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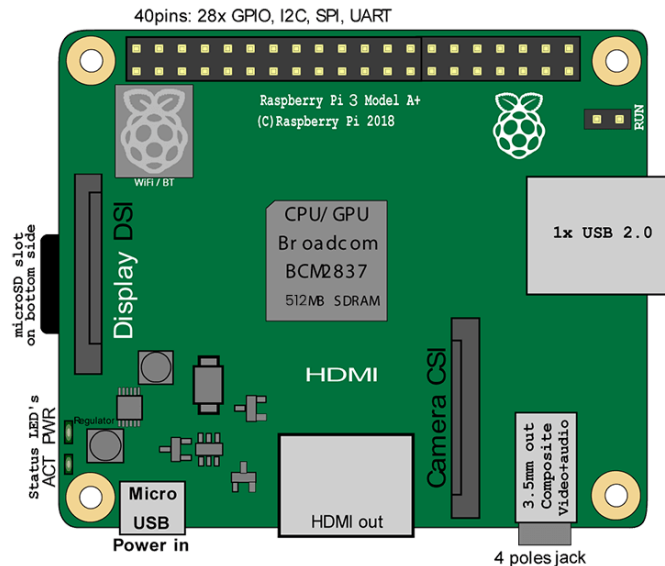
Department of Electrical & Electronic Engineering

EEEE1002: Lab Week 4

“From zero to ‘Pi 3 A+’ with ZERO extra hardware...in about 60 minutes!”

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From zero to 'Pi 3 A+' with ZERO extra hardware...in about 60 minutes!!



Pi 3 A+ top view

Overview

SINCE ORDINARILY YOU'D CONNECT YOUR PI 3 A+ TO AN HDMI SCREEN AND SET UP THE NOOBS MEMORY CARD BY TAPPING A KEYBOARD TO CONFIGURE ITS OPTIONS, THIS BECOMES TRICKY IF YOU DON'T HAVE A MONITOR, AND DOUBLY-SO IF YOU HAVE NO SPARE PLUGGABLE KEYBOARD, AND EVEN HARDER STILL WITH NO EASILY-ACCESSIBLE Wi-Fi.

There is a solution. THIS is the solution.

Using only your existing PC/laptop and a USB A-A cable, it is possible to get the Pi running and for you to see what it's doing and to communicate with it using SSH (Secure Shell) and VNC (Virtual Network Computing).

It would be helpful if you have run Windows Update recently and that you have few (if any) outstanding Windows updates to install, before embarking on this process.

There are several critical steps – please ensure you follow each step very carefully.

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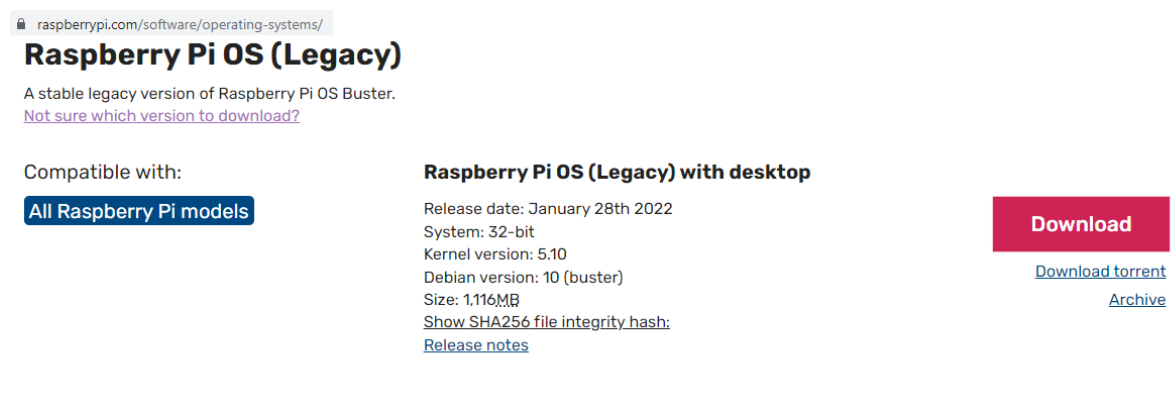
1. INSTALL AN OPERATING SYSTEM

The content of the supplied "NOOBS" (New, Out Of Box Software) card is not much use to you in this circumstance as the first thing it needs you to do is make a selection of your choice of operating system from a menu on the Raspberry Pi using your screen (that you haven't got), keyboard (that you haven't got) and mouse (haven't got one of those either!) !

Solution: Download a ready-generated operating system and write it to the card.

Download a Raspberry Pi Operating Systemⁱ

Because of very recent changes to the Pi Operating system which we haven't had chance to test before deployment, we'll be using a version of Pi OS that ISN'T the latest.

The screenshot shows the Raspberry Pi OS (Legacy) download page. At the top, the URL 'raspberrypi.com/software/operating-systems/' is visible. The main heading is 'Raspberry Pi OS (Legacy)' with a subtext 'A stable legacy version of Raspberry Pi OS Buster.' and a link 'Not sure which version to download?'. Below this, it says 'Compatible with:' followed by a button 'All Raspberry Pi models'. To the right, the title 'Raspberry Pi OS (Legacy) with desktop' is shown, along with release details: 'Release date: January 28th 2022', 'System: 32-bit', 'Kernel version: 5.10', 'Debian version: 10 (buster)', 'Size: 1,116MB', 'Show SHA256 file integrity hash:', and 'Release notes'. A large red 'Download' button is on the right, with links for 'Download torrent' and 'Archive' below it.

From the Operating System selection page, choose "**Raspberry Pi OS (Legacy) with desktop**" and download it.

