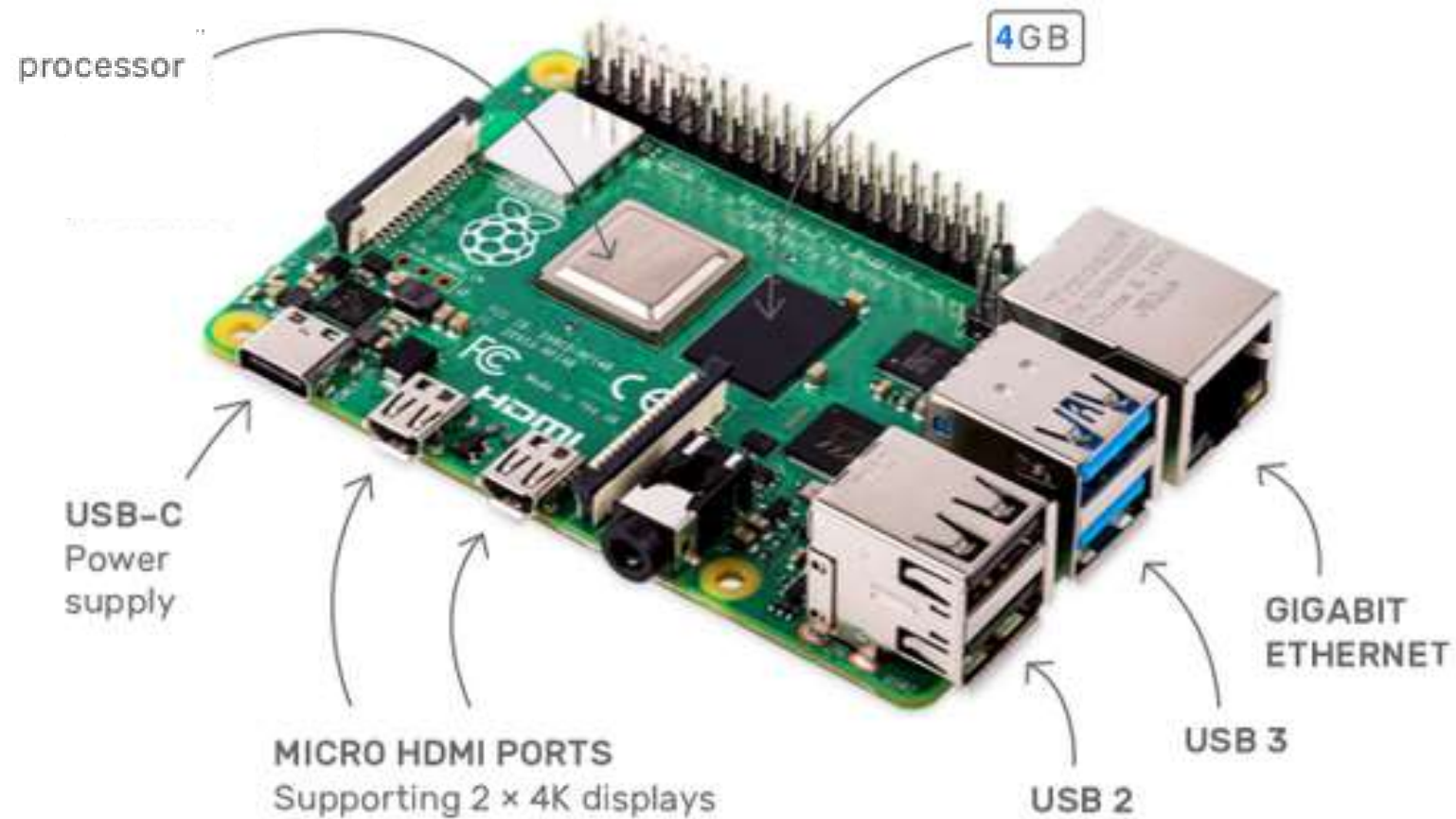
- Materials required to setup the Raspberry Pi:

1. Raspberry Pi 4 Model B
2. Raspberry Pi Camera v2 8 MP
3. 16 GB MicroSD Card with NOOBS
4. Micro HDMI to HDMI connector
5. Monitor with HDMI connection
6. USB Keyboard & mouse
7. Power supply: wall or battery pack with USB-C cable



# Setup

- RPi 4 connectors:





# Setup

- To begin, assemble the required hardware:

1. Unpack RPi, SD card, and Pi camera from shipping boxes
2. Insert SD card into Pi
3. Plug Pi camera into Pi, ensuring proper polarity
4. Connect USB keyboard/mouse to Pi
5. Connect micro HDMI to HDMI connector into monitor

Be gentle!

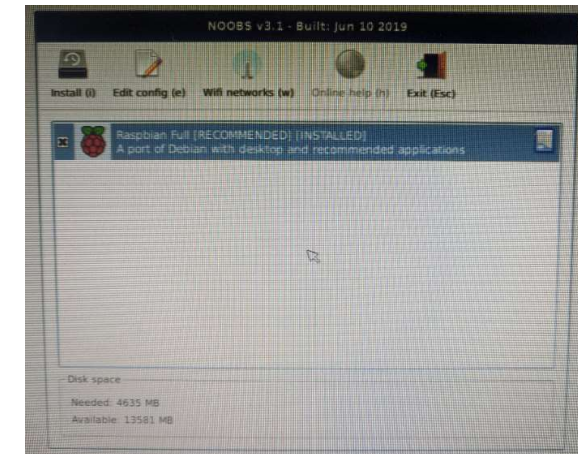




# Setup

- Let's begin from the ground up:
1. Apply USB-C 5V power to Pi: this boots up Pi
  2. When prompted, **hold down the shift key** to enter safe mode
  3. Select and install Raspbian
  4. Confirm “Yes” when prompted to install the selected OS
  5. Once complete, a prompt will appear stating “OS(es) Installed Successfully”
  6. Press “Ok” to restart the Pi

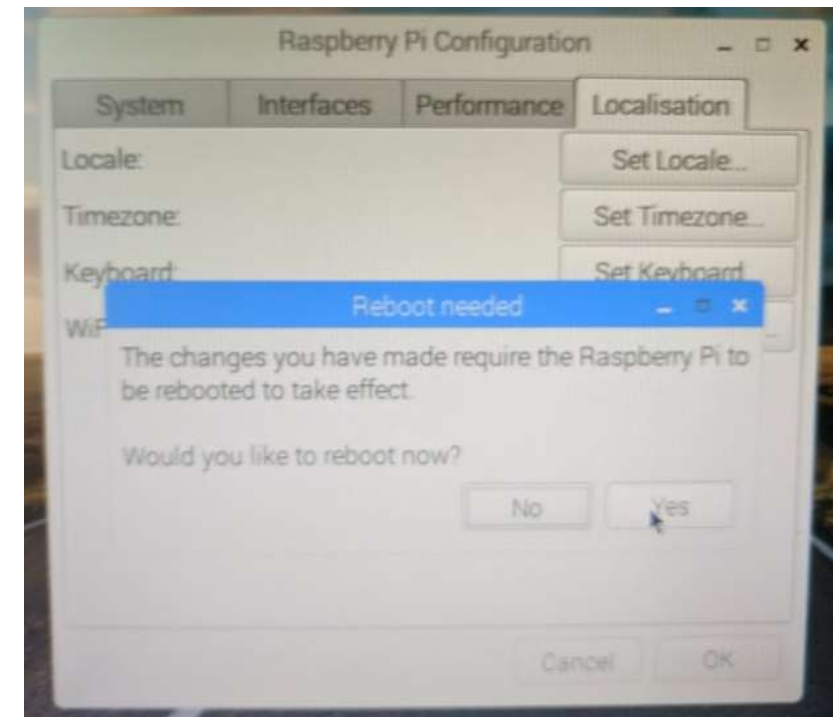
**Time to complete: 15:00**



# Setup

- Once restarted, configure the Pi as follows:
1. Click RPi logo > Preferences > Raspberry Pi Configuration
  2. Interfaces tab > enable Camera, SSH, VNC
  3. Localization tab > set Locale > Country as US (United States)
  4. Localization tab > set Timezone > Area as EST
  5. Localization tab > set Keyboard > Keyboard Layout as United States > English (US)
  6. Localization tab > set WiFi Country > WiFi Country Code as US United States
  7. Press OK
  8. Selected YES to reboot the Pi

