

Tutorial : Raspberry Pi

CPSC 424 / 624

SPRING, 2017

INSTRUCTOR : DR. JIM MARTIN

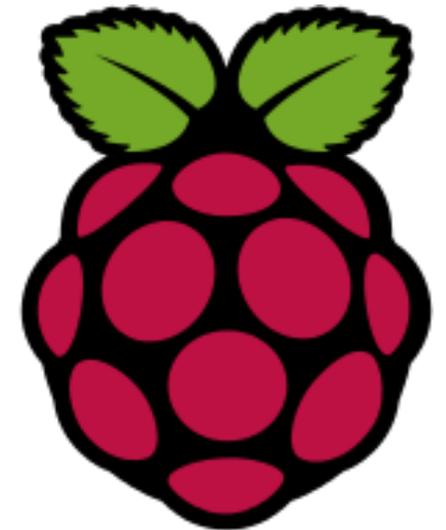
SLIDES DEVELOPED: MANVEEN KAUR (MKaur@Clemson.edu) AND ANJAN R. ([@Clemson.edu](mailto:anj@Clemson.edu))

About this tutorial

This tutorial aims at familiarizing you with Raspberry Pi.

We will discuss the following topics -

- What is Raspberry Pi?
- How many Raspberry Pi models are there?
- What can Raspberry Pi do?
- Where can you buy a Raspberry Pi ?
- How to configure your Raspberry Pi ?
- Some DIY projects that can be done on the Raspberry Pi.



What is Raspberry Pi?

- **Raspberry Pi is a credit card sized bargain micro Linux machine.**
- The goal behind creating Raspberry Pi was to create a low cost device that would improve programming skills and hardware understanding for students.
- The latest model of Raspberry Pi comes sporting 1 GB of RAM, 1200 MHz quad – core ARM Cortex-A53 processor, and basic levels of functionality that enables hobbyists, computer enthusiasts, and students to use this device for DIY projects.
- Raspberry Pi is **open hardware** with the exception of its primary chip, the Broadcom SoC which runs the main components of the board – CPU, graphics, memory, USB controller etc.



Raspberry Pi 3 Model B
(Latest release of Raspberry Pi)

Different models of Raspberry Pi (RPi)

- The current models of the Raspberry Pi available: the Pi 2 Model B, the Pi 3 Model B, the Pi Zero, and the Pi 1 Model B+ and A+.
- The Model A+ is the low-cost variant of the Raspberry Pi. It has 256MB RAM, one USB port, 40 GPIO pins and no Ethernet port.
- The Model B+ is the final revision of the original Raspberry Pi. It has 512MB RAM (twice as much as the A+), four USB ports, 40 GPIO pins, and an Ethernet port.
- The Pi 2 shares many specs with the Pi 1 B+, but it uses a 900MHz quad-core ARM Cortex-A7 CPU and has 1GB RAM.
- The Pi 3 Model B was launched in February 2016; it uses a 1.2GHz 64-bit quad-core ARM Cortex-A53 CPU, has 1GB RAM, integrated 802.11n wireless LAN, and Bluetooth 4.1.
- Pi Zero is half the size of a Model A+, with a 1Ghz single-core CPU and 512MB RAM, and mini-HDMI and USB On-The-Go ports.
- All of these Raspberry Pi Models share the following features:
 - **Operating Systems:** Raspbian RaspBMC, Arch Linux, Rise OS, OpenELEC Pidora
 - **Video Output:** HDMI Composite RCA
 - **Supported Resolutions:** 640x350 to 1920x1200, including 1080p, PAL & NTSC standards
 - **Power Source:** Micro USB

What can RPi do?

Raspberry Pi users have made many creative and impressive projects using this device.

North Carolina Near Space Research (<http://www.ncnearspace.org/>) used a raspberry pi to power very-high-altitude balloons to take pictures from space.

Engineers have used RPi to design a 'dicta-teacher' meant to teach disadvantaged blind children how to read Braille.

A link to a weather station made from Raspberry Pi - <http://embeddedday.com/projects/rescuing-a-foam-box/>

RPi can also be programmed to assist in 'housekeeping' your network by functioning as NAS, LDAP server, web server, media server, DNS server etc.



