

Introduction to Robotics with the Raspberry Pi

INSTALLING RASPBERRY PI

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This workshop is assuming a you are using Windows. If you are using a Mac or Linux machine, good luck... I mean, you will need to look up the proper instructions for your OS. Sorry, I'm a Windows guy, now with a little Linux, but Windows is my got to OS for general use.

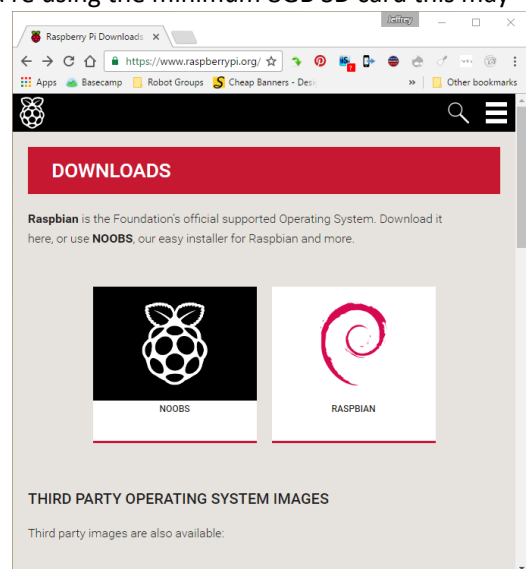
Downloading and Installing Raspbian

The purpose of this series of workshops is to challenge you to build a simple robot that will be expanded over time. It's intended to be difficult. However, it doesn't have to be too difficult or unnecessarily complicated. You'll have plenty of complications coming up. The installation of the operating system on your Raspberry Pi doesn't need to be.

There are, essentially, two methods of installing the OS on your Pi.

The first involves downloading the latest Raspbian image, writing it to the SD card and going from there. This method requires the installation of a third party software package that will write a bootable image on the SD card. The advantage is it takes less room on your SD card. If you're using the minimum 8GB SD card this may be helpful. If you went bigger, then this consideration is moot.

Whereas the direct installation is not all that complicated, rather easy actually, there's an easier way that doesn't involve installing additional software on your system. NOOBS is designed to make the installation and configuration of your Raspberry Pi easier. It will allow you to select from multiple operating systems and simply install. However, the NOOBS package will remain on the card and eat up valuable space. It does allow you to go back and repair your OS or change the OS completely, but this outside the scope of these workshops.



In the end, the choice is yours. I'll go over both options so you can choose whichever installation path works best for you. Regardless of which option you choose, your journey begins here:

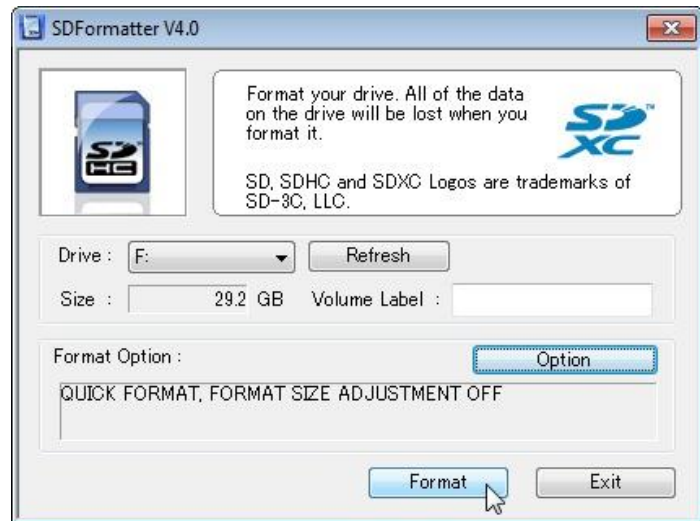
<https://www.raspberrypi.org/downloads/>

The "Hard" Way

This method will install the Raspbian OS image directly on the SD card, ready to boot up.