2. INSTALL ADDITIONAL SOFTWARE TO YOUR PC

While your image is downloading, you should obtain some other software to correctly write the image to the memory card (you can't copy/paste – disk images need to be **mounted/etched**) and for other communication purposes. We **STRONGLY** advise downloading the pieces of free software as shown here, for the purposes indicated. Links are in the "References" section at the end of the document.

SD Card Formatting.

You may find it helpful to wipe (format) the SD Memory Card containing 'NOOBS' before burning the new image onto it.



The SD Association have the **tool** for thisⁱⁱ, which you should download and install and run if you wish.

If you run this, double check the drive letter it's about to erase...let's not go wiping our Windows installation here....

OS Image Mounting.

Next you'll need something like **BalenaEtcher** - a very simple program to assist with getting the Pi operating system correctly onto a memory card.



Download **BalenaEtcher**ⁱⁱⁱ and install it.

With BalenaEtcher, you only need to specify the physical card you're targeting – don't worry if Windows shows it as 2 or more drives.

File Editing (Windows).

You will also need to download and install a useful program called "**Notepad++**" (not to be confused with Windows' own 'Notepad' – we will be using both programs later). Notepad is very good for our purposes as it edits system files without leaving stray characters or hidden formatting, while also making the file you're working on exceptionally easy to read.



Download "**Notepad++**"^{iv} and install it.

SSH (Secure Shell) Terminal Communication

To send commands via a Terminal Window to the Pi, you'll need "**PuTTY**", the definitive TeleType application. Our first communication with the Pi will be via this route.



Download "**PuTTY**"^v and install it.

File Transfer - FileZilla

The simplest way to transfer files from your PC to the Pi is by using FileZilla. (WinSCP also works but FileZilla is preferred)



Download "**FileZilla**"^{vi} and install it.

VNC Viewer

Finally, for now, to show the Pi desktop on our PC/Laptop, we'll need to utilise the VNC Virtual Network Computing available on the Pi (once it's been enabled)



Download "**VNC Viewer**"^{vii} and install it.

3. UNZIP YOUR DOWNLOAD

The operating system you chose downloads as a .zip file so unzip it to a convenient location and it'll become a ".img" disk image file. Right-click, Extract All (or use your preferred decompression tool).

4. ETCH YOUR OS TO THE MEMORY CARD

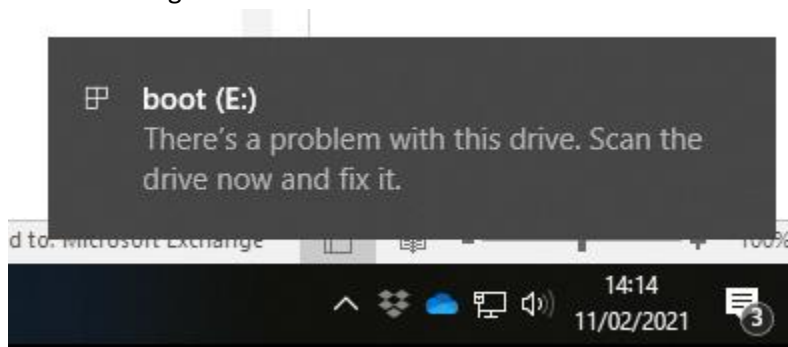
Run **BalenaEtcher**. Select the Operating System Image you unzipped earlier, select the memory card as target (double check that the capacity of the target is the memory card size and check the drive letter...it is possible to wipe something critical otherwise) and select **FLASH!**

The process takes about 15 minutes to flash the image and verify.

If it fails repeatedly to verify correctly, you could also try RaspberryPi's Imager ^{viii}

Once done, remove the memory card from the computer and then PUT IT BACK IN YOUR PC/Laptop.

Windows will almost certainly throw a variety of warnings and "I want to format this card please" sort of messages...



A warning message, earlier

This is expected behaviour and you need to IGNORE or CANCEL all such messages.

Your 32GB card will appear to have shrunk to something like 128MB, but don't panic - this is expected behaviour. The operating system image splits the card into 2 partitions – a small partition called "boot" which is accessible to both Windows AND the Pi operating system, and a much larger partition which is only visible to the Pi, and which contains the Pi OS and space to do work on the Pi.

5. MODIFY THE "BOOT" PARTITION CONTENTS TO ENABLE PI OPERATION

For our purposes, the downloaded Operating System Image doesn't fulfil our needs so we will make some alterations to enable correct operation without the ancillary hardware (keyboard etc.). The Pi needs to be set up so that we can communicate with it via a PC/laptop and as such we need to enable some of its networking functions and set it up to work in this manner.

Open **Windows Explorer** (Windows key + "E") and locate the drive called "**boot**".

This is the windows-accessible part of the Pi operating system disk.

We're going to carefully modify a couple of files in here before we put the card into the Pi.

There is a helpful guide ^{ix} for setting up a Raspberry Pi with no hardware like this, and you may find it beneficial to read it. The first job is to enable SSH communication, which is not enabled by default.

Enable SSH Communication



To communicate with, and send commands to the Pi, we need to enable **Secure Shell Communication (SSH)**.

Since we can't access the Pi without it, but we can't talk to the Pi to enable it without it, we need to trigger the Pi to recognise that we want it enabled when it first boots.

To achieve this, place an empty file named **ssh** (with no filename extension) in the root directory of the card. Here's how:

Open **"Notepad++"** on your laptop/pc. **DO NOT USE WORD or regular 'notepad'!!!**

Open a new file, put in one space and nothing more.

