

# The Raspberry Pi: An Educational Computer

Notes for IFB102

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Note I'm not particularly endorsing any of the suppliers mentioned in this guide. They are just places from where I've bought parts in the past.

## Nomenclature

RPi = Pi = Raspberry Pi

## Where can I find out more information?

QUT blackboard site <https://blackboard.qut.edu.au>

[www.raspberrypi.org](http://www.raspberrypi.org)

<http://learn.adafruit.com/category/learn-raspberry-pi> - good introductions to setting up SD card, attaching sensors etc.

[www.raspberrypi.org/magpi/](http://www.raspberrypi.org/magpi/)

[http://elinux.org/RPi\\_Beginners](http://elinux.org/RPi_Beginners)

These Adafruit articles provide a good introduction to using Linux at the command line:

- <https://learn.adafruit.com/what-is-the-command-line>
- <https://learn.adafruit.com/an-illustrated-shell-command-primer>
- <https://learn.adafruit.com/basic-shell-magic>

## Do I have to use a Raspberry Pi?

Yes – all IFB102 practical classes and mini-projects use Raspberry Pis. All students studying IFB102 need their own Raspberry Pi.

## Why are we using Raspberry Pis?

Because they are cool! Well the real reasons are because they are cheap, open source, very popular and great for learning about computers. They are a good way to learn about computer technology, very flexible, there are lots of resources available and you can play around with systems level software without worrying about damaging a computer you need for your work or studies.

## What is a Raspberry Pi

The main web site: <http://www.raspberrypi.org/>

The Raspberry Pi is a small cheap educational computer board. The board costs \$60, with all the parts < \$100, the price of a text book. The Raspberry Pi comprises mostly open source hardware and software.



There are many versions of the Raspberry Pi, the one above is a Raspberry Pi 3. You can use any Raspberry Pi (except the compute module) for this class. However, it is strongly recommended you purchase the discounted kit from the bookshop.



<http://www.pbs.org/food/fresh-tastes/raspberry-pie/> Also good ☺

## Where can I get a Raspberry Pi

Custom Raspberry Pi kits are available at a discounted price to IFB102 students in the Gardens Point QUT bookshop. You will need to show staff your student card. The kits cost less than \$100. It is strongly recommended you purchase one of these kits.









## I already have my own Raspberry Pi

It is strongly recommended you purchase the discounted kit from the bookshop. If you already have your own Raspberry Pi you may use it but you will probably need to purchase some additional parts. You will need:

- A WiFi dongle (unless it's a Raspberry Pi 3, 4 or Zero W)
- An SD/micro-SD card for the QUT Raspberry Pi OS image (at least 16GB, Sandisk ultra ones are strongly recommended)
- A USB SD/micro-SD reader
- A serial cable to connect you Pi to a computer at QUT. Serial cables can be borrowed from the level 9 resources room in S block, QUT Gardens Point campus (you need to bring your student card.)
- A power supply

Details can be found in [List of parts and suppliers for Raspberry Pis](#)

## Static Electricity

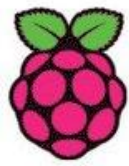
Be careful handling your Raspberry Pi, particular during dry weather: static electricity can damage electronic components.

## What are the different ways I can talk to my Pi?

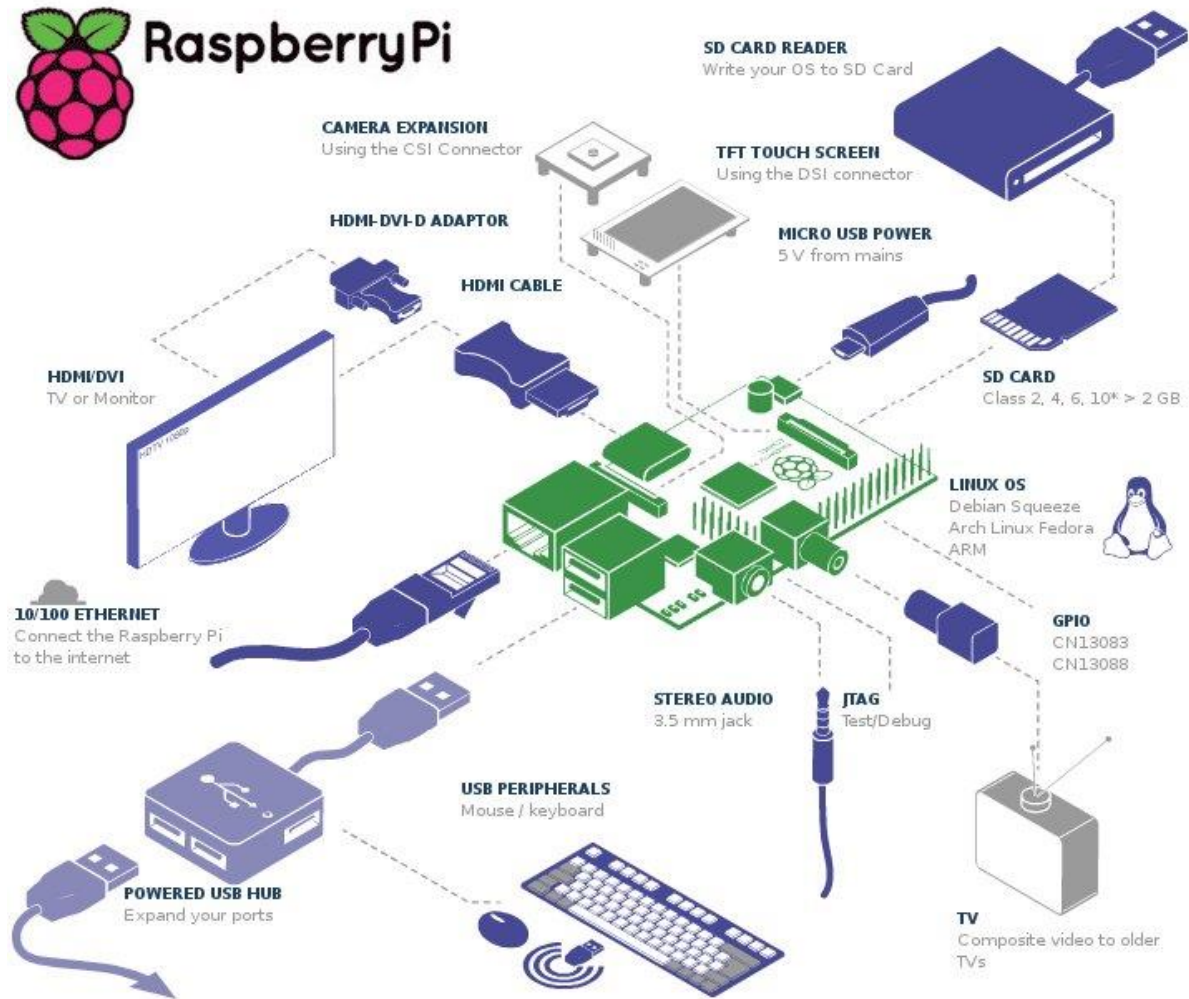
For the IFB102 practical classes we will be using serial cables (option 3) to connect to Raspberry Pis in the QUT labs. There are other ways to connect to a Pi:

1. Attach a USB keyboard, mouse and a screen (HDMI monitor or HDMI tv!) and use it like a PC
2. Connect it to a router using the Ethernet cable and use it like a server – remotely login from another computer or tablet or phone using SSH. You can also connect it using Wi-Fi but some initial configuration will be necessary for which you'll need to use one of the other options. You will need to enable SSH by either configuring it using raspi-config or by putting a file called ssh in the boot partition of your micro SD card e.g. using a PC. (The name of the file turns on ssh its doesn't have to contain anything.) You should be able to use your router at home to determine the IP address of your Pi or you can use one of the other options and make a note of it.
3. Connect to it through a serial line to pins on the GPIO adapter – this is like option 2 except rather than using a network a primitive direct cable connection between the Pi and a PC is used, it's even possible to get rid of the cable and use a Bluetooth adapter but like Wi-Fi this will require some initial configuration. This is the option we will be using in the labs.





# Raspberry Pi



[http://www.element14.com/community/community/raspberry-pi/raspberrypi\\_projects/rocking-raspberry-pi/blog/2014/02/09/rocking-the-rocking-raspberry-pi-challenge-part-2--why-the-pi](http://www.element14.com/community/community/raspberry-pi/raspberrypi_projects/rocking-raspberry-pi/blog/2014/02/09/rocking-the-rocking-raspberry-pi-challenge-part-2--why-the-pi)