- 1) From the downloads page, click on the "Raspbian" image
 - a) Here you have two options for your Raspbian installation. Jessie is the most recent stable version of the operating system and is what we'll be using. The first option is Raspbian Jessie with Pixel, their new, optimized GUI. This is a 1.5GB download and 4.2GB image once it's been decompressed. The second option is Raspbian Jessie Lite, a minimal image which is much smaller as a 300MB download and 1.4GB after decompression. However, minimal means no GUI, so everything is done via the command line. If you're a fan of headless Linux, then this is the option for you. We will be using the larger install with Pixel.
- 2) Select the flavor of Raspbian you wish to install. If you have a BitTorrent client installed click on "Download Torrent". This will be much faster than downloading the zip file.
- 3) Once the download is complete, decompress the file somewhere you'll easily find.
- 4) Download the software
 - a) Download and install Win32 Disk Imager. This will allow you to write the image file we just downloaded to the Micro SD card. You can get it here:
<https://sourceforge.net/projects/win32diskimager/>
 - b) Optionally, you may also want to download SDFormatter to make sure your SD card is properly prepared. You can get that here: https://www.sdcard.org/downloads/formatter_4/
- 5) Insert your Micro SD card into the card reader connected to your computer.
- 6) If you downloaded and installed SDFormatter

- a) Open SDFormatter
- b) Make sure you select the drive representing your SD card. You're about to format it, so if you select the wrong thing it will wipe out whatever you have on that drive. The tool usually selects the right one by default, but double check. It would be wise to disconnect any other external storage devices.



- c) Also make sure "format size adjustment" is set to on. This will remove any other partitions on the card and use the whole things. Leave all the other settings to default.
- d) Click start.
- e) When the process has finished you're ready to move to install the OS.

7) Flash the image to the SD card

- a) Open Win32 Disk Imager
- b) In the image file field, select the Raspbian image you downloaded. You can click on the file folder icon to navigate to it.
- c) Make sure your SD card is selected in the device dropdown box. Again, selecting the wrong device here can lead to a world of hurt, so pay attention.
- d) Click "Write".

8) Remove the card from your card reader

9) Insert the card into the Micro SD card reader on the Raspberry Pi.

That's lengthy to write, but remarkably fast easy to do. Next we'll walk through the NOOBS installation process.

The "Easy" Way

I call this the easy way, though the hard way is pretty easy. What makes this easy is you don't have to write the image directly. You will probably still want to format the card, but if it's a new card, that may not be necessary. To make it even easier, if you bought your Pi as part of a starter kit, it probably came with a micro SD card with NOOBS already installed. In which case you can skip the first couple steps.

- 1) From the downloads page click on the "NOOBS" image.
 - a) Here you'll have two options; NOOBS and NOOBS Lite. NOOBS includes the Raspbian image with the download so you won't have to connect to the network to download anything once it's on your SD card. You will have the option of selecting another OS, if you so choose, but you'll need to have your Pi connected to the network in order for NOOBS to download it. NOOBS Lite does not include the Raspbian image. For our purposes, select the standard NOOBS install.
- 2) Select your flavor of NOOBS. If you have a BitTorrent client installed click on "Download Torrent". This will be much faster than downloading the zip file.
- 3) Optionally, you may also want to download SDFormatter to make sure your SD card is properly prepared. You can get that here: https://www.sdcard.org/downloads/formatter_4/
- 4) If you downloaded and installed SDFormatter
 - a) Open SDFormatter
 - b) Make sure you select the drive representing your SD card. You're about to format it, so if you select the wrong thing it will wipe out whatever you have on that drive. The tool usually selects the right one by default, but double check. It would be wise to disconnect any other external storage devices.
 - c) Also make sure "format size adjustment" is set to on. This will remove any other partitions on the card and use the whole things. Leave all the other settings to default.
 - d) Click start.
 - e) When the process has finished you're ready to move to install the OS.
- 5) Unzip the NOOBS file directly on to the SD card.
- 6) Remove the card from your card reader
- 7) Insert the card into the Micro SD card reader on the Raspberry Pi
- 8) At this point you'll need to hookup your Pi to continue. So, once you've done that come back to this section to continue the setup.
- 9) When you connect the power to the Raspberry Pi it will boot up to the NOOBS installation screen. If you used NOOBS Lite, you'll have your choice of OS. If you used the standard NOOBS download you're only option is Raspbian, which is OK because that's what we're using.
- 10) Click on Raspbian to make sure it's selected. Also make sure you select the correct language at the bottom of the screen, in this case "English (US)".