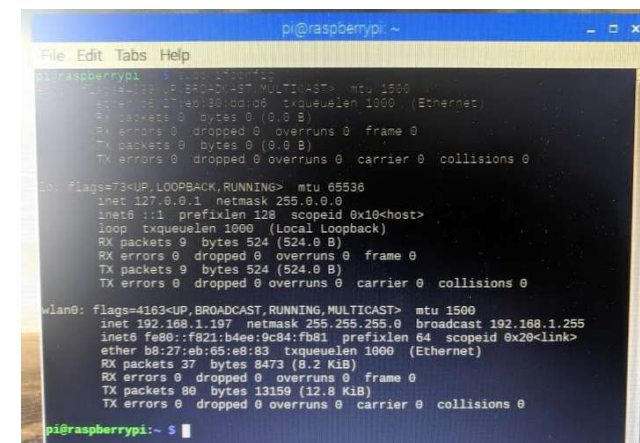
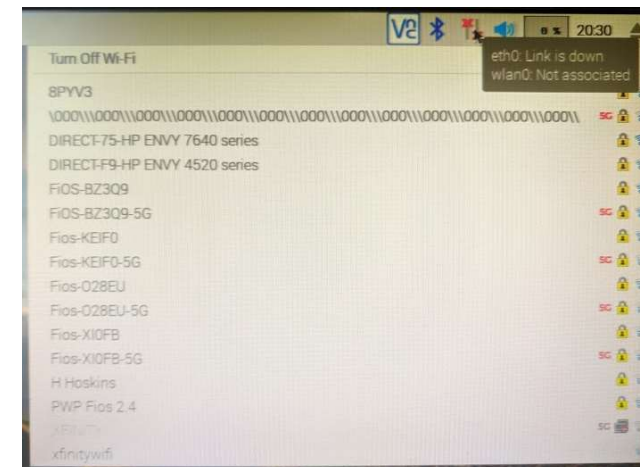
**Time to complete: 8:00**



# Setup

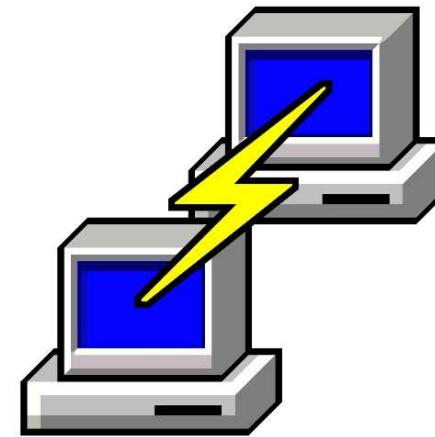
- Once the Pi has rebooted:
  1. Click on WiFi button on top right of toolbar
  2. Connect Pi to wifi
  3. Click Terminal icon in upper left to open a terminal window
  4. **Make a note of the Pi's IP address** by typing **sudo ifconfig** and hitting enter
  5. For example, connection in image at left: 192.168.1.197
  6. Once complete, shutdown Pi by typing **sudo shutdown 0** and hitting “Enter”

**Time to complete: 5:00**



# Setup

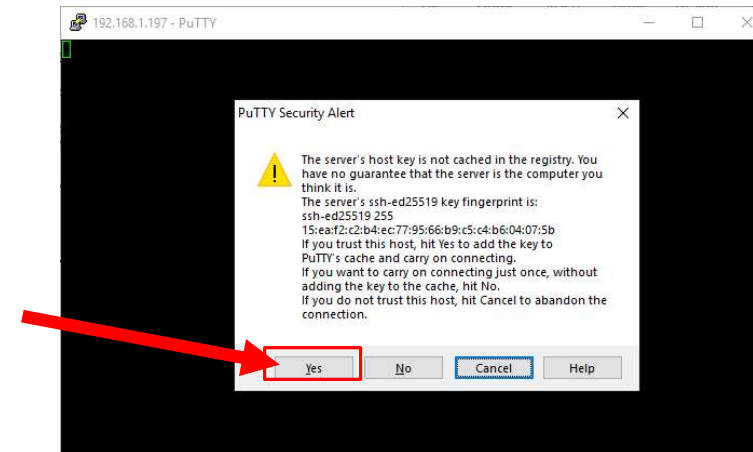
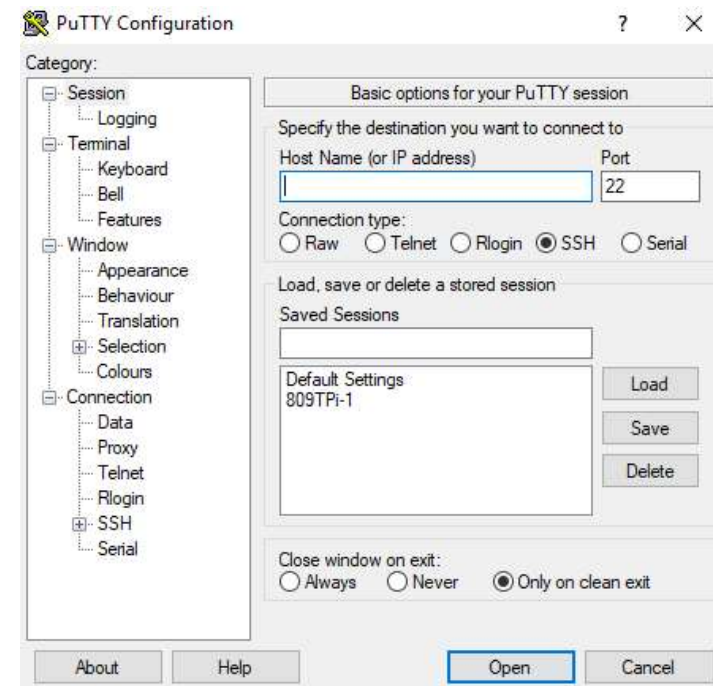
- To reboot the Pi after shutdown, remove then reinsert USB-C power cable, preferably from battery or wall side of cable
- From this point forward *the use of a monitor & keyboard/mouse is optional*
- Typically prefer to interface with the Pi using a **headless** setup
- Recommend Putty (Windows) or Terminal (Mac)





# Setup

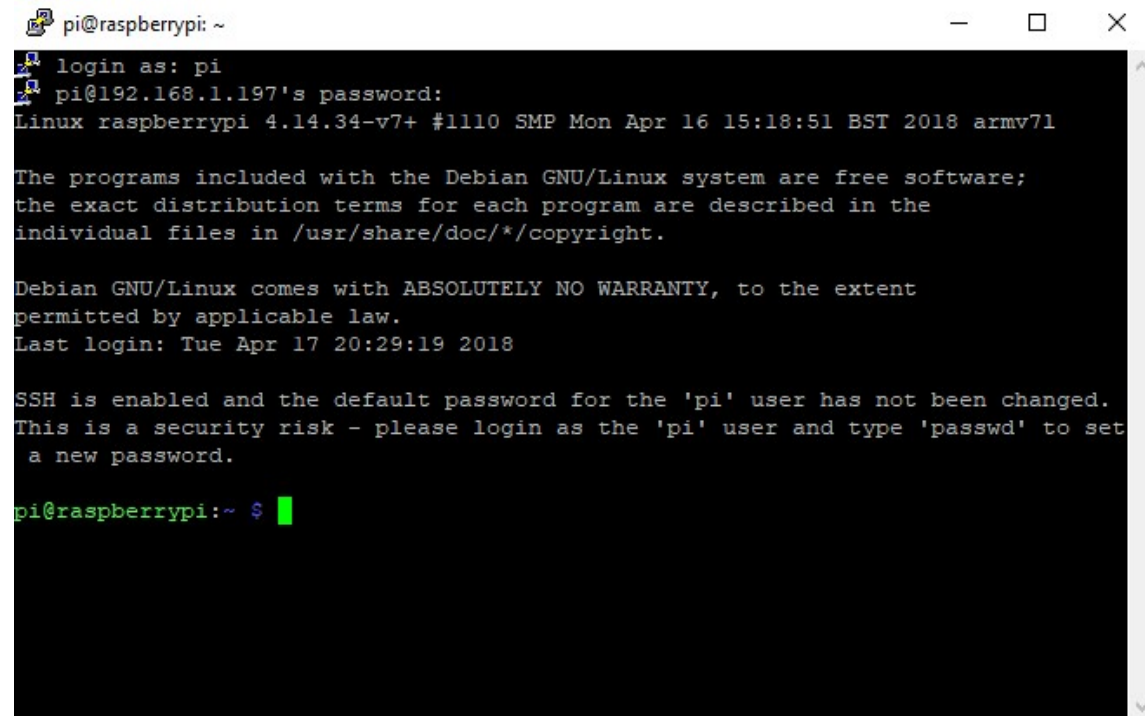
- From this point forward *the use of a monitor & keyboard/mouse is optional*
- Typically prefer to interface with the Pi using a **headless** setup
- Recommend Putty (Windows) or Terminal (Mac)
- Create a connection using the Pi's IP address
  - Wifi or Ethernet cable
  - Serial connection



