IoT with MIT App Inventor

Fundamental

Xincheng Tang

Using your Raspberry Pi

Raspberry Pi Desktop

Your Raspberry Pi runs Raspberry Pi OS, a version of an operating system (OS) called Linux. (Windows and macOS are other common operating systems.)

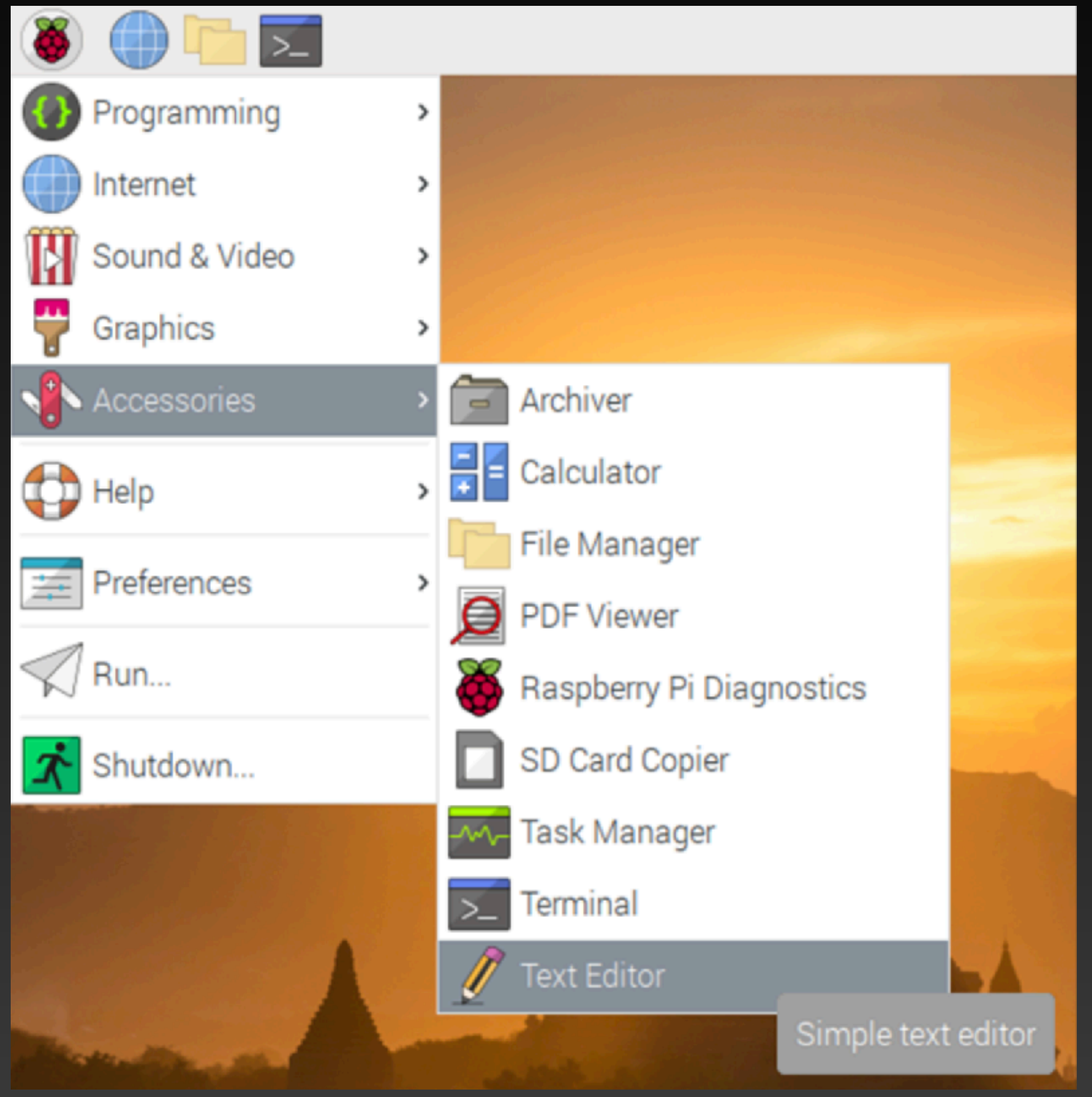
After Raspberry Pi OS starts up, you will see the Desktop appear.

Using your Raspberry Pi

The Raspberry Pi icon in the top left-hand corner is where you access the menu.

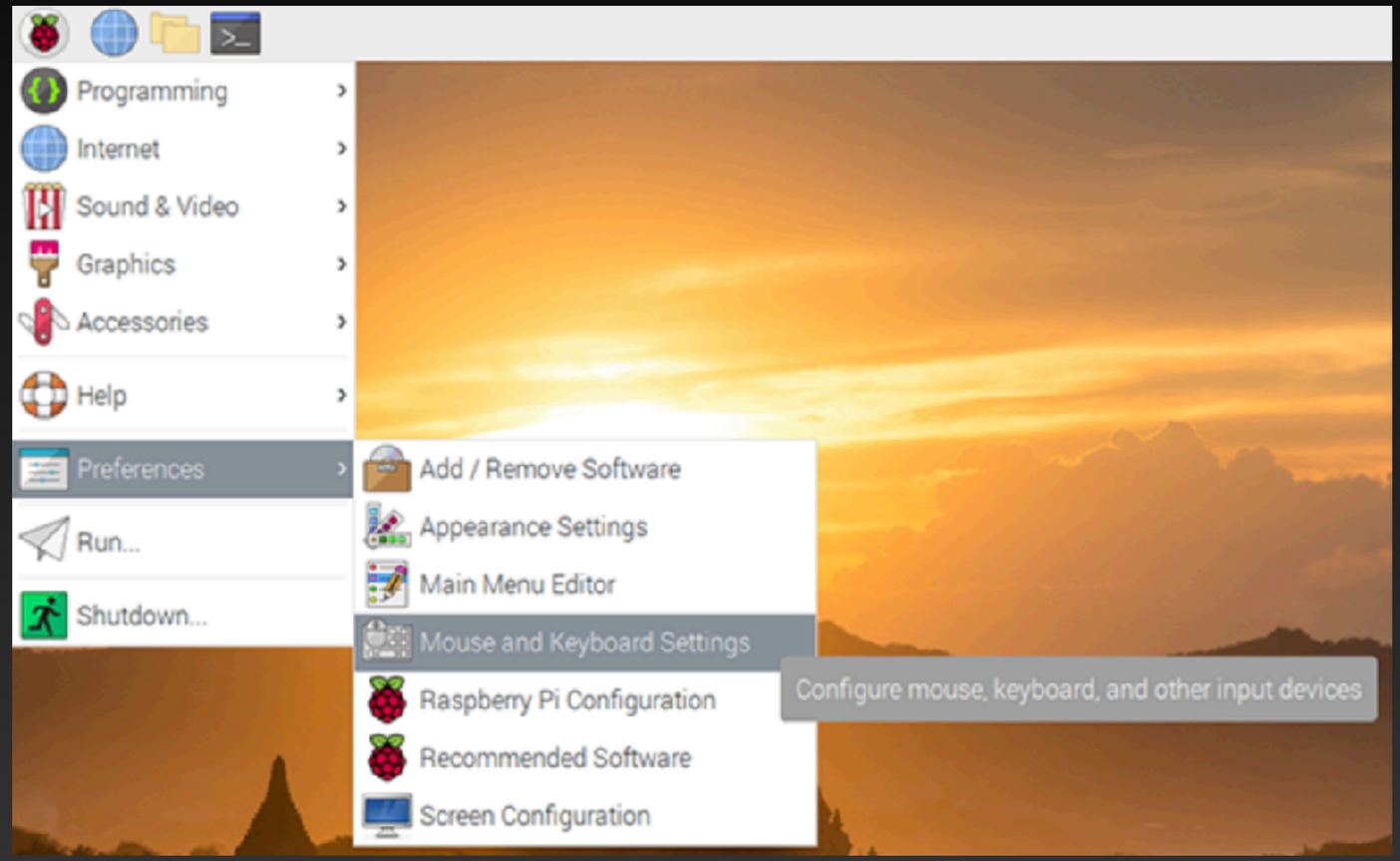
Click on it to find lots of applications, including Programming applications.

To open a text editor, click on Accessories and choose Text Editor.



Using your Raspberry Pi

To set up your mouse and keyboard, select Preferences and then Mouse and Keyboard Settings from the menu.

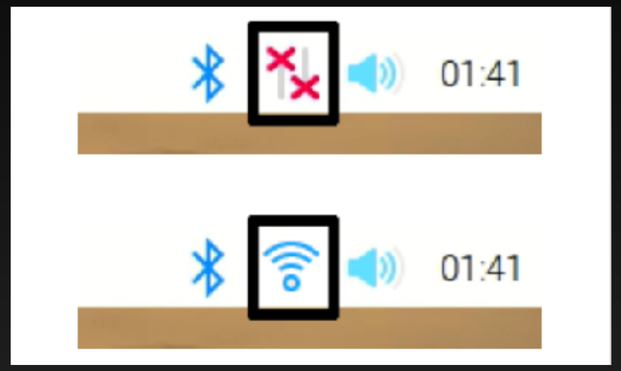


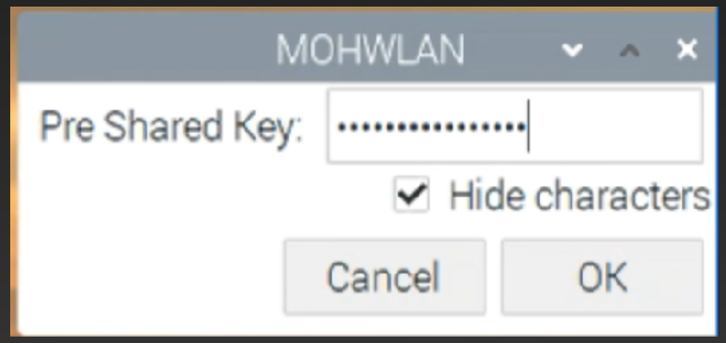
Using your Raspberry Pi

Connecting to a wireless network

Click on the wireless network icon in the top right-hand corner of the screen, and select your network from the drop-down menu.

Type in the password for your wireless network, then click on OK.



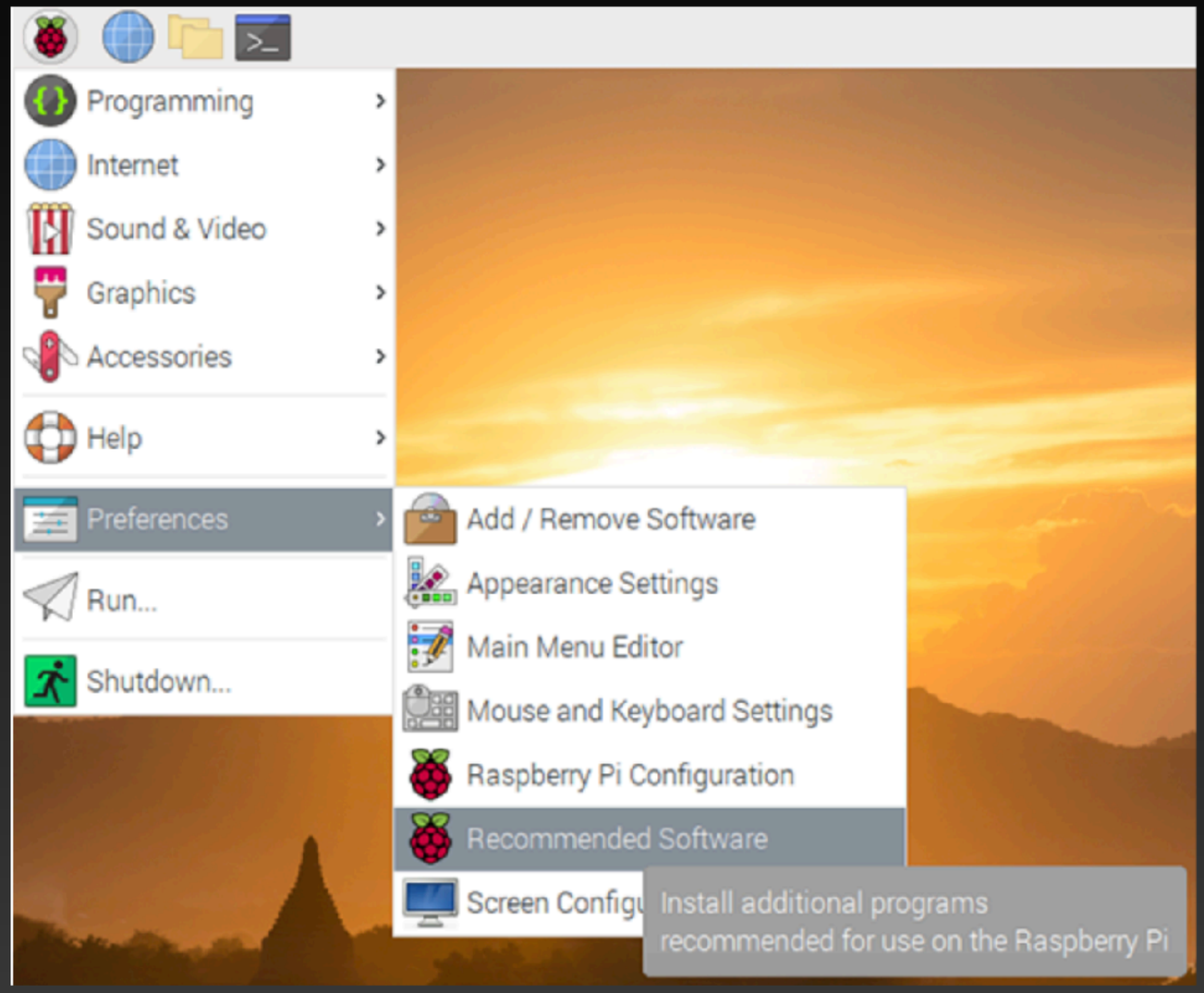


Using your Raspberry Pi

There are many, many software programs and applications you can download and install on Raspberry Pi.

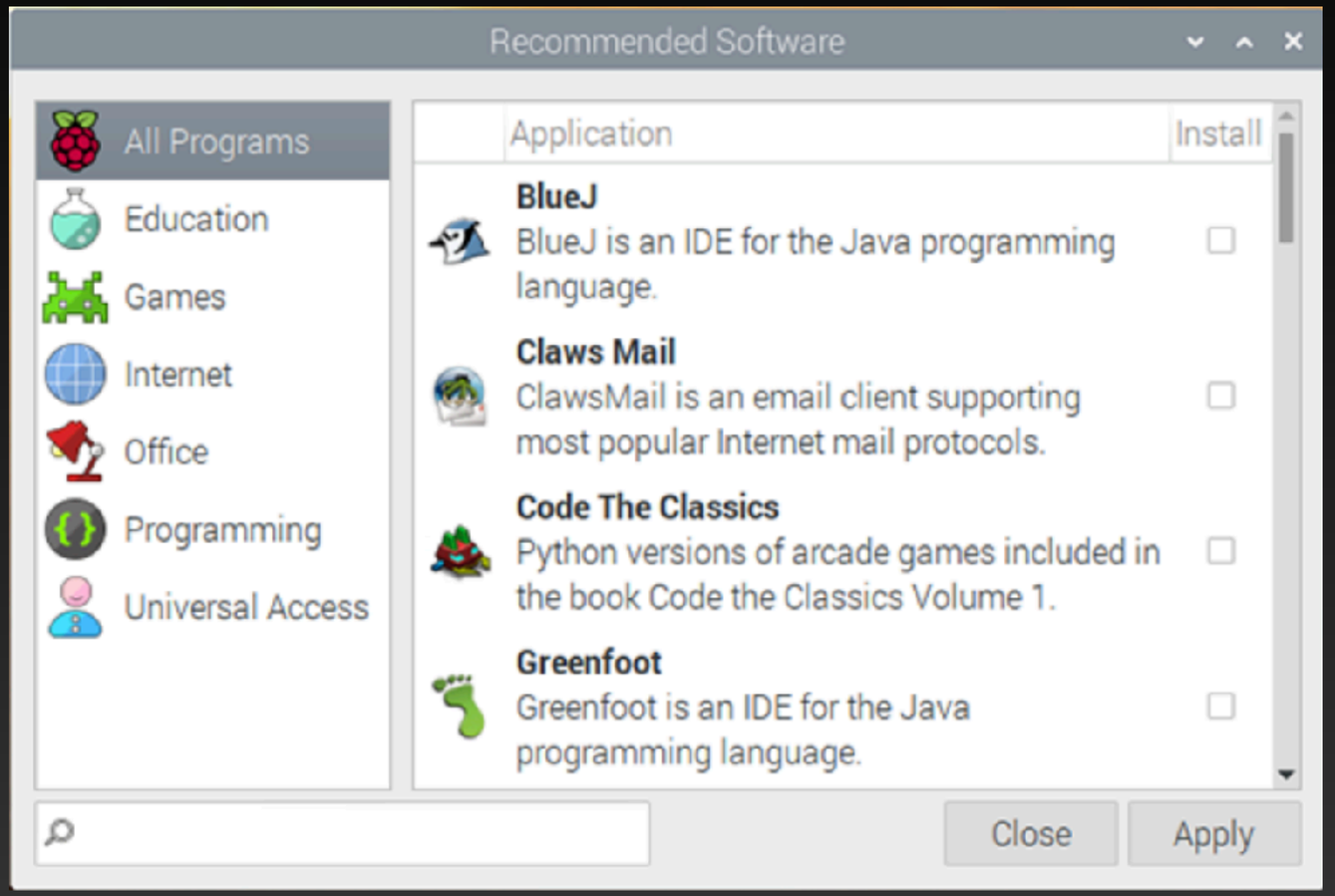
Note: Your Raspberry Pi has to be connected to the internet before you can install software.