- 11) Click on the "Install" button at the top of the screen.
- 12) Wait while it does its thing. This could take a little while, so go ahead and grab that cup of coffee.

Hookup Raspberry Pi

Now that your micro SD card is ready to go, you'll need to hook up your Raspberry Pi. If you're using an original, first generation Pi, this is a little more complicated. However, every model after the original includes multiple USB ports and an HDMI connector to make things easier. Hooking up the Pi is very simple:



- 1) Connect your monitor via the HDMI cable. If you are using a small television that is outfitted with component hookups rather than HDMI, the audio jack on the Pi is also a 4 pole component jack. You'll need the RCA to 3.5mm converter, usually in cable form, to do this.
- 2) Connect your keyboard and mouse to the USB ports. I am using a wireless keyboard/touchpad combination because it's compact and portable.
- 3) Make sure your micro SD card with the Raspbian or NOOBS is installed in the micro SD port on the Pi. This is, essentially, the hard drive for your small computer, so it has to be in the right place. It will not read the OS through an SD card reader connected to one of the USB ports.
- 4) If you are using an Ethernet cable, connect that to the Ethernet port. You may also plug a Wi-Fi dongle to the USB port. If you are using a Pi 3, Wi-Fi is built in.
- 5) Lastly, connect the 5v power to the micro USB port. This port is only for power and you cannot access the board via USB.

That's it. The Pi should be booting on your monitor. If you are installing NOOBS, go back to step 9 of that installation process.

Using raspi-config

Now that we've got the initial installation taken care of we're going to move on to a little customization. The Pi has several features you can enable depending on your particular use. They're not enabled initially in order

to reduce some of the overhead needed to run the OS. Some of the configuration settings we're going to implement are for security and convenience.

In order to make these customizations the good folks at Raspberry Pi Foundation have included a utility called raspi-config. To use this we'll need to use a command line terminal. We're basically entering a single command right now, but as move forward in the workshops you're going to become much more familiar with the terminal window. If you're new to Linux (on which Raspbian is based) this can be a little intimidating. It doesn't need to be and we'll do our best to ease into it. But you will have to learn your way around it.

You can find more information about the raspi-config utility here:

<https://www.raspberrypi.org/documentation/configuration/raspi-config.md>

You should already be booted into your Raspberry Pi.

- 1) Click on the terminal icon at the top of the screen. This will open a terminal window
- 2) Type: `sudo raspi-config`
- 3) Expand file system
 - a) By default Raspbian doesn't use the entire SD card so we'll want to tell it to. If you are using NOOBS this has been done for you, so you can skip this step.
- 4) Make sure "Expand file system" is highlighted
- 5) Press enter
- 6) Change user password
 - a) Make sure "Change user password" is highlighted
 - b) Press enter. The system will display a message saying you're going to be prompted for a new password.
 - c) Press enter. This will drop you into the terminal again to enter the new password
 - d) Enter your new password and press enter
 - e) Confirm your new password and press enter
 - f) When the message appears indicating success, press enter
- 7) Make sure Advanced settings is highlighted and press enter
- 8) Change the Hostname