## Assembling your Raspberry Pi Kit

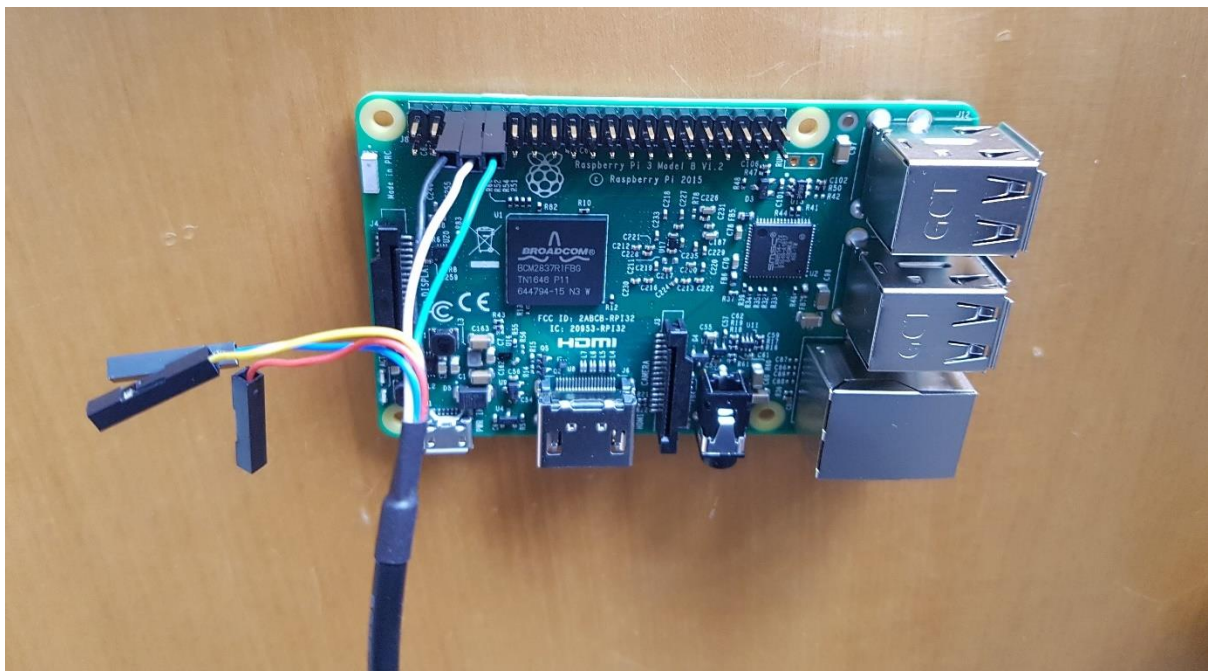
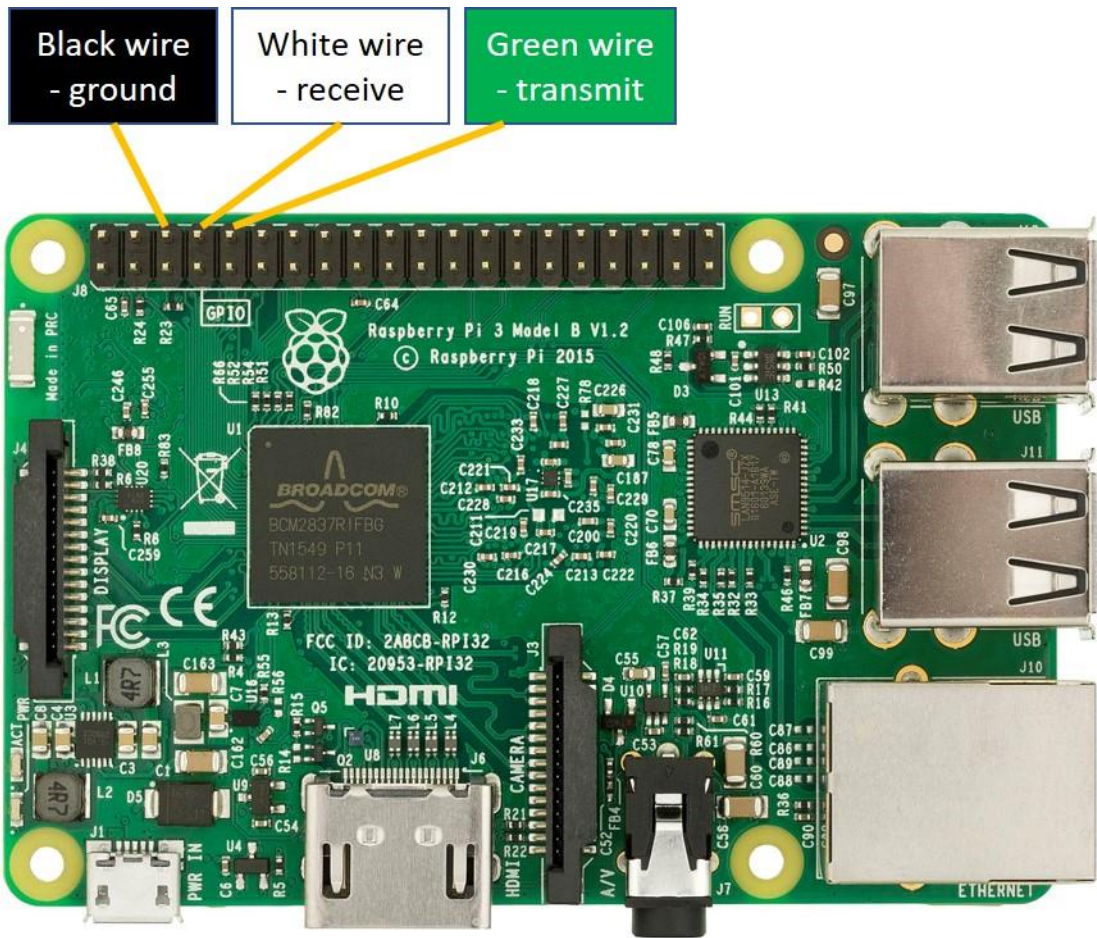
Assembling your Raspberry Pi kit is straightforward. However, care must be taken to connect the right wires to the right pins. Do this carefully.





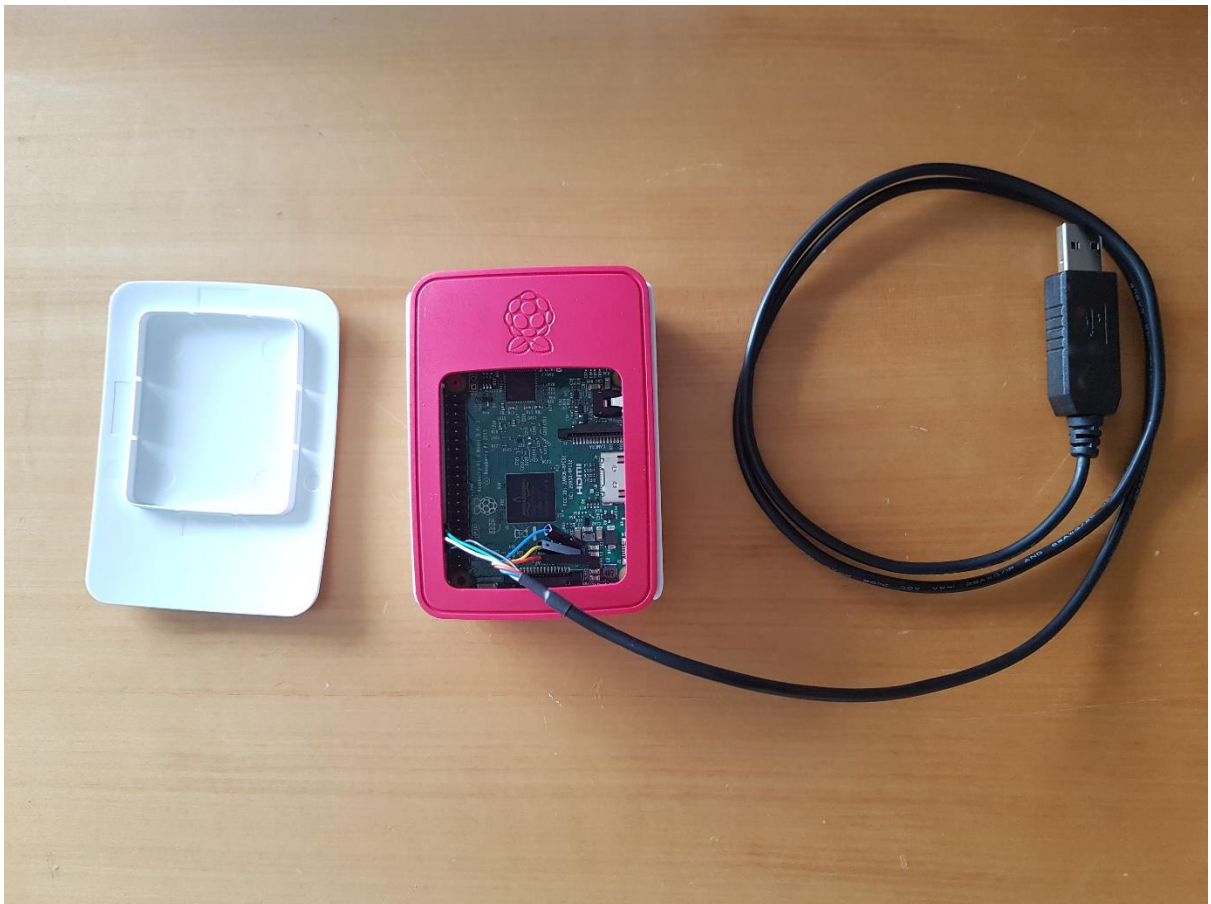
The next bit is important: connecting the serial cable to your Pi. The red wire must not be connected to anything or it could damage your Pi. Only the white, green and black wires should be connected and they must be connected exactly as shown otherwise your Pi won't work and may be damaged.





The yellow, blue and red wires should not be connected to anything.







I recommend leaving the serial cable connected to your Raspberry Pi.

How do I set-up the software (Operating System) on my Raspberry Pi for the first time use in the labs?

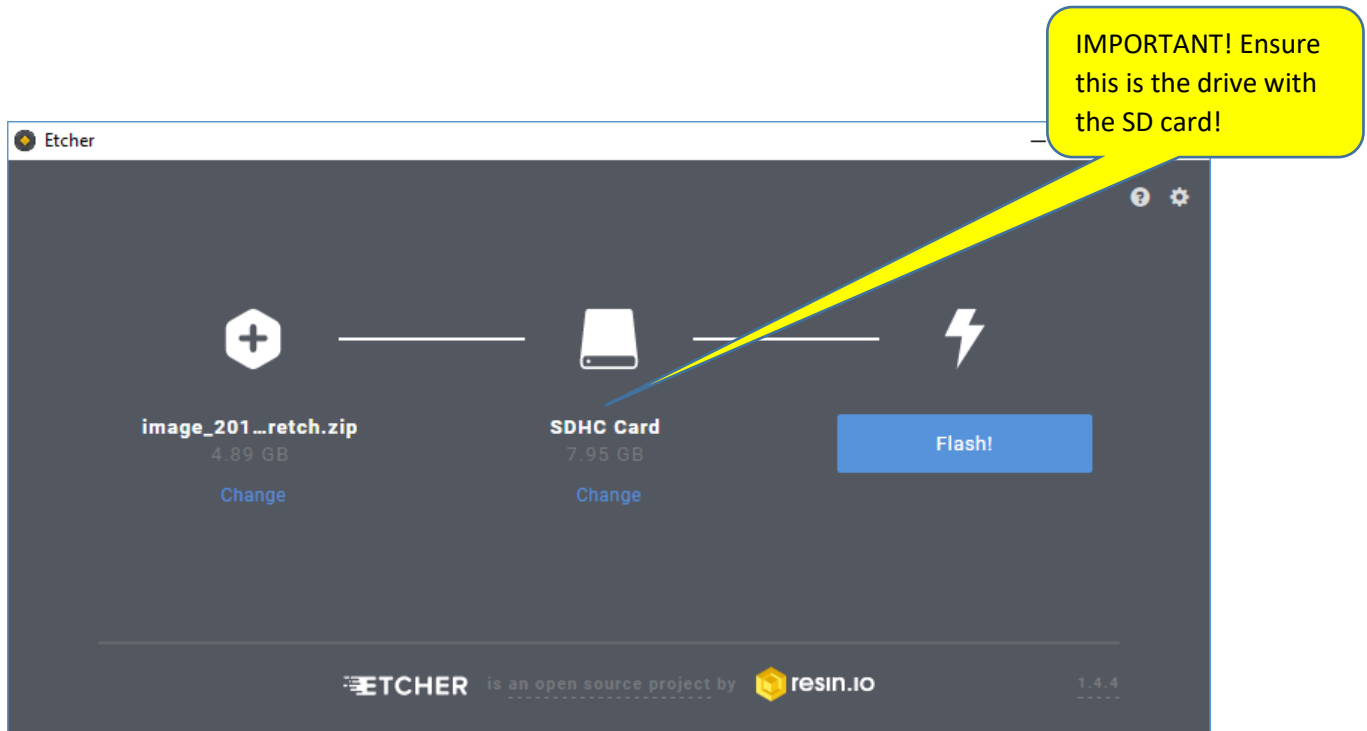
This is for setting up one of the Pis in the lab. Additional general set-up details are available here <https://learn.adafruit.com/adafruits-raspberry-pi-lesson-2-first-time-configuration> and here <https://www.raspberrypi.org/documentation/installation/installing-images/README.md> (including details for Mac and Linux).

