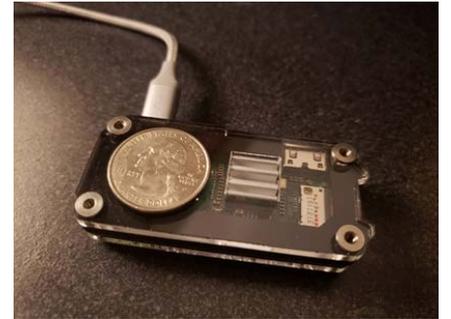




Raspberry Pi Overview

Christopher Thompson

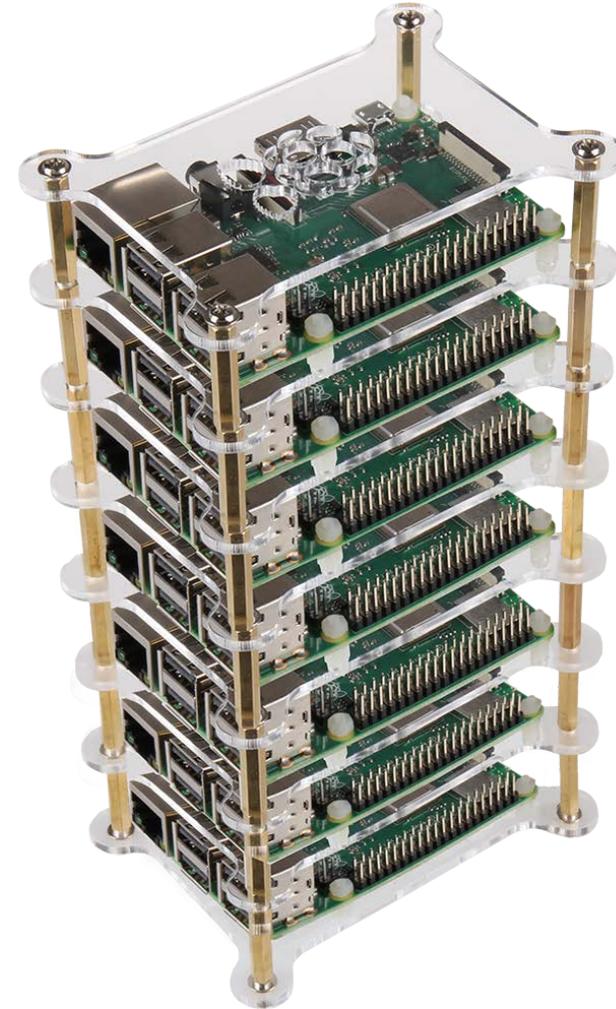
Agenda



1. What is a Raspberry pi, and what hardware does it run on?
2. What operating systems options are there for the raspberry pi?
3. Tips and useful commands to know when working with pis
4. Different applications and use cases that Pis have

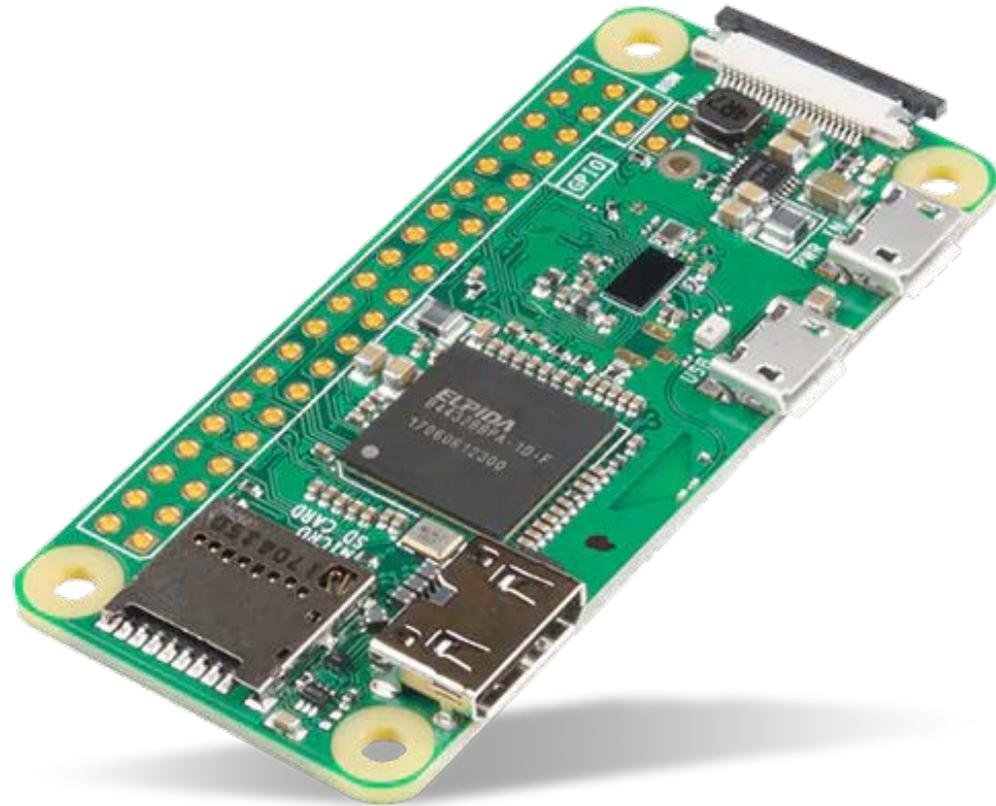
What is a raspberry pi?

- Small Single-Board computer
 - Powered by ARM processors
 - Storage is a MicroSD card
- Popular for their high utility, and low cost for the features they include