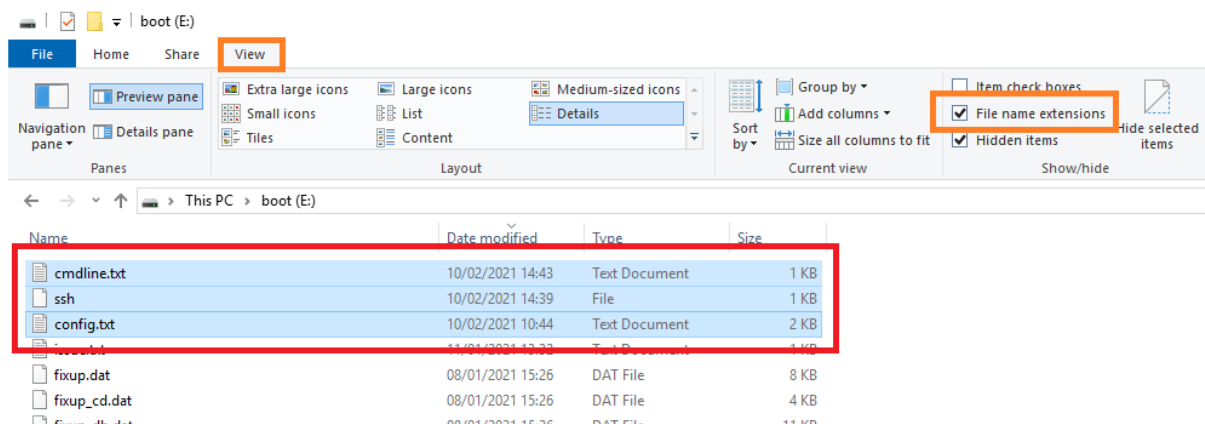
Click **File / Save As ...**

Be sure to set **"Save as type"** to **"All Files"** (so the file is NOT saved with a .txt extension).

Call the file **ssh** and save it in the **"boot"** drive...close the file.

Check that Windows hasn't added a .txt extension anyway...

Depending on your computer/laptop setup, file extensions may not be visible. If so, in Windows Explorer, click the **"View"** tab and tick the **"File name extensions"** checkbox. If necessary, right-click and rename the **"ssh.txt"** file and delete the .txt extension...accept the warning...and OK.



This is correct!

This plain "ssh" file is the trigger the Pi needs to enable SSH communication when it boots.

Modify file: config.txt

Next, in the **"boot"** partition, we need to edit the **"config.txt"** file:

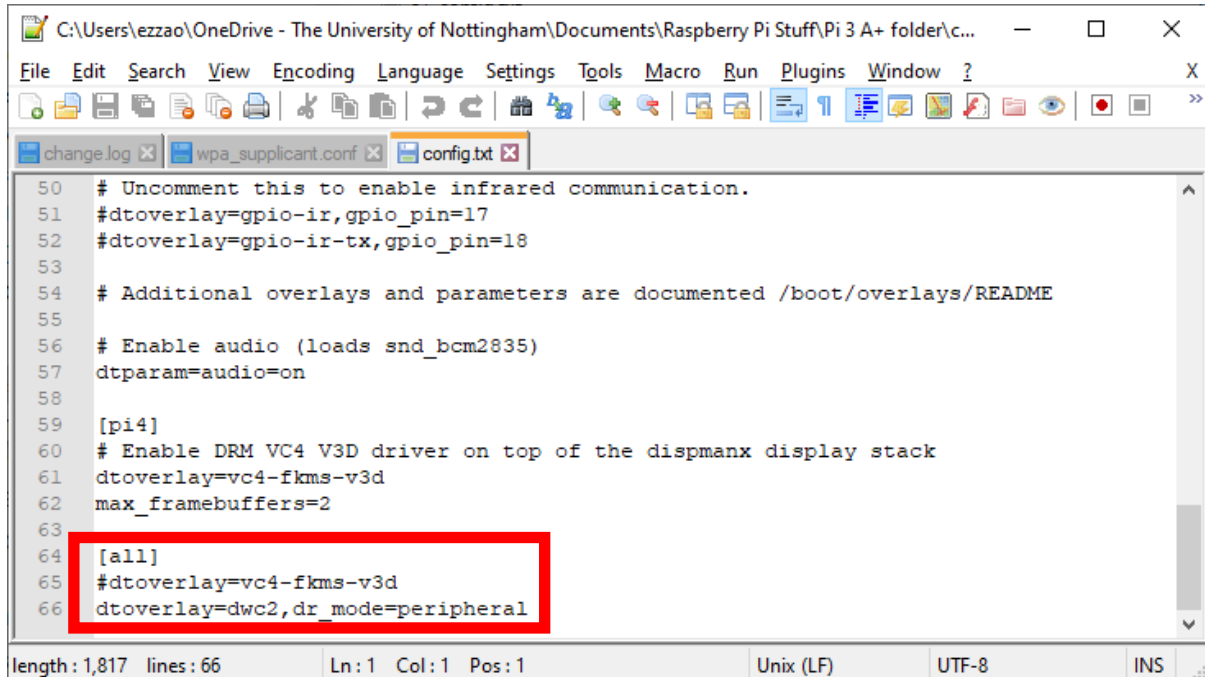
In the root folder of the SD card, open config.txt using **Notepad++**

DO NOT USE WORD or regular 'notepad'!!!

Append this line to the bottom of that file (to enable the dwc2 USB drivers in the Device Tree, and to set the device's dual-role mode to that of a peripheral. While the Pi is a standalone device, we're going to use it briefly as an addon (peripheral) device with our PC):

dtoverlay=dwc2,dr_mode=peripheral

The end of the file should look like this:



```
50 # Uncomment this to enable infrared communication.
51 #dtoverlay=gpio-ir,gpio_pin=17
52 #dtoverlay=gpio-ir-tx,gpio_pin=18
53
54 # Additional overlays and parameters are documented /boot/overlays/README
55
56 # Enable audio (loads snd_bcm2835)
57 dtparam=audio=on
58
59 [pi4]
60 # Enable DRM VC4 V3D driver on top of the dispmanx display stack
61 dtoverlay=vc4-fkms-v3d
62 max_framebuffers=2
63
64 [all]
65 #dtoverlay=vc4-fkms-v3d
66 dtoverlay=dwc2,dr_mode=peripheral
```

Save the file and close it.