Video showing a smartphone made with Raspberry Pi .

Where can you buy RPi from?

- From the Raspberry Pi website : <http://swag.raspberrypi.org/>
- From the Raspberry Pi's main distributors : Premier Farnell/Element 14 (<https://www.element14.com/community/community/raspberry-pi>) and RS Components/Allied Electronics (<http://uk.rs-online.com/web/generalDisplay.html?id=raspberrypi>)
- Resellers of Raspberry Pi such as Adafruit (<https://www.adafruit.com/products/998>) or Amazon.
- **How much does it cost?**
 - The Model A+ costs \$20
 - The Model B+ costs \$25
 - Pi 2 costs \$35
 - The Pi 3 costs \$35
 - The Pi Zero costs \$5
 - Power supply and SD card are not included in this price but are available from the same sellers.

Refer to http://elinux.org/RPi_Buying_Guide for further information on buying

What hardware do you need to setup your RPi ?

1. A Raspberry Pi
2. An HDMI or composite video capable television or monitor
3. An HDMI or composite video cable
4. An SD card that is compatible with your Raspberry Pi - http://elinux.org/RPi_SD_cards has a list of SD cards you should use
5. A USB keyboard and mouse (Bluetooth keyboard/mouse work for latest model but with minor connectivity issues)
6. Standard Ethernet cable
7. Micro USB power supply (that can provide at least 700mA at 5V)
8. A 3.5 mm stereo audio cable if your project requires Raspberry Pi to be connected to external speakers.

Steps to setup your RPi

Each of the following steps is detailed in the subsequent slides.

Step 1 : SD Card Setup

Step 2 : Raspberry Pi cabling

Step 3 : Booting your RPi for the first time

Step 4 : Load GUI environment to your RPi

Sep 5 : Setup a network connection

After completing this setup , you will have your device powered up and working as a full fledged Linux box running Debian.

Step 1: SD Card Setup

- RPi **will NOT** start without a properly formatted SD Card (with a bootloader and suitable OS).
- Two of the most important RPi OS options are Raspbian (based on Debian) and Pidora (based on Fedora)
- **IMPORTANT - The formatted SD Card has to be inserted before powering the RPi; and the RPi has to be shut down before unplugging the card.**
- Ways to setup the SD card:
 - Easy/ Safe way – Buy a preloaded card from a reputable supplier (Available for sale <http://swag.raspberrypi.org/> and <https://thepihut.com/> . There have been reports of problems with SD cards purchased from ebay or Amazon so be cautious if buying from there)
 - Create your own SD card for Rpi
 - Using NOOBS
 - Flashing the SD Card using Windows, Mac, or Linux

Step 1: SD Card setup using NOOBS

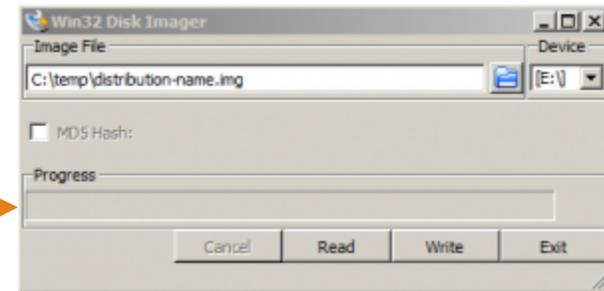
- NOOBS (New Out Of Box Software) is an easy way to install RPi distributions.
- It is a 1 GB download compared to the 500 MB size of images used for flashing.
- Download NOOBS from the [raspberrypi.org downloads page](https://www.raspberrypi.org/downloads)
- Insert a (4 GB+) SD Card into your computer
- Format the disk using instructions mentioned in notes for this slide.
- If your monitor doesn't work with NOOBS, press 1-4 for the following troubleshooting options:
 - Default HDMI Mode
 - HDMI Safe Mode - Use this if Default (1) doesn't work and you cannot see anything
 - Composite PAL Mode - Use this or 4. if you are using the yellow and black outputs on the opposite side to the HDMI output
 - Composite NTSC Mode