- a) The hostname is how your Raspberry Pi will appear on the network. You'll want to give your Pi a unique name, especially when you consider how many of them may be on the network at any given time. The hostname should be meaningful to the application but unique.
- 9) Highlight "Hostname" and press enter.
- 10) A dialog box will appear explaining the requirements for a host name. Basically it's alphanumeric characters and no other symbols. No hyphens, no underscores. Press enter to continue.
- 11) Enter your new host name and press enter.
- 12) Enable SSH

SSH will allow us to access the Pi through a terminal window (SSH Client) from another computer. On Windows PuTTY is a very popular, free SSH client. SSH does not provide a GUI and all interactions will be using terminal commands. This is helpful if you want to quickly execute a program, install software, etc. As you get more familiar with the terminal you will likely find yourself using SSH to connect for simple commands while reserving VNC (remote desktop) for more involved tasks such as writing programs.

- a) Go back into the advanced options menu
- b) Select Enable SSH and press enter
- c) Confirm you want to enable SSH and press enter
- d) Press enter again to return to the menu

13) Enable I2C

I2C is a serial communications protocol that is very popular in embedded systems like the Pi, Arduino, etc. It allows for robust communication with multiple devices using a minimum number of pins. The motor control board we are using communicates via I2C. Later, if you choose to add other boards, such as the servo control board, it will also use I2C. As long as the devices have different addresses, you can keep stacking them.

- a) Go back into the advanced options menu
- b) Select Enable I2C and press enter
- c) Confirm you want to enable SSH and press enter
- d) Press enter again to return to the menu

14) Enable VNC

VNC is a protocol that allows you to remotely access and view your desktop from another computer. We'll be setting this up towards the end of this workshop and is what we'll be using to access the Pi without hooking it up to a keyboard, mouse, and monitor each time.

- a) Go back into the advanced options menu
- b) Select Enable VNC and press enter
- c) Confirm you want to enable SSH and press enter
- d) Press enter again to return to the menu

15) Force Logon with Password

We will be adding a custom user to the Raspberry Pi for you to use. Later we may go so far as to remove the default user, but not in this workshop. In order to use the new user you will want to make sure the Pi asks for user credentials when it boots.

- a) Go to boot options and press enter
- b) Select "B3 Desktop" and press enter

16) With all of the settings updated, highlight "Finish" and press enter.

17) The Pi will ask you if you want to reboot. Select "Yes" and press enter

At this point your Pi will reboot. It may take a couple minutes, especially if you did not install via NOOBS and the Pi has to expand your file system. Next we will create a new user to use rather than the default Pi user.

Users

The default user on every installation of Raspbian is Pi. Earlier we changed the password to make it more secure. However, you probably don't want to always log on as the Pi user. This is going to be a short section, but very important. You can get more information about managing users here:

<https://www.raspberrypi.org/documentation/linux/usage/users.md>

Remember when I said we'd start using the terminal more. Well, that starts now. The easiest way to create and manage users is through the command line. We're going to walk through that process now. We'll be creating a new user, setting that user's password, and then adding that user to the sudo user group so you will be able to do, pretty much, everything you'll need to do through that user rather than the default Pi user. There's nothing preventing you from using the default Pi user and never creating a new one. But it's generally good practice to use a custom user.

When a new user is created a home directory is created for that user. This is where your files and most of your work will occur by default.

Create a new user

- 1) Open a terminal window
- 2) Enter: `sudo adduser <username>`
 - a) Where user name is the user name you are adding, and without the brackets (< >)
- 3) When prompted enter a new password for this user. Note: no characters will appear while entering passwords.
- 4) Re-enter the password to confirm.
- 5) Optionally, enter the personal information for this user when prompted. Otherwise press enter for the default values.
- 6) Enter: `sudo visudo`
 - (1) This will bring up the `sudoers.tmp` file for editing.
- 7) Find the line `"root ALL=(ALL:ALL) ALL`
- 8) After that line enter: `<username> ALL = NOPASSWD: ALL`
 - a) Where user name is the user name you are adding, and without the brackets (< >)
 - b) This will give that user passwordless sudo permissions
- 9) While holding down the control key, press X
- 10) You will be asked if you want to save before exiting. Hit the Y key
- 11) It will then ask you for the filename. Hit the enter key to accept the default name already populated.