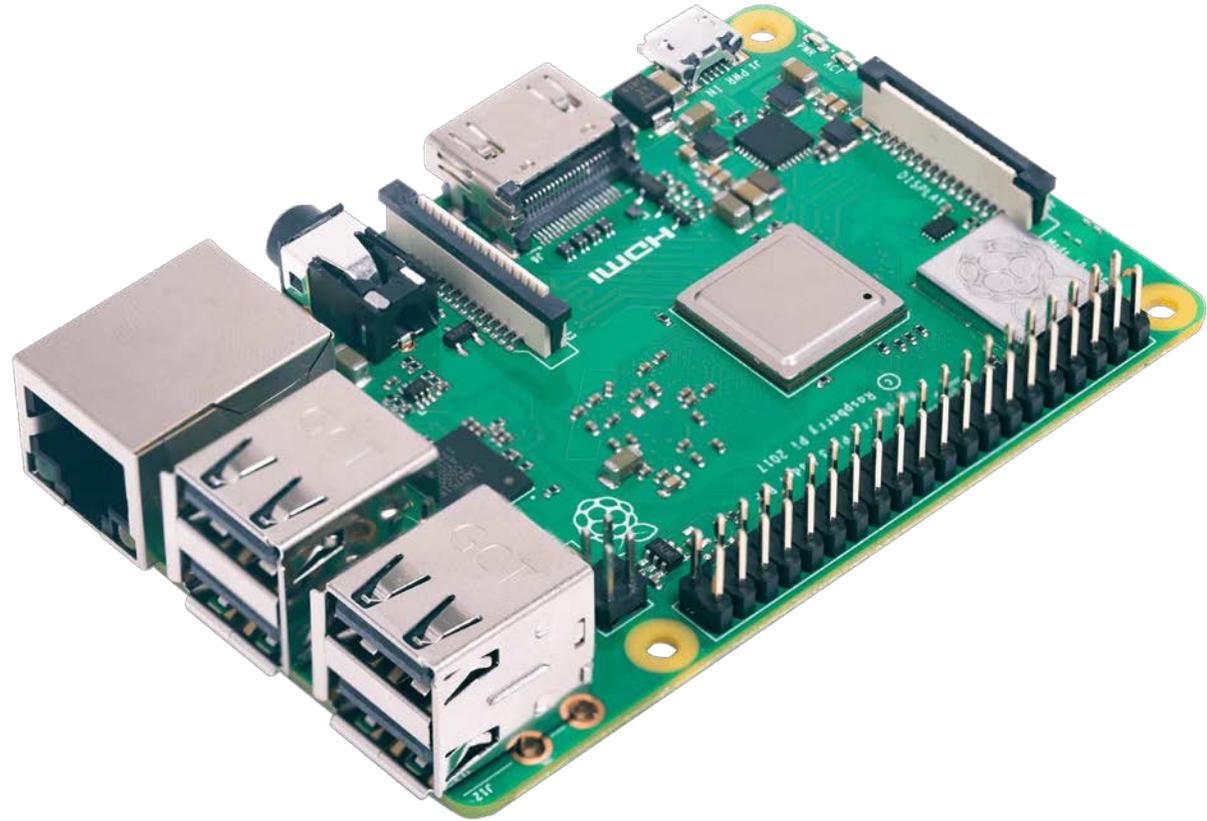
PI Specs – Zero W

- Single core ARM11 processor running at 1GHz
- 512mb RAM
- Mini-HDMI output
- 1 Micro-USB port
- 2.4GHz Wireless
- Bluetooth
- Board costs only \$10



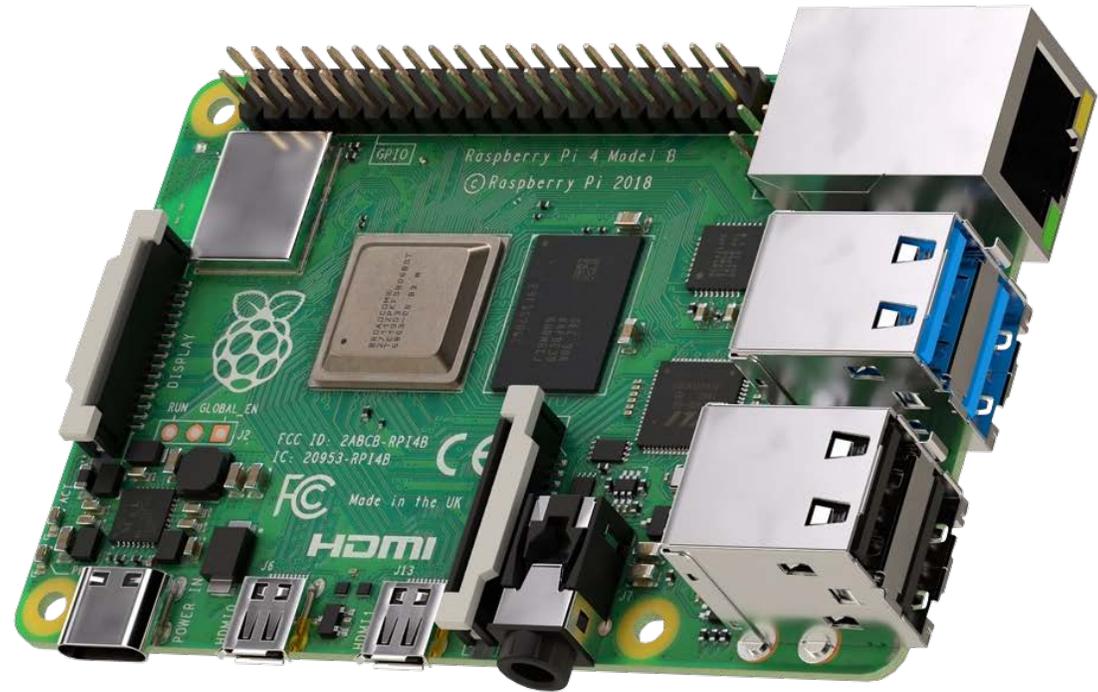
PI Specs - 3B+

- Quad core ARMv8 processor running at 1.4GHz
- 1GB RAM
- HDMI output
- 3.5mm audio jack output
- 4 USB 2.0 ports
- 1 Gigabit Ethernet port
- 2.4GHz/5GHz Wireless
- Bluetooth
- Board costs \$35