<https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html>

# Setup

- Standard login information
  - user: **pi**
  - password: **raspberrypi** or **raspberr**

A terminal window titled 'pi@raspberrypi: ~' showing the login process. The user 'pi' logs in from IP '192.168.1.197'. The system is Linux raspberrypi 4.14.34-v7+ #11110 SMP Mon Apr 16 15:18:51 BST 2018 armv7l. It displays the Debian GNU/Linux license and a warning about the default password. The prompt 'pi@raspberrypi:~ \$' is shown at the bottom.

```
pi@raspberrypi: ~
login as: pi
pi@192.168.1.197's password:
Linux raspberrypi 4.14.34-v7+ #11110 SMP Mon Apr 16 15:18:51 BST 2018 armv7l

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Tue Apr 17 20:29:19 2018

SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set
a new password.

pi@raspberrypi:~ $
```

# Setup

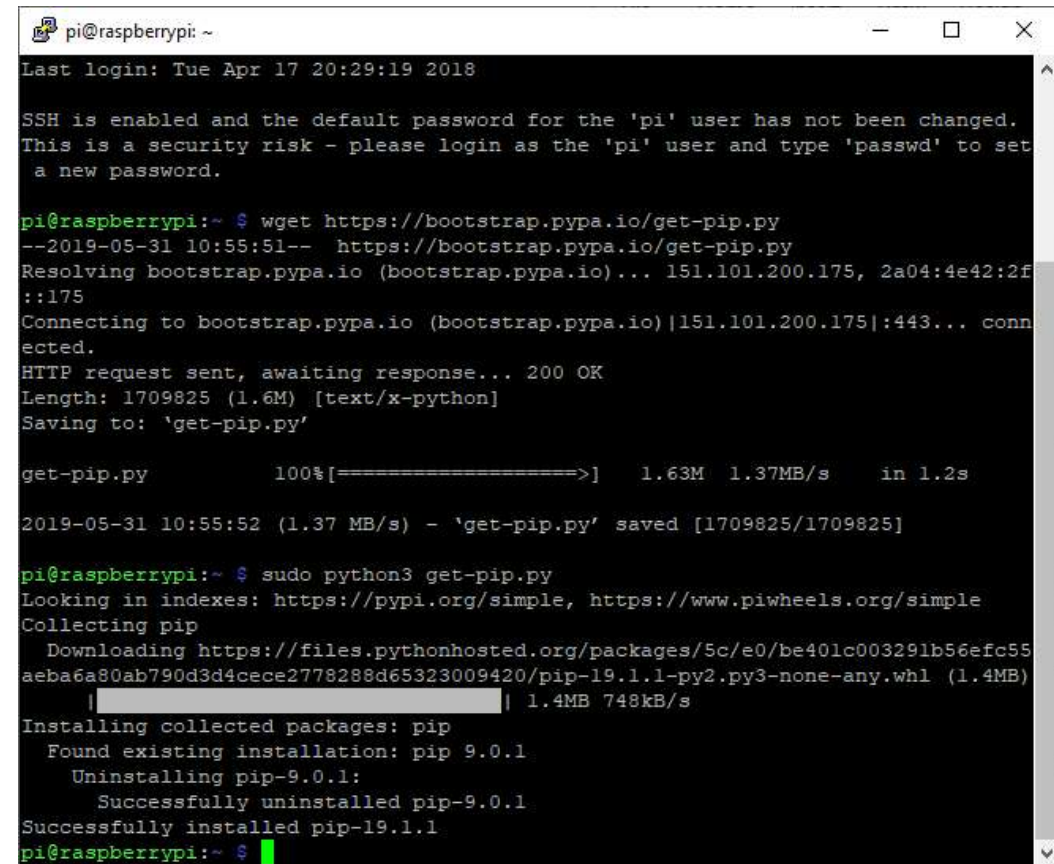
- Once logged in, confirm your Raspberry Pi is running Raspbian Buster
1. Type **cat /etc/os-release** and hit enter



```
pi@raspberrypi: ~  
pi@raspberrypi:~ $ cat /etc/os-release  
PRETTY_NAME="Raspbian GNU/Linux 10 (buster)"  
NAME="Raspbian GNU/Linux"  
VERSION_ID="10"  
VERSION="10 (buster)"  
VERSION_CODENAME=buster  
ID=raspbian  
ID_LIKE=debian  
HOME_URL="http://www.raspbian.org/"  
SUPPORT_URL="http://www.raspbian.org/RaspbianForums"  
BUG_REPORT_URL="http://www.raspbian.org/RaspbianBugs"  
pi@raspberrypi:~ $
```