One of the IFB102 tutors Zen Chai has made a great video on how to set-up your Pi see here: <https://www.youtube.com/watch?v=VMlhpxy-rM>.





1. Put an operating system on the SD card
  - Download the QUT version of Raspberry Pi operating system (a Linux operating system) - (zip file). This version of the operating system has been already set-up for QUT networking and IFB102. This is available on blackboard under Learning Resources -> Raspberry Pi. The image is quite large (approximately 1.7GB) so I recommend you download it at QUT. You do not need to unzip the file.
  - Use Etcher (<https://www.balena.io/etcher/>) (Windows, Mac or Linux) to burn the operating system image onto the SD card (<https://www.youtube.com/watch?v=PijX8GDco-g>). You might need to use a USB SD card reader/writer dongle to connect the card to your computer. **Be very careful to ensure that you write the Raspberry Pi operating system zip file to the right drive (the one that is your SD card) and not some other removable hard drive!**

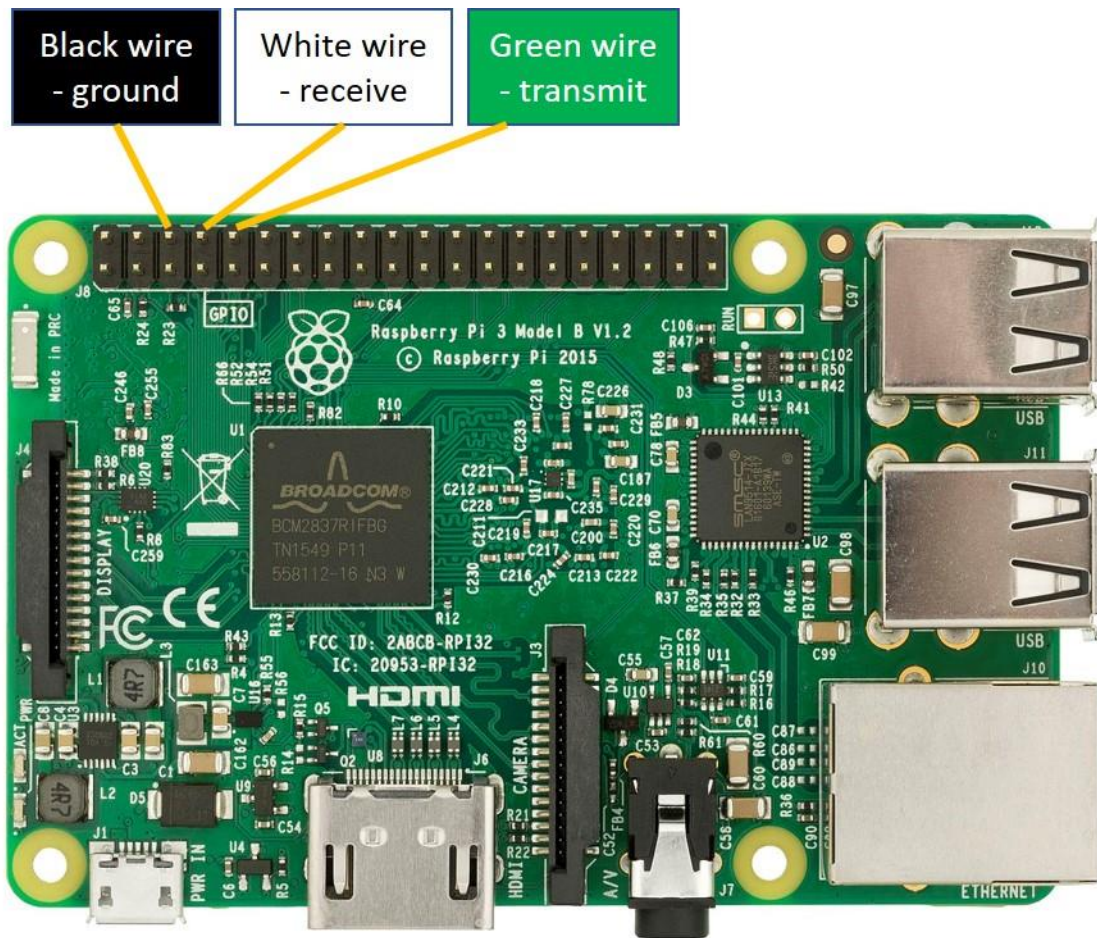


2. Place the SD card in the Raspberry Pi, it goes in upside down – again be careful the Raspberry pi and care are delicate.
3. If it's not already connected, connect the serial cable to the Raspberry Pi. It's important to connect the wires exactly as shown. The red and any other wires shouldn't be connected to anything, the white, green and black wires should be connected as in the photos below. **It's very important you connect the right wires to the correct pins and don't connect the red to anything or you risk damaging the Pi.** The serial cable connections for all the Raspberry Pis are the same.





The serial connections for all the Raspberry Pi models are the same.



- Before plugging the USB end of your serial cable into your computer, ensure you are connected to the internet so any necessary drivers can be installed. In the labs use a web browser to go to an external web page to ensure you are connected. Wait a while for the serial cable driver to be automatically downloaded and installed. If the drivers do not automatically install for the QUT Raspberry Pis the driver can be manually downloaded from here: <http://www.ftdichip.com/Drivers/VCP.htm>.

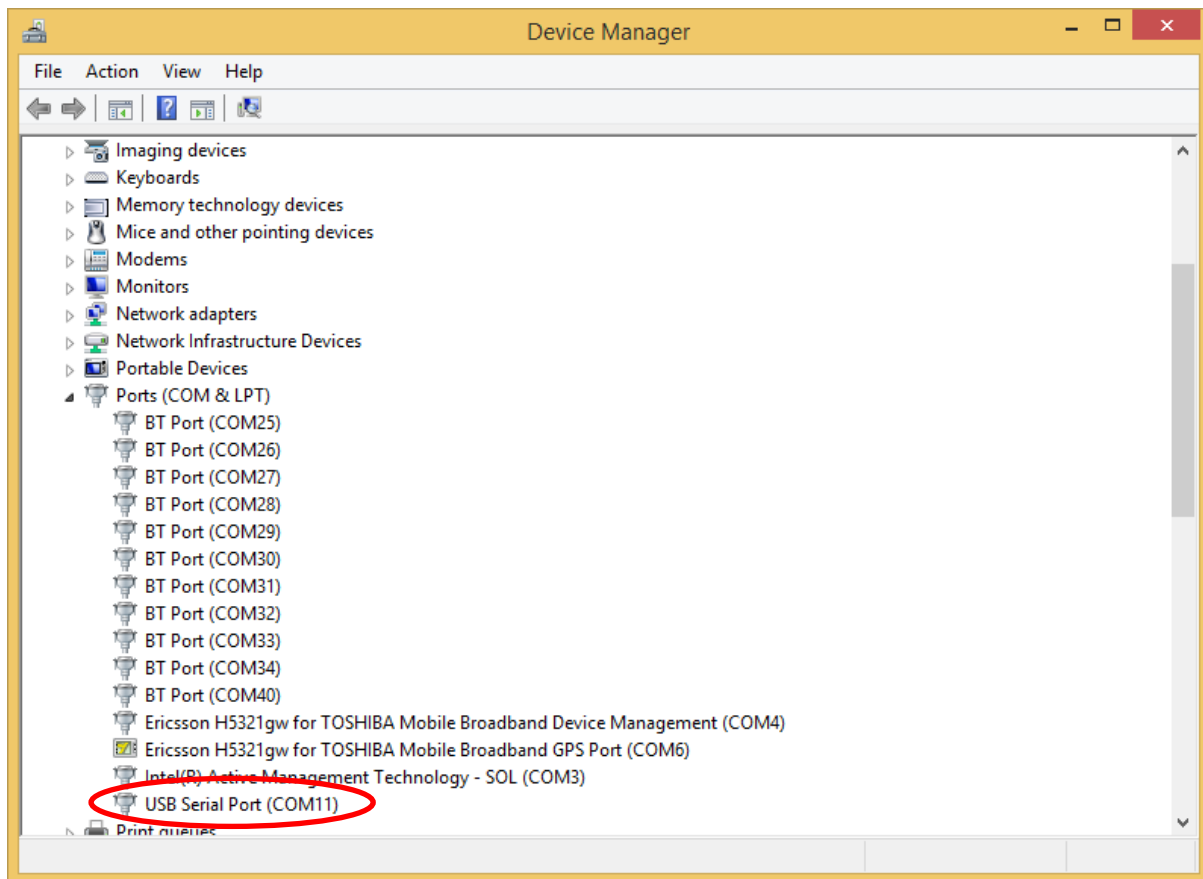
(If you are using a Mac or Linux you can follow the instructions here on how to connect via the serial cable – but please don't attached the red power lead!

<https://learn.adafruit.com/adafruits-raspberry-pi-lesson-5-using-a-console-cable/overview> )

- Determine which com port your serial cable is attached to.

## Windows

On Windows 10, right click on the start menu and open the device manager, expand the Ports (COM & LPT), look for the USB serial port and make a note of the associated number. (In older versions of windows look in the control panel for the device manager.) E.g.