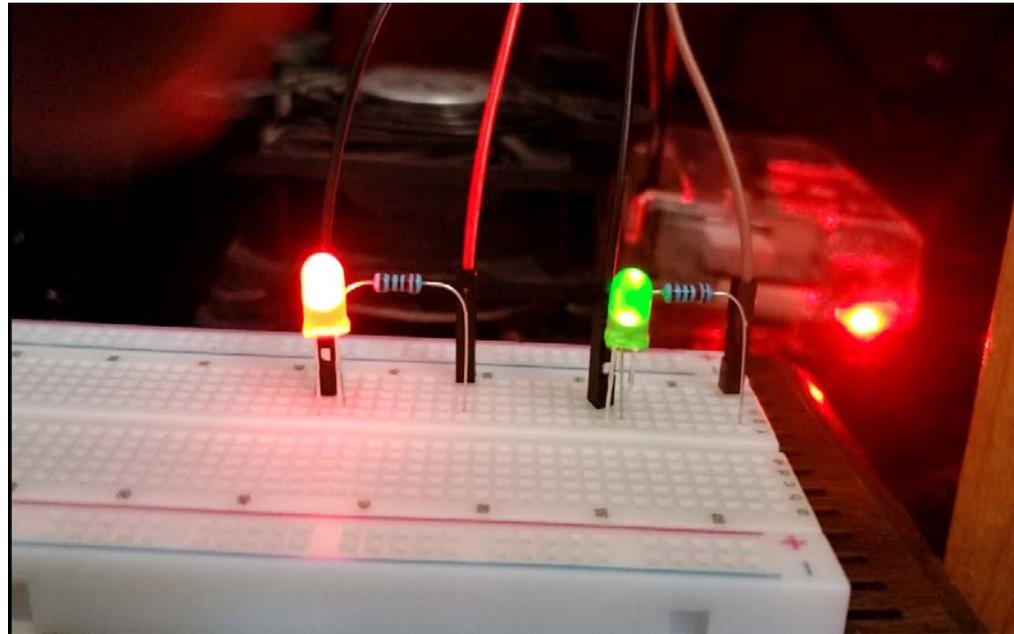
PI Specs – Model 4

- Quad core ARMv8-A processor running at 1.6GHz
- 1,2,4, or 8 GB RAM
- 2 MicroHDMI outputs
- 3.5mm audio jack output
- 2 USB 2.0 ports
- 2 USB 3.0 ports
- 1 Gigabit Ethernet port
- 2.4GHz/5GHz Wireless
- Bluetooth
- Board costs \$35-\$75



PI Specs – The GPIO Pins

- Every PI comes included with GPIO pins that can be controlled via an included python module
- Much more advanced things can be done with them, like accepting input from buttons, and sending out data
- What is shown on the right is a basic implementation where I used them to illuminate these LED lights in a pattern



Pi Model B/B+			
3V3 Power	1	2	5V Power
GPIO2 SDA1 I2C	3	4	5V Power
GPIO3 SCL1 I2C	5	6	Ground
GPIO4	7	8	GPIO14 UART0_TXD
Ground	9	10	GPIO15 UART0_RXD
GPIO17	11	12	GPIO18 PCM_CLK
GPIO27	13	14	Ground
GPIO22	15	16	GPIO23
3V3 Power	17	18	GPIO24
GPIO10 SPI0_MOSI	19	20	Ground
GPIO9 SPI0_MISO	21	22	GPIO25
GPIO11 SPI0_SCLK	23	24	GPIO8 SPI0_CE0_N
Ground	25	26	GPIO7 SPI0_CE1_N
ID_SD I2C ID EEPROM	27	28	ID_SC I2C ID EEPROM
GPIO5	29	30	Ground
GPIO6	31	32	GPIO12
GPIO13	33	34	Ground
GPIO19	35	36	GPIO16
GPIO26	37	38	GPIO20
Ground	39	40	GPIO21

www.raspberrypi-spy.co.uk

PI Specs – The GPIO Pins

```
#!/usr/bin/python3.7
import RPi.GPIO as GPIO
import time

#Set the mode for the board
GPIO.setmode(GPIO.BCM)

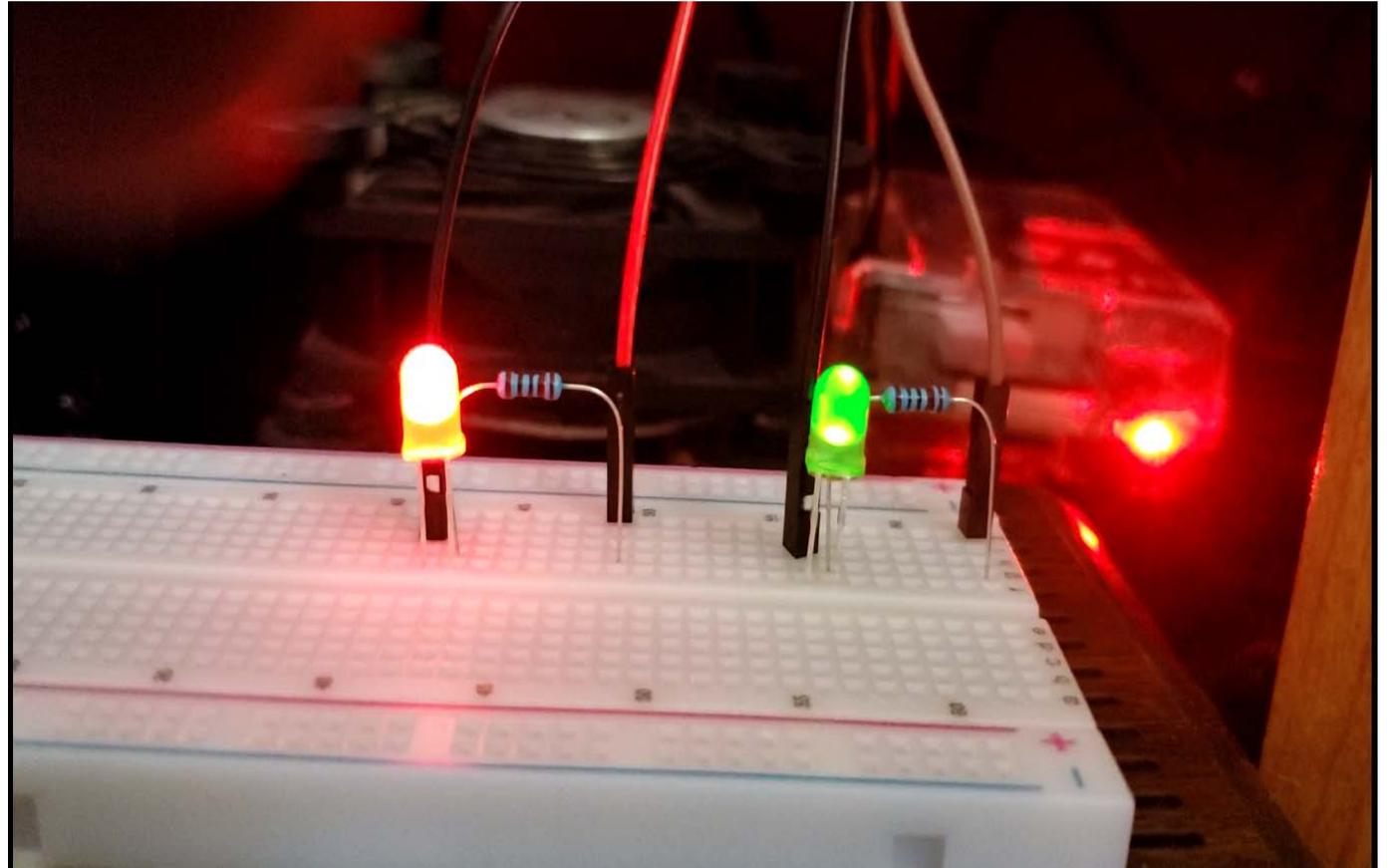
#Set pins 18 and 17 as output
GPIO.setup(18, GPIO.OUT)
GPIO.setup(17, GPIO.OUT)

#Turn it on and off for 10 cycles
count = 0
while count < 10:
    GPIO.output(18, True)
    time.sleep(1)
    GPIO.output(17, True)
    time.sleep(1)

    GPIO.output(18, False)
    time.sleep(1)
    GPIO.output(17, False)
    time.sleep(1)

    count += 1

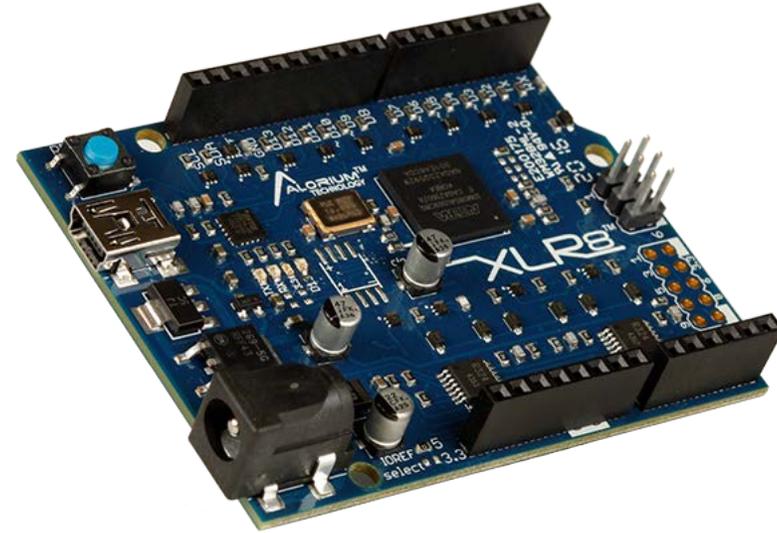
#Reset the pin to its default state (input)
GPIO.setup(18, GPIO.IN)
GPIO.setup(17, GPIO.IN)
```