Step 1: SD Card setup by flashing the card

Instructions for Windows

- Using the **Win32DiskImager** program

1. Download the distribution from [raspberrypi.org downloads page](http://raspberrypi.org/downloads). *Make sure the distribution is for Raspberry Pi (it will mostly be a compressed file ending in .zip or .gz).* Extract this image.
2. Insert the SD card into your SD card reader and make note of what drive your SD Card is assigned.
3. Download the Win32DiskImager utility from <https://sourceforge.net/projects/win32diskimager/> . This can be run from a USB drive.
4. Extract the executable from the zip file and run the Win32DiskImager utility (might need to 'Run as Administrator'; Right-click on the file, and select 'Run as Admin').
5. If you see a file error when Win32DiskImager loadsv(in windows 7), ignore the error.
6. Select the image file you extracted and the drive letter of SD card as shown here →
7. Click 'Write' and wait for write to complete.
8. Exit imager and eject SD card. It can now be plugged into RPi.



If you are unable to chose the device in Win32DiskImager, try using 'flashnul' to do a similar installation. Alternatively, you can use the Fedora ARM Installer to download and install RPi Fedora Remix images (http://fedoraproject.org/wiki/Fedora_ARM_Installer)

Step 1: SD Card setup by flashing the card

Instructions for Mac OS X

- One way is to run an app with a GUI such as Pi Filler, ApplePi-Baker, or PiWriter; but the way that has worked out for most users is by **using systems tool from the command line**.
- First, download the image you want here : <http://www.raspberrypi.org/downloads>
- Verify the file using the published hash value - from the command line: \$ openssl sha1 **path_to_file.img**, or drag&drop the .img file into command window instead of typing the full path and file name.
- Unzip the file to extract the image (.img) file (an app like Unarchiver worked better than the OS X file de-compressor).
- Follow this link for instructions on installing OS images from the latest version of MAC OS : <https://www.raspberrypi.org/documentation/installation/installing-images/mac.md>

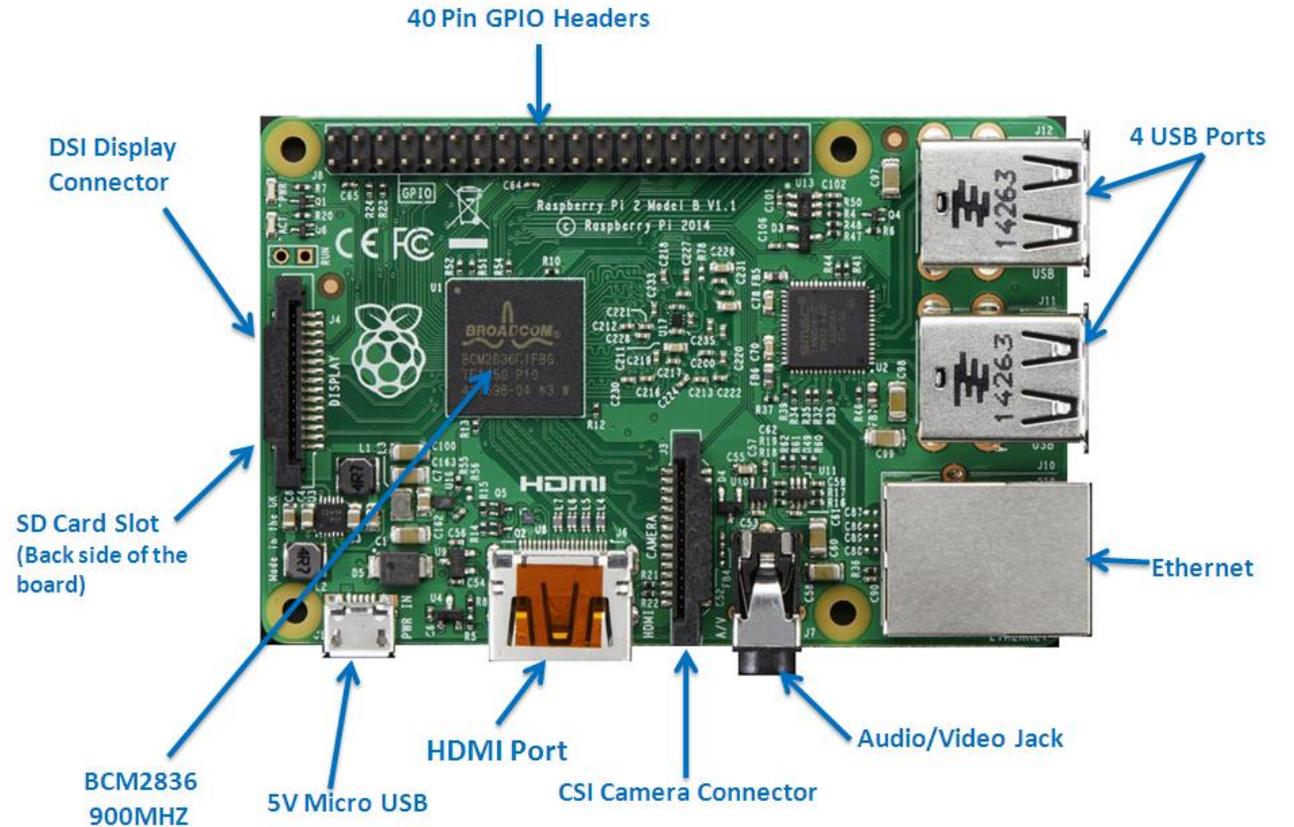
Step 1: SD Card setup by flashing the card