In the menu, click on Preferences and then on Recommended Software.



Using your Raspberry Pi

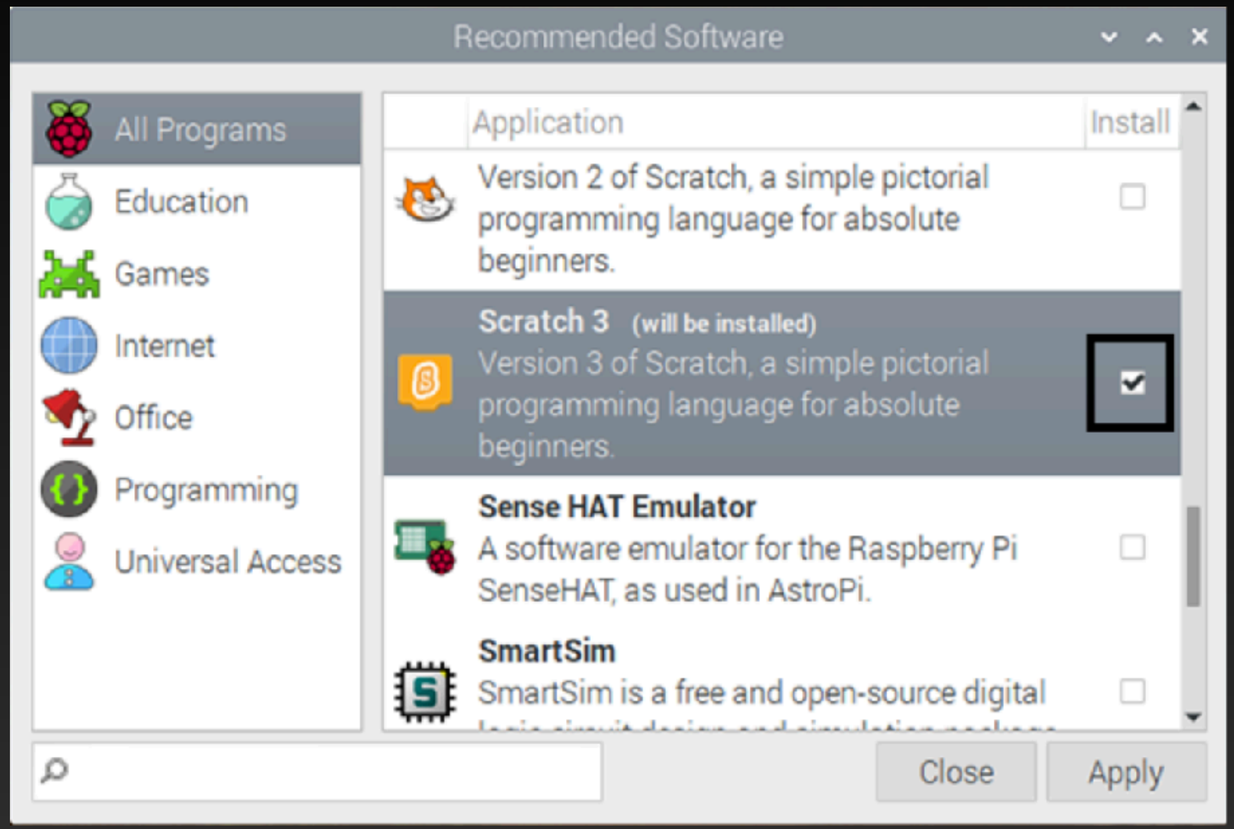
You can browse all the recommended software, or filter it by category.

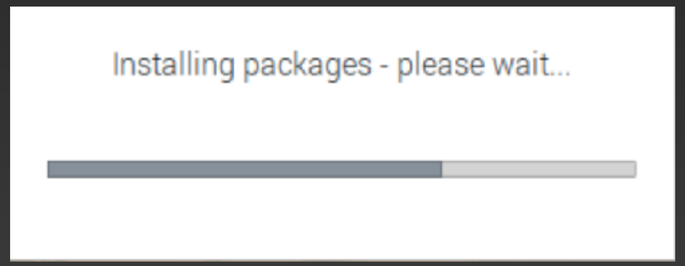


Using your Raspberry Pi

To install a piece of software, click to mark the checkbox to its right.

Then click on OK to install the selected software.

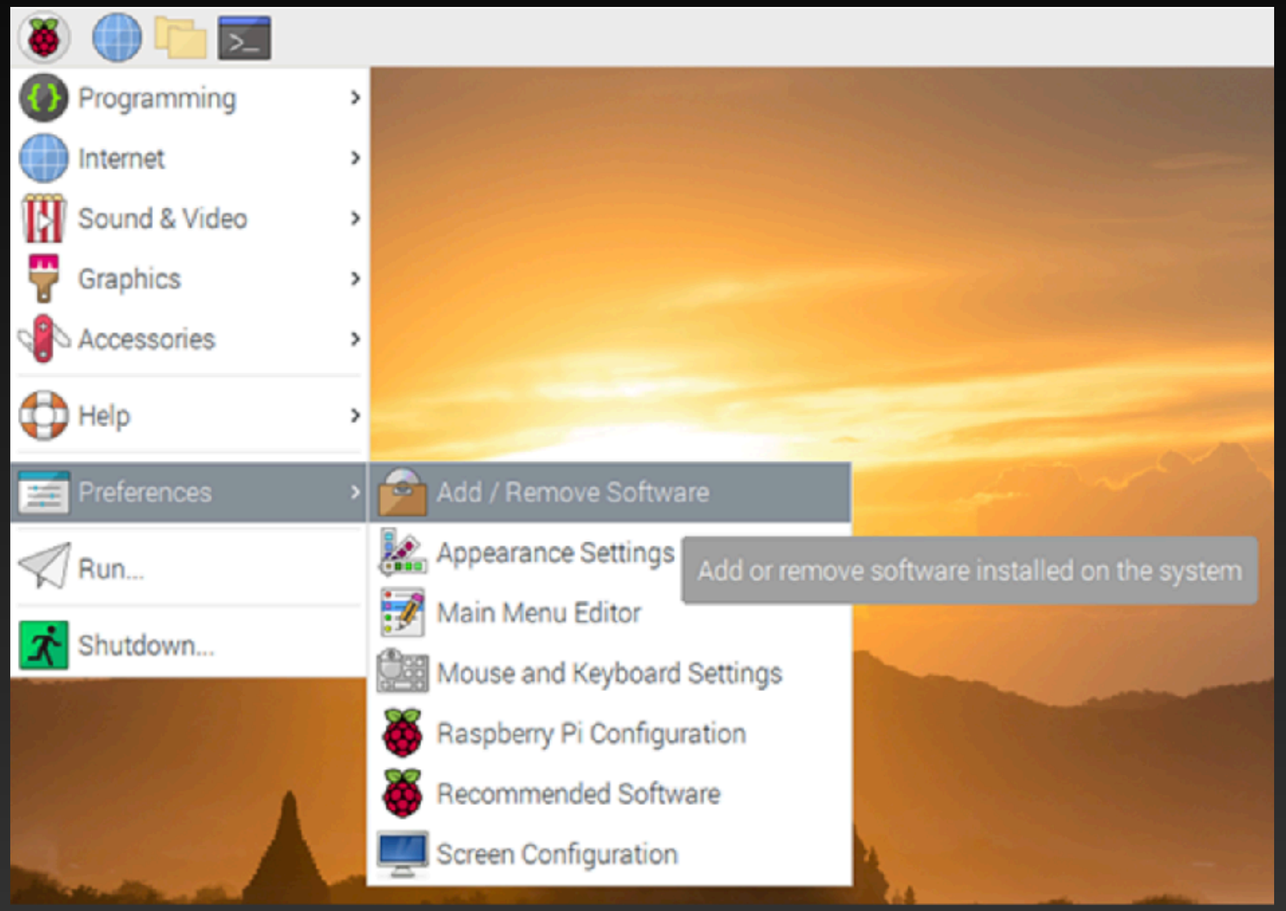




Updating your Raspberry Pi

It’s a good idea to regularly update the software on your Raspberry Pi with the latest features and fixes.

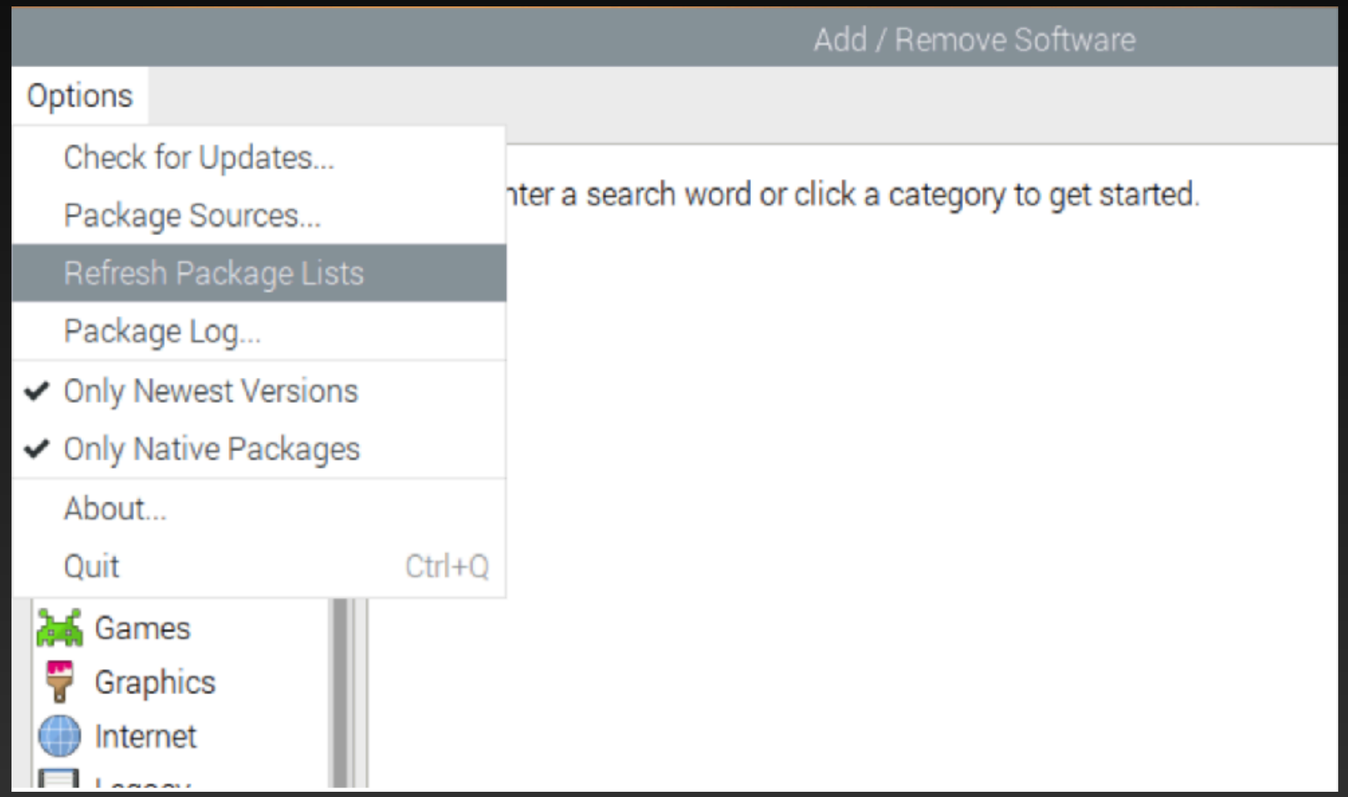
You can update your Raspberry Pi using the Add / Remove Software application: open it by selecting it from the Preferences section of the menu.



Updating your Raspberry Pi

Before you check and install any updates, you should refresh the software package lists on your Raspberry Pi.

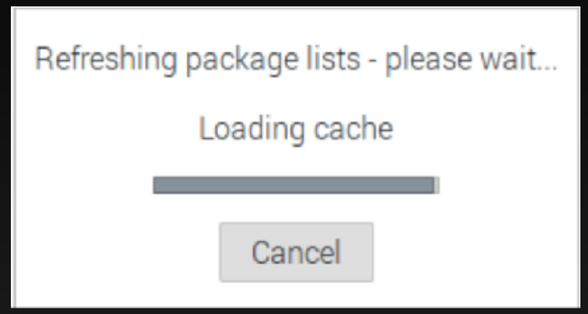
Click on Options in the top left-hand corner, and select Refresh Package Lists.

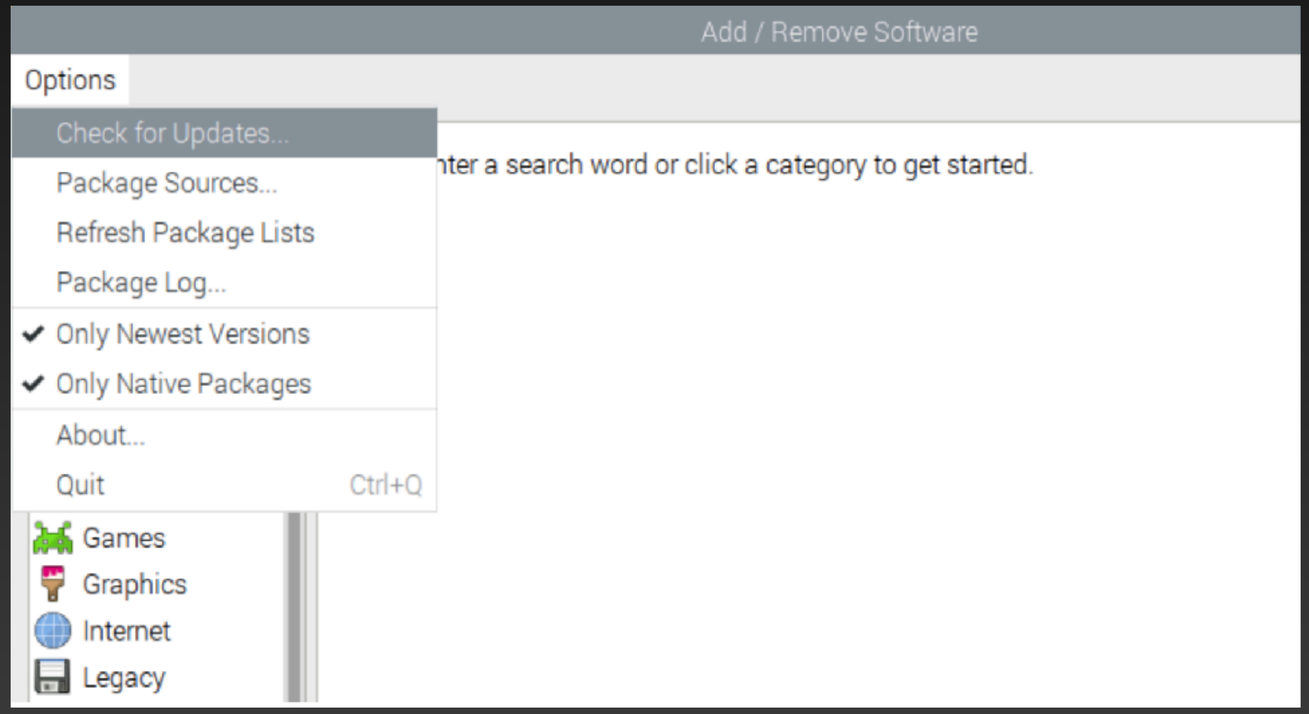


Updating your Raspberry Pi

Your Raspberry Pi will then update all lists of packages.