# Setup

- Install the Python packages required for ENPM 809T
- Begin by installing the Python package manager **pip** on your Rpi:
  1. Open a Terminal Window
  2. Type **sudo wget https://bootstrap.pypa.io/get-pip.py** and hit enter
  3. Type **sudo python3 get-pip.py** and hit enter



```
pi@raspberrypi: ~
Last login: Tue Apr 17 20:29:19 2018

SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set
a new password.

pi@raspberrypi:~ $ wget https://bootstrap.pypa.io/get-pip.py
--2019-05-31 10:55:51-- https://bootstrap.pypa.io/get-pip.py
Resolving bootstrap.pypa.io (bootstrap.pypa.io)... 151.101.200.175, 2a04:4e42:2f
::175
Connecting to bootstrap.pypa.io (bootstrap.pypa.io)|151.101.200.175|:443... conn
ected.
HTTP request sent, awaiting response... 200 OK
Length: 1709825 (1.6M) [text/x-python]
Saving to: 'get-pip.py'

get-pip.py          100%[=====>]  1.63M  1.37MB/s   in 1.2s

2019-05-31 10:55:52 (1.37 MB/s) - 'get-pip.py' saved [1709825/1709825]

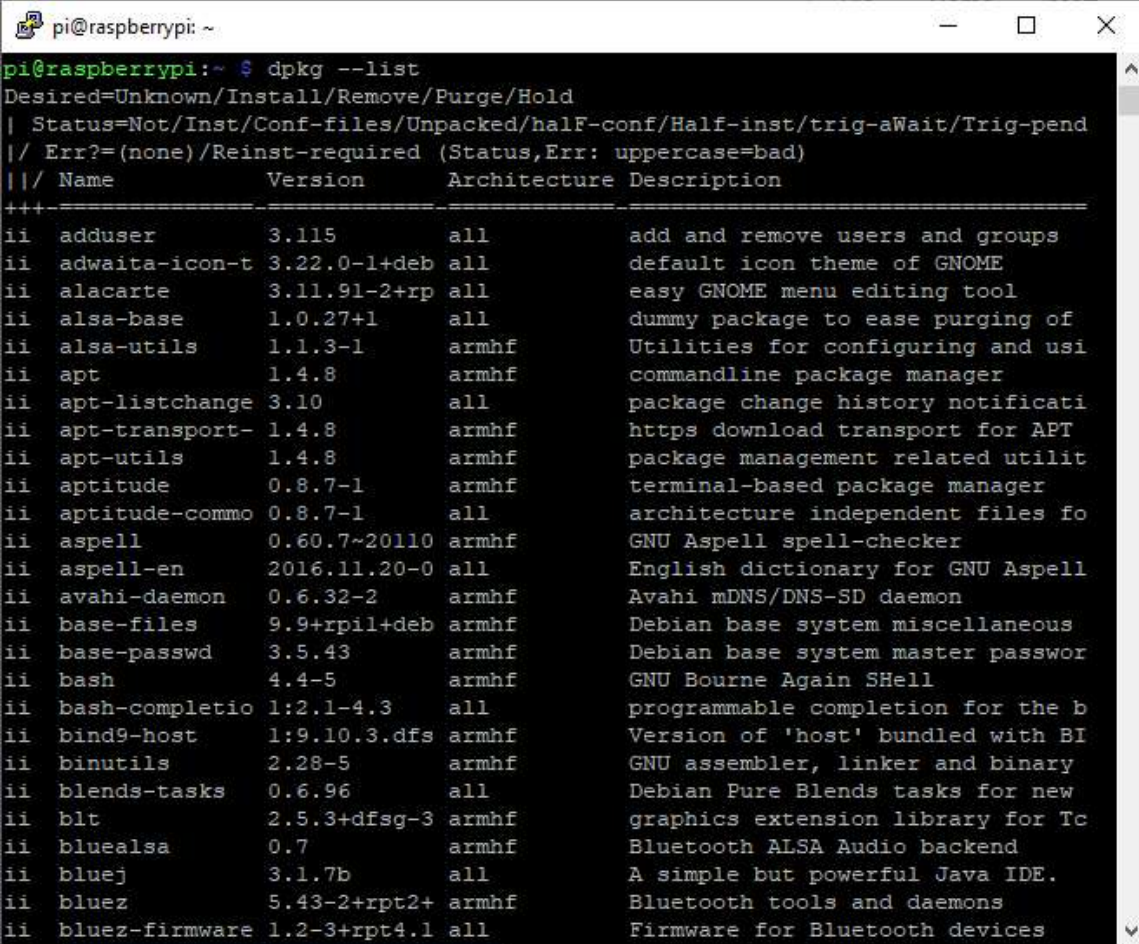
pi@raspberrypi:~ $ sudo python3 get-pip.py
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple
Collecting pip
  Downloading https://files.pythonhosted.org/packages/5c/e0/be401c003291b56efc55
aeba6a80ab790d3d4cece2778288d65323009420/pip-19.1.1-py2.py3-none-any.whl (1.4MB)
    | 1.4MB 748kB/s
Installing collected packages: pip
  Found existing installation: pip 9.0.1
  Uninstalling pip-9.0.1:
    Successfully uninstalled pip-9.0.1
Successfully installed pip-19.1.1
pi@raspberrypi:~ $
```



# Setup

- To view a list of the packages are a installed on the Pi:

1. Open a Terminal Window
2. Type **dpkg --list** and hit enter



```
pi@raspberrypi: ~  
pi@raspberrypi:~$ dpkg --list  
Desired=Unknown/Install/Remove/Purge/Hold  
| Status=Not/Inst/Conf-files/Unpacked/halF-conf/Half-inst/trig-aWait/Trig-pend  
|/ Err?=(none)/Reinst-required (Status,Err: uppercase=bad)  
||/ Name Version Architecture Description  
++-+-----+-----+-----+-----+  
ii adduser 3.115 all add and remove users and groups  
ii adwaita-icon-t 3.22.0-1+deb all default icon theme of GNOME  
ii alacarte 3.11.91-2+rp all easy GNOME menu editing tool  
ii alsa-base 1.0.27+1 all dummy package to ease purging of  
ii alsa-utils 1.1.3-1 armhf Utilities for configuring and usi  
ii apt 1.4.8 armhf commandline package manager  
ii apt-listchange 3.10 all package change history notificati  
ii apt-transport- 1.4.8 armhf https download transport for APT  
ii apt-utils 1.4.8 armhf package management related utilit  
ii aptitude 0.8.7-1 armhf terminal-based package manager  
ii aptitude-commo 0.8.7-1 all architecture independent files fo  
ii aspell 0.60.7~20110 armhf GNU Aspell spell-checker  
ii aspell-en 2016.11.20-0 all English dictionary for GNU Aspell  
ii avahi-daemon 0.6.32-2 armhf Avahi mDNS/DNS-SD daemon  
ii base-files 9.9+rp11+deb armhf Debian base system miscellaneous  
ii base-passwd 3.5.43 armhf Debian base system master passwor  
ii bash 4.4-5 armhf GNU Bourne Again SHell  
ii bash-completio 1:2.1-4.3 all programmable completion for the b  
ii bind9-host 1:9.10.3.dfs armhf Version of 'host' bundled with BI  
ii binutils 2.28-5 armhf GNU assembler, linker and binary  
ii blends-tasks 0.6.96 all Debian Pure Blends tasks for new  
ii blt 2.5.3+dfsg-3 armhf graphics extension library for Tc  
ii bluealsa 0.7 armhf Bluetooth ALSA Audio backend  
ii bluej 3.1.7b all A simple but powerful Java IDE.  
ii bluez 5.43-2+rpt2+ armhf Bluetooth tools and daemons  
ii bluez-firmware 1.2-3+rpt4.1 all Firmware for Bluetooth devices
```

# Setup

- Open Python 3

```
pi@raspberrypi: ~  
pi@raspberrypi:~ $ python3  
Python 3.7.3 (default, Apr  3 2019, 05:39:12)  
[GCC 8.2.0] on linux  
Type "help", "copyright", "credits" or "license" for more information.  
>>>
```

- Attempt to import the 4x packages used this semester
- Take note of which (if any) fail to import



<https://github.com/jrosebr1/imutils>

# Setup

- Install the packages required for 809T
1. Open a Terminal Window
  2. Type **sudo pip3 install matplotlib** and hit enter

**Note:** RPi *may* come from factory with matplotlib already installed

```
pi@raspberrypi: ~  
pi@raspberrypi:~ $ sudo pip3 install matplotlib  
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple  
Requirement already satisfied: matplotlib in /usr/lib/python3/dist-packages (3.0.2)  
pi@raspberrypi:~ $
```