Instructions for Linux command line

- Download the zip file containing the image of the distribution : <http://www.raspberrypi.org/downloads>
- Extract image with : **unzip ~/2012-12-16-wheezy-raspbian.zip**
- Run **df -h** to see what devices are currently mounted.
- Insert SD card into your computer and run **df -h** again. Your SD card will be listed as something like `"/dev/mmcblk0p1"` or `"/dev/sdd1"`. The last part ("`p1`" or "`1`" respectively) is the partition number, but you want to write to the whole SD card, not just one partition, so you need to remove that part from the name (getting for example `"/dev/mmcblk0"` or `"/dev/sdd"`).
- Now, unmount the SD card (and all its partitions that show up) - **umount /dev/sdd1** (*replace /dev/sdd1...*)
- In the terminal write the image to the card with this command, making sure you replace the input file **if=** argument with the path to your .img file, and the `"/dev/sdd"` in the output file **of=** argument with the right device name (IMPORTANT !!! The wrong device name will cause you to lose all data on the hard drive)
dd bs=4M if=~/2012-12-16-wheezy-raspbian.img of=/dev/sdd --- *Might need to sudo for this.*
- As root run the command **sync** or if a normal user run **sudo sync**(this will ensure the write cache is flushed and that it is safe to unmount your SD card)
- Remove SD card from reader and insert in RPi.

Step 2: Raspberry Pi cabling

- Push SD card into the SD card slot.
- Plug the HDMI cable into the HDMI output of the Raspberry Pi and connect to the TV/monitor.
- Turn on monitor and switch to the HDMI port.
- Insert the network cable and connect to the router.
- Connect the keyboard and mouse via USB ports.
- Plug the power supply into the micro USB.
- The device is now ready for the next steps.



Step 3: Booting your RPi for the first time

- These steps are for the Debian distribution of Raspberry pi, Raspbian.
- The first time you boot the Raspberry Pi you'll see a configuration tool called "raspi-config."
- Calling "raspi-config" command from the terminal of your device will open this configuration screen again, if you need to see it.
- Select "expand_rootfs" and press enter (As shown in the images below). *This option expands the installed image to use the maximum available size of your SD card.*

```
Raspi-config

info          Information about this tool
expand_rootfs Expand root partition to fill SD card
overscan      Change overscan
configure_keyboard Set keyboard layout
change_pass   Change password for 'pi' user
change_locale Set locale
change_timezone Set timezone
memory_split  Change memory split
ssh           Enable or disable ssh server
boot_behaviour Start desktop on boot?
update        Try to upgrade raspi-config

                <Select>                <Finish>
```



```
Root partition has been resized.
The filesystem will be enlarged upon the next reboot

                <Ok>
```

Step 3: Booting your RPi for the first time

- Select “configure_keyboard” from the main menu and press enter. From the list of keyboard options that comes up, select your keyboard setup. If you are unable to find your keyboard setup. Select the default 105-key option.