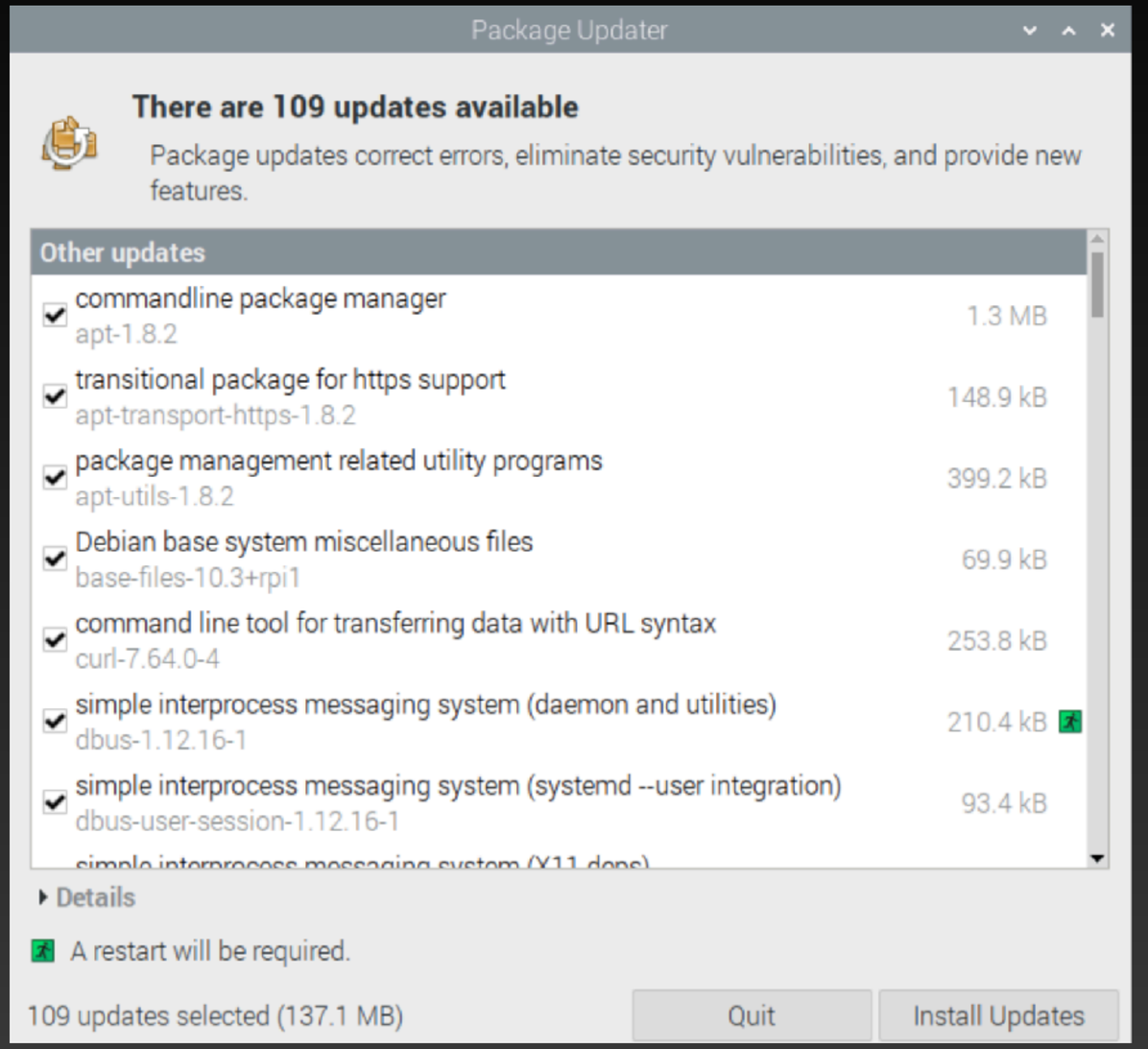
When this is done, click on Options and select Check for Updates.





Updating your Raspberry Pi

The Package Updater will open and automatically check whether updates are available. It will display anything it finds in a list.

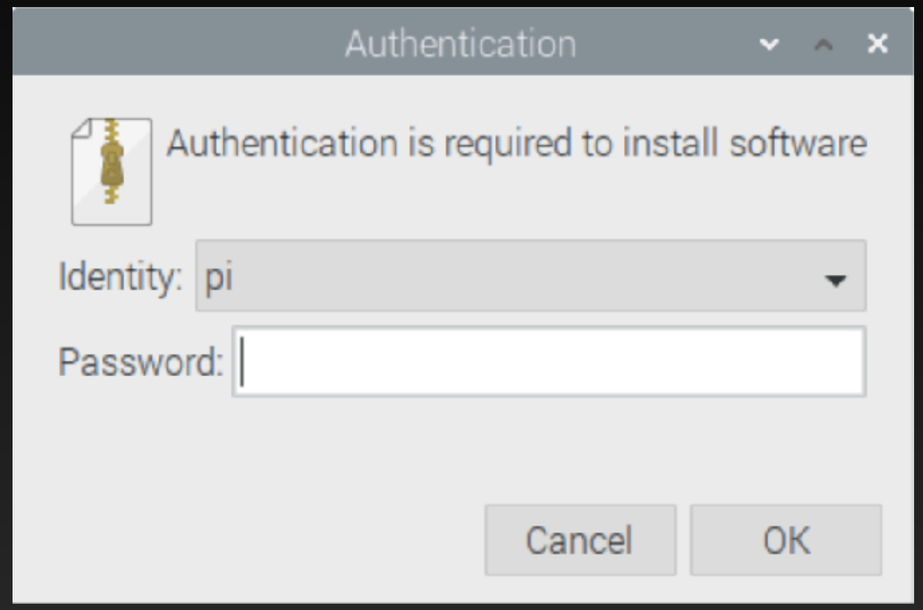


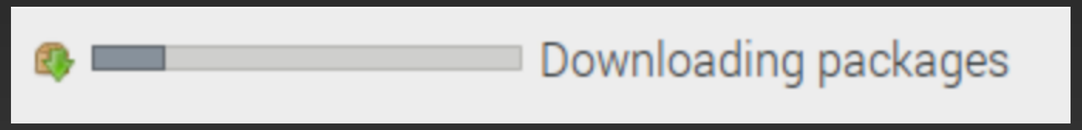
Updating your Raspberry Pi

Click on Install Updates to install all the available updates.

When prompted, enter your password; if you haven't changed the password, it will be 'raspberry'.

The updates will then be downloaded and installed. You can see the installation by checking the progress bar in the bottom left-hand corner.

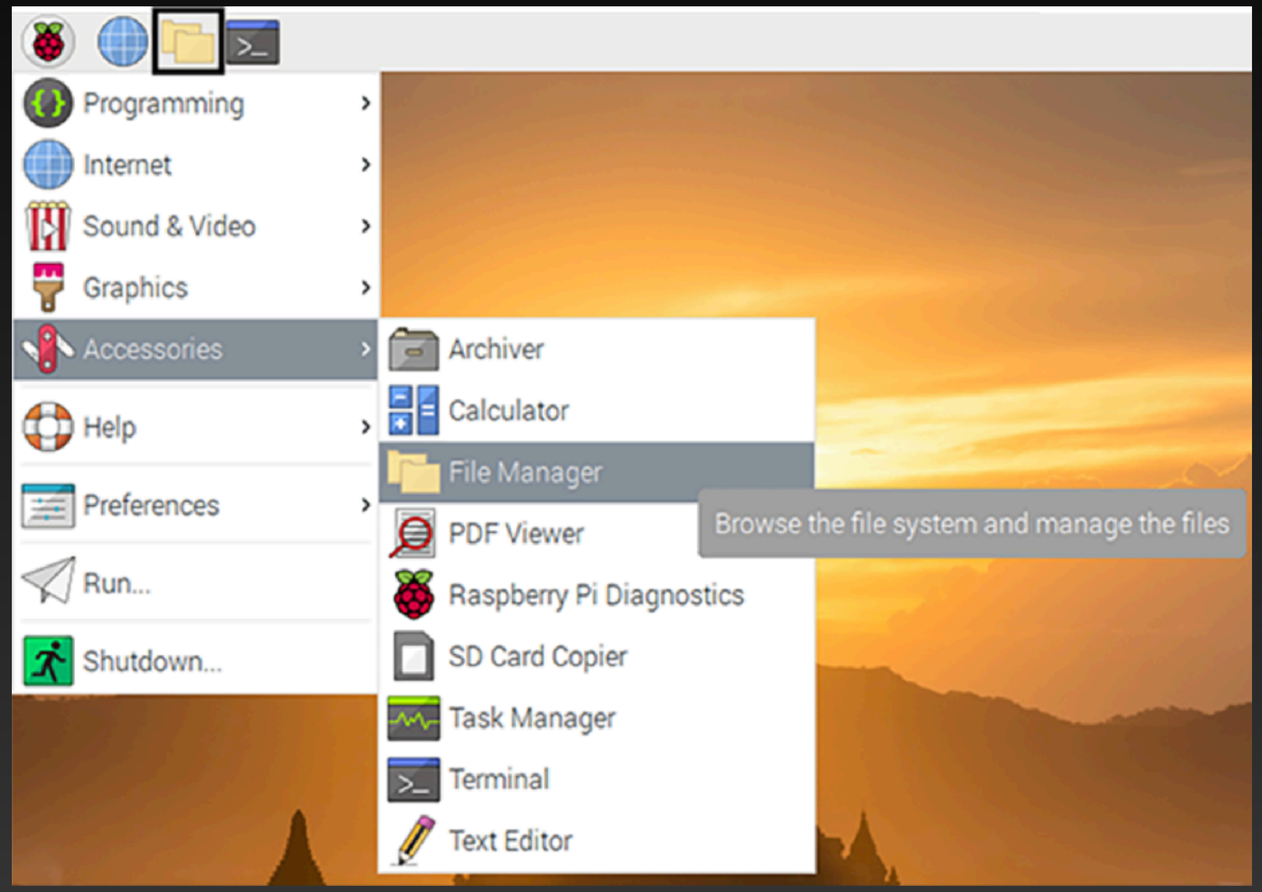




Accessing your files

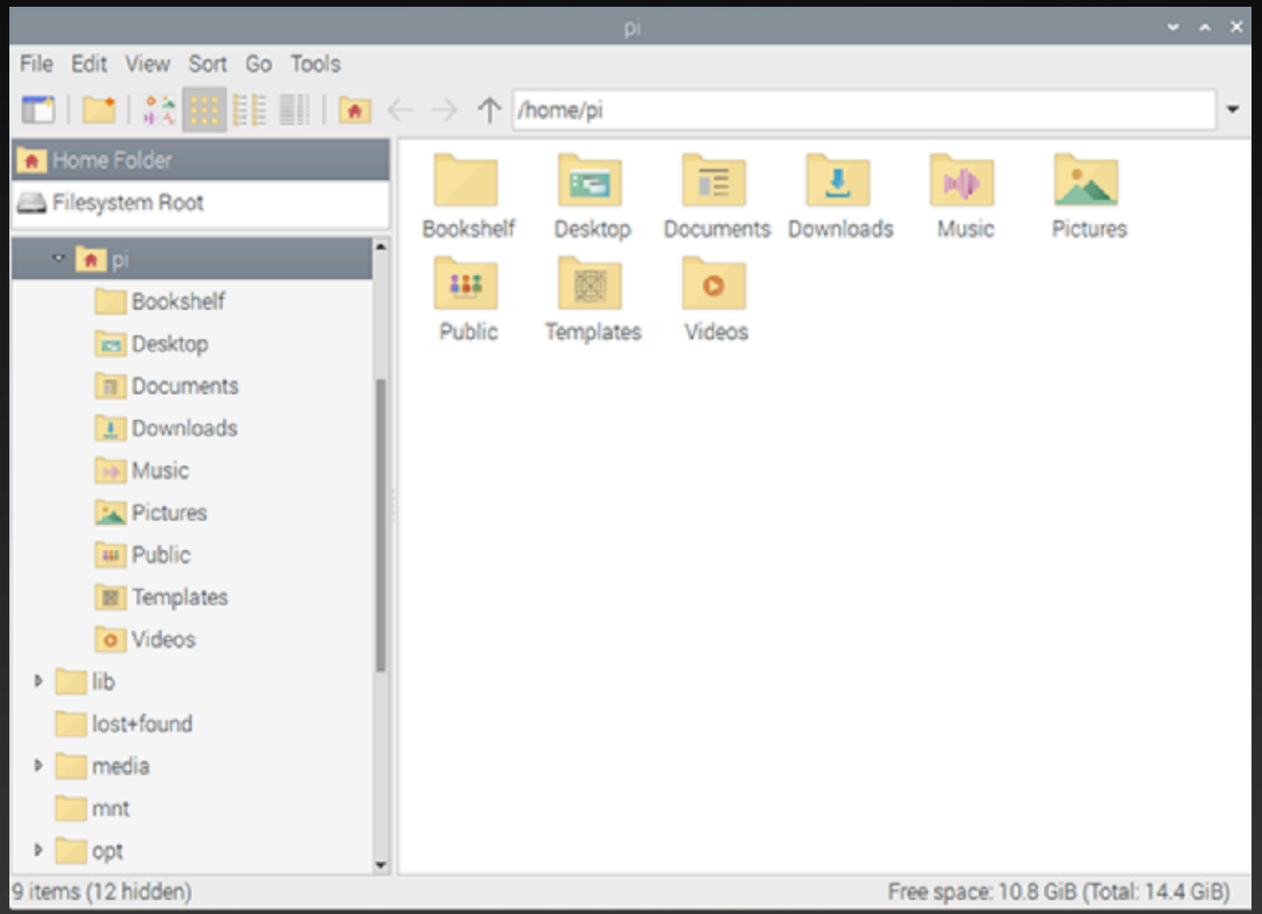
All the files on your Raspberry Pi, including the ones you create yourself, are stored on the SD card. You can access your files using the File Manager application.

Click on Accessories and then on File Manager in the menu, or select the File Manager icon on the menu bar.



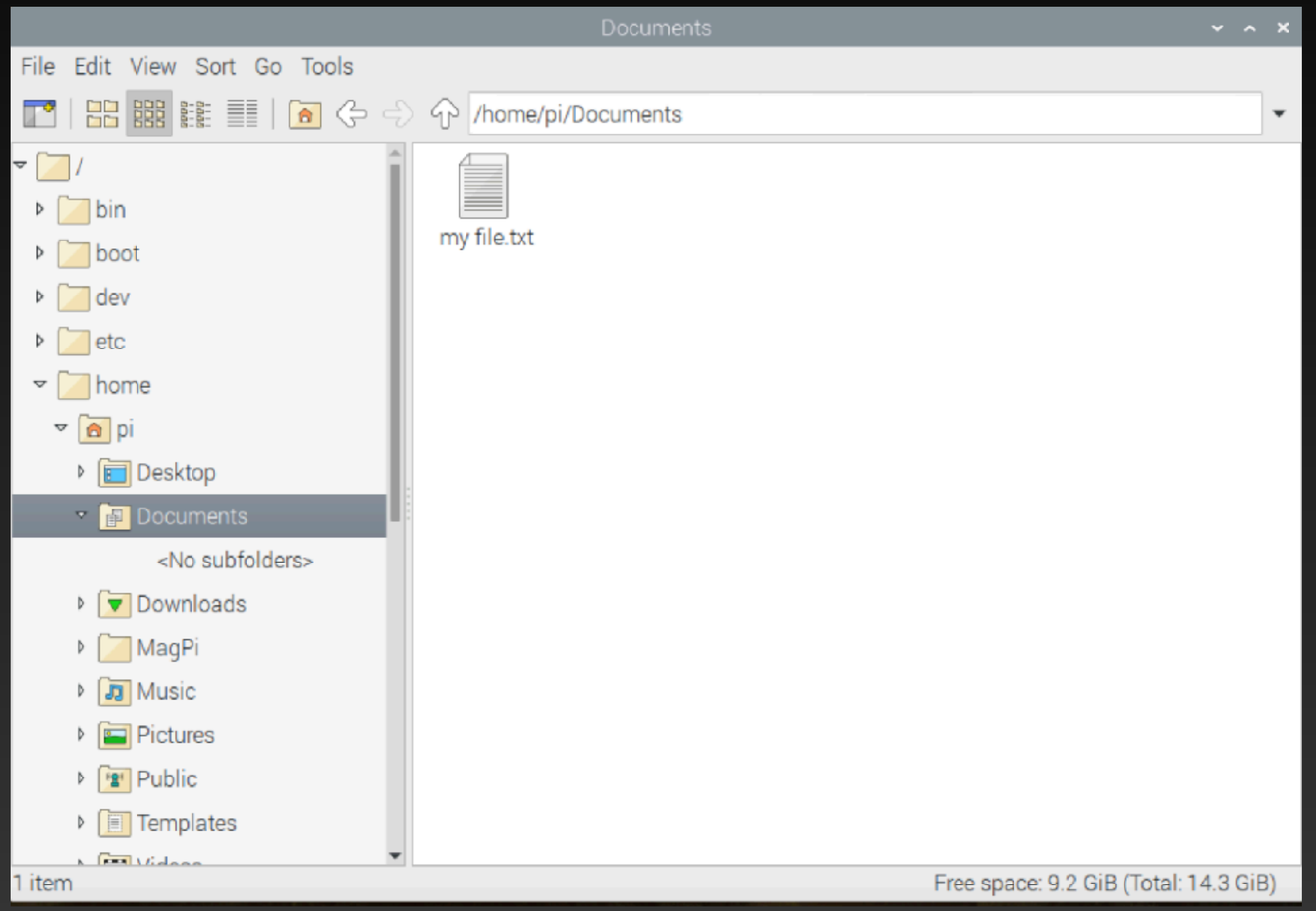
Accessing your files

When the File Manager opens, you will be shown the `pi` directory — this is where you can store your files and create new subfolders.