**Time to complete: 7:00**

```
pi@raspberrypi: ~  
pi@raspberrypi:~ $ sudo pip3 install matplotlib  
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple  
Collecting matplotlib  
  Downloading https://files.pythonhosted.org/packages/26/04/8b381d5b166508cc258632b225adbafec49bbe69aa9a4falf1b461428313/matplotlib-3.0.3.tar.gz (36.6MB)  
    | 36.6MB 684kB/s  
Collecting cyclor>=0.10 (from matplotlib)  
  Downloading https://files.pythonhosted.org/packages/f7/d2/e07d3ebb2bd7af696440ce7e754c59dd546ffebbbe732c8ab68b9c834e61/cyclor-0.10.0-py2.py3-none-any.whl  
Collecting kiwisolver>=1.0.1 (from matplotlib)  
  Downloading https://files.pythonhosted.org/packages/16/e7/df58eb8868d183223692d2a62529a594f6414964a3ae93548467b146a24d/kiwisolver-1.1.0.tar.gz  
Requirement already satisfied: numpy>=1.10.0 in /usr/lib/python3/dist-packages (from matplotlib) (1.12.1)  
Collecting pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 (from matplotlib)  
  Downloading https://files.pythonhosted.org/packages/dd/d9/3ec19e966301a6e25769976999bd7bbe552016f0d32b577dc9d63d2e0c49/pyparsing-2.4.0-py2.py3-none-any.whl (62kB)  
    | 71kB 1.1MB/s  
Collecting python-dateutil>=2.1 (from matplotlib)  
  Downloading https://files.pythonhosted.org/packages/41/17/c62faccbfbd163c7f57f3844689e3a78baelf403648a6afb1d0866d87fbb/python_dateutil-2.8.0-py2.py3-none-any.whl (226kB)  
    | 235kB 2.8MB/s  
Requirement already satisfied: six in /usr/lib/python3/dist-packages (from cyclor>=0.10->matplotlib) (1.10.0)  
Requirement already satisfied: setuptools in /usr/lib/python3/dist-packages (from kiwisolver>=1.0.1->matplotlib) (33.1.1)  
Building wheels for collected packages: matplotlib, kiwisolver  
  Building wheel for matplotlib (setup.py) ... done  
  Stored in directory: /root/.cache/pip/wheels/f7/69/71/df177de59d50adeb7f18fe72dcff609eladd35572ea538f0cb  
  Building wheel for kiwisolver (setup.py) ... done  
  Stored in directory: /root/.cache/pip/wheels/8e/7f/55/25e48fe2e6380060898a949bdd60a6cf507463436eb7144ea5  
Successfully built matplotlib kiwisolver  
Installing collected packages: cyclor, kiwisolver, pyparsing, python-dateutil, matplotlib  
Successfully installed cyclor-0.10.0 kiwisolver-1.1.0 matplotlib-3.0.3 pyparsing-2.4.0 python-dateutil-2.8.0  
pi@raspberrypi:~ $
```



# Setup

- Repeat the process to install all required packages
1. Open a Terminal Window
  2. Type **sudo pip3 install matplotlib** and hit enter
  3. Type **sudo pip3 install imutils** and hit enter

**Time to complete: 1:00**

A terminal window titled 'pi@raspberrypi: ~' with standard window controls. The terminal output shows the command 'sudo pip3 install imutils' being executed. It displays the search for the package in PyPI and Pi Wheels, the download of the wheel file, and the successful installation of imutils-0.5.3.

```
pi@raspberrypi:~ $ sudo pip3 install imutils
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple
Collecting imutils
  Downloading https://www.piwheels.org/simple/imutils/imutils-0.5.3-py3-none-any.whl
Installing collected packages: imutils
Successfully installed imutils-0.5.3
pi@raspberrypi:~ $
```



# Setup

- Repeat the process to install all required packages
1. Open a Terminal Window
  2. Type **sudo pip3 install matplotlib** and hit enter
  3. Type **sudo pip3 install imutils** and hit enter
  4. If required, type **sudo pip3 install numpy** and hit enter

*\*It is likely that NumPy is already be installed*

*Re-installing will take time*

```
pi@raspberrypi: ~  
pi@raspberrypi:~ $ dpkg --get-selections  
Desired=Unknown/Install/Remove/Purge/Hold  
| Status=Not/Inst/Conf-files/Unpacked/halF-conf/Half-inst/trig-aWait/Trig-pend  
|/ Err?=(none)/Reinst-required (Status,Err: uppercase=bad)  
||/ Name          Version          Architecture Description  
+++-  
ii python3-numpy  1:1.12.1-3      armhf           Fast array facility to the Python
```

# Setup

- Begin OpenCV installation by manually installing dependencies
- Enter **y** for “yes” and hit enter when asked

1. Open a Terminal Window
2. Type **sudo apt-get install libhdf5-dev** and hit enter
3. Type **sudo apt-get install libhdf5-serial-dev** and hit enter
4. Type **sudo apt-get install libhdf5-100** and hit enter
5. Type **sudo apt-get install libhdf5-103** and hit enter
6. Type **sudo apt-get install libqtgui4** and hit enter
7. Type **sudo apt-get install libqtwebkit4** and hit enter
8. Type **sudo apt-get install libqt4-test** and hit enter
9. Type **sudo apt-get install libqt4-dev** and hit enter
10. Type **sudo apt-get install python3-pyqt5** and hit enter
11. Type **sudo apt-get install libatlas-base-dev** and hit enter
12. Type **sudo apt-get install libjasper-dev** and hit enter
13. Type **sudo apt-get install libcbblas-dev** and hit enter

**Time to complete: 12:00**

```
pi@raspberrypi: ~  
pi@raspberrypi:~ $ sudo apt-get install libqt4-test  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
The following NEW packages will be installed:  
  libqt4-test  
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.  
Need to get 0 B/97.7 kB of archives.  
After this operation, 248 kB of additional disk space will be used.  
Selecting previously unselected package libqt4-test:armhf.  
(Reading database ... 125471 files and directories currently installed.)  
Preparing to unpack .../libqt4-test_4%3a4.8.7+dfsg-11+rpil_armhf.deb ...  
Unpacking libqt4-test:armhf (4:4.8.7+dfsg-11+rpil) ...  
Processing triggers for libc-bin (2.24-11+deb9u3) ...  
Setting up libqt4-test:armhf (4:4.8.7+dfsg-11+rpil) ...  
Processing triggers for libc-bin (2.24-11+deb9u3) ...  
pi@raspberrypi:~ $ sudo apt-get install python3-pyqt5  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
The following additional packages will be installed:  
  libqt5clucene5 libqt5designer5 libqt5help5 libqt5sql5 libqt5sql5-sqlite  
  libqt5test5 python3-sip  
Suggested packages:  
  python3-pyqt5-dbg  
The following NEW packages will be installed:  
  libqt5clucene5 libqt5designer5 libqt5help5 libqt5sql5 libqt5sql5-sqlite  
  libqt5test5 python3-pyqt5 python3-sip  
0 upgraded, 8 newly installed, 0 to remove and 0 not upgraded.  
Need to get 5,010 kB of archives.  
After this operation, 20.7 MB of additional disk space will be used.  
Do you want to continue? [Y/n] y  
Get:1 http://mirror.umd.edu/raspbian/raspbian stretch/main armhf libqt5clucene5  
armhf 5.7.1-1 [217 kB]  
Get:2 http://mirror.umd.edu/raspbian/raspbian stretch/main armhf libqt5designer5  
armhf 5.7.1-1 [2,639 kB]  
Err:3 http://raspbrian.raspberrypi.org/raspbian stretch/main armhf libqt5sql5 arm
```


# Setup

- Finally, install OpenCV
  1. Open a Terminal Window
  2. Type **sudo pip3 install opencv-python==3.4.4.19** and hit enter
- Once installation is complete, confirm proper installation
  1. Enter Python 3 by typing **python3** and hit enter
  2. Once inside Python 3, type **import cv2** and hit enter
  3. Type **cv2.\_\_version\_\_** and hit enter
  4. Python should display the version of OpenCV, such as '3.4.4'

**Time to complete: 1:00**

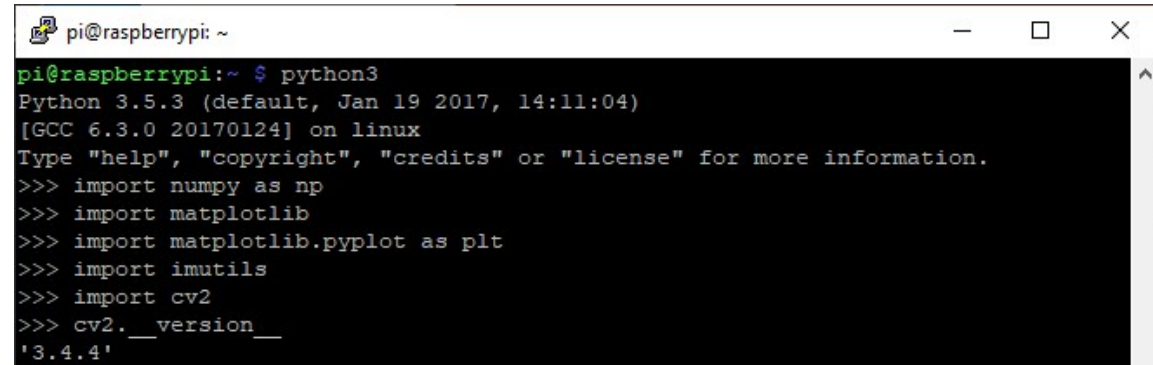
```
pi@raspberrypi: ~  
pi@raspberrypi:~ $ sudo pip3 install opencv-python==3.4.4.19  
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple  
Collecting opencv-python==3.4.4.19  
  Downloading https://www.piwheels.org/simple/opencv-python/opencv_python-3.4.4.19-cp37-cp37m-linux_armv7l.whl (8.8 MB)  
    |#####| 8.8 MB 47 kB/s  
Requirement already satisfied: numpy>=1.16.2 in /usr/lib/python3/dist-packages (from opencv-python==3.4.4.19) (1.16.2)  
Installing collected packages: opencv-python  
Successfully installed opencv-python-3.4.4.19  
pi@raspberrypi:~ $
```

```
pi@raspberrypi: ~  
pi@raspberrypi:~ $ python3  
Python 3.7.3 (default, Apr  3 2019, 05:39:12)  
[GCC 8.2.0] on linux  
Type "help", "copyright", "credits" or "license" for more information.  
>>> import cv2  
>>> cv2.__version__  
'3.4.4'  
>>>
```