- Select the keyboard layout as required
- **The last option to set in the Keyboard configuration is the ALT / CTRL / BACKSPACE feature to kill X11. It is recommended that you enable this, so that in case your GUI ever crashes you can safely kill it without rebooting.**

Step 3: Booting your RPi for the first time

- Setting user password on your device.
- From the main menu, select “change_pass” and press Enter. You will be prompted to enter new UNIX password.
- Set your “locale” which is the general character set used in your native language (en_US.UTF-8 for USA). Set this as the default locale when prompted.
- Set your timezone by selecting the “Change_timezone” option.
- Select “Finish” and reboot. Once you are back online, you will see a login prompt like this.

```
Raspi-config

info          Information about this tool
expand_rootfs Expand root partition to fill SD card
overscan     Change overscan
configure_keyboard Set keyboard layout
change_pass   Change password for 'pi' user
change_locale Set locale
change_timezone Set timezone
memory_split Change memory split
ssh          Enable or disable ssh server
boot_behaviour Start desktop on boot?
update       Try to upgrade raspi-config

                <Select>                <Finish>
```

```
My IP address is 192.168.11.22

Debian GNU/Linux wheezy/sid raspberrypi tty1

raspberrypi login: _
```

Step 4 : Load GUI environment to RPi

- Log in from the login prompt with the username “pi” and the password you set earlier.
- After logging in, type “startx” to get the GUI environment loaded.
- After a loading sequence, you will see a UI which looks similar to the Windows UI. It is the LXDE Window Manager which is a light weight UI that runs well on Raspberry Pi.
- After finishing the whole setup sequence, you now have your device powered up and the LXDE WM running. You can now use this Pi for your projects, or for general computing tasks.

Step 5 : Setup a network connection

- Your device can be connected to the internet in the following different ways, depending on the model you have used:
 - The LAN interface via Ethernet cable to your Internet router (Models B & B +, not the A, A + and Zero)
 - *If you are using the Ethernet option and your router is configured for DHCP, you should be able to connect without any further configuration.*
 - The built-in wireless card - Only the Raspberry Pi 3
 - A USB wireless dongle - available for all models
 - *This option consumes more power than other options. If you are using this option, make sure you hve a power supply that can support it.*

Wifi can be setup using either the command line or the graphical interface. Instructions on setting up wifi are available in detail in this document : <https://learn.adafruit.com/downloads/pdf/adafruits-raspberry-pi-lesson-3-network-setup.pdf>

Getting started with IDLE on RPi

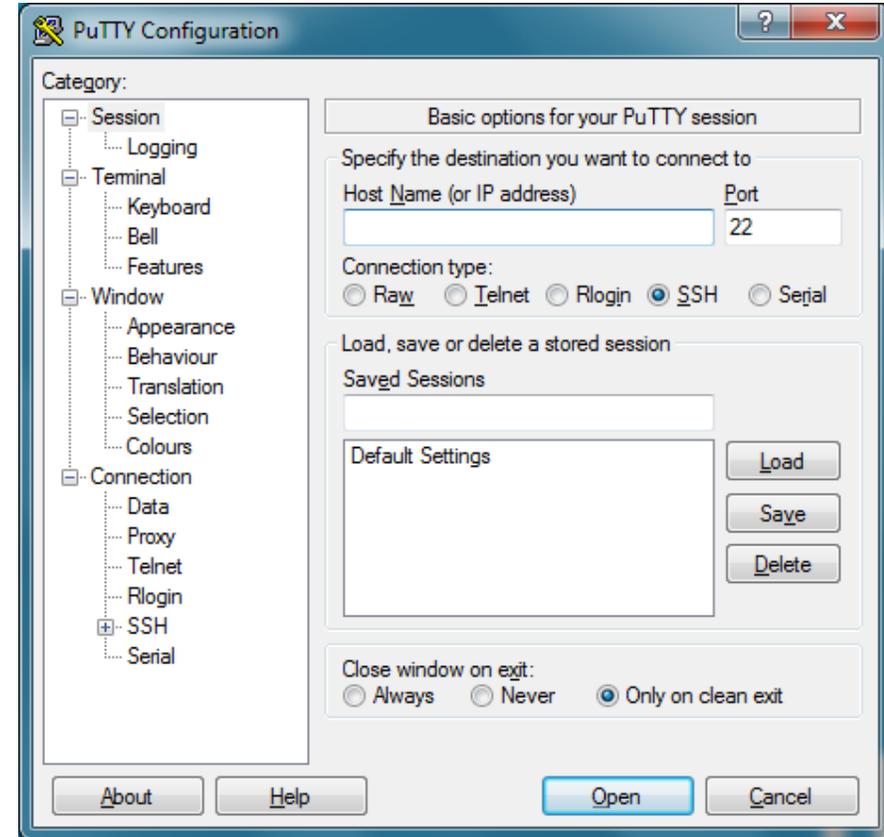
- Raspbian comes preloaded with Python, the official programming language of the Raspberry Pi and IDLE 3 which is a Python Integrated Development Environment.
- IDLE3 can be loaded up by double-clicking the icon on your LXDE desktop.
- Click File > New Window, which will then bring up a new blank window which you can type in.
- Type in your code and save.
- Click Run > Run Module or press F5 to run your code.