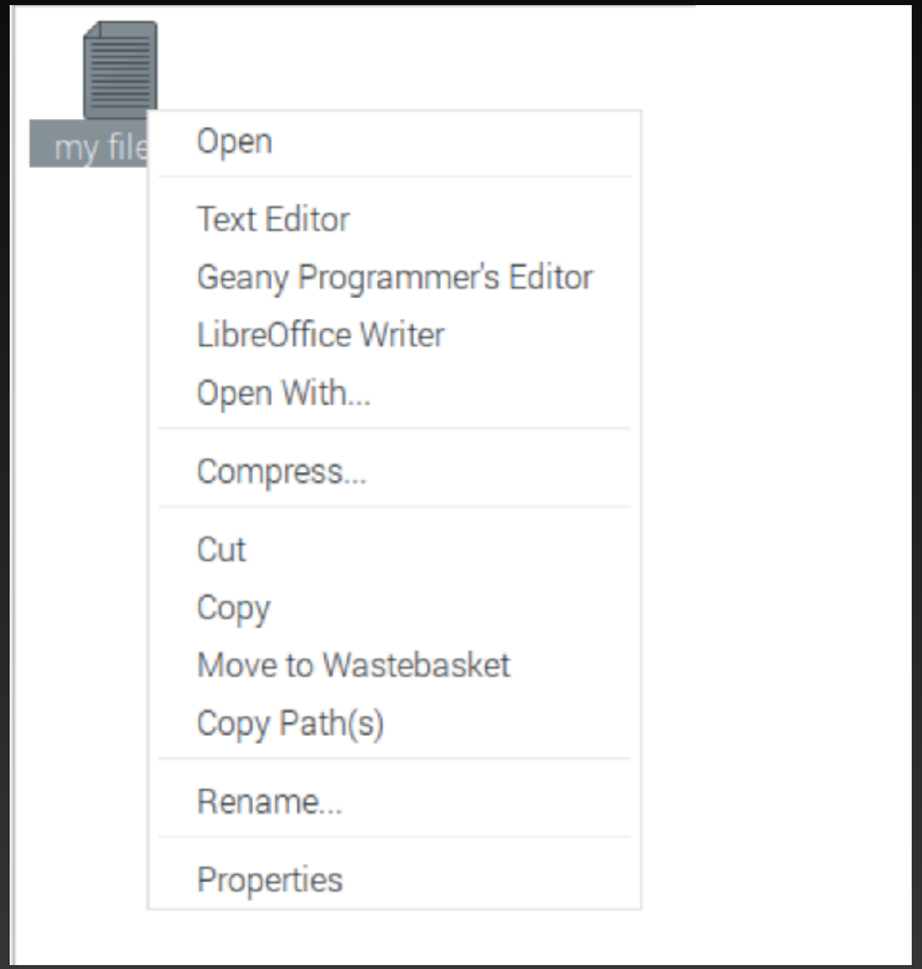
Accessing your files

Double-click on the Documents icon to open the directory and view the files inside.



Accessing your files

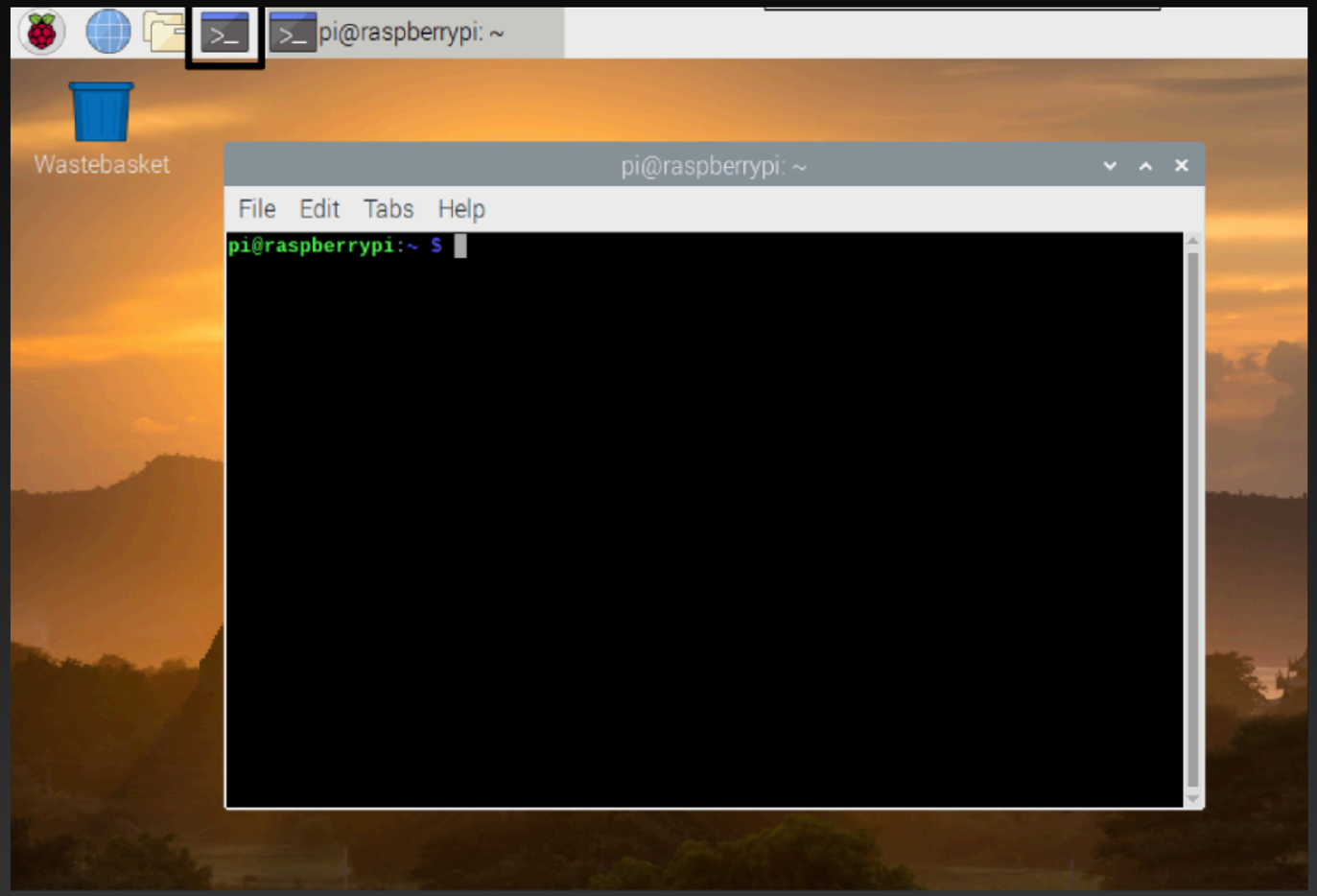
To open a file, double-click on its name, or right-click on it to open the file menu for more options.



Using the terminal

The terminal is a really useful application: it allows you to navigate file directories and control your Raspberry Pi using typed commands instead of clicking on menu options. It's often in many tutorials and project guides, including the ones on our website.

To open a terminal window, click on the Terminal icon at the top of the screen, or select Accessories and then Terminal in the menu.



Using the terminal

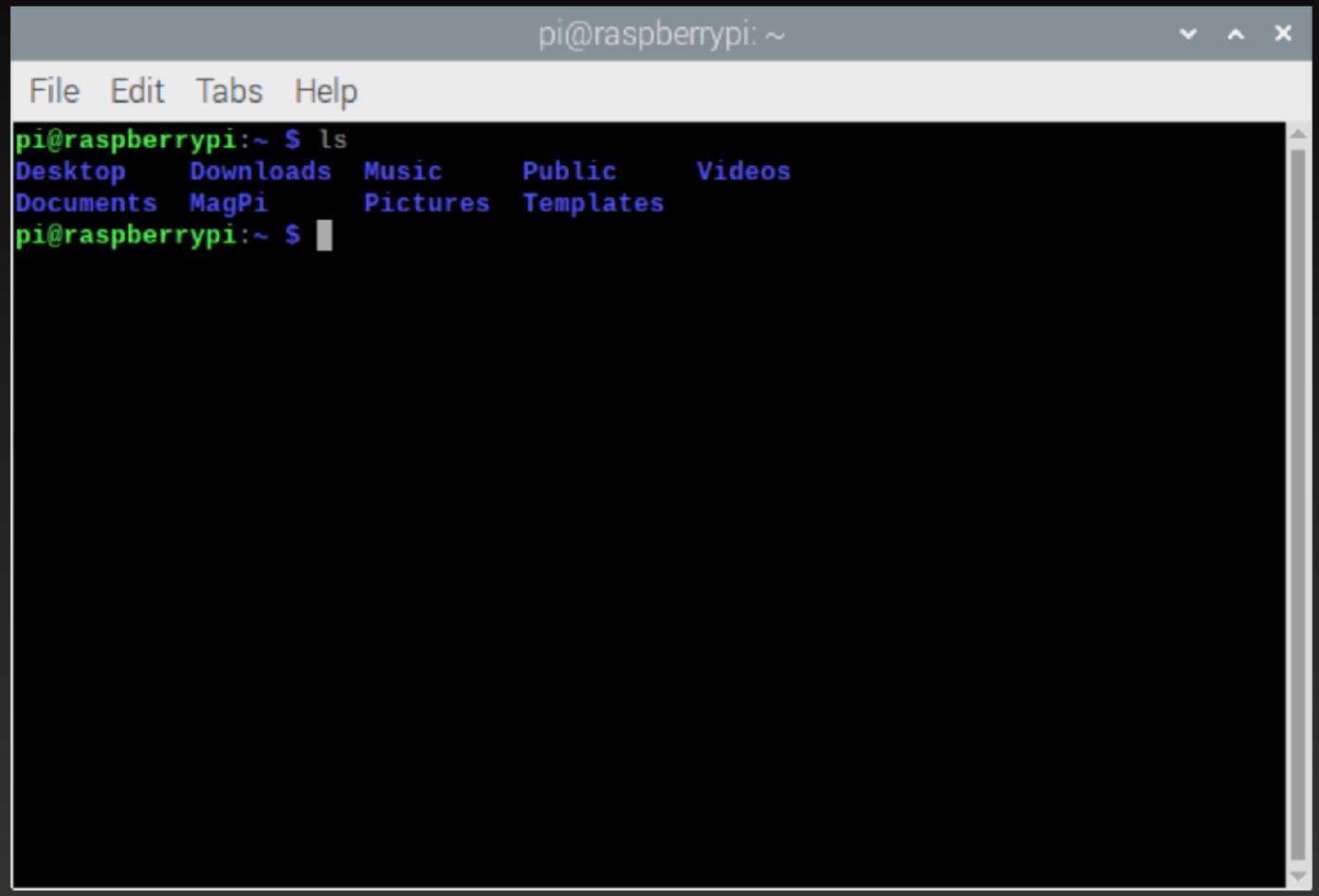
You can type commands into the terminal window and run them by pressing Enter on your keyboard.

In the terminal window, type:

```
ls
```

Then press Enter on the keyboard.

The command `ls` lists all the files and subdirectories in the current file directory. By default, the file directory that the terminal accesses when you open it is the one called pi.



Using the terminal

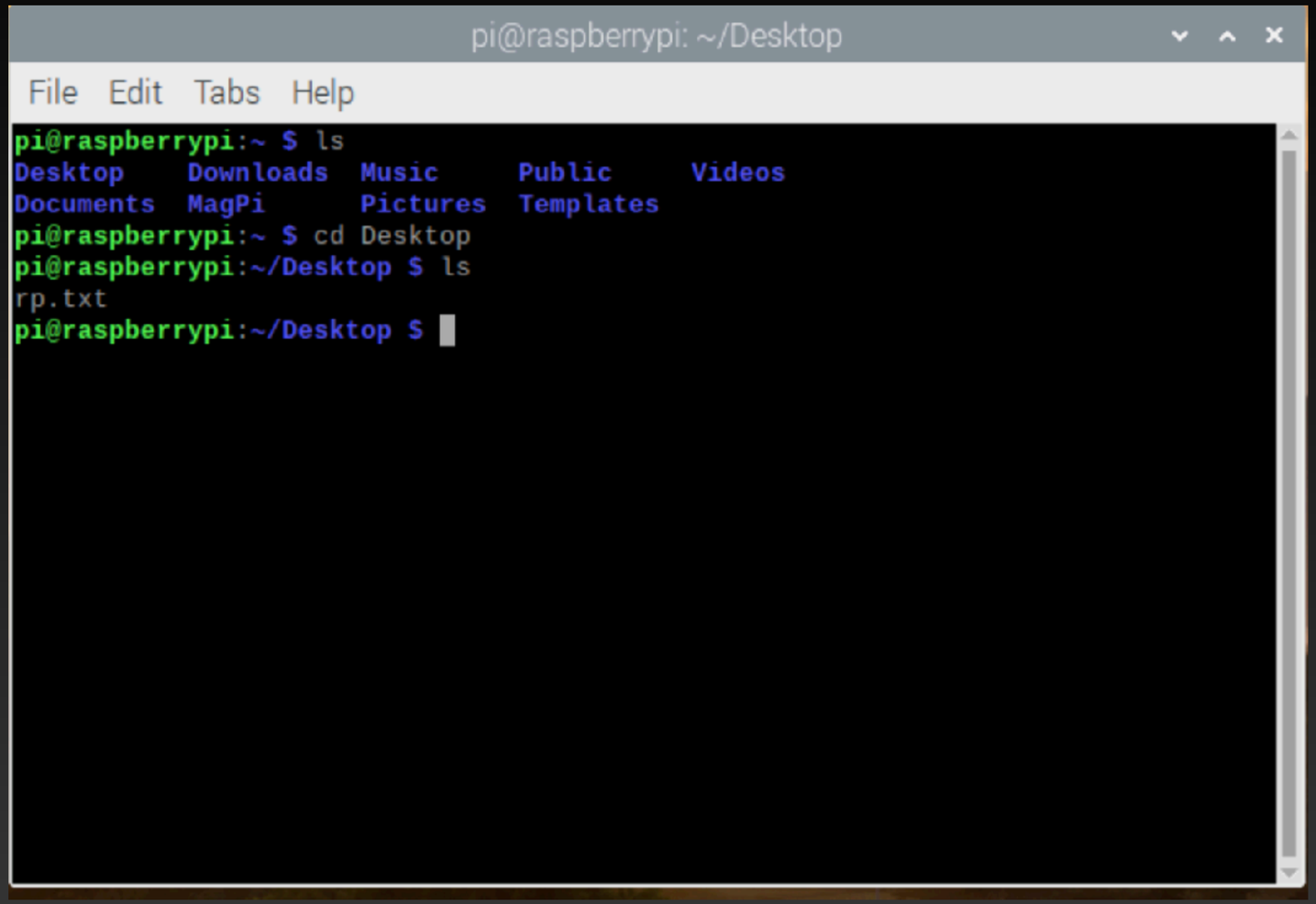
Now type in this command
to change directory to the Desktop.

```
cd Desktop
```

You have to press the `Enter` key after every command.