# Setup

- Confirm packages have been installed and will properly import into Python
1. Type **import numpy as np** and hit enter
  2. Type **import matplotlib** and hit enter
  3. Type **import matplotlib.pyplot as plt** and hit enter
  4. Type **import imutils** and hit enter
  5. Type **import cv2** and hit enter

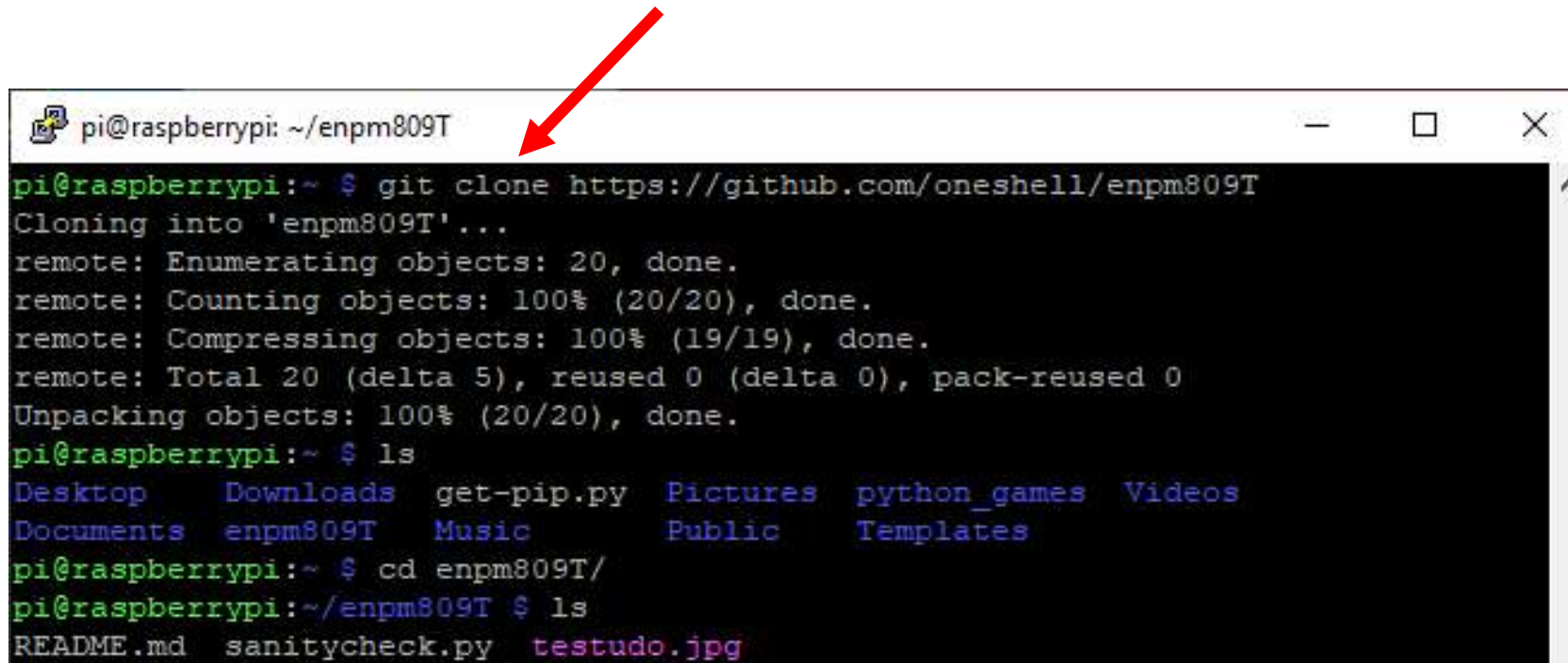
A terminal window titled 'pi@raspberrypi: ~' with standard window controls. The terminal shows a Python 3.5.3 shell session. The user enters 'python3' at the prompt, which shows the Python version and GCC information. Then, the user enters a series of import statements: 'import numpy as np', 'import matplotlib', 'import matplotlib.pyplot as plt', 'import imutils', and 'import cv2'. Finally, the user enters 'cv2.\_\_version\_\_' and the terminal outputs '3.4.4'.

```
pi@raspberrypi:~ $ python3
Python 3.5.3 (default, Jan 19 2017, 14:11:04)
[GCC 6.3.0 20170124] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import numpy as np
>>> import matplotlib
>>> import matplotlib.pyplot as plt
>>> import imutils
>>> import cv2
>>> cv2.__version__
'3.4.4'
```



# Setup

- Once all packages are installed and properly import into Python, clone the ENPM 809T GitHub repository onto your Rpi:

A terminal window on a Raspberry Pi. The title bar shows 'pi@raspberrypi: ~/enpm809T'. A red arrow points to the terminal window. The terminal output shows the command 'git clone https://github.com/oneshell/enpm809T' being executed, followed by cloning progress and a directory listing. The directory listing shows 'enpm809T' as a subdirectory in the home directory.

```
pi@raspberrypi:~ $ git clone https://github.com/oneshell/enpm809T
Cloning into 'enpm809T'...
remote: Enumerating objects: 20, done.
remote: Counting objects: 100% (20/20), done.
remote: Compressing objects: 100% (19/19), done.
remote: Total 20 (delta 5), reused 0 (delta 0), pack-reused 0
Unpacking objects: 100% (20/20), done.
pi@raspberrypi:~ $ ls
Desktop  Downloads  get-pip.py  Pictures  python_games  Videos
Documents  enpm809T  Music      Public    Templates
pi@raspberrypi:~ $ cd enpm809T/
pi@raspberrypi:~/enpm809T $ ls
README.md  sanitycheck.py  testudo.jpg
```

# Setup



- In order to run the sanitycheck.py script and view the proper outputs, we have to first install VNC
- Putty/Terminal will not display images/videos
- To begin, open a Terminal Window
  1. Type **sudo apt-get install tightvncserver** and hit enter
  2. Type “y” for yes when prompted

```
pi@raspberrypi: ~  
pi@raspberrypi:~$ sudo apt-get install tightvncserver  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
The following additional packages will be installed:  
  xfonts-base  
Suggested packages:  
  tightvnc-java  
The following packages will be REMOVED:  
  realvnc-vnc-server  
The following NEW packages will be installed:  
  tightvncserver xfonts-base  
0 upgraded, 2 newly installed, 1 to remove and 0 not upgraded.  
Need to get 6,461 kB of archives.  
After this operation, 26.5 MB disk space will be freed.  
Do you want to continue? [Y/n] y  
Get:1 http://mirror.umd.edu/raspbian/raspbian stretch/main armhf tightvncserver  
armhf 1:1.3.9-9 [550 kB]  
Get:2 http://mirror.umd.edu/raspbian/raspbian stretch/main armhf xfonts-base all  
1:1.0.4+nmul [5,911 kB]  
Fetched 6,461 kB in 6s (1,038 kB/s)  
(Reading database ... 125480 files and directories currently installed.)  
Removing realvnc-vnc-server (6.2.1.32538) ...  
  
(gconftool-2:18404): GConf-WARNING **: Client failed to connect to the D-BUS dae  
mon:  
Unable to autolaunch a dbus-daemon without a $DISPLAY for X11  
Selecting previously unselected package tightvncserver.  
(Reading database ... 125404 files and directories currently installed.)  
Preparing to unpack .../tightvncserver_1%3a1.3.9-9_armhf.deb ...  
Unpacking tightvncserver (1:1.3.9-9) ...  
Selecting previously unselected package xfonts-base.  
Preparing to unpack .../xfonts-base_1%3a1.0.4+nmul_all.deb ...  
Unpacking xfonts-base (1:1.0.4+nmul) ...  
Processing triggers for gconf2 (3.2.6-4) ...  
Processing triggers for mime-support (3.60) ...  
Processing triggers for desktop-file-utils (0.23-1) ...
```