Modify file: `cmdline.txt`

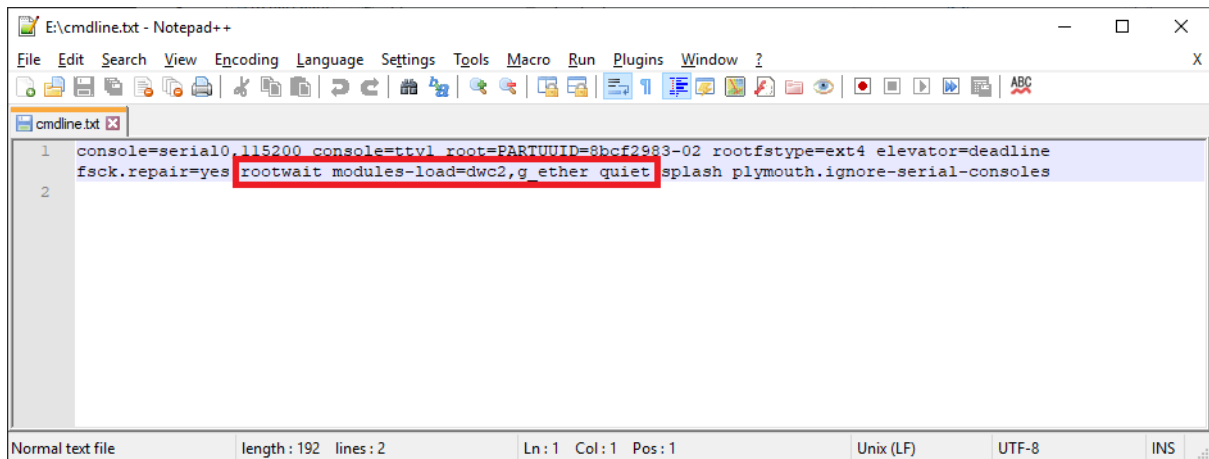
In the root folder of the SD card, open `cmdline.txt` in **Notepad++**

DO NOT USE WORD or regular 'notepad'!!!

After **rootwait**, append the following text, leaving only one space between **rootwait** and the new text (otherwise it might not be parsed correctly), in order to load the virtual ethernet-via-USB Gadget sharing module:

modules-load=dwc2,g_ether

If there was any text after the new text make sure that there is only one space between that text and the new text, so it looks like this:



```
1 console=serial0,115200 console=tty1 root=PARTUUID=8bcf2983-02 rootfstype=ext4 elevator=deadline
2 fsck.repair=yes rootwait modules-load=dwc2,g_ether quiet splash plymouth.ignore-serial-consoles
```

Save the file and close it.

Double-check that the file we created earlier is called “ssh” and not “ssh.txt” ...

6. BOOT YOUR PI!

WARNING!

The USB A-A cable with which you have been provided is an unusual assembly and is only for use in specific circumstances, such as the method in use here. If you connect 2 other devices with this cable, it is possible to severely damage or destroy a USB power system, or cause severe overheating and fire. **DO NOT USE THIS CABLE FOR ANY OTHER PURPOSE.**

Now you can boot up your Pi.

Insert the memory card into the Pi and plug the USB A-A cable into the large USB socket on the Pi, and the other end into your laptop/PC.

DON'T USE THE PI'S ONBOARD POWER SOCKET AT THIS TIME....

Let it boot.

It will take 2-3 minutes the first time.

Be patient. You won't see much, maybe the activity light on the Pi.

While this is happening, why not install the ancillary software you downloaded earlier!

Applications like PuTTY, VNC etc. should be able to find the Raspberry Pi on your network using its hostname followed by .local (default example: **raspberrypi.local**) typed into the address box thanks to a network service called **mDNS** discovery.

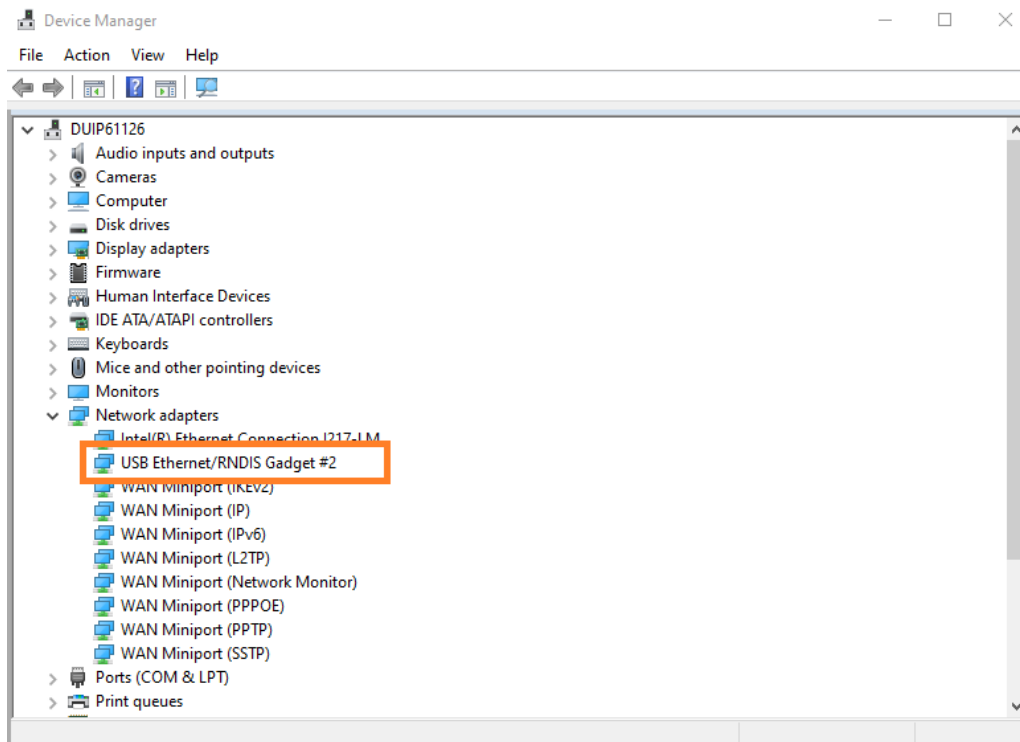
For this to work in Windows, a service called “**Bonjour**” needs to be installed first.