Enable SSH on your RPi

- If you want to access the command line (*not the full desktop environment*) of your RPi from another computer, you can use `ssh`
- SSH can be enabled using “raspi-config”.
- Enter `sudo raspi-config` in the terminal, navigate to `ssh`, hit Enter, and select `Enable` or `disable ssh server`
- For access to the full desktop environment via remote control, you can use VNC. It transmits the keyboard and mouse events from the controller, and receives updates to the screen over the network from the remote host.
- Instructions to enable VNC are here : <https://www.raspberrypi.org/documentation/remote-access/vnc/README.md>

SSH into Rpi using Windows

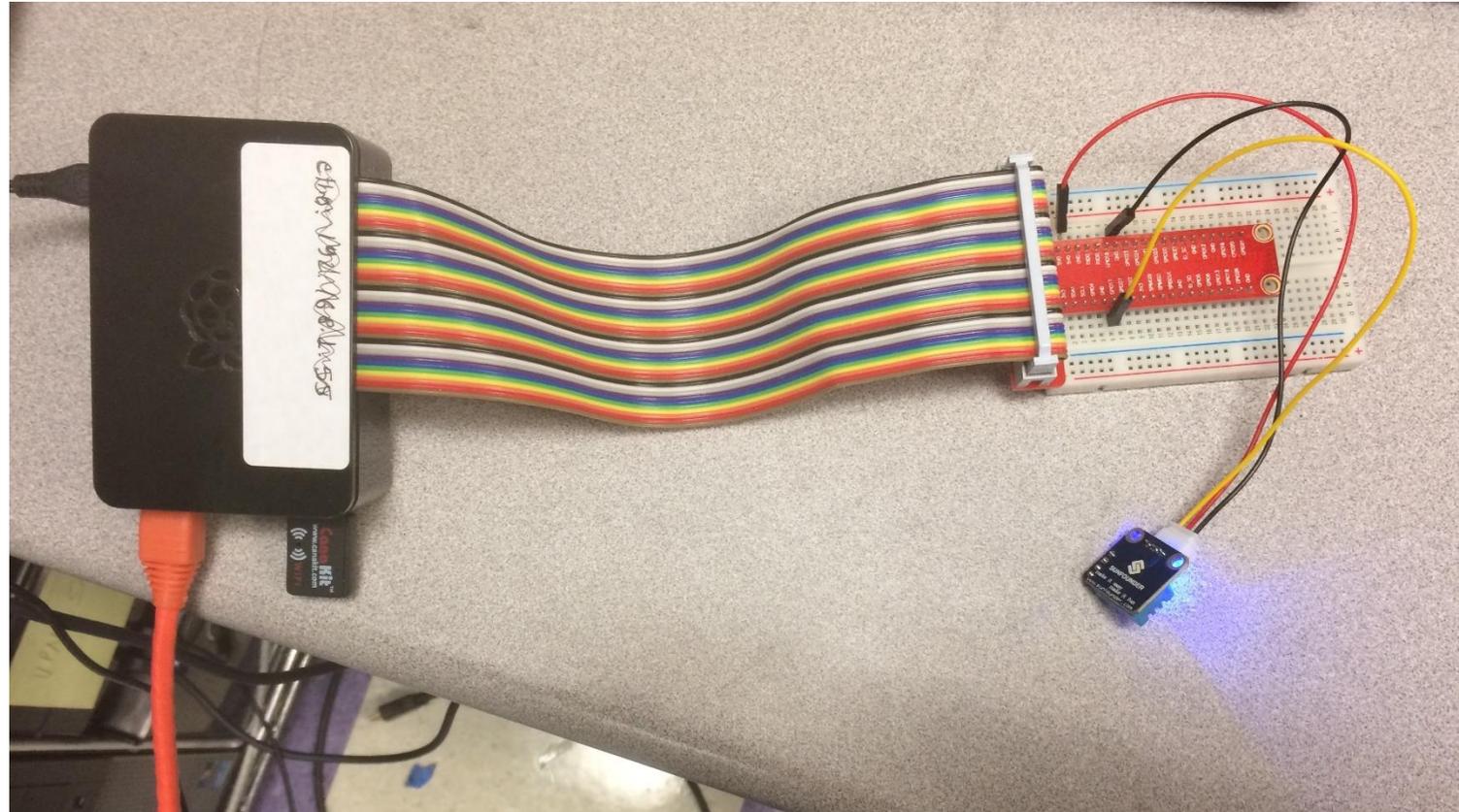
- Download PuTTY (available as 'putty.exe')
- When you run it, you will see a configuration screen like this ->
- Type the RPi's IP address into the Host name field and 'Open'.
(Find the IP address using `hostname -I`)
- When the connection starts, you will see a security warning about the server's host key not cached in the registry. This can be safely ignored. Click 'Yes'.
- You will now get the usual RPi login prompt. Log in with 'pi' as username and the password you set earlier.
- Type `exit` to close the putty window.
- You can use 'Saved sessions' on the configuration screen to connect the second time. You can change the 'Seconds between keepalives' value in the left hand pane to 30 to allow PuTTY to leave the remote connection open for long periods without any activity on your RPi.