## Mac

Look for files called `tty.usb` in the `/dev` folder, using `ls /dev/tty.usb*` at the command prompt:

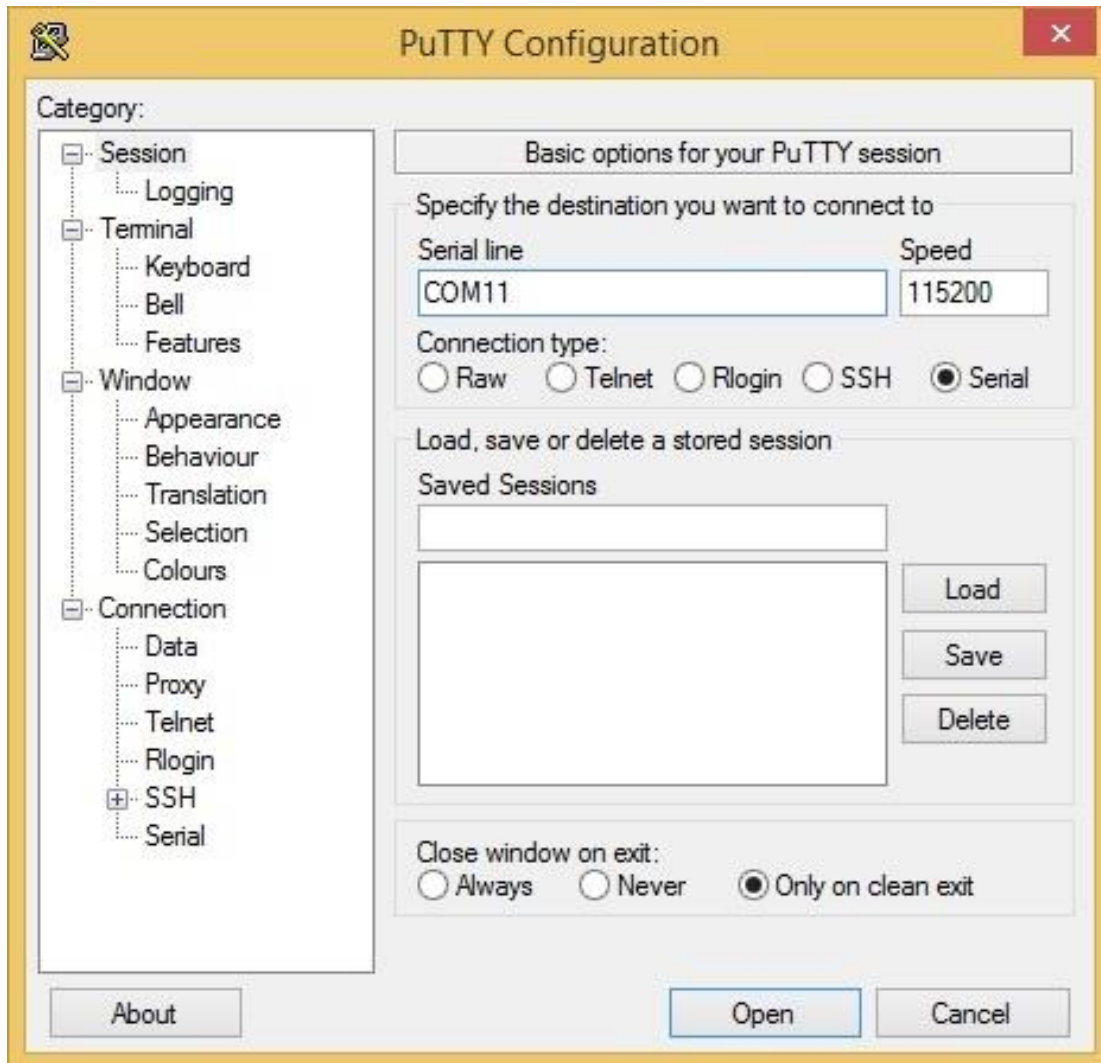
```

n7686315 — -bash — 100x50
Last login: Tue Mar  5 18:05:47 on ttys000
(base) SEF-PA00074213:~ n7686315$ ls /dev/tty.usb*
/dev/tty.usbserial-A907NQP1
(base) SEF-PA00074213:~ n7686315$ screen /dev/tty.usbserial-A907NQP1 115200
  
```

6. Connect to the Raspberry Pi: on Windows use putty, on Mac or Linux use screen.

## Windows

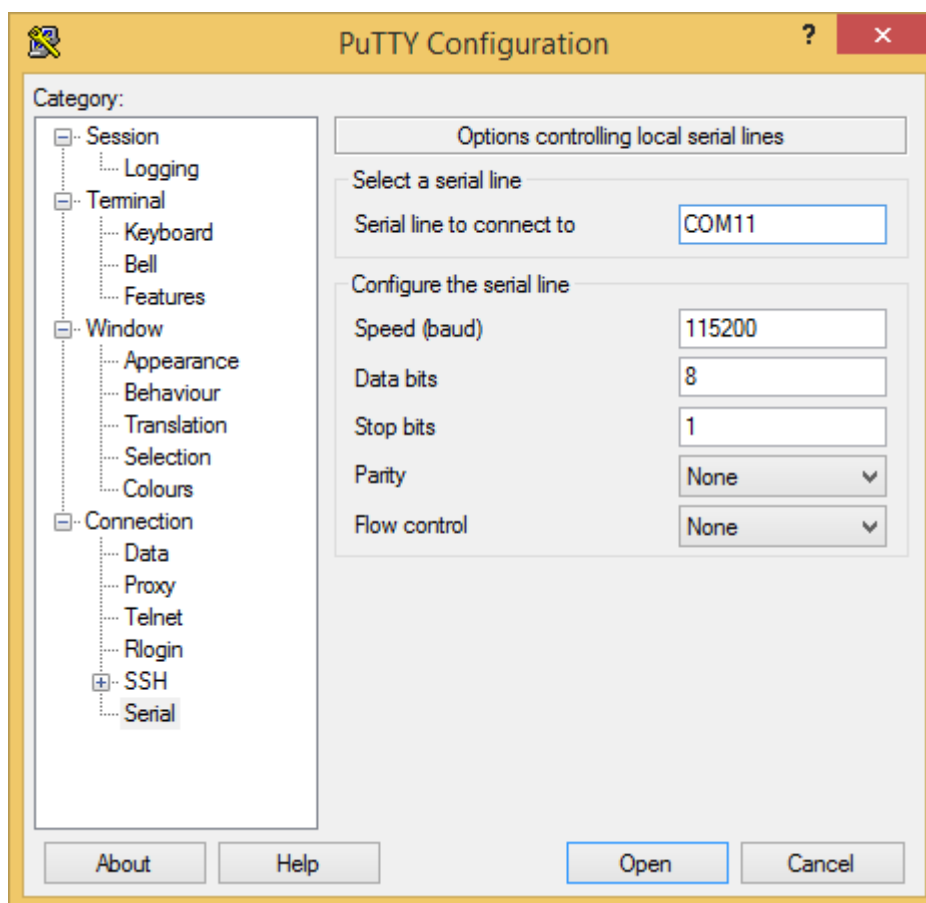
On Windows run the putty program on your computer to connect to the Raspberry Pi over the serial cable. Putty is on the lab machines or can be downloaded here: <http://www.chiark.greenend.org.uk/~sgtatham/putty/> In putty you need to set the connection type to serial, the speed to 115200 and the serial line to e.g. COM11 – the same as the COM port number you found in the device manager e.g.



Then click open and you should see a black console window appear (nothing will happen until you power on your Pi).



You shouldn't need to change the serial settings. However if you want to or need to check, click on Serial in the left hand Category view and you should see this (the COM port, COM11 in this case will vary, but the other settings should all be the same).

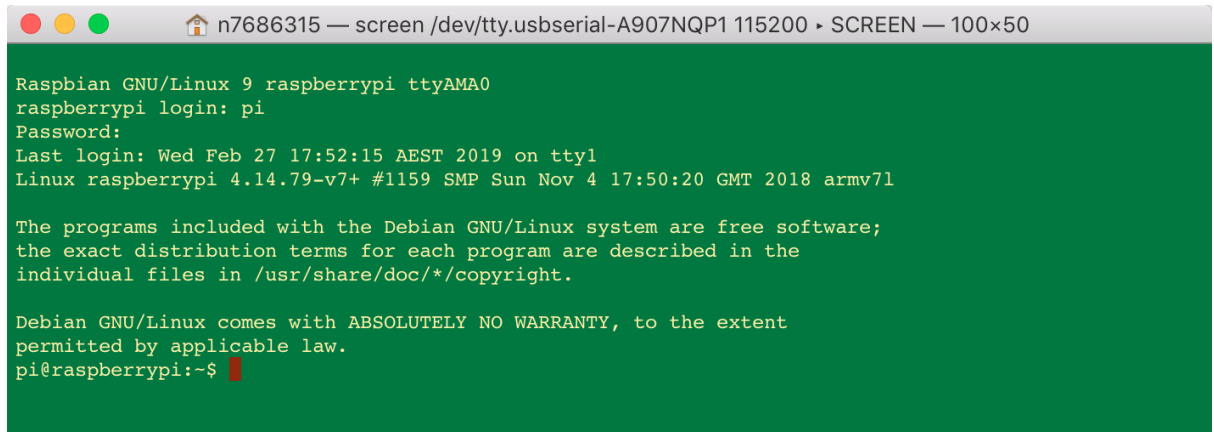




## Mac or Linux

On Mac and Linux use the screen program. You may need to install the screen program (package) on Linux. On a Mac run a terminal application and type (you may need to adjust the name of the USB serial device):

```
screen /dev/tty.usbserial* 115200
```



The screenshot shows a terminal window titled "n7686315 — screen /dev/tty.usbserial-A907NQP1 115200 ▸ SCREEN — 100x50". The terminal output is as follows:

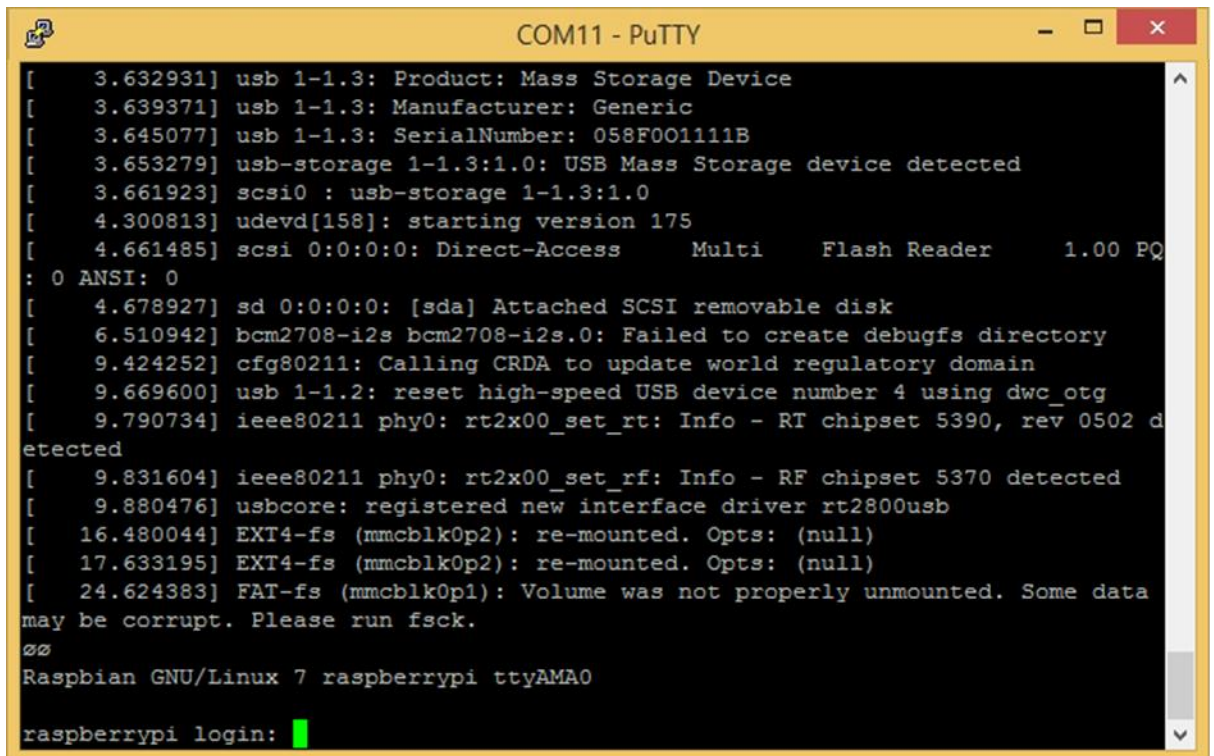
```
Raspbian GNU/Linux 9 raspberrypi ttyAMA0
raspberrypi login: pi
Password:
Last login: Wed Feb 27 17:52:15 AEST 2019 on tty1
Linux raspberrypi 4.14.79-v7+ #1159 SMP Sun Nov 4 17:50:20 GMT 2018 armv7l

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.
pi@raspberrypi:~$
```

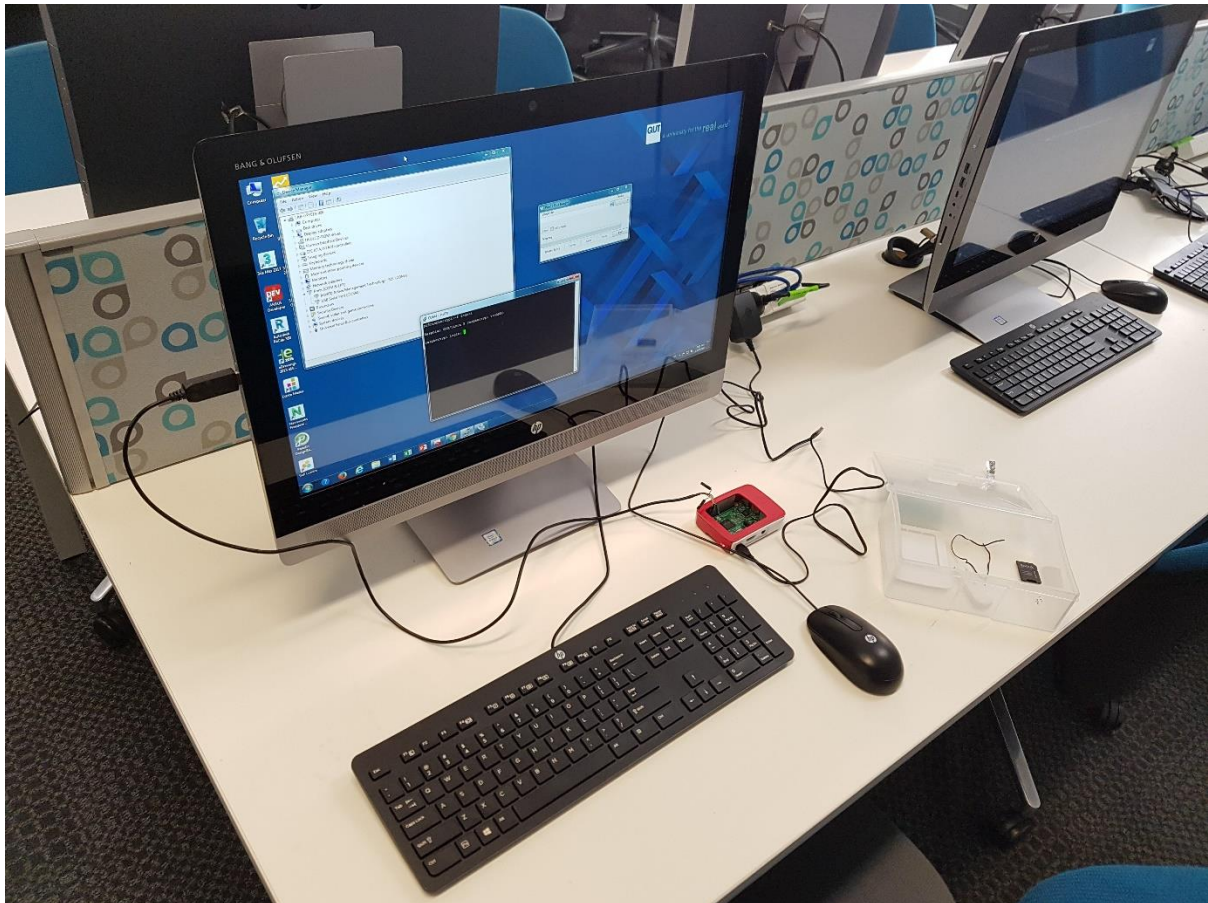
For further details see: <https://learn.adafruit.com/adafruits-raspberry-pi-lesson-5-using-a-console-cable/test-and-configure>

7. Plug in the micro-usb power adapter and connect it to the RPi – the RPi will immediately start booting. You should see lots of messages appear on your putty terminal as your raspberry pi boots. If not check you have wired up all the cables correctly and have putty connected to your serial cable. You should see the red power light (PWR) illuminated on your Pi and the activity light (ACT) should periodically flash to indicate the Pi is busy. Eventually you should get a login prompt. The default user name is “pi” and password is “raspberry”



```
[ 3.632931] usb 1-1.3: Product: Mass Storage Device
[ 3.639371] usb 1-1.3: Manufacturer: Generic
[ 3.645077] usb 1-1.3: SerialNumber: 058F001111B
[ 3.653279] usb-storage 1-1.3:1.0: USB Mass Storage device detected
[ 3.661923] scsi0 : usb-storage 1-1.3:1.0
[ 4.300813] udevd[158]: starting version 175
[ 4.661485] scsi 0:0:0:0: Direct-Access      Multi      Flash Reader      1.00 PQ
: 0 ANSI: 0
[ 4.678927] sd 0:0:0:0: [sda] Attached SCSI removable disk
[ 6.510942] bcm2708-i2s bcm2708-i2s.0: Failed to create debugfs directory
[ 9.424252] cfg80211: Calling CRDA to update world regulatory domain
[ 9.669600] usb 1-1.2: reset high-speed USB device number 4 using dwc_otg
[ 9.790734] ieee80211 phy0: rt2x00_set_rt: Info - RT chipset 5390, rev 0502 detected
[ 9.831604] ieee80211 phy0: rt2x00_set_rf: Info - RF chipset 5370 detected
[ 9.880476] usbcore: registered new interface driver rt2800usb
[ 16.480044] EXT4-fs (mmcblk0p2): re-mounted. Opts: (null)
[ 17.633195] EXT4-fs (mmcblk0p2): re-mounted. Opts: (null)
[ 24.624383] FAT-fs (mmcblk0p1): Volume was not properly unmounted. Some data
may be corrupt. Please run fsck.
Raspbian GNU/Linux 7 raspberrypi ttyAMA0
raspberrypi login: █
```

With everything plugged in, and the operating system running, your RPi should look like this. The red power light (PWR) should be on and the green activity light (ACT) should occasionally flash. After lots of boot messages a login prompt should be shown like in the screenshot above.



Note, you only need to prepare your operating system once. After that you can simply power on you Pi, hook up the serial cable to the computer and talk to the Pi using Putty. If you mess-up your operating system you can reflash a new one using etcher as in the earlier instructions.

8. Login, the raspberry pi has a user called “pi” with a password “raspberry”. **Important** Once you have logged in change your password using the `passwd` command – your tutor will show you how. Do not use your QUT password, think of another strong password.

```
passwd
```

9. Configure Wi-Fi – see [“How do I connect to the QUT network?”](#) section then reboot:

```
sudo reboot
```

10. Have fun playing with your Pi!
11. Note putty on Windows uses the mouse left and right buttons to copy and paste text. This takes some getting used to but will be useful in some of the practical exercises.
12. To turn off your Pi before unplugging the power shut down the operating system:

```
sudo shutdown -h now
```

Wait a couple of minutes before turning off the power.

## I've set-up everything exactly as stated and it's not working – help!

There are several things which can go wrong. Find a friend with a working Pi or your tutor. Try swapping the cards and Pis around leave all the cables and power adapters as they were so only try swapping the cards. This will enable you to know if there is something wrong with your SD card or Raspberry Pi operating system image or if it is the Pi.

If your SD card doesn't work in your tutors/friends Pi (which you know works) there must be a problem with your card / Raspberry Pi OS image. Try re-downloading the image (do this at QUT on one of the lab machines), formatting the SD card and burning the image onto the SD card. If this doesn't work your card may be damaged. Get another card and try burning the image to that.

Does your SD card work in your friends/tutors Pi – if so there must be something wrong with you Pi hardware. Check is there power – does the Pi power light come on. Does the Pi activity light flash? Is your serial cable attached correctly and are the serial drivers installed and the correct COM port and baud rate set for putty. If the activity light and power light do both come on try using your friends/tutors serial cable and their computer and putty to see if it's the serial connection which at fault. You could also try your friends working SD card in your Pi, perhaps also with their serial cable to see if there is something wrong with your Pi.

In summary try systematically swapping components to discover which part is not working correctly: keep careful track of the parts. If there is something wrong with your Pi hardware you can also ask for help at the level 9 S block resources room. If it's just a configuration issue then you and your tutor should be able to fix the problem.