Use the command `ls` to list the files in the Desktop directory.

```
ls
```



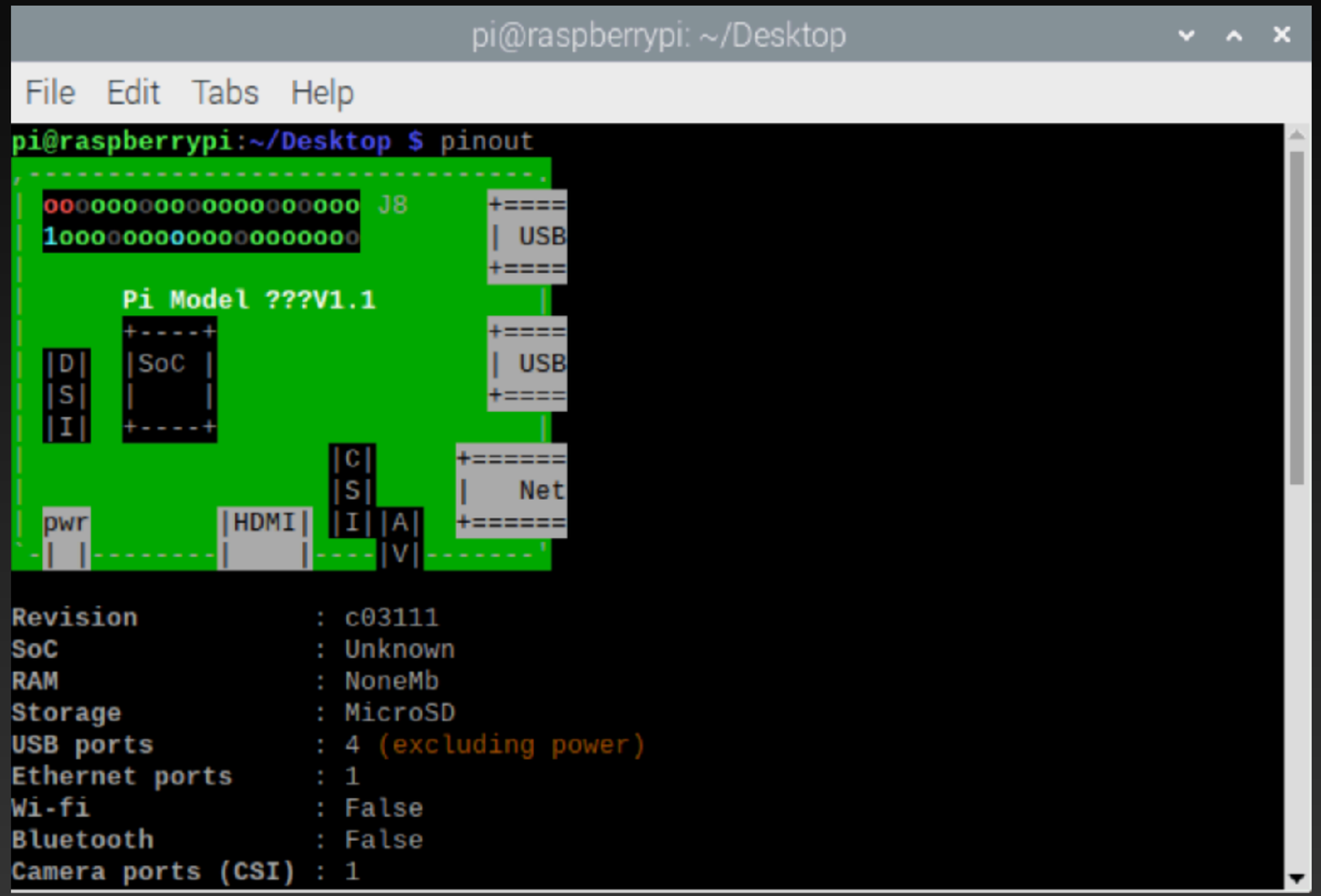
Using the terminal

The terminal can do a lot more than list files — it's a very powerful way of interacting with your Raspberry Pi!

As just one small example, try the command `pinout`:

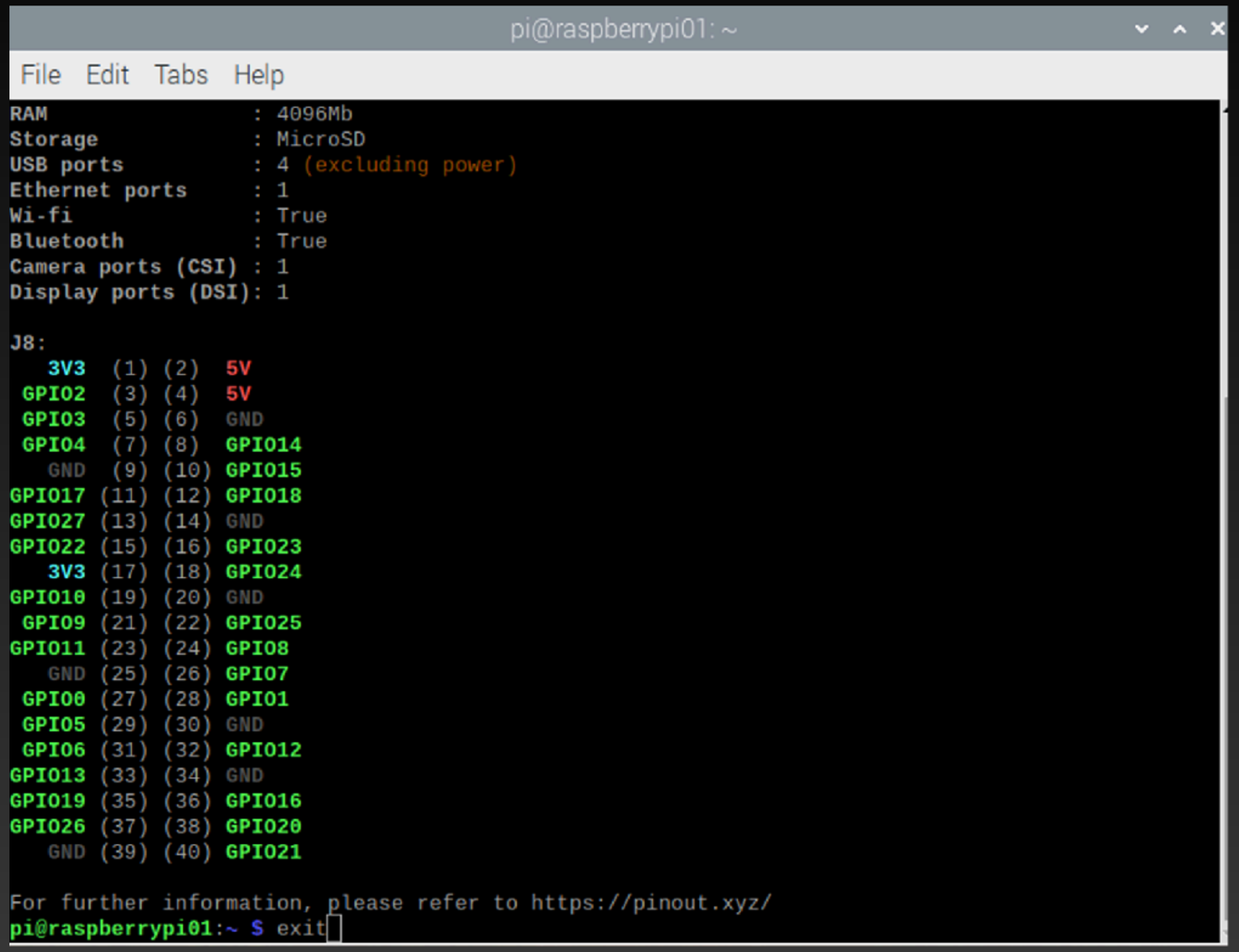
```
pinout
```

This will show you a labelled diagram of the GPIO pins, and some other information about your Raspberry Pi.



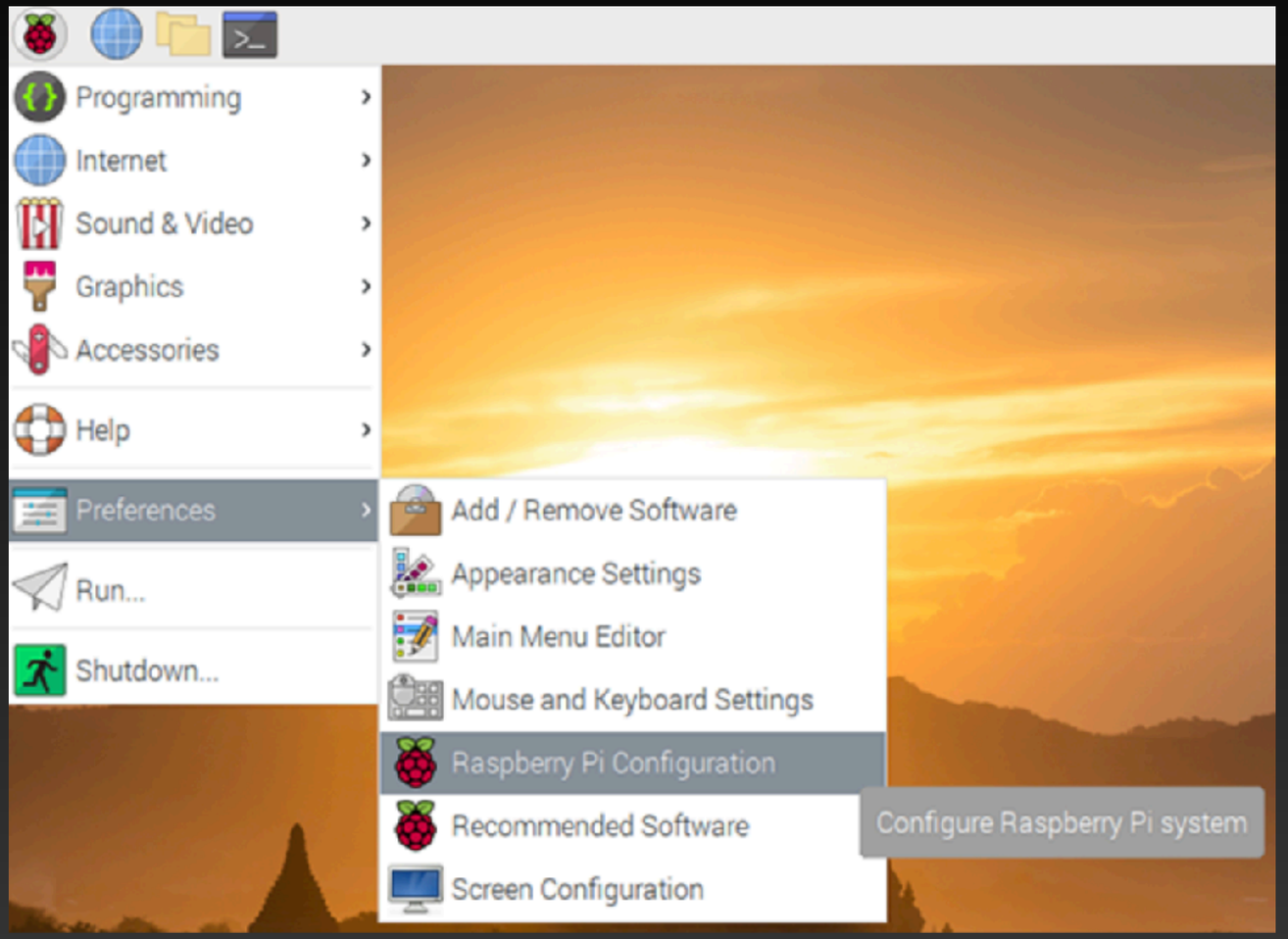
Using the terminal

Close the terminal window by clicking on the x in the top right-hand corner, or using the command exit.



Configuring your Raspberry Pi

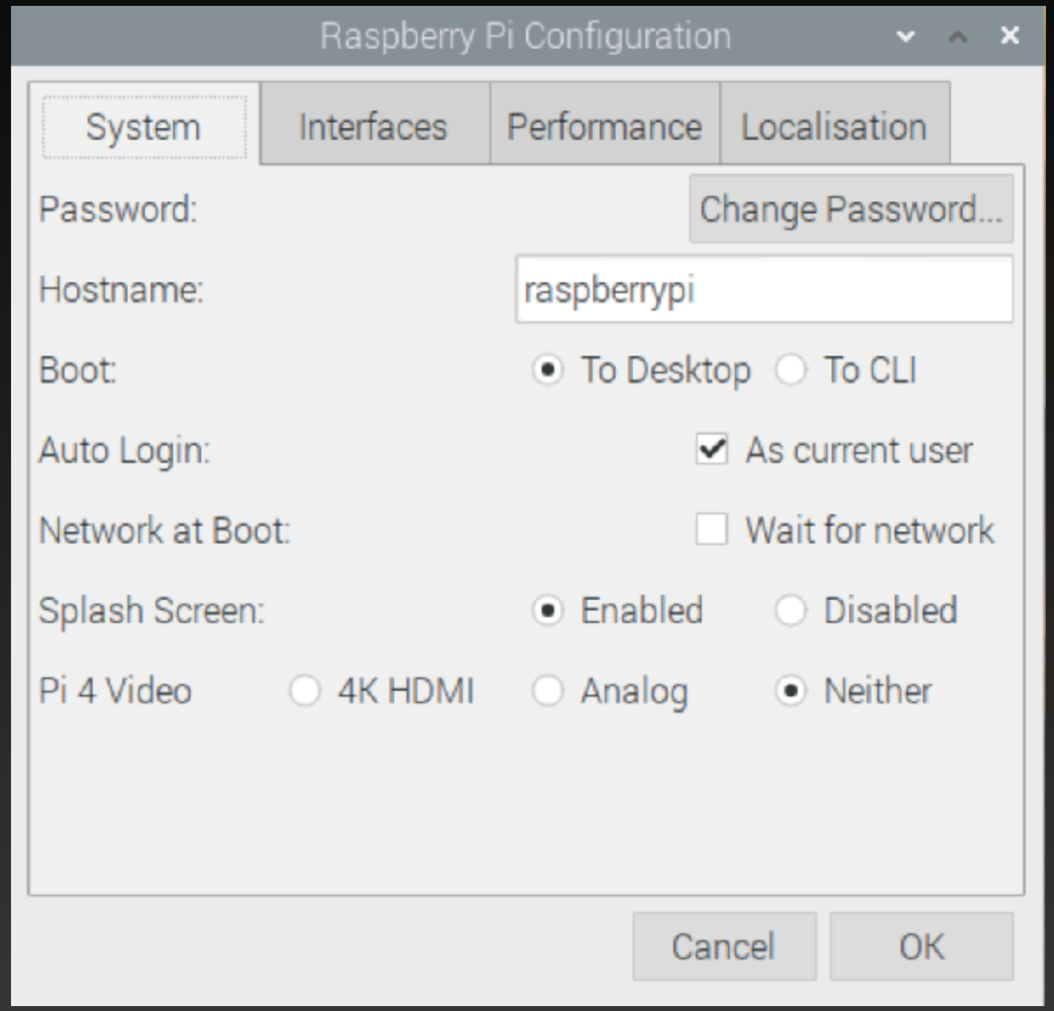
You can control most of your Raspberry Pi's settings, such as the password, through the Raspberry Pi Configuration application found in Preferences on the menu.



Configuring your Raspberry Pi

System

In this tab you can change basic system settings of your Raspberry Pi.