(If you have iTunes installed on Windows you probably don't have to do this as it gets installed with that application. If you don't, browse to the **support link** * and run the installer.)

Make sure Windows can see your Pi correctly.

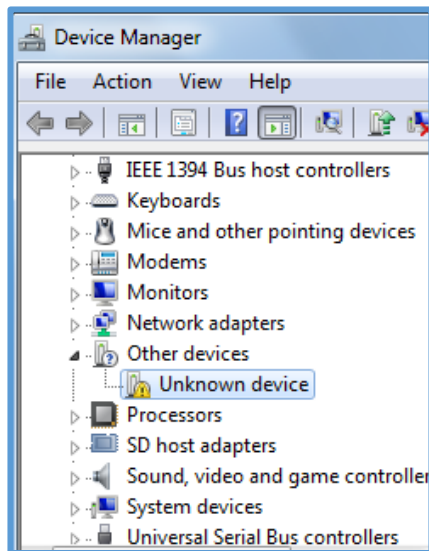
While your Pi boots, Windows should acknowledge it and recognise it. A few seconds after plugging it in to the PC, you should hear the familiar Windows “plugging a USB device in” “B-Ding!” sound.

To check that Windows recognises the Pi, Open Device Manager and cascade the “Network Adapters” section.



A correctly configured Pi will show up as a “USB Ethernet/RNDIS Gadget”. If you don’t see this, you may need to revisit your initial pi config (section 5 of this document), to double-check the changes to config.txt and cmdline.txt, or see the next paragraph about installing the appropriate drivers if you’re certain those files are correctly modified.

If Windows doesn’t recognise your Pi in the Network Connections window, it may be a Windows Driver issue.



Open up Device Manager in windows.

If you can't see the RNDIS gadget, you will almost certainly have a rogue entry "Unknown Device" in the Device Manager tree that's got a yellow exclamation mark next to it.

Or, in "Other devices" find "RNDIS/Ethernet Gadget" or "unknown device", and right click on it. Then click "Update driver software" from the menu:

In the next window, select "Browse my computer for driver software":

Now click "Let me pick from a list of device drivers on my computer":

Scroll down the list and select "Network adapters", then click

Next:

Now scroll down the "Manufacturers" list in the window on the left, and select "Microsoft". Then scroll down the "Network Adapters" list on the right side window until you find a line that says "Remote NDIS Compatible Device". Select that, then click Next:

A warning will pop up about Windows not being able to verify the driver, but just click "Yes" to get past it:

Once installed, your Pi should appear under the Network Communications window.

No suitable entry in the "Network Adapters" box? What you see in that box is dependent upon your exact Windows installation, and all are not the same. Try this – a compatible driver by the good people at Acer ^{xi}.

Pick the version best suited to your operating system, click the "Download" button, and then in the popup window, right-click the .cab file link and "save link as", and save the file somewhere convenient.

It is likely that your security system will object to this file – that is expected owing to the nature of cabinet files. This one, however, is straight from Microsoft's site and can be used safely. If necessary, on the download bar, KEEP this file.

Having downloaded successfully, locate the file, double-click on it and 2 files appear. Drag a box round them, right click and EXTRACT to a suitable location You should end up with 2 files: rndis.cat and RNDIS.inf

In windows' Device Manager right-click the rogue USB device, select "Update Driver", browse to where you extracted the RNDIS.inf file to, earlier, and select the folder. Your device should (possibly after a reboot of the PC) show up correctly as a USB Ethernet/RNDIS Gadget.

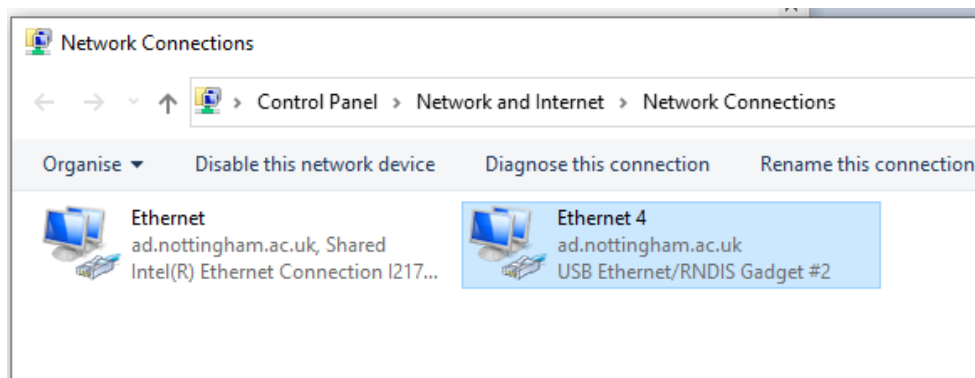
7. SHARE AN INTERNET CONNECTION VIA USB TO THE PI

Before you jump into the other guide to complete the setup for this lab session, you will need to share your laptop/PC's internet connection with your Pi 3 A+. Some of the files it needs and some of the files you need are downloaded from repositories online.