Pi vs Arduinos



- Runs a full Linux operating system, running at 1+GHz
- Is a complete computer reduced to a single tiny board

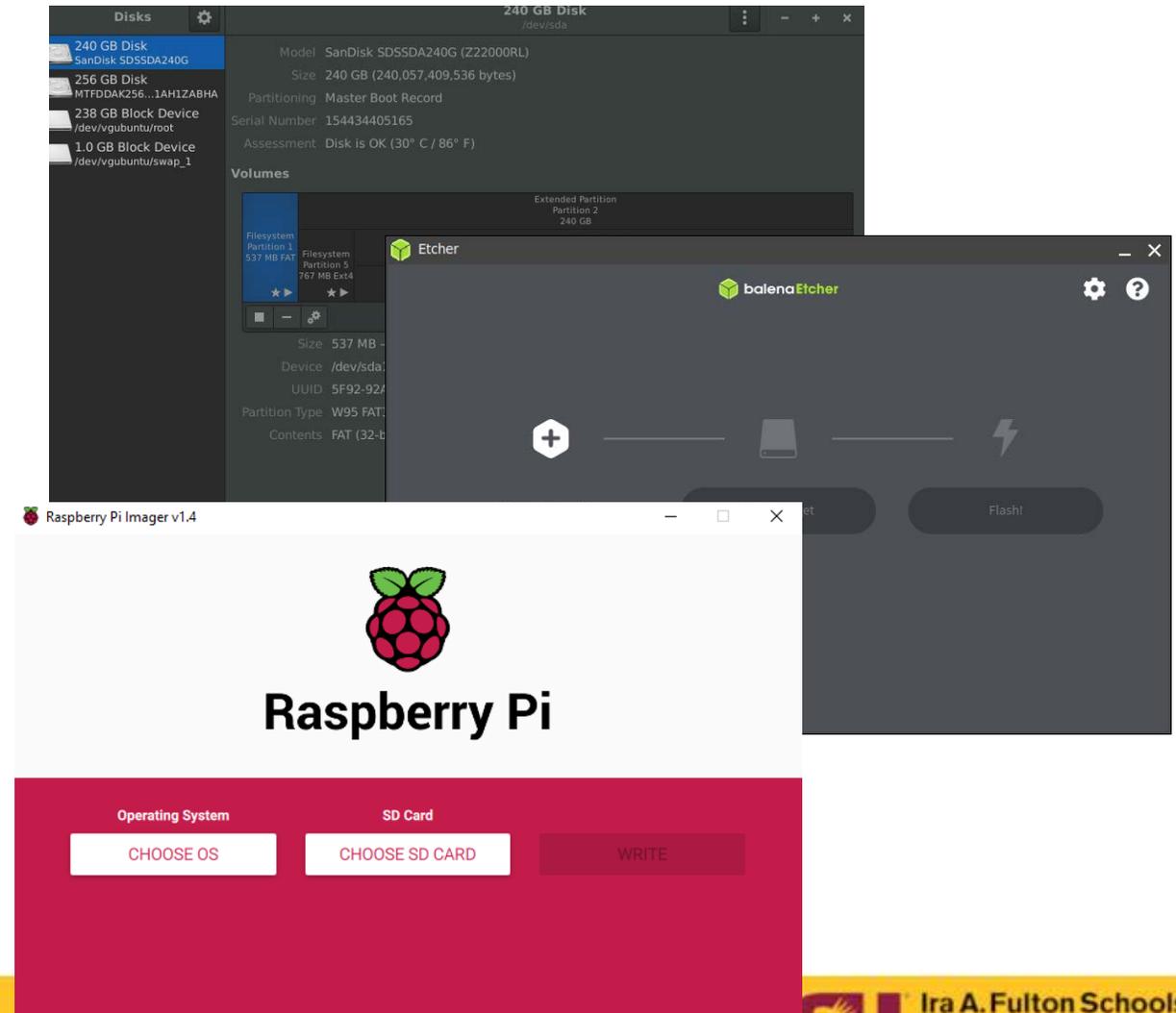


- Doesn't run an operating system, and runs at 10-100MHz
- Can be programmed by a computer, and set to autonomously perform a task until powered off
- Due to lack of overhead the Arduino is fantastic at performing repetitive tasks with excellent timing

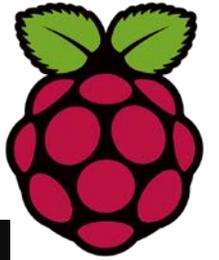
Operating System Installation

- Instead of inserting a USB and running through setup like a typical computer, the OS is imaged onto the microSD card in advance on another computer, and unpacks itself once the pi boots
- As of March 5th this year, they've created an official utility to make imaging pis easy. It handles the downloading and imaging of most officially endorsed operating systems for you
- In the past, other imagers I've used with success include:
 - balenaEtcher (Windows)
 - gnome-disks (Linux)