## How can I edit a text file from the command line?

Nano is the easiest editor to use e.g.

```
nano myfile.txt
```

There are lots of online guides e.g. <http://www.raspberrypi-spy.co.uk/2013/11/quick-guide-to-nano-text-editor-on-the-raspberry-pi/>

## How do I turn my Pi off?

At the command prompt type:

```
sudo shutdown -h now
```

wait for a while, then turn the power off, there's no switch, the best way is to turn off the power at the mains socket or by unplugging the usb cable, but not at the RPi end – it's a bit fragile.



## My Pi has stopped what should I do?

Check if the activity light is flashing – if so it is probably still working. The serial cables are temperamental and can get locked up. The simple solution is to unplug the usb end and re-plug it in. You will have to restart your putty session but it should be where you left off, all logged in etc. the COM port probably won't change from what it was previously.

You can quit most command line program by entering **<Ctrl> C** - hold the control key down then at the same time press the c key.

In the worst case if all fails cycle the power. This won't damage your Pis hardware but it can cause problems on the SD card. If it refuses to boot or boots with lots of errors you'll need to reformat your memory card and reinstall the operating system.

## Help my SD card has shrunk?

Do not wash your SD card in the laundry 😊

There are two different things you may notice.

Your SD card will only look 66MB or so big on Windows. Don't panic, this is because the SD card is formatted with two partitions and Windows can only see the small boot partition, Windows can't read the larger partition which has a Unix file system on it (Macs and Unix computer can see this partition).

Alternatively, you may find when you boot your Raspberry Pi that the file system is smaller than the size of your SD card (even allowing for the 66MB boot partition). In this case you can use raspi-config to ensure the Unix file system is using all your SD cards available space. Run the command

```
sudo raspi-config
```

And under the advanced options select expand file system. Any extra space will appear after a reboot.

## How do I connect to the QUT WiFi network?

Prerequisite: you need a Raspberry Pi 3, Zero W or Raspberry Pi with a WiFi Adapter.

If you have used the QUT operating system image then you simply need to edit this file `/etc/wpa_supplicant/wpa_supplicant.conf` to contain your QUT username and a hash of your password.

(Note if you are using an older version of the QUT Raspberry Pi OS image then you simply put your password in between the quotes for the password setting.)

How do you generate a hash of your password for this file - run the utility program ([here](#))

```
sudo ~/wifi-pass.sh
```

and enter your password. This will output a long string of characters, for example:

```
hash:066ddfd4ef0e9cd7c256fe77191ef43c
```

But you need to use your password to generate this. Carefully copy and paste this string in the `wpa_supplicant.conf` file to replace the dummy password has in there and put your QUT username in there too:

```
sudo nano /etc/wpa_supplicant/wpa_supplicant.conf
```

**Please edit the file carefully; pay particular attention to quotes and brackets: you should not delete or change any of these.**

Here's a guide to using the nano editor <http://www.raspberrypi-spy.co.uk/2013/11/quick-guide-to-nano-text-editor-on-the-raspberry-pi/>

Your Pi is now ready to connect to the QUT network. You will need to reboot your pi (`sudo reboot`), you can test if it is connected by typing `ifconfig` to see the state of the network interfaces. Note it can take several minutes to connect so be patient.

**Important:** if you borrowed your Pi remember to delete your QUT access password from the `wpa_supplicant.conf` file before you return your Pi.

## How do I connect to my home WiFi network?

Prerequisite: you need a Raspberry Pi 3, Zero W or Raspberry Pi with a WiFi Adapter.

The procedure is similar to connecting to the QUT network except you don't need to generate a password hash. If you have used the QUT operating system image then you simply need to edit this file `/etc/wpa_supplicant/wpa_supplicant.conf` Edit the part after the QUT network settings, you need to change the setting for your home network (ssid) name and the passphrase (psk) to be your home network password.

If your home network requires you to login or authenticate through a web browser e.g. in an internet café then there are a few options. If you can connect a screen, keyboard and mouse to your Raspberry Pi then you can authenticate in this way. Alternatively, you can connect via a different device e.g. phone or laptop and share your internet connection with your Raspberry Pi.

## How do I connect to the internet using a wired Ethernet connection?

All the RaspberryPi B's have an Ethernet port which can be used to connect to the Ethernet via a wired connection. (The model A RaspberryPi's have no Ethernet port so this isn't possible unless you use a USB Ethernet adapter.)

The settings for the Ethernet connection are stored in `/etc/network/interfaces` you shouldn't need to change these unless you want to allocate a static IP address. In general you just plug in the Ethernet cable and it should work. You can use the `ifconfig` command to test if you

have an IP address. At QUT you need to authenticate to go beyond the LAN to the Ethernet. There is a program on the QUT Raspberry Pi image to do this. Follow these steps:

1. Go into this directory `~/InternetAccessClient`

**`cd ~/InternetAccessClient`**

2. The first time you do this you need to set your QUT username and password, do this by running this command:

**`./IAClientConfigCmd`**

Use the default settings (press enter) for everything except your username and password.

3. Run the following command in the background to authenticate with QUT and gain access to the internet:

**`./IAClient &`**

The `&` is important, it runs the IAClient program in the background as a separate process so you can do other things in the command shell. For further general details on IAClient read the readme file in this directory.

## How can I tell if I'm connected to the internet?

A simple way is to try downloading a web page e.g.

```
pi@raspberrypi:~$ wget www.wikipedia.org
```

You can also check that you have an IP address e.g. via `ifconfig` e.g.

```
pi@raspberrypi:~ $ ifconfig
eth0: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
    ether b8:27:eb:6a:7a:bc txqueuelen 1000 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
    inet6 ::1 prefixlen 128 scopeid 0x10<host>
    loop txqueuelen 1 (Local Loopback)
    RX packets 828194 bytes 46934153 (44.7 MiB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 828194 bytes 46934153 (44.7 MiB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

wlan0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 172.19.17.239 netmask 255.255.192.0 broadcast 172.19.63.255
    inet6 fe80::1ee9:e5db:cffc:3486 prefixlen 64 scopeid 0x20<link>
    ether b8:27:eb:3f:2f:e9 txqueuelen 1000 (Ethernet)
    RX packets 1373198 bytes 260950319 (248.8 MiB)
    RX errors 0 dropped 22642 overruns 0 frame 0
    TX packets 318678 bytes 31334174 (29.8 MiB)
```

```
TX errors 0   dropped 0 overruns 0   carrier 0   collisions 0
```

Notice how the WiFi adapter wlan0 has an ip address (172.19.17.239).

## Help I'm no longer connected to the QUT network

### Manual Reconnect Instructions

If you were previously connected and ifconfig shows you are no longer connected e.g.

```
pi@raspberrypi:~ $ ifconfig
eth0: flags=4099<UP,BROADCAST,MULTICAST>  mtu 1500
    ether b8:27:eb:6a:7a:bc  txqueuelen 1000  (Ethernet)
    RX packets 0   bytes 0 (0.0 B)
    RX errors 0   dropped 0   overruns 0   frame 0
    TX packets 0   bytes 0 (0.0 B)
    TX errors 0   dropped 0 overruns 0   carrier 0   collisions 0

lo:  flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
    inet 127.0.0.1  netmask 255.0.0.0
    inet6 ::1  prefixlen 128  scopeid 0x10<host>
    loop  txqueuelen 1  (Local Loopback)
    RX packets 828194  bytes 46934153 (44.7 MiB)
    RX errors 0   dropped 0   overruns 0   frame 0
    TX packets 828194  bytes 46934153 (44.7 MiB)
    TX errors 0   dropped 0 overruns 0   carrier 0   collisions 0
```

Notice how there is no entry for the wlan0 WiFi adapter or you may find there is no inet entry for the adapter.

Then you can try to reconnect thus:

```
pi@raspberrypi:~$ sudo ifconfig wlan0 up
```

If that doesn't work try rebooting.

## How can I copy files onto a usb memory key?

1. Plug in your usb memory key.
2. Your usb key should show up under /media/pi
3. It will need to be formatted with a filesystem which Linux can read like Fat32

## How can I copy files between a PC and my Raspberry Pi?

There are many ways to move data from your Raspberry Pi to a PC or other device.

- The easiest way is to plug a USB memory key into your Pi. It should automatically appear under the /media directory
- Use SSH with the psftp tool which comes with the putty package  
<http://www.chiark.greenend.org.uk/~sgtatham/putty/> Instructions for how to copy files are here: <http://the.earth.li/~sgtatham/putty/0.67/htmldoc/Chapter6.html#psftp> This requires your PC and Raspberry Pi to both be on a network and accessible to one another.
- Make your Raspberry Pi share some of its file system over a network using Samba  
<https://www.raspberrypi.org/magpi/samba-file-server/>
- Small files can be copied onto the small FAT32 partition of the SD card, which can be seen by windows and other operating systems.

## How can I retrieve files from a broken or corrupt micro SD card which no longer boots?

If you have another working Pi, e.g. purchase a new SD card and burn a new version of the operating system onto it, then you can put your old SD card in a USB SD card reader and put the USB reader in a USB port of the Raspberry Pi. Files will appear under /media/boot and /media/rootfs. For example the old Raspberry Pi home directory will appear as /media/rootfs/home/pi/. Note you need a new working Raspberry Pi operating system which is on an SD card in the regular Raspberry Pi slot.



## Graphical Interface

Whilst we use the command line interface in this subject so we can get closer to the underlying hardware and operating system, you may wish to use a graphical interface for your project. There are two options to do this:

1. Use an HDMI cable to connect your Pi to a monitor; you will also need a mouse and a keyboard. This may not be easy to do in the labs depending on the type of computers there.



2. Use a remote desktop over a network connection, in particular VNC. This requires a VNC client on the PC or laptop computer and for the Raspberry Pi to be accessible from the PC being used as the UI host <https://www.raspberrypi.org/documentation/remote-access/vnc/>. This will work well for graphical applications with low performance requirements but some games and video playback may not work or may be slow.

## When to use sudo?

The sudo command enables you to run commands with admin (root user) privileges. You should only use it when necessary, so first try without the sudo command. Sudo is rather like the “Run as administrator” in windows, it helps prevent inadvertent errors. It’s used for commands that change the system for all users like upgrading the kernel, editing a system file or shutting the machine down.

## How do I change the keyboard configuration?

You shouldn’t need to do this but if you need to change the keyboard configuration to a US one, use the following command:

```
sudo dpkg-reconfigure keyboard-configuration
```

## How do I reformat my SD card?

You might want to reformat your SD card if it has gone wrong, you want to use it in a different device, you think your SD card has become corrupted etc. Typically an operating system like Raspberry Pi OS will put several partitions on the SD card including a boot partition. Windows in particular will only show the boot partition, so it will look like a small SD card of only 60MB. To reformat your card you need to first remove the partitions. This is a dangerous operation because it’s easy to reformat your computer’s hard drive rather than the SD card.