Remote access

We're not going to want to haul around an extra monitor, keyboard and mouse while we're working through these workshops. To make our lives much, much easier, we're going to set it up so we can access the Pi's desktop remotely from another computer. For more information on setting VNC go here:

<https://www.raspberrypi.org/documentation/remote-access/vnc/>

When we first powered up the Pi we went into `raspi-config` to enable several services. One of those was VNC. This is also why we changed the default password right at the start. Now we're going to get you setup on your PC. There are a couple pieces of software you're going to need on your PC/laptop; An SSH client and a VNC viewer.

The most common SSH client is probably PuTTY. It's free to use and can be downloaded here:

<http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html>

You'll also want to install the VNC viewer. This can be downloaded from RealVNC at <https://www.realvnc.com/download/viewer/>. You don't have to stop at your Pi. If you're so inclined you can install VNC Connect on all of your computers and control all of the remotely. However, this is obviously outside the scope of this workshop.

Both of these files are executables and don't need installing. Put them on your desktop or somewhere easy to find. To access your Pi remotely you're going to need to know the Pi's IP address on the network. Generally a network switch will retain the device's IP from session to session, however this isn't always the case. If this becomes an issue, the Raspberry Pi Foundation has an article on how to get your IP address without connecting a monitor, etc. at <https://www.raspberrypi.org/documentation/remote-access/ip-address.md>

Regardless, you'll need the Pi's IP address to make the initial connection. You will probably have to do this again once you get home and connect to your own network.

- 1) Open a terminal window
- 2) Enter: `sudo ip link set wlan0 up`
- 3) Enter: `sudo systemctl enable vncserver-x11-serviced.service`
 - a) This will enable your VNC server to startup automatically whenever your Pi is booted.
- 4) For now, start the VNC server by entering: `vncserver`
- 5) Once it's done launching you'll see a line like "New desktop is demopi:1 (192.158.1.128:1)" Make note of the numbers in parenthesis. This is the IP and desktop ID assigned to the Pi.
- 6) On your PC, run VNC Viewer
- 7) At the top, enter the numbers you found in the parenthesis. This is the VNC server address. You'll want take note of the first 4 numbers. In this case 192.158.1.128. This is the IP address assigned by the network router.
- 8) Press enter to connect to your Pi
- 9) Enter your username and password and you'll be in. Since you are currently logged on to the Pi directly you'll probably get an error about the user already existing. Click OK.
- 10) Close the VNC window
- 11) Reboot your Pi and wait for it to boot
- 12) Open the VNC viewer and connect to the Pi
- 13) You should be asked for you username and password. If so, then you're all set up.
- 14) Close VNC viewer

15) Shutdown the Pi

16) Disconnect the monitor, mouse and keyboard.

17) Power on your Pi and give it a moment to boot up.

18) Open VNC viewer

19) Connect to your Pi

If your VNC server does not start automatically when you reboot, you'll need to launch it manually. That's why we downloaded Putty.

1) Launch PuTTY

2) Enter the IP address you noted from your PI. Remember, the IP does not include the colon and number, just the first four numbers separated by periods.

3) Press enter

4) A terminal window will open on your PC prompting you for a login. Enter your login and press enter

5) Enter your password and press enter.

6) When the login is complete, at the prompt enter: vncserver

This will launch the VNC server. You should now be able to connect with VNC Viewer.

Explore

At this point you should be set up to work on your Pi from your PC. Take some time to poke around the interface. Get familiar with it. You'll want to know where the shutdown command is and how to open Putty. In the next workshop, we'll start with an introduction to Python.