# Setup



- To run the VNC server:
  1. Type **vncserver :1** and hit enter
  2. When prompted, enter an 8-character password such as **raspberr**
- In the future, to start the VNC server:
  1. Login to the Pi using Putty/Terminal
  2. Open a Terminal Window
  3. Type **vncserver :1** and hit enter

A terminal window titled 'pi@raspberrypi: ~' showing the execution of 'vncserver :1'. The output includes prompts for a password, verification, and a view-only password, followed by confirmation that the desktop is created and the server is running.

```
pi@raspberrypi:~$ vncserver :1
You will require a password to access your desktops.
Password:
Verify:
Would you like to enter a view-only password (y/n)? n
New 'X' desktop is raspberrypi:1
Creating default startup script /home/pi/.vnc/xstartup
Starting applications specified in /home/pi/.vnc/xstartup
Log file is /home/pi/.vnc/raspberrypi:1.log
pi@raspberrypi:~$ vncserver :1
A VNC server is already running as :1
pi@raspberrypi:~$
```

# Setup

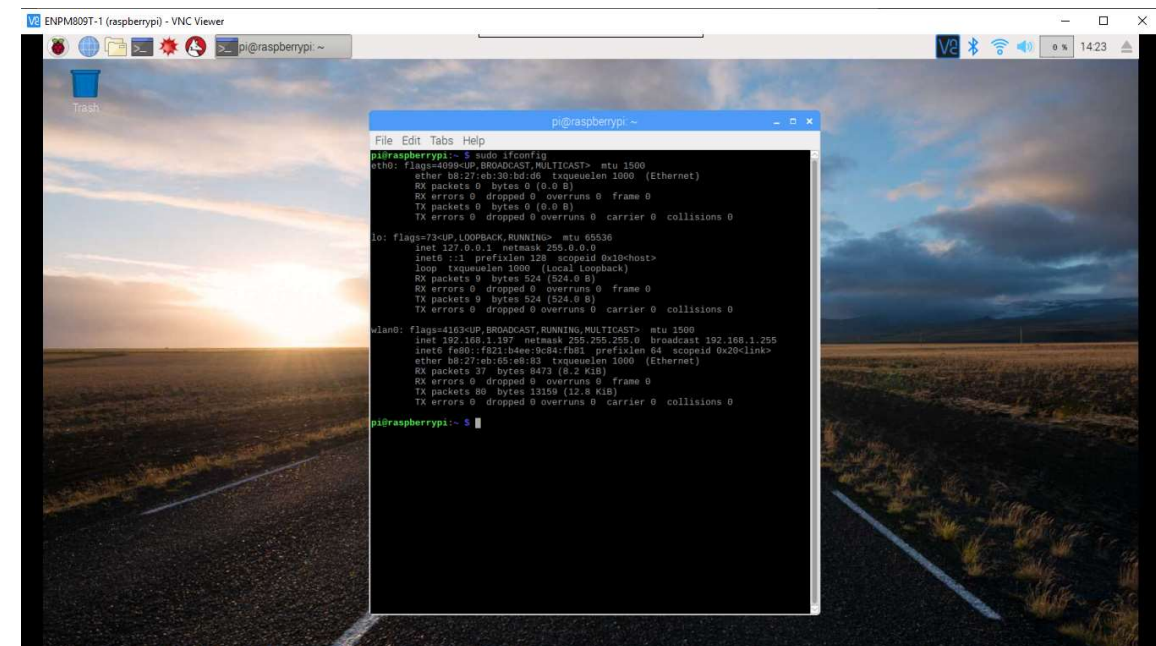


- Install VNC Viewer on your laptop:

*<https://www.realvnc.com/en/connect/download/viewer/>*

- Open VNC Viewer

1. Create New Connection
2. Enter IP address of Raspberry Pi
3. Click “Continue” when prompted
4. Log in to the Pi

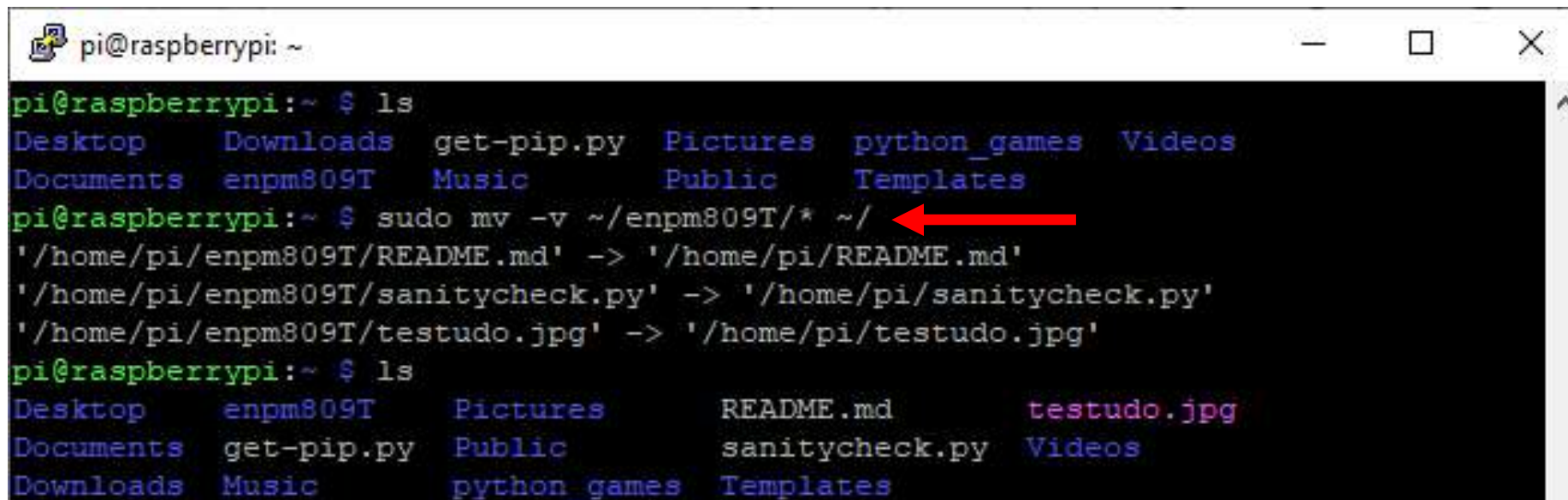


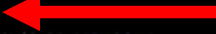
**Note: often the IP address entered into VNC must include :1 at the end**