<https://www.raspberrypi.org/downloads/>



OS Options – Raspberry Pi OS



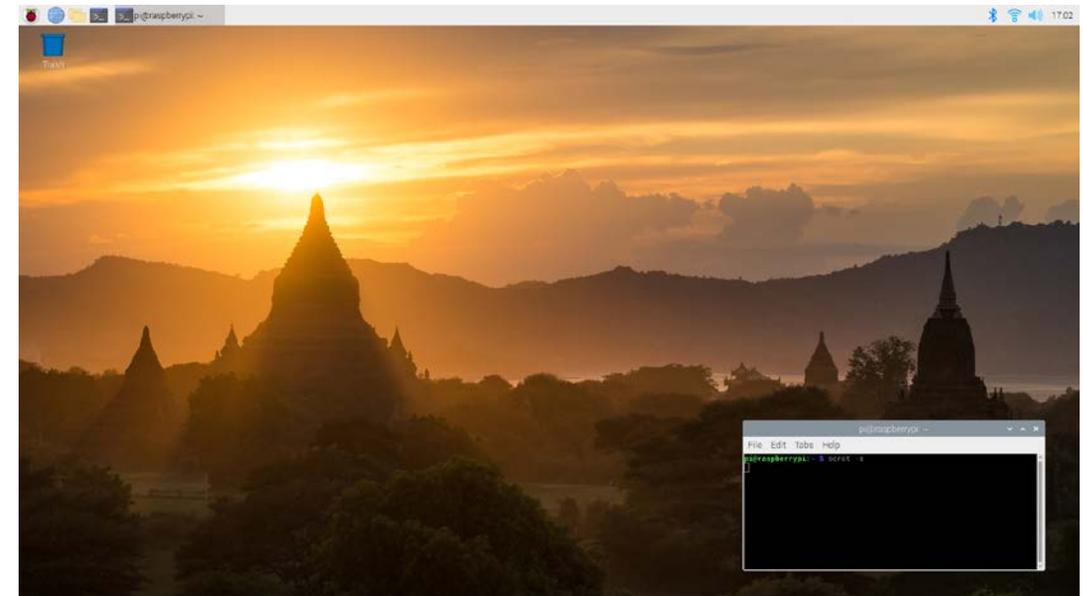
<https://www.raspberrypi.org/downloads/raspberry-pi-os/>

- The “official” operating system for raspberry pis
- 32-bit operating system based on Debian Linux that’s been officially endorsed by the raspberry pi foundation since 2015
- Will run without issue on any raspberry pi model you plug it into
- Comes in 2 options
 1. A standard image that includes a desktop environment and utilities to view things like word documents
 2. A minimal, command line only image for use cases that don’t need the overhead of a desktop

```
Linux piserver 5.4.51+ #1333 Mon Aug 10 16:38:02 BST 2020 armv6l

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: Mon Sep  7 01:05:18 2020 from 192.168.12.102
pi@piserver:~ $
```



OS Options – Ubuntu Server



- A command line version of Ubuntu made to run on the raspberry pi.
- Compatible with Pi Models 2,3, and 4
- Versions 18.04-LTS and 20.04-LTS are available, with 32-bit and 64-bit options available for each
- Provides much of the same functionality of Raspberry Pi OS, but with Ubuntu base instead of a Debian base
- Good if you have a use case that lends itself better to ubuntu's framework, or just have a preference for Ubuntu over Debian

<https://ubuntu.com/download/raspberry-pi>

```
Welcome to Ubuntu 20.04.1 LTS (GNU/Linux 5.4.0-1019-raspi aarch64)

* Documentation:  https://help.ubuntu.com
* Management:    https://landscape.canonical.com
* Support:        https://ubuntu.com/advantage

7 updates can be installed immediately.
0 of these updates are security updates.
To see these additional updates run: apt list --upgradable

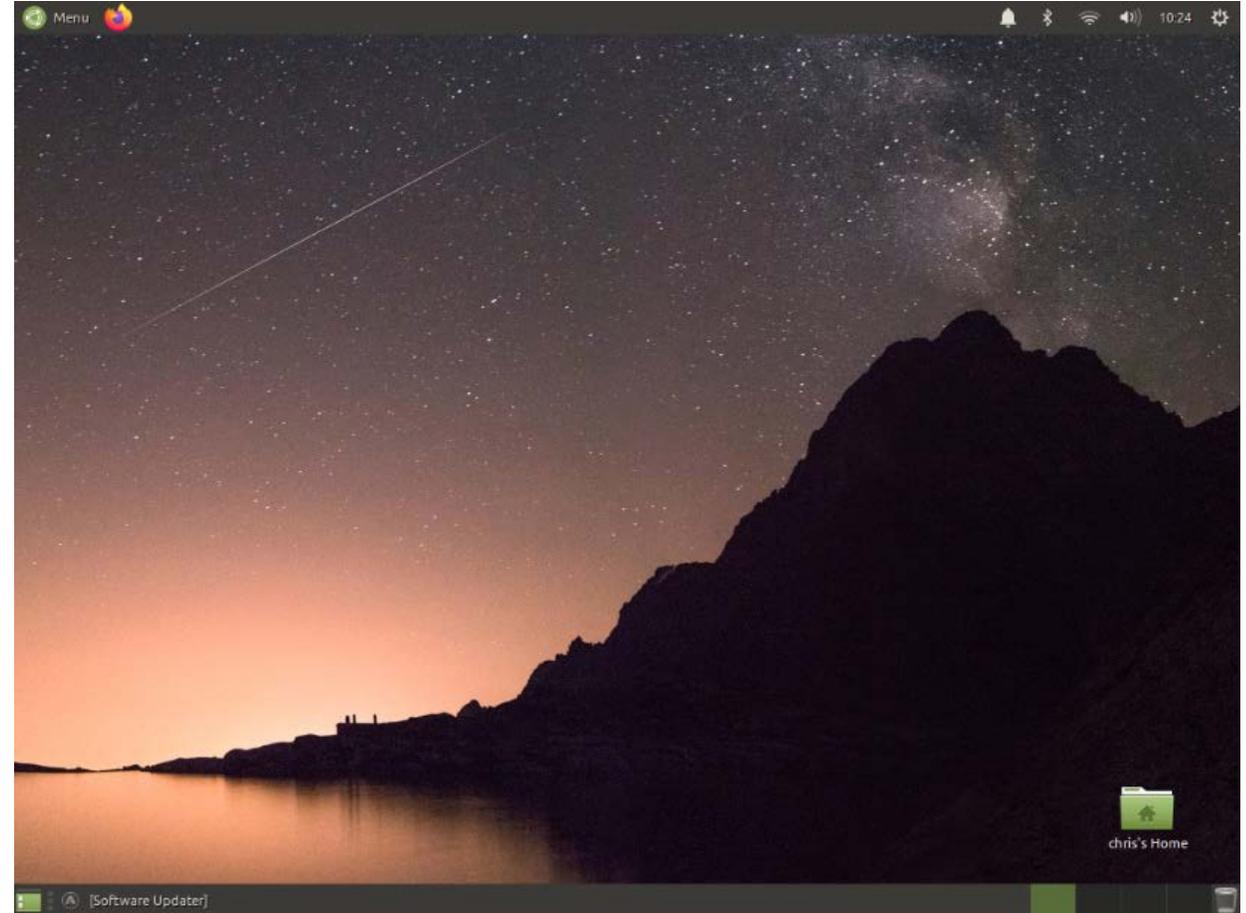
Last login: Mon Sep 28 21:55:15 2020 from 10.0.0.2
chris@chris-pi4:~$
```