We need to get an internet connection shared to the Pi, and we can use the USB A-A cable for this. There is a helpful guide online ^{xii} to enable sharing of internet connections that may be worth browsing.

With your Pi 3 A+ plugged in, powered on and recognised properly, navigate to Windows' "Network Connections" window. (Control Panel, Network and Internet, Change Adapter Options)

Your Pi will show up as a separate network connection. It will say something like "USB Ethernet/RNDIS Gadget" under the connection name and will have a name like "Ethernet 4".



Now you should decide which internet connection you want to share with your Pi (i.e. WiFi or Ethernet). On a laptop you will probably want your Pi to access the internet using your computer's shared WiFi connection, so you'll need to alter your WiFi connection to allow sharing. Right click on the connection you want to use for sharing, then select "Properties":

In the connection Properties window, click on the "Sharing" tab:

Status

Network status



You're connected
If you have a limited
metered connection

[Change connection](#)

[Show available networks](#)

Change your network

Change adapter
View network status

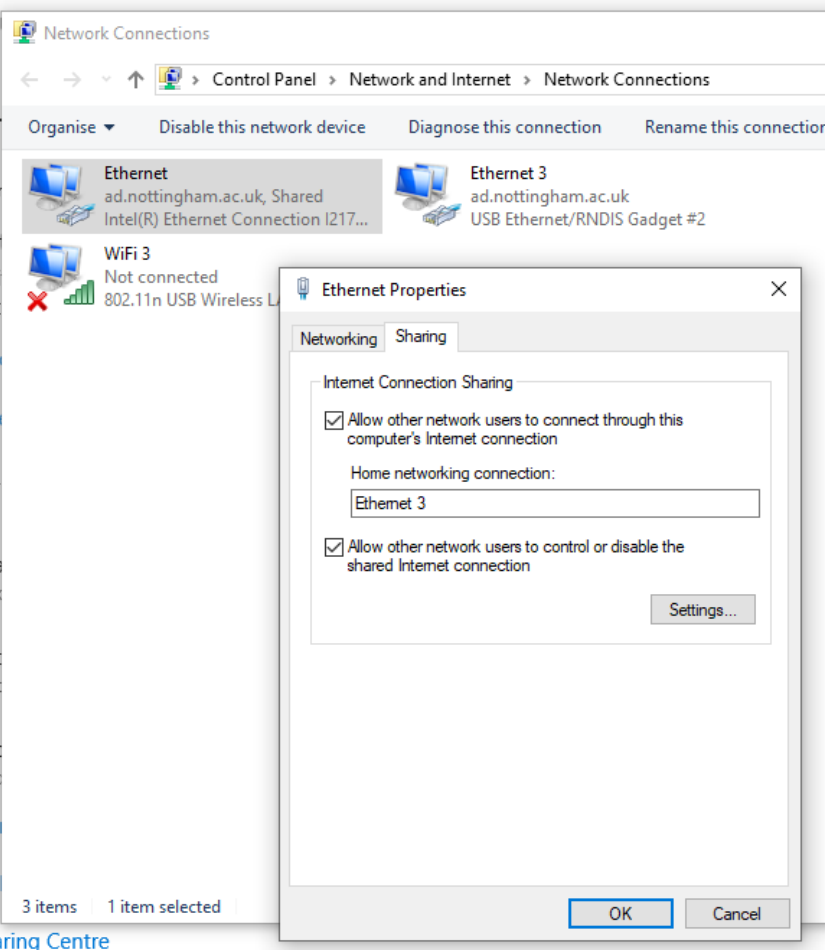
Sharing options
For the network

Network troubleshoot
Diagnose and fix problems

[View your network](#)

[Windows Firewall](#)

[Network and Sharing Centre](#)

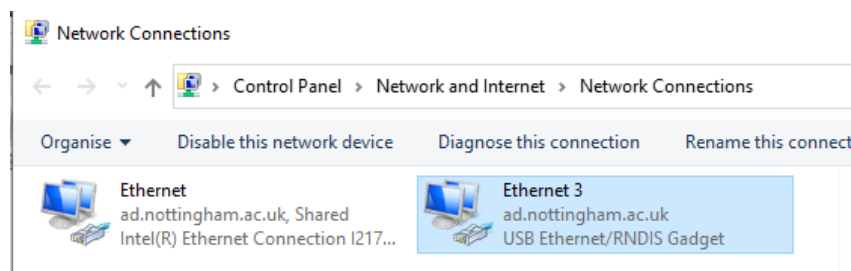


Click the box that says, “Allow other network users to connect through this computer’s Internet connection”.

Depending on your Windows installation and network configuration, you may not see the drop menu (especially if you only have 1 additional device that you could share to)

If you DO have a drop menu, find the network device name given to your Pi (Ethernet 3 in the example above), select it, and then click OK:

The network you chose to share access with your Pi will show the name of your internet network, followed by “Shared” in the “Network Connections” window.