# Setup

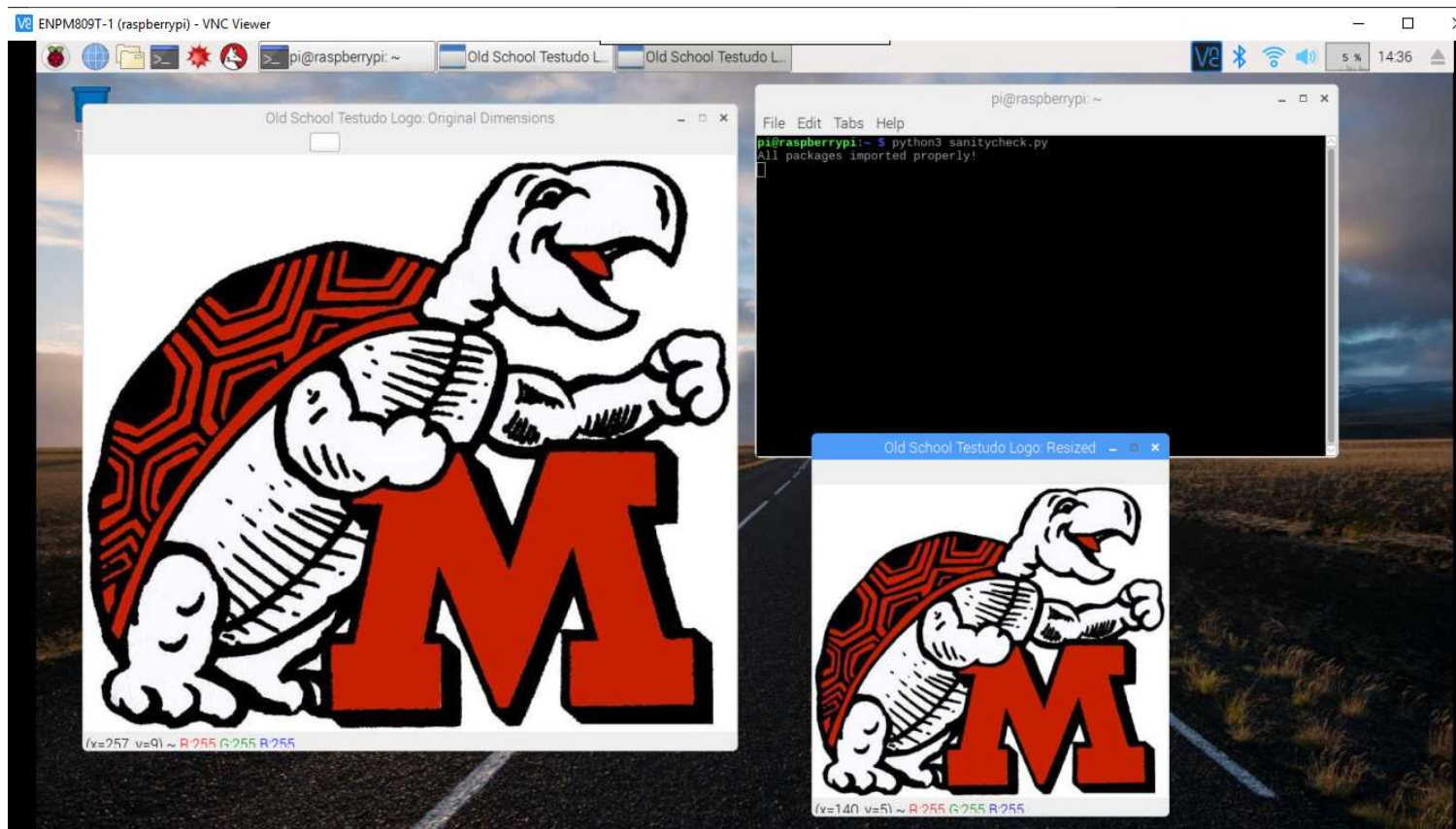
- We need to run the **sanitycheck.py** script to confirm all packages have been installed properly
- \*First, recall that Python 3 and our packages are installed in the root directory
- Therefore, move all files in /enpm809T up to the root directory:



```
pi@raspberrypi: ~  
pi@raspberrypi:~ $ ls  
Desktop    Downloads  get-pip.py  Pictures  python_games  Videos  
Documents  enpm809T   Music       Public    Templates  
pi@raspberrypi:~ $ sudo mv -v ~/enpm809T/* ~/   
'/home/pi/enpm809T/README.md' -> '/home/pi/README.md'  
'/home/pi/enpm809T/sanitycheck.py' -> '/home/pi/sanitycheck.py'  
'/home/pi/enpm809T/testudo.jpg' -> '/home/pi/testudo.jpg'  
pi@raspberrypi:~ $ ls  
Desktop    enpm809T   Pictures    README.md    testudo.jpg  
Documents  get-pip.py  Public      sanitycheck.py  Videos  
Downloads  Music       python_games  Templates
```

# Setup

- Run the **sanitycheck.py** script to confirm all packages have been installed properly by typing **python3 sanitycheck.py**



# Transferring Files

- Transferring files from the Raspberry Pi to your laptop can be accomplished in a number of ways:
  1. Upload files to Gmail
  2. Insert a USB into the Pi and transfer files
  3. FTP into the Pi from your laptop using an FTP client such as WinSCP
  4. Transfer files to Dropbox



# Setup

- Finally, verify the Pi camera has been properly installed
  1. Record an image using `raspistill`
  2. Type **`raspistill -o testpic.jpg`** and hit enter
  3. View image by typing **`xdg-open testpic.jpg`** and hit enter



# Setup

- Finally, verify the Pi camera has been properly installed
- First, install MP4Box by typing **sudo apt-get install gpac** and hit enter, then respond “y” for yes when prompted
  1. Record video using **raspivid**
  2. Type **raspivid -o testvideo.h264 -t 5000** and hit enter
  3. Type **MP4Box -add testvideo.h264 testvideo.mp4** and hit enter
  4. Transfer video file to your laptop to view

**Note: if gpac does not install, try `sudo apt-get update` then reinstall gpac**

<https://www.raspberrypi.org/documentation/usage/camera/raspicam/raspivid.md>

# Picamera

- Package that provides Python interface to the Raspberry Pi camera module

```
# import the necessary packages
from picamera.array import PiRGBArray
from picamera import PiCamera
import time
import cv2
```

```
# initialize the Raspberry Pi camera
camera = PiCamera()
camera.resolution = (640, 480)
camera.framerate = 25
rawCapture = PiRGBArray(camera, size=(640,480))

# allow the camera to warmup
time.sleep(0.1)

# keep looping
for frame in camera.capture_continuous(rawCapture, format="bgr", use_video_port=False):

    # grab the current frame
    image = frame.array

    # show the frame to our screen
    cv2.imshow("Frame", image)
    key = cv2.waitKey(1) & 0xFF

    # clear the stream in preparation for the next frame
    rawCapture.truncate(0)

    # press the 'q' key to stop the video stream
    if key == ord("q"):
        break
```

*[https://picamera.readthedocs.io/en/release-1.10/api\\_camera.html](https://picamera.readthedocs.io/en/release-1.10/api_camera.html)*

# Picamera

- Camera can be operated with a variety of settings:

<https://www.raspberrypi.org/documentation/hardware/camera/>

<https://picamera.readthedocs.io/en/release-1.12/fov.html>





# Picamera

- To save video file:

```
# define the codec and create VideoWriter object  
fourcc = cv2.VideoWriter_fourcc(*'XVID')  
out = cv2.VideoWriter('videoname.avi', fourcc, 10, (640, 480))
```

```
# write frame to video file  
out.write(image)
```

# Shutting down the Pi

- To reboot the Raspberry Pi, type **sudo reboot** and hit enter
- To shutdown the Raspberry Pi, type **sudo shutdown 0** and hit enter
  - 0 for “zero seconds from now”

# References

- *The Awesome Story of Raspberry Pi*
  - <https://raspberrytips.com/raspberry-pi-history/>
- Raspberry Pi Blog
  - <https://www.raspberrypi.org/blog/>
- Benching Raspberry Pi GPIO Speed
  - <https://codeandlife.com/2012/07/03/benchmarking-raspberry-pi-gpio-speed/>
- Adrian Rosebrock via PyImageSearch: pip install opencv
  - <https://www.pyimagesearch.com/2018/09/19/pip-install-opencv/>
- Adrian Rosebrock via PyImageSearch: Install OpenCV 4 on Raspberry Pi 4 and Raspian Buster
  - <https://www.pyimagesearch.com/2019/09/16/install-opencv-4-on-raspberry-pi-4-and-raspbian-buster/>