Configuring your Raspberry Pi

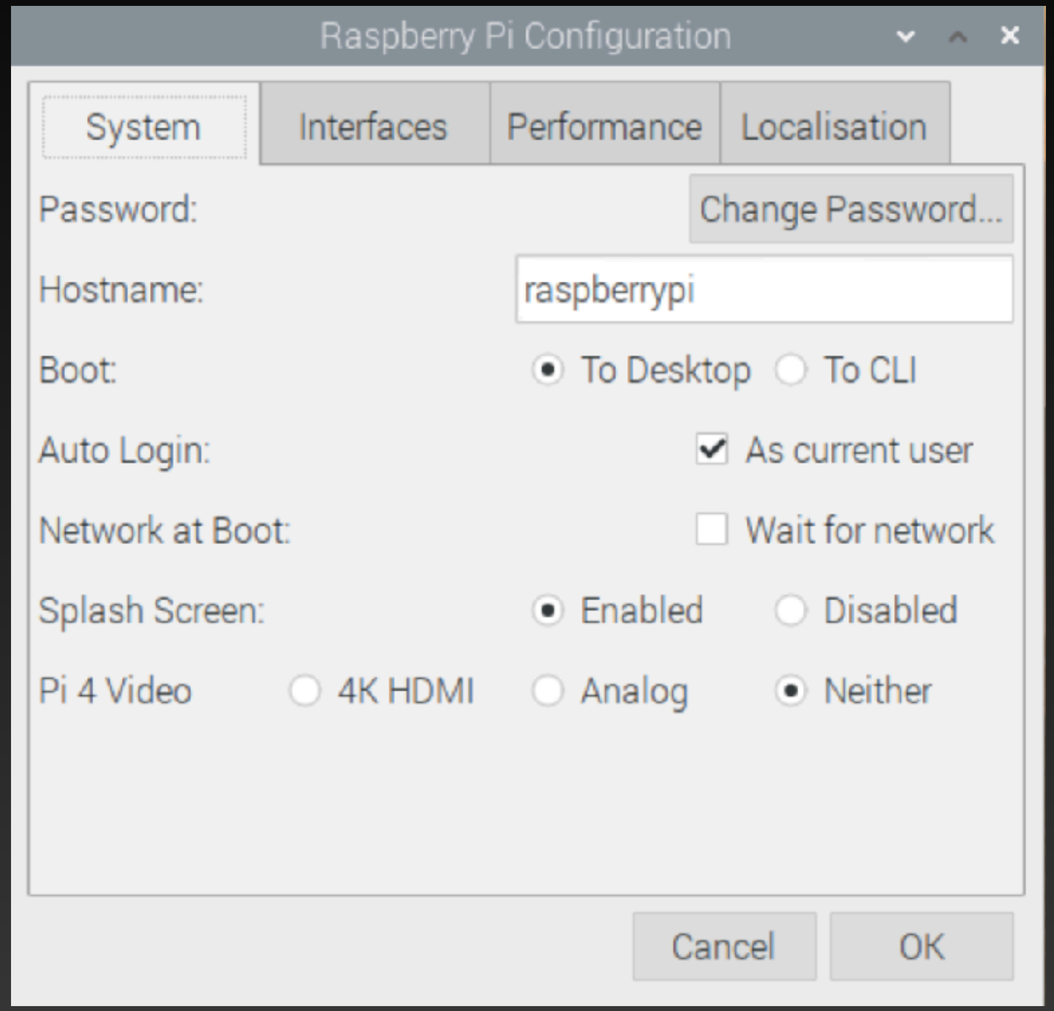
Password — set the password of the pi user (it is a good idea to change the password from the factory default ‘raspberry’)

Boot — select to show the Desktop or CLI (command line interface) when your Raspberry Pi starts

Auto Login — enabling this option will make the Raspberry Pi automatically log in whenever it starts

Network at Boot — selecting this option will cause your Raspberry Pi to wait until a network connection is available before starting

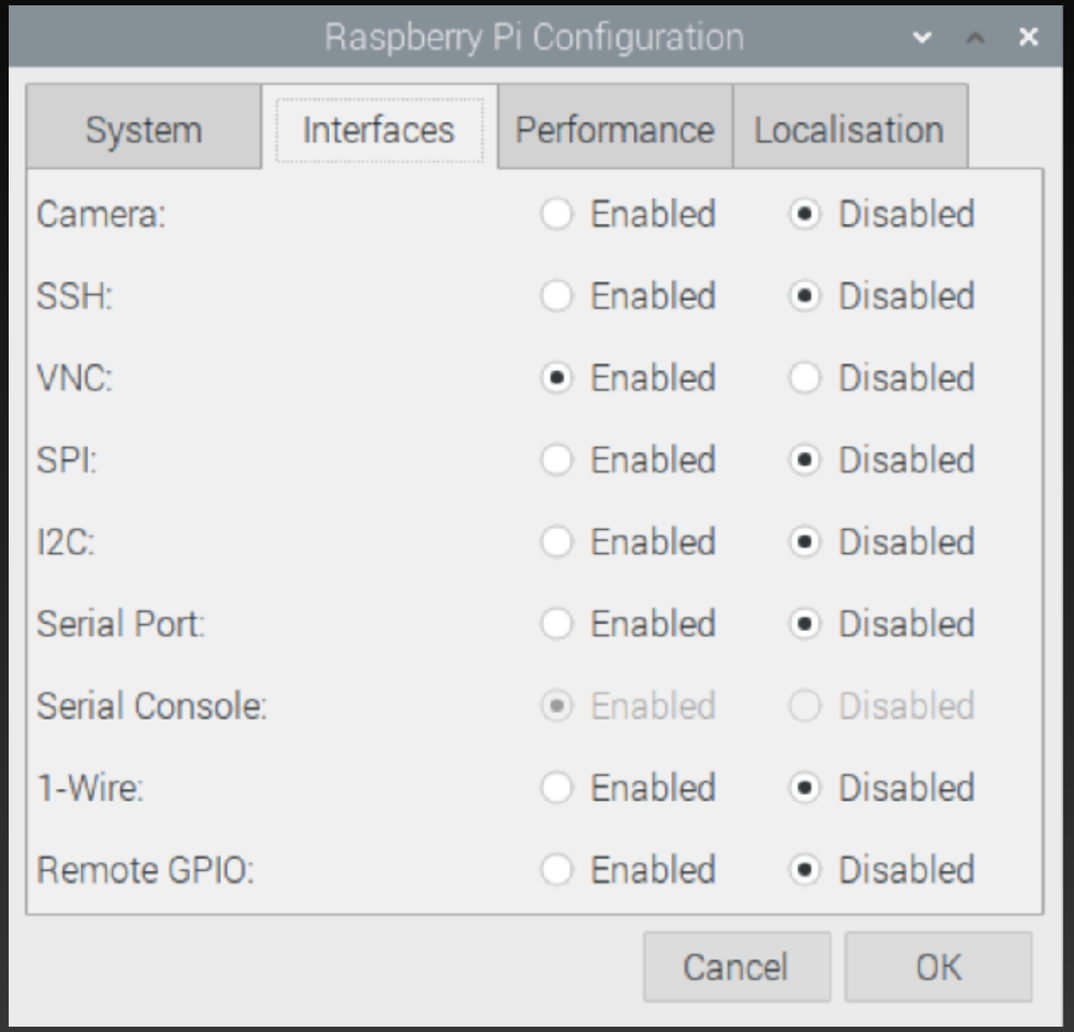
Splash Screen — choose whether or not to show the splash (startup) screen when your Raspberry Pi boots



Configuring your Raspberry Pi

Interfaces

You can link devices and components to your Raspberry Pi using a lot of different types of connections. The Interfaces tab is where you turn these different connections on or off, so that your Raspberry Pi recognizes that you've linked something to it via a particular type of connection.



Configuring your Raspberry Pi

Camera — enable the Raspberry Pi Camera Module

SSH — allow remote access to your Raspberry Pi from another computer using SSH

VNC — allow remote access to the Raspberry Pi Desktop from another computer using VNC

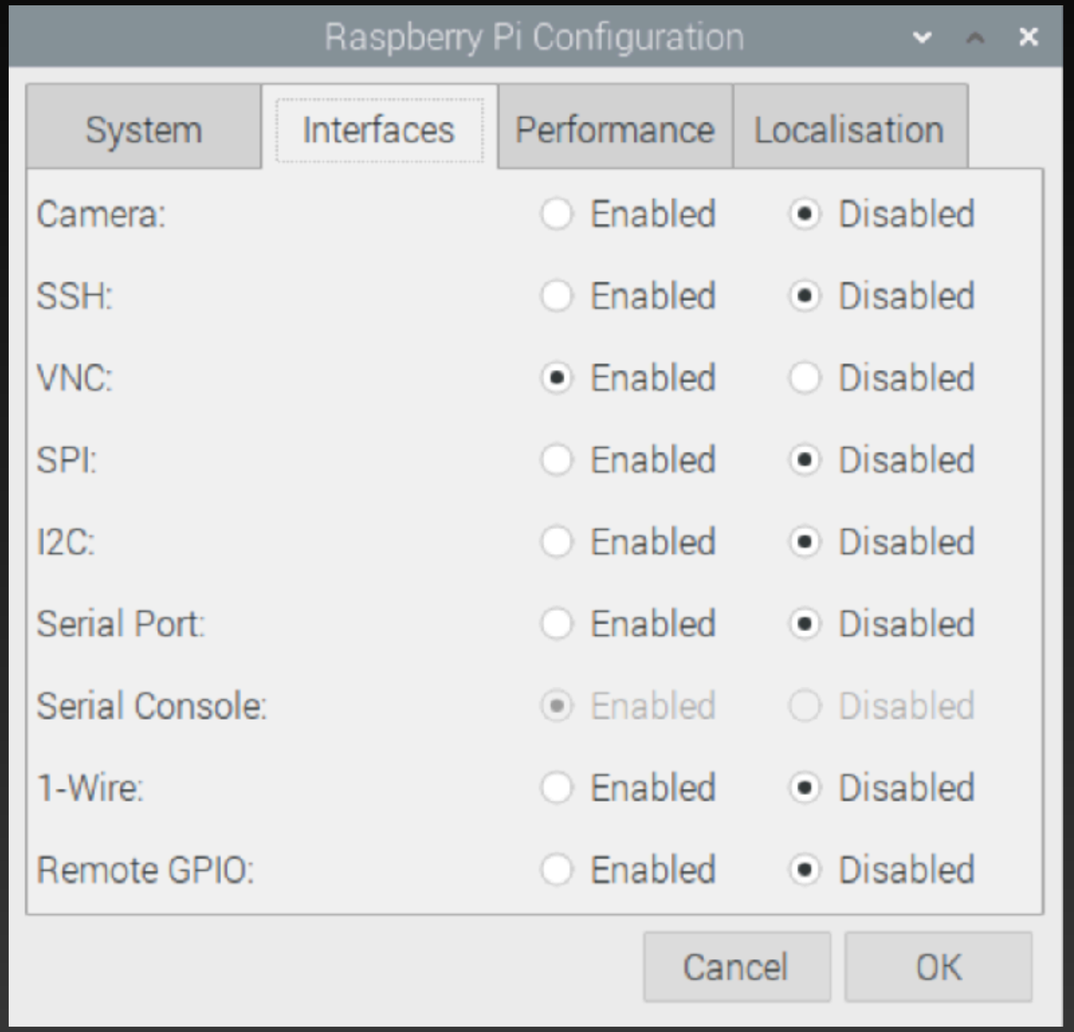
SPI — enable the SPI GPIO pins

I2C — enable the I2C GPIO pins

Serial — enable the Serial (Rx, Tx) GPIO pins

1-Wire — enable the 1-Wire GPIO pin

Remote GPIO — allow access to your Raspberry Pi's GPIO pins from another computer

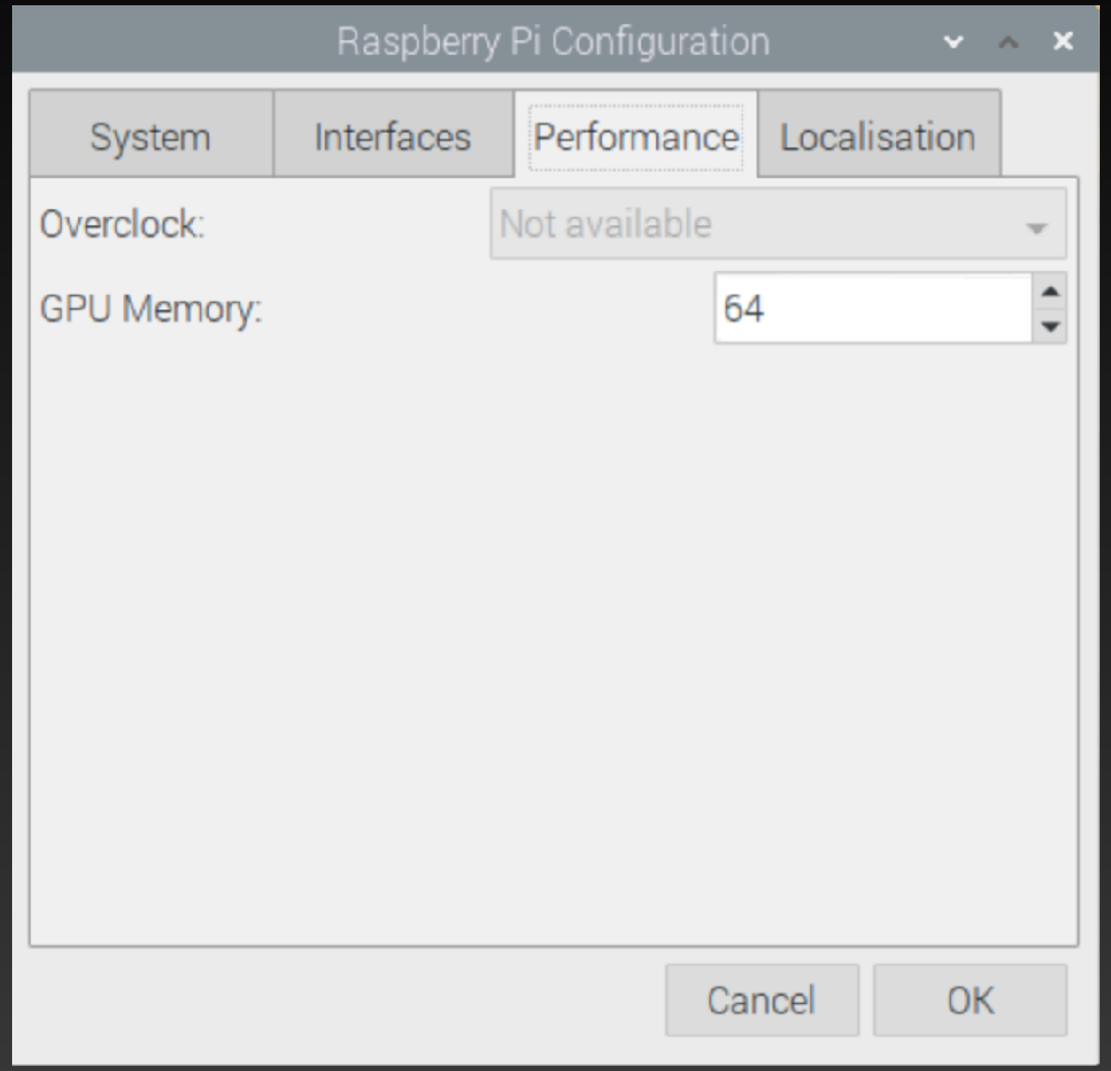


Configuring your Raspberry Pi

Performance

If you need to do so for a particular project you want to work on, you can change the performance settings of your Raspberry Pi in this tab.

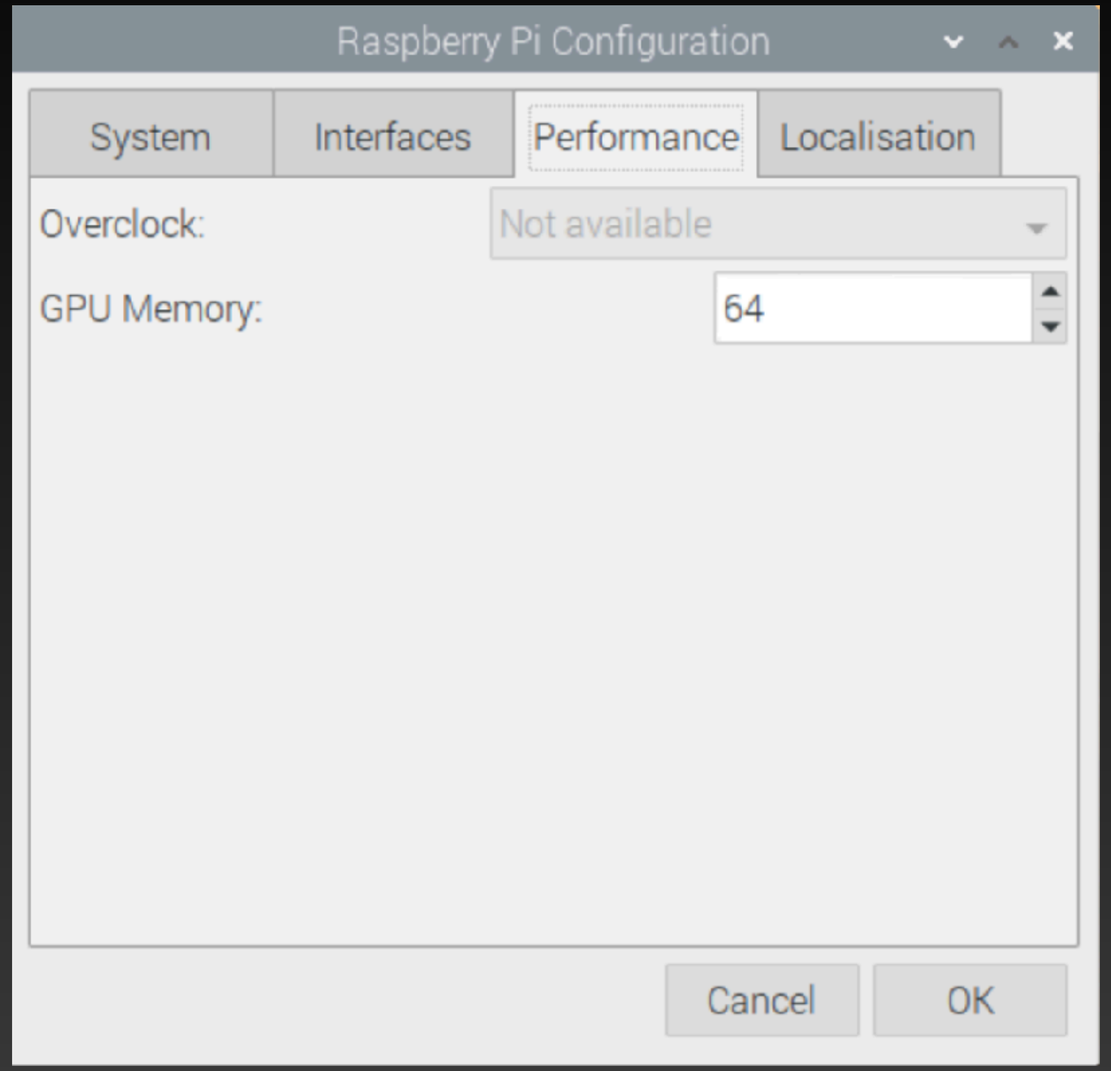
Warning: Changing your Raspberry Pi's performance settings may result in it behaving erratically or not working.