SSH into RPi using Linux/ Mac OS

- SSH from Linux or Mac OS doesn't require any software installations.
- Get your device's IP address from the terminal using `hostname -I`
- Type the command `ssh pi@<IP>` where <IP> is the IP address of the RPi into the terminal window of the Linux or Mac OS devices. If your RPi user name is not 'pi', replace 'pi' in the command with your user name.
- If you receive a 'connection timed out', check if you have the RPi's correct IP address.
- When you get a security authenticity warning, type yes.
- You will now be prompted for the password for the pi (username: pi; password: as in the setup).
- X-Forwarding can also be set up from Linux or Mac OS by using the `-Y` flag as `ssh -Y pi@<IP>`
With X-forwarding, When you type in commands such as `idle3` & you can now open up graphical windows such as Python Editor IDLE remotely.

R-Pi Temperature/Humidity Sensing



Optional project : Setup an FTP server on RPi

- Install the **vsftpd** package `sudo apt-get install vsftpd`
- By default **vsftpd** is configured for anonymous access with read-only permissions. It needs to be changed so that it requires you to authenticate with a local user.
- Open the configuration file `sudo nano /etc/vsftpd.conf`
Change or uncomment the following values

```
anonymous_enable=NO
local_enable=YES
write_enable=YES
Local_umask=022
chroot_local_user=YES
user_sub_token=$USER
local_root=/home/$USER/ftp
```
- Restart the **vsftpd** service
- Create a couple folders in your local user's home folder. The **ftp** folder will be the root when you connect.
- Vsftpd doesn't allow root to have write permissions so you need to create a sub-folder inside the root called **files** which our local user will be allowed to write to. This is where you'd upload/download files from with an FTP client.
- You can now connect to your RPi from any FTP client and start uploading/downloading files.

Resources for learning about RPi

- Learning resources : <https://www.raspberrypi.org/resources/learn/>
- Raspberry Pi projects : http://elinux.org/RPi_Projects
- Raspberry Pi learning community <https://www.element14.com/community/welcome>
- A project aiming at creating an enhanced router using Raspberry Pi <https://ronnyvdbr.github.io/>