An easy way and safe way to reformat your card is to put it in a camera and reformat it there. It will put a few folders on the card which you can subsequently delete.

Another way is to use the official SD card formatting tool:

[https://www.sdcard.org/downloads/formatter\\_4/](https://www.sdcard.org/downloads/formatter_4/) and in the options turn on the format size adjustment. Unfortunately this tool can’t be installed in the labs. **Make sure you select the right drive to format!**

Another way is to format the card using another Pi – that way you don’t risk much if things go wrong.

1. Install the dosfstools package
  - a. `sudo apt update`

- b. `sudo apt install dosfstools`
2. Put the SD card to be formatted in the usb SD card reader and place this in the Pis usb.
3. Run `sudo cfdisk` to remove the partitions from the drive (make sure you have the right device `/dev/sda`)
  - a. delete the partitions
  - b. write the changes
  - c. create a new partition (type = primary)
  - d. select the partition type to be 0C (W95 FAT32 LBA)
  - e. write the changes and quit
4. `sudo mkfs.vfat /dev/sda1`

## Some useful commands

Note some commands require super user privileges and therefore must be run with `sudo`. For details on how to use the commands consult your best friend – google!

|                       |  |
|-----------------------|--|
| <code>sudo</code>     | Run command as superuser   |
| <code>nano</code>     | Text file editor   |
| <code>cd</code>       | Change directory   |
| <code>ls</code>       | List files in the current directory  |
| <code>cp</code>       | Copy files   |
| <code>mv</code>       | Move or rename files or directories  |
| <code>mkdir</code>    | Create directory   |
| <code>rmdir</code>    | Remove directory   |
| <code>chmod</code>    | Change file permissions  |
| <code>chown</code>    | Change file owner  |
| <code>shutdown</code> | Shutdown computer e.g. <code>sudo shutdown -h now</code>                             |
| <code>reboot</code>   | Reboot computer e.g. <code>sudo reboot</code>  |
| <code>ifconfig</code> | Look at network cards configuration / status e.g. check wifi up                      |
| <code>ifdown</code>   | Disable network interface e.g. <code>sudo ifdown wlan0</code> disable wifi           |
| <code>ifup</code>     | Enable network interface e.g. <code>sudo ifup wlan0</code> enable wifi               |
| <code>ps</code>       | List processes   |
| <code>top</code>      | List running processes and see which are using memory / cpu                          |
| <code>mount</code>    | Mount a filesystem e.g. mount a memory key <code>sudo mount /dev/sda /mnt/usb</code> |

These Adafruit articles provide a good introduction to using Linux at the command line:

- <https://learn.adafruit.com/what-is-the-command-line>
- <https://learn.adafruit.com/an-illustrated-shell-command-primer>
- <https://learn.adafruit.com/basic-shell-magic>

## Commands to Install Software Packages

(Taken from <http://docs.getchip.com/chip.html#install-and-update-software>)

- `sudo apt update` updates the information from repositories, so any installs you make with install will be the latest package
- `sudo apt upgrade` upgrades any installed packages.
- `sudo apt install (name of package)` to install a package and any of its dependencies.
- `sudo apt remove (name of package)` will remove a package and any dependencies not used by other packages
- `sudo apt purge (name of package)` will remove a package and any dependencies not used by other packages along with all settings data
- `apt search (search terms)` will search through the package repositories for names and descriptions that include your search term.

## Windows Software

This is the software you will need to set-up and run the Raspberry Pis on windows.

<http://www.ftdichip.com/Drivers/VCP.htm> (VCP - Virtual COM Port - driver for the USB serial cable)

<https://www.balena.io/etcher/> Etcher (program to write the Raspberry Pi operating systems to an SD card)

<http://sourceforge.net/projects/win32diskimager/> (alternative program to write the Raspberry Pi operating systems to an SD card)

[https://www.sdcard.org/downloads/formatter\\_4/index.html](https://www.sdcard.org/downloads/formatter_4/index.html) (SD card formatter - can resize)

<http://www.chiark.greenend.org.uk/~sgtatham/putty/> (Putty program to talk to the Raspberry Pi through the serial cable and psftp program to copy files between PC and Raspberry Pi)

QUT Raspberry Pi OS (Raspberry Pi operating system) – see link on IFB102 blackboard site under Learning Resources, Raspberry Pi.

## Mac and Linux Instructions

To connect a Mac or Linux computer to a Pi using the serial cable I recommend following these instructions:

<https://learn.adafruit.com/adafruits-raspberry-pi-lesson-5-using-a-console-cable>

It's simplest to set-up your SD card in the labs using windows software and then just use a mac or Linux to talk to the Pi.

If you want to use a mac or Linux then follow these instructions:

[http://elinux.org/RPi\\_Easy\\_SD\\_Card\\_Setup](http://elinux.org/RPi_Easy_SD_Card_Setup)

I do not recommend using the dd utility on macs or linux because it's very easy to corrupt your whole computer.

Official Linux instructions: <https://www.raspberrypi.org/documentation/installation/installing-images/linux.md>

Official Mac instructions: <https://www.raspberrypi.org/documentation/installation/installing-images/mac.md>

Adafruit mac instructions:

<https://learn.adafruit.com/adafruit-raspberry-pi-lesson-1-preparing-and-sd-card-for-your-raspberry-pi/making-an-sd-card-using-a-mac>

SD card formatter [https://www.sdcard.org/downloads/formatter\\_4/](https://www.sdcard.org/downloads/formatter_4/)

FTDI drivers <http://www.ftdichip.com/Drivers/VCP.htm>

## Manual configuration of WiFi

These instructions are only for **advanced use only**. Most students should not need to use these. If you have **not** used the QUT operating system image you need to follow these instructions. These assume you are working from the command line.

The steps are:

1. Edit the file `/etc/wpa_supplicant/wpa_supplicant.conf` e.g.

```
sudo nano /etc/wpa_supplicant/wpa_supplicant.conf
```

it should contain this:

```
country=AU
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1
# QUT
network={
    ssid="QUT"
    key_mgmt=WPA-EAP
    eap=PEAP
    # put your QUT username between these quotes
    identity="my qut username"
    # replace the hash:... with a hash of your password
    # from ./wifi-pass.sh
    password=hash:01c21fa0e6502da2251670012db4feff
```



```

        phase1="peaplabel=0"
        phase2="auth=MSCHAPV2"
        priority=10
    }

```

You will need to change the user name and password hash to your username and hashed-password (see [How do I connect to the QUT WiFi network?](#)). You might also want to add an entry for other WiFi networks you wish to use e.g.

```

country=AU
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1
network={
    ssid="QUT"
    key_mgmt=WPA-EAP
    eap=PEAP
    # put your QUT username between these quotes
    identity="my qut username"
    # replace the hash:... with a hash of your password
    # from ./wifi-pass.sh
    password=hash:01c21fa0e6502da2251670012db4feff
    phase1="peaplabel=0"
    phase2="auth=MSCHAPV2"
    priority=10
}
# My Home network
network={
    ssid="my home network ssid"
    key_mgmt=WPA-PSK
    psk="my home network password"
}

```

Your Pi is now ready to connect to the QUT network. You will need to reboot your pi (`sudo reboot`), you can test if its connected by typing `ifconfig` to see the state of the network interfaces. Note it can take several minutes to connect so be patient.

A less secure alternative is to include your QUT username in plain text within `wpa_supplicant.conf` E.g.

```

country=AU
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1
network={
    ssid="QUT"
    key_mgmt=WPA-EAP
    eap=PEAP
    # put your QUT username between these quotes
    identity="my qut username"
    # put your QUT password between these quotes

```

```

        password="my QUT password"
        phase1="peaplabel=0"
        phase2="auth=MSCHAPV2"
        priority=10
    }
    # My Home network
    network={
        ssid="my home network ssid"
        key_mgmt=WPA-PSK
        psk="my home network password"
    }

```

## Bluetooth Isn't Working on my Pi: Serial Cable and Bluetooth on the Pi

On the Raspberry Pi 3 and Zero W WiFi and Bluetooth are built-in. Unfortunately, Bluetooth and the serial connection use the same hardware. The default settings for the version of Raspberry Pi OS on the raspberrypi.org web site have Bluetooth disabled. There are a number of options to enable the serial connection. In the QUT image Bluetooth has been disabled to enable the serial connection (option 1 below). If you want to use Bluetooth you will need use option 2 or 3.

1. Disable Bluetooth – this is already done in the QUT image

Edit `/boot/config.txt` you can do this by putting the SD card in a PC and editing the file directly `config.txt`.

Add to the end of the file:

```
dtoverlay=pi3-disable-bt
```

We also need to run to stop BT modem trying to use UART

```
sudo systemctl disable hciuart
```

2. Slow down the Pi so that both the serial cable and Bluetooth can be used

Edit `/boot/config.txt` you can do this by putting the SD card in a PC and editing the file `config.txt`.

Add to the end of the file:

```
enable_uart=1
```

If it's the QUT image you should also delete the line:

```
dtoverlay=pi3-disable-bt
```

and start the BT modem:

```
sudo systemctl enable hciuart
```

3. Don't use the serial cable – SSH (need to know the Pis IP address) or connect an HDMI monitor to the Pi.

## Bluetooth

Bluetooth is turned off in the QUT distribution: see prior section. Bluetooth can be difficult on Linux so it depends a lot on what you are trying to connect. Some devices don't work or connect. You will need to search to see if its possible to connect a particular device and how to connect it. Often it's easier to connect from the graphical interface. So for projects it's best if Bluetooth isn't a vital component.

## The QUT Raspberry Pi OS Image

The QUT Raspberry Pi OS image is a recent version of the Raspberry Pi OS (<https://www.raspberrypi.org/downloads/raspbian/>) with a few minor modifications as follows. (Note the Raspberry Pi OS used to be called Raspbian.) If you get the QUT image you don't need to make these changes – they are already done for you.