Configuring your Raspberry Pi

Overclock — change the CPU speed and voltage to increase performance

GPU Memory — change the allocation of memory given to the GPU



Configuring your Raspberry Pi

Localisation

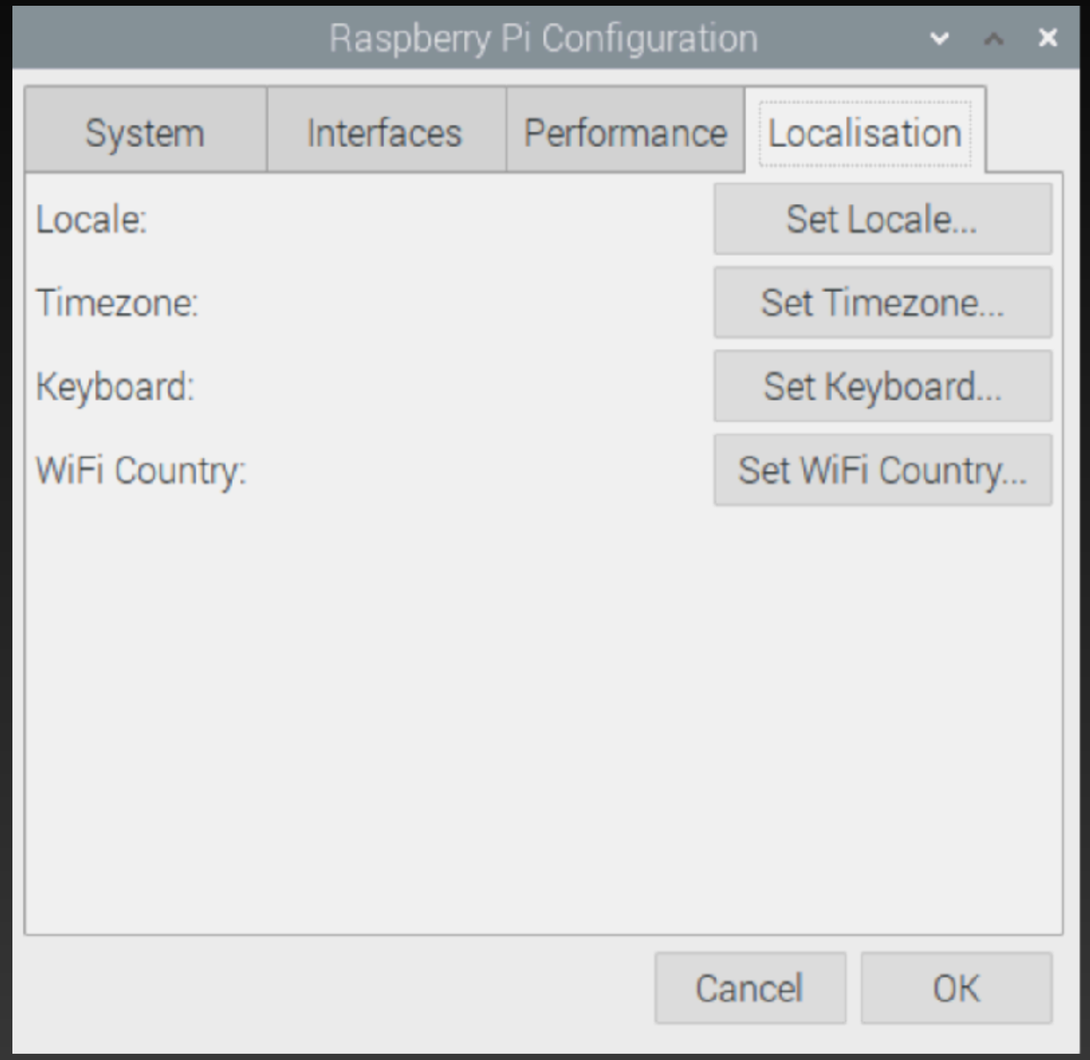
This tab allows you to change your Raspberry Pi settings to be specific to a country or location.

Locale — set the language, country, and character set used by your Raspberry Pi

Timezone — set the time zone

Keyboard — change your keyboard layout

WiFi Country — set the WiFi country code

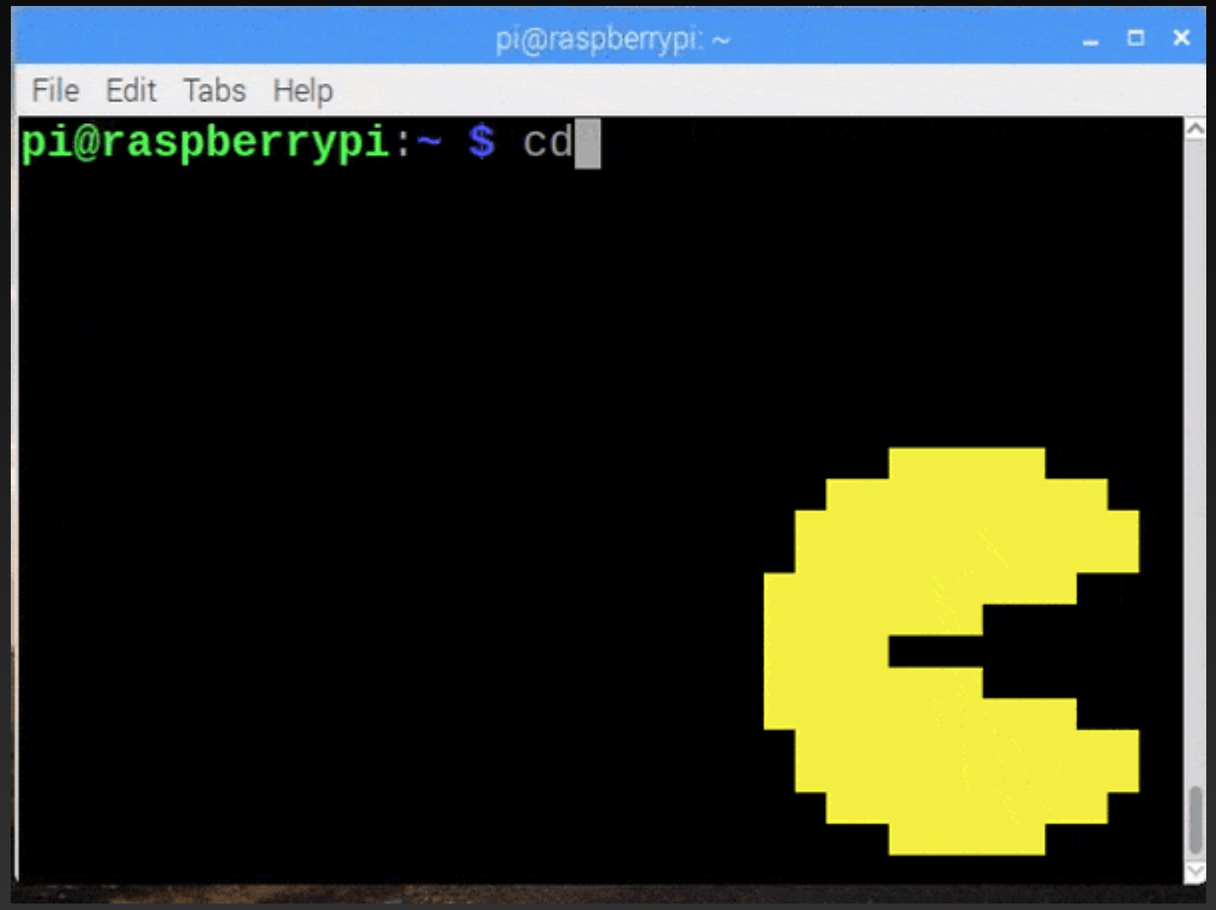


Hack the Raspberry Pi's Terminal

Introduction

Hack the Raspberry Pi's terminal and learn basic cybersecurity skills through a Pac-Man–themed treasure hunt.

You will take the first steps towards being an awesome ethical hacker! This project will take you on a journey through your Raspberry Pi's terminal and you'll learn to navigate the terminal and protect your computer against nasty attackers.



Hack the Raspberry Pi's Terminal

You will learn some basic hacking and find out about basic cybersecurity concepts and threats.

You will also learn how to do these things in the terminal:

- Download and run a script
- Navigate your computer
- Create a directory
- Copy and move files around your computer
- Delete files

Hack the Raspberry Pi's Terminal

Your mission

For this project, you will be Pac-Man:

This is the situation: there is a huge problem with your computer system — it's being attacked by nasty viruses. These viruses are the Pac-Man ghosts:

Pac-Man treasure hunt project

Your goal is to catch and get rid of all of these ghosts! Once you have caught all the ghosts, you can go about collecting your treasure.

To catch the ghosts, you will need to navigate the maze that is your computer. You can navigate your Raspberry Pi computer by using **the command line.**

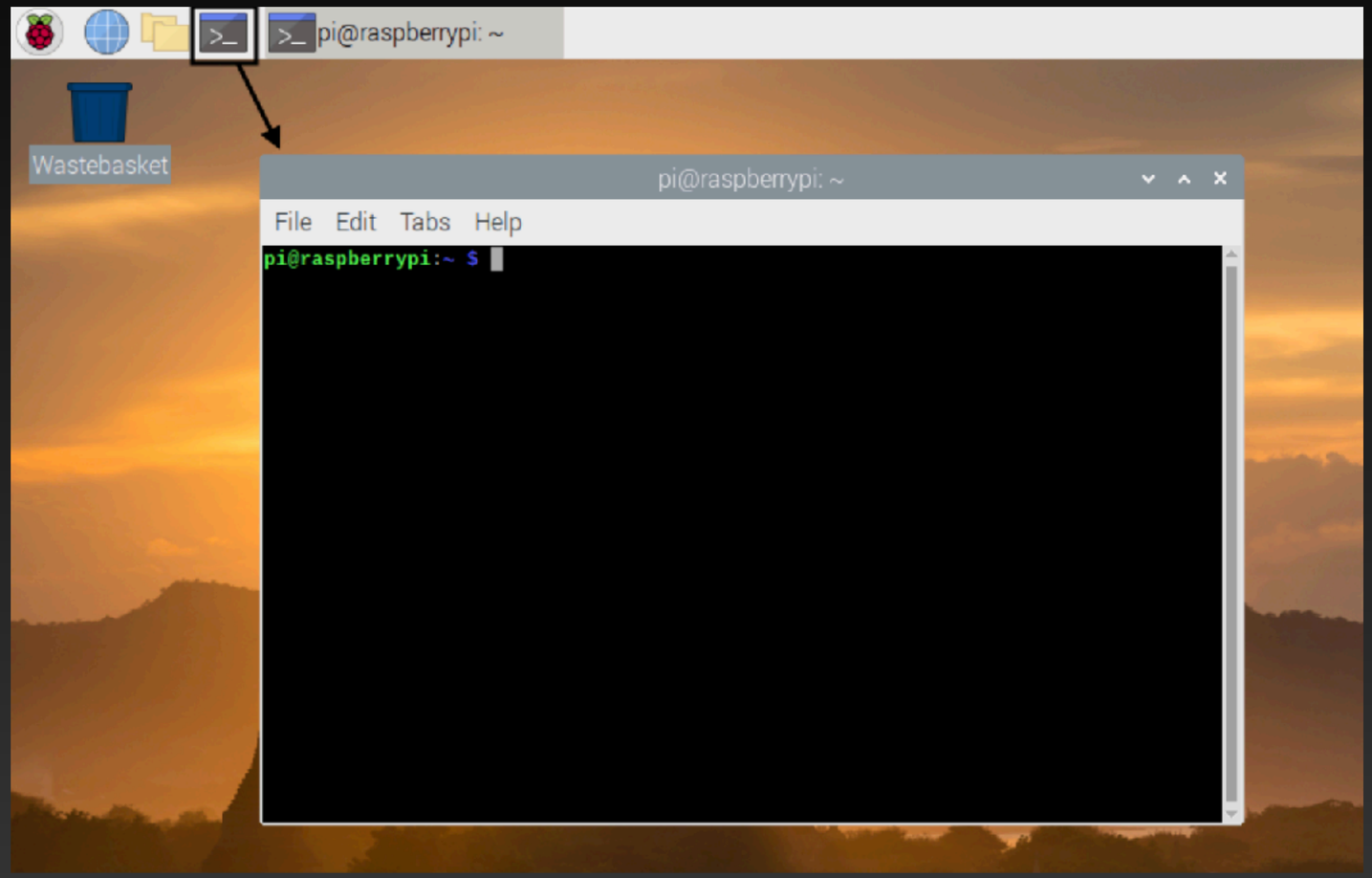
The command line is a text interface for your computer that you can use to give commands to the computer's operating system. From the command line, you can navigate through files and folders on your computer, just as you would with Finder on macOS or Explorer on Windows. The difference is that the command line is fully text-based! The command line is a powerful tool, and with it you can run programs, write scripts to automate tasks, and combine simple commands to handle more difficult jobs.

Pac-Man treasure hunt project

So, to complete the treasure hunt you must:

- Find the ghosts
- Trap the ghosts
- Collect your treasure

To access the command line on your Raspberry Pi, open a terminal window by clicking on the Terminal icon at the top of the screen, or select Accessories and then Terminal in the menu.



Pac-Man treasure hunt project

Start the treasure hunt

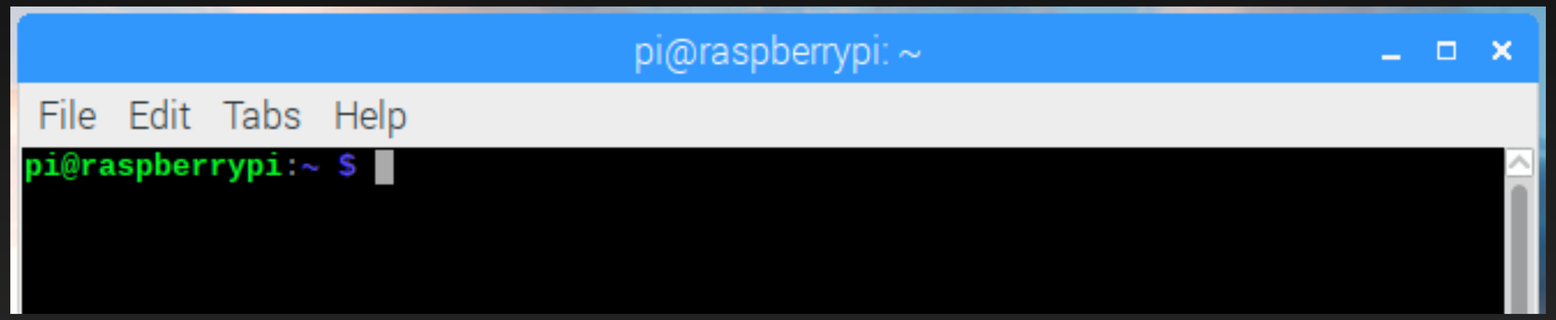
To start the treasure hunt, you will need to download a file that will unleash the Pac-Man ghosts! Please note that you will not download real viruses by completing this step. The files you'll download are completely safe and cannot do any damage to your computer.