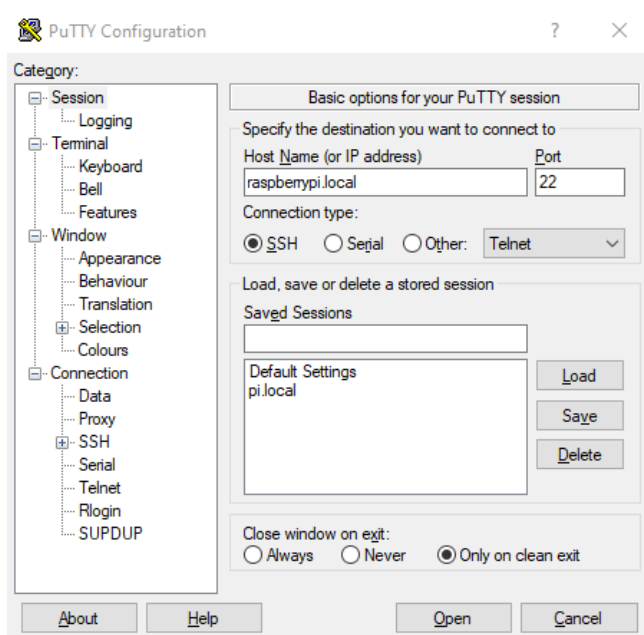
8. LOG IN TO YOUR PI!

Finally - Login over USB using **PuTTY**

This part assumes that you correctly enabled SSH for your image and that the default user is “pi” with a password of “raspberrypi”. (no quotation marks for either userid or password!)

Launch **PuTTY**.

If this is a new installation, set the Host Name (or IP address) field to **raspberrypi.local**
Check that Port 22 chosen, and that the connection type is SSH.



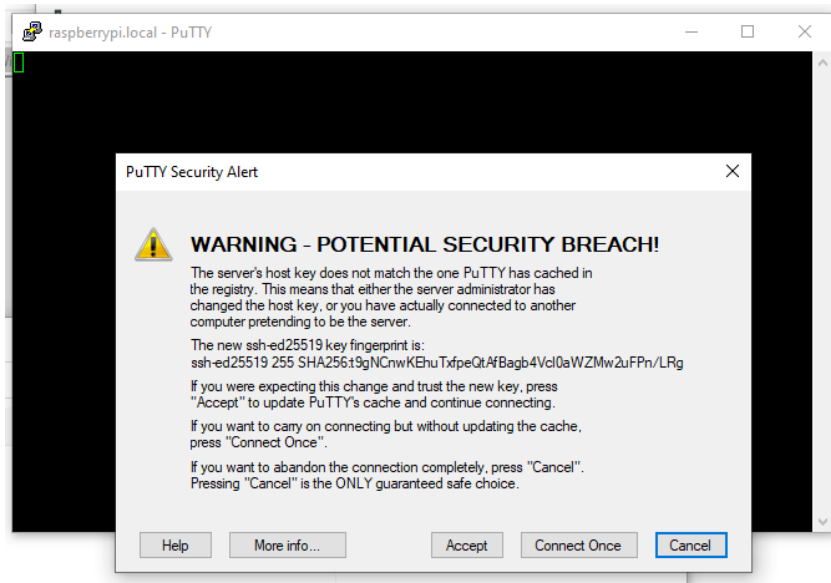
We will be changing this hostname later, but for the moment the default “raspberrypi.local” address should find your pi.

(if you have previously modified your Pi installation, use
whateveryouchangedyourpihostnameto.local)

By default the Port should be set to 22 and Connection type should be set to SSH

Click Open

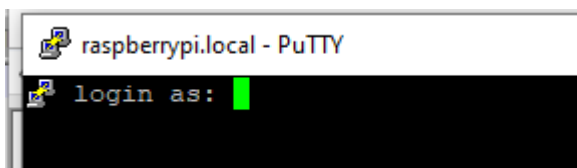
When you connect to a previously unconnected Pi the first time, you’ll see a security warning like this:



This is expected – and is a safeguard in case someone quietly swaps your Pi for another one.

ACCEPT this warning

A new terminal window should appear prompting you for a user name



For user name on a new image enter: pi

For a new image the default password is: raspberry (and you won't see any evidence of your typing for security reasons)...and press enter.

Congratulations! You can now access your Pi Zero with just a USB cable.

9. GO THROUGH THE PI BASIC CONFIGURATION

When you start a Pi up, it runs through an on-screen configuration wizard. We don't have a monitor screen plugged in to the Pi, so we need to access the pi desktop by another method (VNC) in order to see it.

To do this we first have to enable the VNC Server on the Pi, which is done through the Raspberry Pi Configuration wizard.

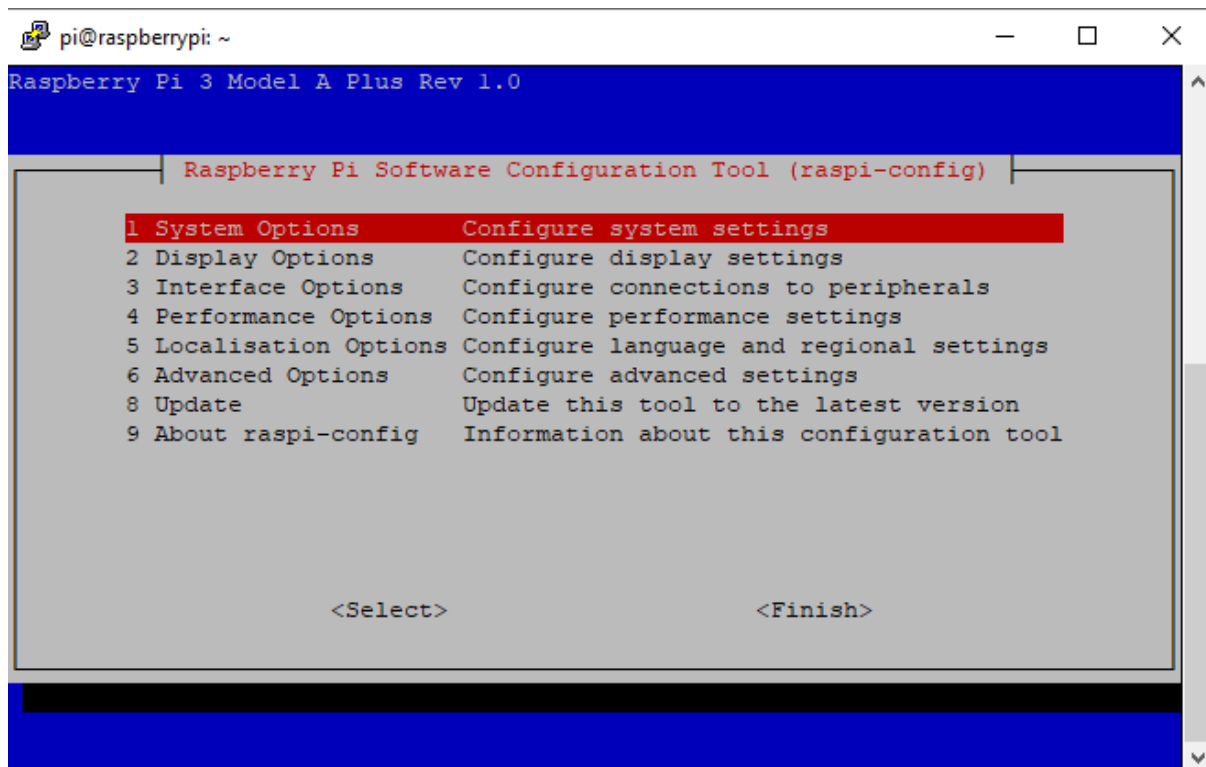
Since this wizard can make fundamental changes to the pi setup, it requires **SuperUser** confirmation to access it.