- Disable Bluetooth so serial cable works on Pi 3 as per [Serial Cable and Bluetooth on Raspberry Pi 3](#)
- Using raspi-config (`sudo raspi-config`)
  - Set timezone to Australia/Brisbane
  - Expand file system
  - Enable i2c
  - Enable ssh
- Edit `/etc/wpa_supplicant/wpa_supplicant.conf` as per [Manual configuration of WiFi](#)
- Update software

```
sudo apt update
sudo apt upgrade
```
- Create a guest account `sudo adduser guest` (password guest)
- Copy the password hash generating script `wifi-pass.sh` into `/home/pi`  
(The script is [here](#).)
- Create file with software version e.g. `cd ~; touch qut-v32-raspbian-buster`

Install all the following Raspberry Pi OS packages:

e.g.

```
sudo apt install filters espeak python-smbus haveged
```

| Package      | Purpose   |
|--------------|---|
| filters      | Filters for jive, pirate etc<br><a href="https://manpages.debian.org/buster/filters/jive.6.en.html">https://manpages.debian.org/buster/filters/jive.6.en.html</a> |
| espeak       | Text to speech  |
| python-smbus | Needed for python i2c sensor demos  |
| haveged      | For generating entropy for security demos   |
| dnstools     | Host command amongst others   |
| net-tools    | Ifconfig, route etc   |
| netstat      | Netstat – shows tcp and udp connections   |
| tcpdump      | display TCP/IP and other packets being tx or rx   |
| nmap         | Nmap network scanner  |
| ntp          | Time update – needed for htpdate?   |
| htpdate      | For time updated over http at QUT so date gets updated  |
| netcat       | Netcat ????   |
| fortune      | For fortune telling   |
| figlet       | For ascii text banners  |
| cowsay       | For cowsay filter   |
| default-jdk  | Default most recent open jdk (java)   |
| lighttpd     | Web server  |
| zip          | To zip files (unzip already installed?)   |
| python-smbus | Probably already installed  |
| i2c-tools    | Probably already installed  |
| pip3         | Probably already installed  |
| git          | Probably already installed  |

Install the following python3 packages for sensors:

```
sudo pip3 install RPI.GPIO
```

```
sudo pip3 install adafruit-blinka
```

```
sudo pip3 install adafruit-circuitpython-tmp007
```

```
sudo pip3 install rpi_ws281x adafruit-circuitpython-neopixel
```

## List of parts and suppliers for Raspberry Pis

For Raspberry Pi's I recommend you purchase a kit from the QUT bookshop, see [Where can I get a Raspberry Pi.](#)

Element 14 offers a special discount for students see: <http://au.element14.com/students> RS Components is another good supplier <http://au.rs-online.com/web/> both have deals for free shipping if you spend over a certain amount of money.



Adafruit has lots of good accessories, boards and sensors for Raspberry Pis [www.adafruit.com](http://www.adafruit.com) as does [www.icstation.com](http://www.icstation.com) but Adafruit has much more documentation including tutorials and how to documents. <http://core-electronics.com.au/> is Australian distributor for Adafruit products.

- Auseparts [http://www.auseparts.com.au/index.php?route=product/product&product\\_id=281](http://www.auseparts.com.au/index.php?route=product/product&product_id=281)
- AusPi Technologies <http://www.buyraspberrypi.com.au/shop/raspberry-pi-3-model-b/>
- Little Bird Electronics <http://raspberrypi.iaustralia.com.au/products/raspberry-pi-3-model-b>
- <http://www.buyraspberrypi.com.au/>
- <https://www.sparkfun.com/categories/233>

SD card or micro SD card e.g. Sandisk Ultra 16GB SD Card Class 10

- Officeworks <http://www.officeworks.com.au>
- [www.umart.com.au](http://www.umart.com.au)

USB SD card reader

- <https://www.umart.com.au/umart1/pro/Products-details.phtml?id=10&id2=25&bid=2&sid=267042>
- <http://www.cheapchips.com.au/memory/shintaro-mini-multi-card-reader>
- <http://www.megabuy.com.au/transcend-rdf5-portable-usb-30-card-reader-black-p598410.html>

USB WiFi (not needed for Raspberry Pi 3, 4 or Zero W)

- WiPi Element14 <http://au.element14.com/element14/wipi/dongle-wifi-usb-for-raspberry/dp/2133900>
- Umart [www.umart.com.au](http://www.umart.com.au) choose a compatible one e.g. Edimax EW-7811Un
- List of compatible cards: [http://elinux.org/RPi\\_USB\\_Wi-Fi\\_Adapters](http://elinux.org/RPi_USB_Wi-Fi_Adapters)

USB to serial communications cable, FTDI compatible with Win 8/8.1/10, Android etc:

<http://www.icstation.com/serial-cable-adapter-ftdi-chipset-ft232-cable-p-1658.html>  
<https://www.sparkfun.com/products/12977>

Breadboard

- <http://core-electronics.com.au/solderless-breadboard-740-tie-points-zy-w101.html>
- <http://core-electronics.com.au/breadboard-full-size-bare.html>

Jumper wires

- <http://core-electronics.com.au/search?q=jumper%20wires>

Micro USB power supplies, at least 2 Amp

- <http://au.element14.com/pro-power/psu-raspberry-pi-2a-5v/psu-raspberry-pi-5v-2a-micro-usb/dp/244459602>,
- <http://au.rs-online.com/web/p/plug-in-power-supply/7653311/>

For the case you can use a Tupperware box or make your own! Custom boxes are also available from e.g.

- <http://shop.pimoroni.com/collections/pibow>
- <https://www.modmypi.com/shop/raspberry-pi-cases>
- <http://www.seeedstudio.com/depot/Raspberry-Pi-Clear-PS-Enclosure-p-1772.html> (very cheap!)
- One compartment storage box <http://www.on-lineplastics.com.au/fischer-storage-compartment-boxes/35-1-comp-medium.html>
- Or a supermarket plastic sandwich box

## Optional Sensors and Hardware for the Raspberry Pi

Some of these may require soldering. The S block level 9 technical service staff provide some courses to do this.

### Light sensors

- <http://www.icstation.com/icstation-bh1750-digital-light-intensity-sensor-module-p-5267.html>
- <http://core-electronics.com.au/sensors-modules/light-imaging/luminosity-sensor-breakout-tsl2561.html>

### Pressure sensors

- <http://www.icstation.com/bmp180-atmospheric-pressure-sensor-module-barometric-sensor-p-3673.html>
- <http://core-electronics.com.au/sensors-modules/pressure/gy-68-bmp180-digital-pressure-sensor-module-replaces-bmp085.html>

### Temperature and humidity sensors

- [https://www.tindie.com/products/DORJI\\_COM/dsth01-temperature-and-humidity-sensor-module-si7005-sensor-module/](https://www.tindie.com/products/DORJI_COM/dsth01-temperature-and-humidity-sensor-module-si7005-sensor-module/)

### Temperature sensor (DS18B20 temperature sensor)

- <http://www.icstation.com/ds18b20-temperature-measurement-sensor-module-arduino-p-2761.html>
- <https://www.adafruit.com/products/374>
- Instructions: <https://learn.adafruit.com/adafruits-raspberry-pi-lesson-11-ds18b20-temperature-sensing/hardware>

#### PIR (Passive Infrared) Movement sensors

- <https://www.tindie.com/products/exlene/2pcslot-hc-sr501-human-body-infrared-sensing-module-pyroelectric-infrared-sensor-probe-bfa3/>
- [http://www.icstation.com/product\\_info.php?products\\_id=1390](http://www.icstation.com/product_info.php?products_id=1390)
- <https://www.adafruit.com/products/189>
- Instructions: <https://learn.adafruit.com/adafruits-raspberry-pi-lesson-12-sensing-movement>

#### Mini LCD display

- <https://www.dfrobot.com/product-1884.html> (with buttons and no wiring!)
- Note you need a 10K trimmer to adjust the display otherwise you won't be able to see anything (level 9 resources room has these)
- <http://www.icstation.com/1602a-hd44780-character-display-module-blue-backlight-p-1419.html>
- Instructions: <https://learn.adafruit.com/character-lcd-with-raspberry-pi-or-beaglebone-black/> (older ones <https://learn.adafruit.com/drive-a-16x2-lcd-directly-with-a-raspberry-pi/overview>)

#### IR remote receiver

- <http://core-electronics.com.au/sensors-modules/light-imaging/ir-sensor-tsop38238.html>
- <http://www.icstation.com/hs0038b-hs0038-sip3-infrared-receiver-receiver-p-2685.html>
- IR receiver + remote <http://www.icstation.com/infrared-wireless-remote-control-kits-arduino-p-2728.html>
- Instructions: <https://learn.adafruit.com/using-an-ir-remote-with-a-raspberry-pi-media-center/overview>
  - You can run a shell script by creating an appropriate .lircrc configuration file see <http://www.lirc.org/html/configure.html> Configure your remote first using the first part of the media centre instructions

#### Buzzer

- Instructions <http://hackaholic.info/raspberry-pi-buzzer/>

#### USB Bluetooth 4.0

- <https://www.umart.com.au/umart1/pro/Products-details.phtml?id=10&id2=125&bid=2&sid=194127>

#### Capacitive touch

- <http://www.icstation.com/mpr121-breakout-capacitive-touch-sensor-controller-module-keyboard-p-6585.html>
- Instructions <https://learn.adafruit.com/mpr121-capacitive-touch-sensor-on-raspberry-pi-and-beaglebone-black/overview>

## RFID

- MIFARE RC522 <http://www.icstation.com/mifare-rc522-card-read-module-tags-interface-read-write-p-2192.html>
- Instructions <http://raspmer.blogspot.com.au/2015/07/how-to-use-rfid-rc522-on-raspbian.html>

## USB Microphone

- <https://core-electronics.com.au/mini-usb-microphone.html>

## What Power supply do I need?

You can use a standard micro-usb phone charger or buy a usb power supply, for the old Raspberry Pis you need a 1 amp supply for the model 2 or 3 you need 2 amps. Any supply will do but make sure it is approved for use in Australia (don't buy one from ebay or from an overseas company!).

- <http://au.element14.com/pro-power/psu-raspberry-pi-2a-5v/psu-raspberry-pi-5v-2a-micro-usb/dp/244459602>
- <http://au.rs-online.com/web/p/plug-in-power-supply/7653311/>

or I think the RS will ship the power supply for free.

A usb port on a PC or notebook may also work but sometimes these can't supply enough power. One reason for unreliable WiFi can be a weak power supply.

## Bash Script for wifi-pass.sh

To recreate this script carefully cut and paste this text into a file called `wifi-pass.sh`, then make the file executable `chmod +x wifi-pass.sh`

```
#!/bin/bash
echo "Enter your password (it will be hidden) then press \"Enter\""
read -s PASSWORD
echo "Your encrypted password is:"
echo -n ${PASSWORD} | iconv -t utf16le | openssl md4 | \
  cut -d' ' -f2 | (echo -n "hash:" && cat)
echo "Use this in your wpa supplicant (networking) config file"
```