OS Options – Ubuntu Mate

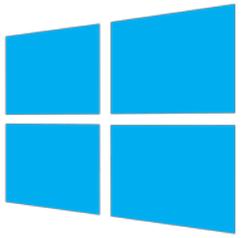


<https://ubuntu-mate.org/ports/raspberry-pi/>

- Full 64-bit Ubuntu 20.04 Desktop for raspberry pi
- Compatible with pi 3 and 4, but 4 is highly recommended for it to perform well
- Includes the entire catalogue of Ubuntu repositories that you would have on a desktop
- Has performance that's on par with lower powered laptops. Is an excellent option if you have a pi 4, and intend to use it as a desktop computer

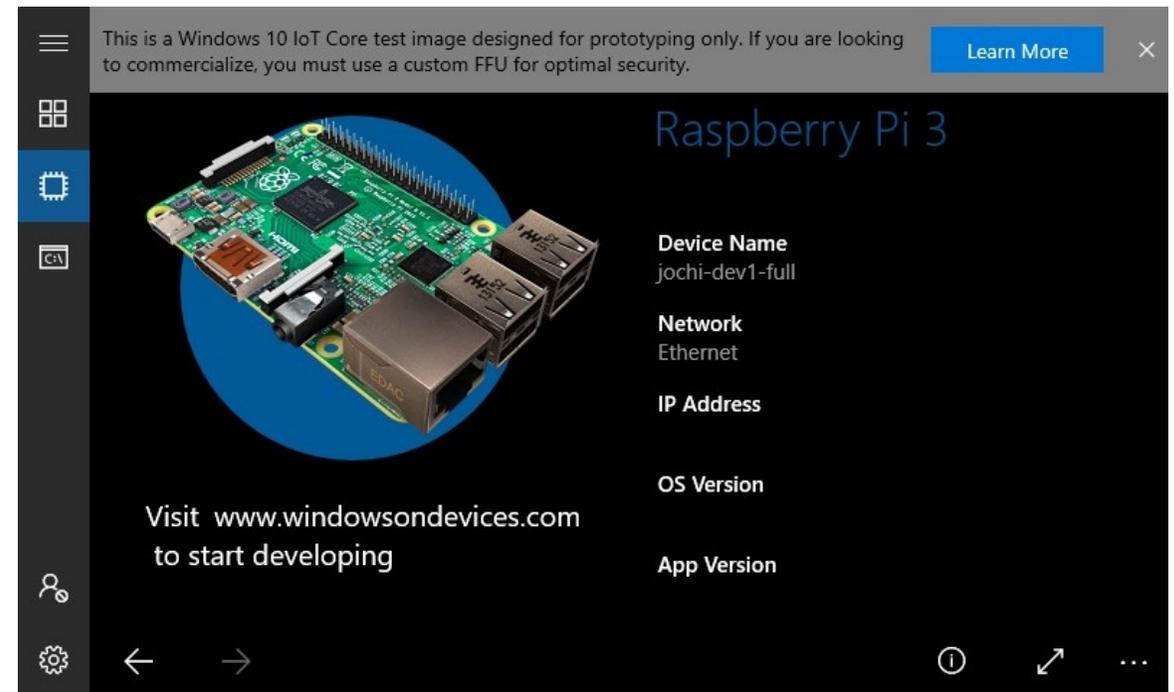


OS Options – Windows 10 (kind of)



<https://www.microsoft.com/en-us/software-download/windows10IoTCore>

- Created by Microsoft to run on the raspberry pi, but unfortunately doesn't appear to have been updated since October 2018
- Compatible with models 2 and 3 (3B+ experimental)
- After demoing it, it appears very limited in functionality compared to the Linux options. Limiting you to only a basic PowerShell command line, and a few simple included applications