The **SuperUser** access is one you'll use frequently so get used to prefixing some commands with the word "**sudo**" (without quotes) – **SuperUser DO** (something)

With PuTTY open on your PC (above) type the command :

sudo raspi-config

The terminal window will respond with a menu of options.



Use your keyboard's arrow keys to navigate to Interface Options (3), and select with the ENTER key

Arrow down to the VNC entry and select Yes, OK.

You might also want to revisit the Interfaces menu and enable the camera, SPI and I2C communication systems to save time later.

10. CHANGE YOUR PI HOSTNAME

If everyone follows this guide, and then connects their Pi to Eduroam, we're going to have severe problems with network clashes. If your Pi is still using its default hostname, it won't work. It is therefore important that you change your Pi's hostname from its default (raspberrypi) to something unique.

A sensible suggestion would be to include your bench number and surname (so for example **b31smith** or **c29west** or something like that) .

THIS NEW HOSTNAME IS WHAT YOU WILL USE WITH .local TO ACCESS YOUR PI SO WRITE IT DOWN SOMEWHERE.

In the raspi-config tool, select option 1 (System Options) and arrow down to **S4 Hostname**. Change the default hostname from raspberrypi to your chosen hostname, and TAB to OK, reboot if necessary.

To prevent malicious access, you should also change the default password for your Pi.

In the raspi-config tool, select option 1 (System Options) and arrow down to **S3 Password**.

Type and confirm your new password

THIS NEW PASSWORD IS WHAT YOU WILL USE TO ACCESS YOUR PI SO DO NOT FORGET IT.

You can now press your keyboard's "Tab" key, to jump to the bottom menu, arrow across to "Finish" and press Enter, and you'll probably be asked to reboot, which you should do at this time.

With the Pi's VNC Server now enabled, you can now open VNC Viewer on your PC, and connect to the VNC Server on the Pi – the address is now formed with the new hostname you chose above, with .local on the end (so b31smith.local or c29west.local if we're looking at the examples above

The username is pi, and the access password is what you changed it to above.

You'll see a similar security warning here to the one you had with PuTTY, and for the same reason.

On the now-visible Pi desktop you should see a warning about default SSH passwords, and behind that, the "Welcome to the Raspberry Pi" wizard which you should go through carefully.

When the Pi asks to reboot, do so.

If you don't see the "Welcome to Raspberry Pi" wizard, open up a Terminal window (click the black square icon on the Pi menu bar) and type

sudo piwiz

and press enter.

You won't be able to connect to Eduroam using the wifi section of PiWiz – the security settings on Eduroam are too good for Piwiz. That's a whole other document.

11. CHECK FOR PI SYSTEM UPDATES AND INSTALL THEM

Pi operating system and its dependent systems are being updated and upgraded continuously. The OS you downloaded is only 2 weeks old but there will be updates for parts of it.

At a terminal prompt, type: ^{xiii}

sudo apt update

Once complete, type:

sudo apt full-upgrade

You may need to press "Y" one or more times during this, to confirm any space usage requests.

When done,

sudo reboot

...and don't forget to unshare then re-share your Windows network connection.

Done. Go on to the next task.

At this point, with your Pi working correctly, you should move on to the document “Pi 3 A+ as a Wireless Station”

References

i <https://www.raspberrypi.org/software/operating-systems/>

ii <https://www.sdcard.org/downloads/formatter/>

iii <https://www.balena.io/etcher/>

iv <https://notepad-plus-plus.org/>

v <https://www.putty.org>

Download the 64-bit MSI (Windows Installer)

Open it to run the installer (if asked for permission, click Yes)

Select: Add shortcut to PuTTY on the Desktop

vi <https://filezilla-project.org/>

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

viii <https://www.raspberrypi.com/software/>

ix <https://desertbot.io/blog/headless-pi-zero-ssh-access-over-usb-windows>

x https://support.apple.com/kb/DL999?locale=en_US

xi https://www.catalog.update.microsoft.com/Search.aspx?q=usb%5Cvid_0525%26pid_a4a2

xii <https://www.circuitbasics.com/raspberry-pi-zero-ethernet-gadget/>

xiii <https://pimylifeup.com/raspberry-pi-update/>