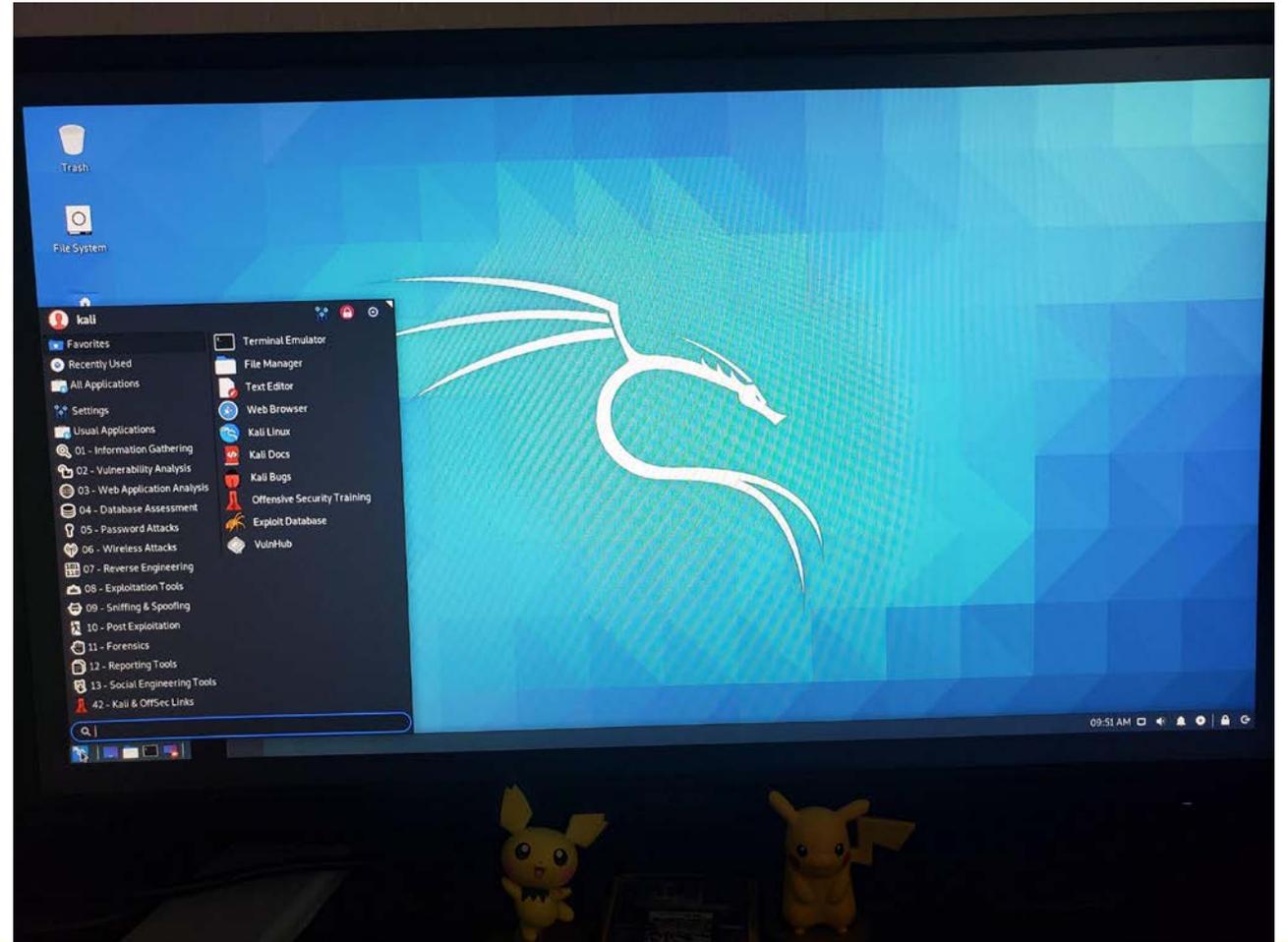


OS Options – Kali Linux

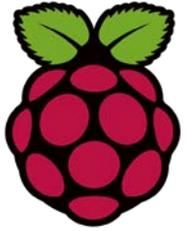


<https://www.offensive-security.com/kali-linux-arm-images/>

- Kali Linux images are offered for Pi from Offensive-Security
- Supports all models of raspberry pi
- Includes nearly the entire suite of applications included with standard kali on desktop
- Good for running security scans on your home network without hassling with virtual machines, or installing kali onto a desktop/laptop

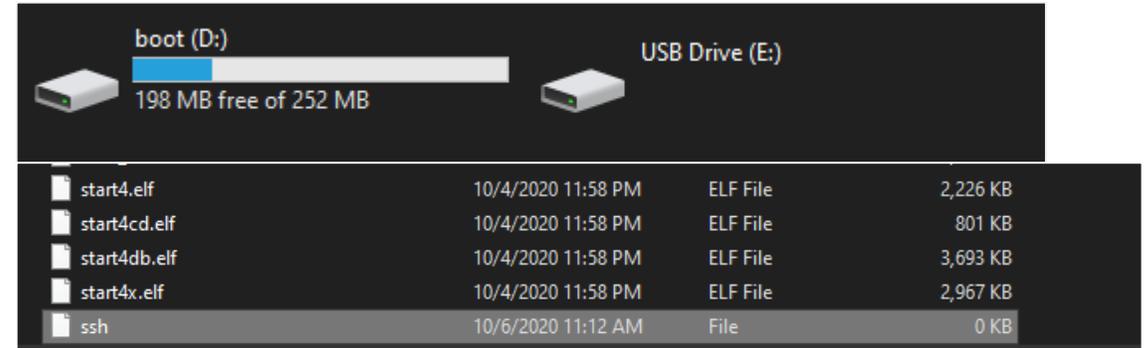


Tips for Raspberry Pi OS



Creating a blank SSH file before plugging into pi, so it enables SSH by default

- After imaging the OS onto an SD card, one partition should show up as readable to windows in your file explorer. If you place a blank file named “ssh” in that directory, it’ll enable SSH on startup when it’s unpacking the operating system



File Name	Modified	Type	Size
start4.elf	10/4/2020 11:58 PM	ELF File	2,226 KB
start4cd.elf	10/4/2020 11:58 PM	ELF File	801 KB
start4db.elf	10/4/2020 11:58 PM	ELF File	3,693 KB
start4x.elf	10/4/2020 11:58 PM	ELF File	2,967 KB
ssh	10/6/2020 11:12 AM	File	0 KB

- If you’re working on a Linux machine, it’s possible to enter the Linux filesystem before you even boot the pi, and change configuration files. Enabling you to do things like set up a static IP address for ethernet before even starting up

Appended to the end of /etc/dhcpd.conf

```
interface eth0
static ip_address=192.168.0.42/24
```

Useful Commands

- `ssh [username]@[pi's_IP_address]`
 - Is the same syntax on both windows and linux command lines, and allows you to remote terminal into the raspberry pi

```
PS C:\Users\sun-c> ssh pi@192.168.12.1
pi@192.168.12.1's password:
Linux piserver 5.4.51+ #1333 Mon Aug 10 16:38:02 BST 2020 armv6l

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 Oct  6 19:03:04 2020 from 192.168.12.100
pi@piserver:~ $ |
```

• Screen

- Installed with “*sudo apt-get install screen*”
- Is a command that comes pre-installed on some distributions of linux, that allows you to open a terminal session and have it continue running even after you logout of ssh

1. Open a screen with the command
 - `screen`
 2. After starting any long running processes, disconnect from the screen with
 - `Ctrl-A + Ctrl-D`
 3. Later, even on a different ssh session, re-open the screen with the command
 - `screen -r`
- There may be more than 1 running screen, and this can be checked with
 - `screen -ls`

Applications – Windows File Share

<https://ubuntu.com/tutorials/install-and-configure-samba#4-setting-up-user-accounts-and-connecting-to-share>

- An incredibly useful utility that allows the pi to host a fileshare that can be accessed by windows PCs
- Allows a directory of the pi to be treated like a network drive by windows, allowing files to be easily sent to and from the pi
- Lets you do things like edit python scripts with VSCode or your favorite editor and immediately save straight to the pi for fast demoing

1. Install with the command
 - `sudo apt install samba samba-common-bin`
2. Append this to `/etc/samba/smb.conf`

```
[share]
Comment = Raspberry pi fileshare
Path = /path/to/shared/folder
follow symlinks = no
wide links = no
Browseable = Yes
Writeable = Yes
only guest = no
create mask = 0777
directory mask = 0777
public = Yes
guest ok = no
```

3. Add user “pi” to the fileshare with
 - `sudo smbpasswd -a pi`
4. Reload the server to apply changes with
 - `sudo /etc/init.d/smbd restart`

Applications – LAMP Stack

- Linux Apache Mysql PhP (LAMP) is your standard web stack for linux that includes
 - Apache Webserver
 - Mysql Database
 - PhP middleware to connect the two
- Great for demoing web projects and databases, in environment that's extremely easy to reset if you mess things up too much



Instructions to set up LAMP stack on raspberry pi found at <https://projects.raspberrypi.org/en/projects/lamp-web-server-with-wordpress>
(Wordpress is optional)

Applications – Access point + DHCP

- In addition to running Apache Webserver, MySQL Database, and Windows Fileshare, this pi is also using broadcasting itself as an Access Point
- Using the packages
 - hostapd: for broadcasting an access point using US frequency options. Typical practical use of this is for extending Wi-Fi networks when just 1 router isn't enough
 - isc-dhcp-server: to run a DHCP server that hands out addresses to devices that successfully connect to it
- My goal with this was to be able to connect to the pi directly without going through a wireless network, and these two packages together facilitate

<https://www.raspberrypi.org/documentation/configuration/wireless/access-point-routed.md>
https://wiki.debian.org/DHCP_Server

Wireless Network Configuration

```
#Interface
interface=wlan0

#Network Name
ssid=pinet

#Use channel 6
channel=6
#2.4GHz band
hw_mode=g
#Use only WPA algorithms
auth_algs=1
#Support 802.11n
ieee80211n=1
wmm_enabled=1
#Only permit frequencies allowed in the US
ieee80211d=1
country_code=US

#WPA Management
wpa=2
wpa_passphrase=
wpa_key_mgmt=WPA-PSK
wpa_pairwise=TKIP
rsn_pairwise=CCMP
```

DHCP config appended to the end of
/etc/dhcp/dhcpd.conf

```
subnet 192.168.12.0 netmask 255.255.255.0 {
    range 192.168.12.100 192.168.12.200;
    default-lease-time 600;
    max-lease-time 7200;
    option domain-name "pinet.local";
    option routers 192.168.12.1;
}
```

Applications – Pi-hole

- Downloaded from pi-hole.net
- Pi-hole is an open source, DNS level ad blocker that blocks requests to known domains that ads are served from
- By configuring devices on your network to use this as a DNS server, it allows you to block ads on devices that would normally be difficult to block ads on. (In-app ads on your phone, ads on smart TVs, etc.)
- Easy to set up and configure



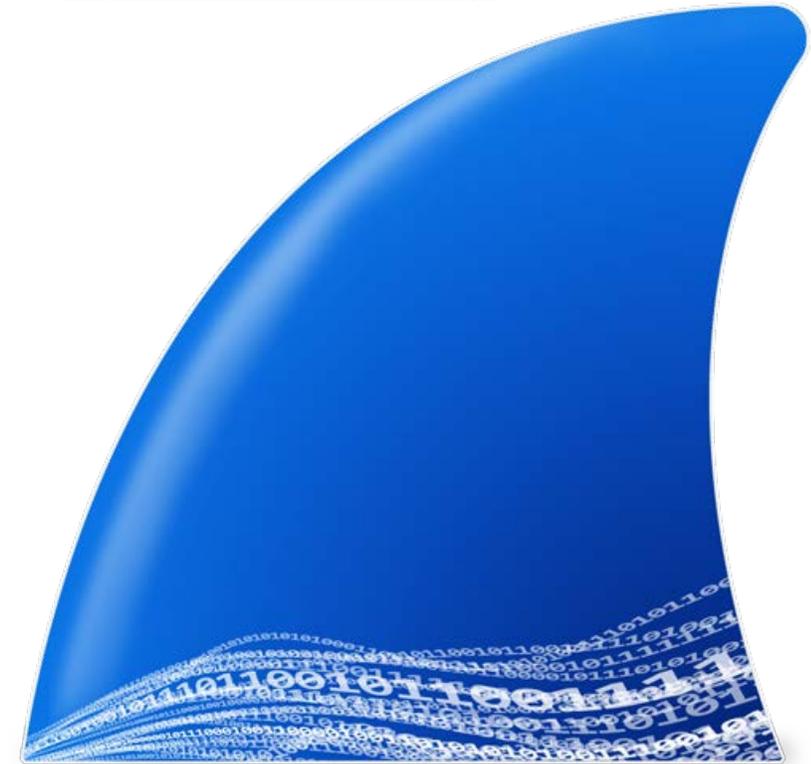
<https://pi-hole.net/>

Applications – Home Network Monitor

- With access to Kali Linux, its utilities can be leveraged to perform security operations. Such as monitoring your local network to spot any suspicious activity
- nmap
 - Network scanning utility that allows you to check what devices/ports are open on your LAN
 - The command “nmap -sP 192.168.1.0/24” for example, will list all online devices on the network 192.168.1.0
- Wireshark
 - Can be utilized to capture packets traveling across your network, and allow you to do analysis on what packets are going where

<https://nmap.org/>

<https://www.wireshark.org/>



Helpful Links

GPIO pin manual

- Read this manual before messing with gpio, to get an idea of how to use it safely and what the limitations of the pins are:
<https://www.raspberrypi.org/documentation/usage/gpio/>

Operating system installation and images

- Raspberry Pi Imager: <https://www.raspberrypi.org/downloads/>
- Raspberry Pi OS: <https://www.raspberrypi.org/downloads/raspberry-pi-os/>
- Ubuntu Server: <https://ubuntu.com/download/raspberry-pi>
- Ubuntu Mate: <https://ubuntu-mate.org/ports/raspberry-pi/>
- Windows IoT: <https://www.microsoft.com/en-us/software-download/windows10IoTCore>
- Kali Linux: <https://www.offensive-security.com/kali-linux-arm-images/>

Commands and cool features

- Windows Fileshare (Procedure is pretty much identical on the raspberry pi as it's shown here for ubuntu):
<https://ubuntu.com/tutorials/install-and-configure-samba>
- LAMP stack install: <https://projects.raspberrypi.org/en/projects/lamp-web-server-with-wordpress>
- Access Point: <https://www.raspberrypi.org/documentation/configuration/wireless/access-point-routed.md>
- DHCP Server: https://wiki.debian.org/DHCP_Server
- PiHole: <https://pi-hole.net/>
- Nmap: <https://nmap.org/>
- Wireshark: <https://www.wireshark.org/>