In the terminal, you can download and open files or scripts very easily using bash. Bash is a program that listens to your commands and does what you tell it to do. Hackers are concerned with problems in computer systems and programs, and they need to give commands to find these problems and fix them. Therefore, they need to be good at using commands in programs like bash.

Pac-Man treasure hunt project

To access bash, make sure you have opened a terminal window.

In the terminal, you will see `$`. This is called a shell prompt. It appears when the terminal is ready to accept a command.



Next to the `$` (the shell prompt), type or copy and paste:

```
wget -O - https://rpf.io/pacmanstart | bash
```

Pac-Man treasure hunt project

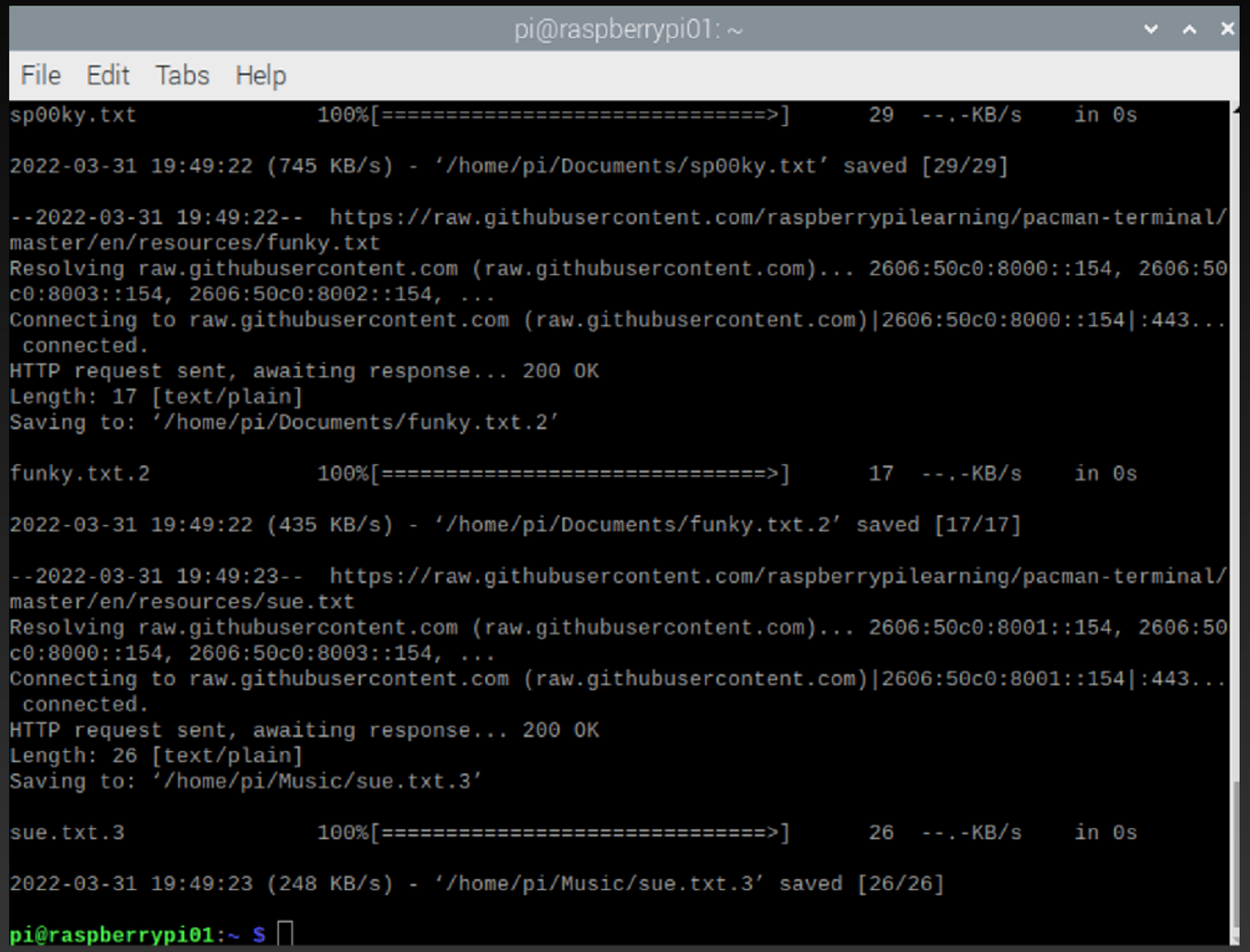
Press the Enter key to run this line of code. You will see a lot of text appear in the terminal. This means it is downloading the files to start the treasure hunt.

Note: the `| bash` command at the end tells bash to automatically run the file after it is downloaded. Using this command is generally not very secure, because it means the downloaded files will be run without you checking them first. However, here it is the easiest way to start the treasure hunt, and it also shows you how easy it is to download viruses.

Pac-Man treasure hunt project

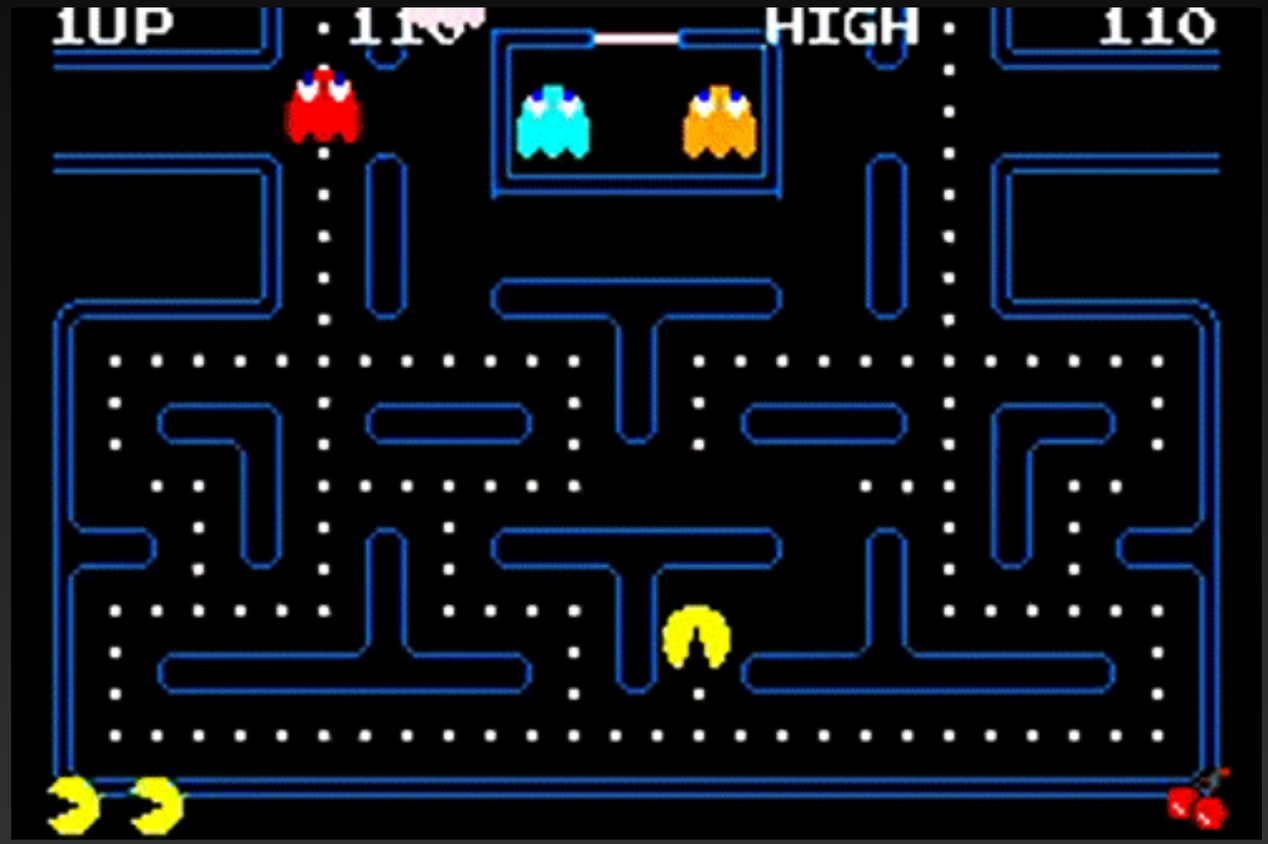
Press Ctrl I(L) to clear the terminal window.

Next you'll learn how to navigate the command line so you can start finding and catching the ghosts.



Pac-Man treasure hunt project

In this step, you will learn how to get Pac-Man to navigate your Raspberry Pi's terminal, just like when Pac-Man moves around his maze.



Pac-Man treasure hunt project

Listing directory content

The `ls` command looks at the folder you are in and then lists the files and directories inside it (`ls` stands for ‘list’). When you’re using the terminal, folders are called directories.

After the shell prompt, type `ls` and press Enter. Make sure you type the letter `l` as in “lime” and not the number `1`.

```
pi@raspberrypi:~ $ ls
Desktop    Downloads  Pictures  python_games  Scratch Projects  Videos
Documents  Music      Public    Scratch       Templates
```

Pac-Man treasure hunt project

```
pi@raspberrypi:~ $ ls
Desktop    Downloads  Pictures  python_games  Scratch Projects  Videos
Documents  Music      Public    Scratch       Templates
```

Here, you cannot see any files, because there aren't any, but you can see lots of directories.

The directory, or folder you are in, therefore contains these directories:
`Desktop`, `Downloads`, `Pictures`, `python_games`, `Scratch Projects`, `Videos`, `Documents`, `Music`, `Public`, `Scratch`, and `Templates`

Pac-Man treasure hunt project

Print working directory

`pwd` stands for ‘print working directory’. This command shows where you are in your Raspberry Pi’s file system, meaning it tells you what directory you are currently in in the command line — your working directory! You can use this command at any time to not get lost.

Type `pwd` and press Enter.

Pac-Man treasure hunt project

```
pi@raspberrypi:~ $ ls
Desktop    Downloads  Pictures  python_games  Scratch Projects  Videos
Documents  Music      Public    Scratch       Templates
pi@raspberrypi:~ $ pwd
/home/pi
pi@raspberrypi:~ $
```

Here you can see that you are in the `/home/pi` directory. This means you're inside the `pi` directory, which itself is stored inside the `home` directory. (The `/` symbols aren't part of the directory names; the command line just uses them to show you directories.)

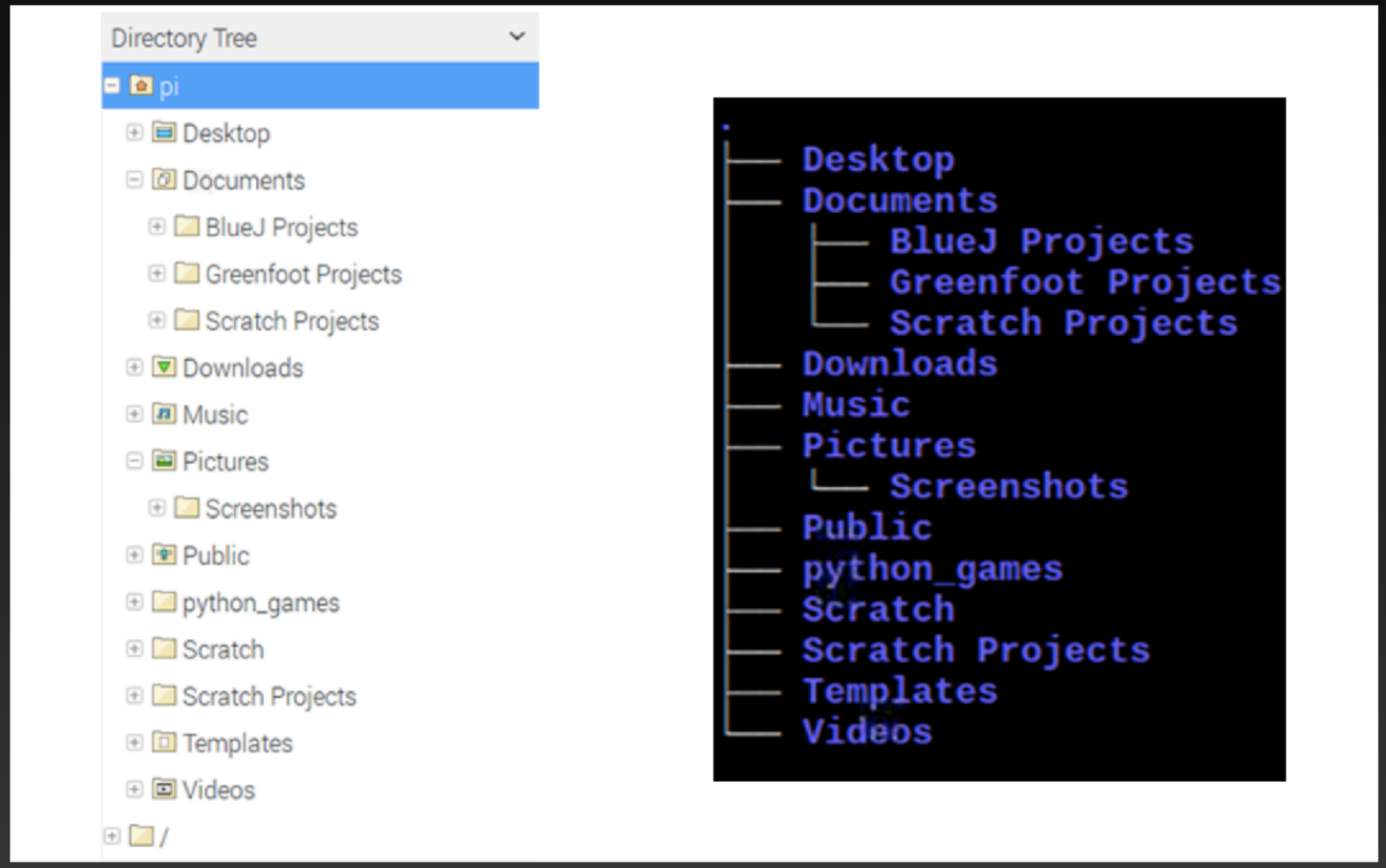
Note:

This directory is your `home` directory. It is where you can save all your files.

If you are using a different username to pi, your home directory will have a different directory, but it will always have the shortcut `~`, as you can see at the start of the shell prompt.

Pac-Man treasure hunt project

The file system is the way files and directories on your computer are organized. A computer's file system usually has a tree structure:



Pac-Man treasure hunt project

Change directory

`cd` stands for ‘change directory’. Just the same as you can click on a folder icon in a graphic file manager to go into it, `cd` lets you go into the directory you tell it. To get into a directory, just type the command `cd` followed by a space, and then the name of the directory and a forward slash `/`.

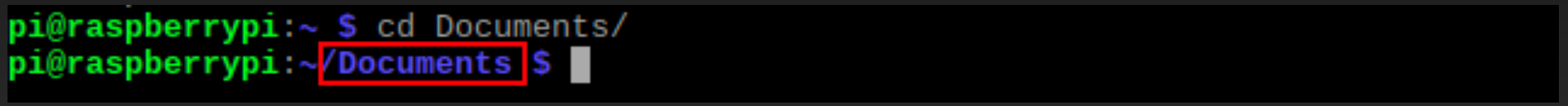
To try moving into a different directory, type `cd Documents/` and press Enter.

```
pi@raspberrypi:~ $ cd Documents/
pi@raspberrypi:~/Documents $
```

Pac-Man treasure hunt project

Now you've navigated into the `Documents` directory!

The terminal tells you here that you are in `Documents`:



Pac-Man treasure hunt project

Moving between directories

You can move up (or back, depending on how you want to imagine it) one directory in the file system by typing `cd` followed by a space and two full stops `..`, and then pressing Enter.

`cd ..` navigates up from `home/pi/Documents` back to `home/pi`.

You can quickly check you're in the right directory using the `pwd` command:

```
pi@raspberrypi:~/Documents $ cd ..
pi@raspberrypi:~ $ pwd
/home/pi
pi@raspberrypi:~ $
```

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Now you’re ready to catch your first ghost!

Catch and quarantine your first ghost

In this step, you will create a quarantine folder to put your ghosts in. You will then catch all of the ghosts and stick them in this folder so that they stop ghosting around and harming your computer like viruses do.

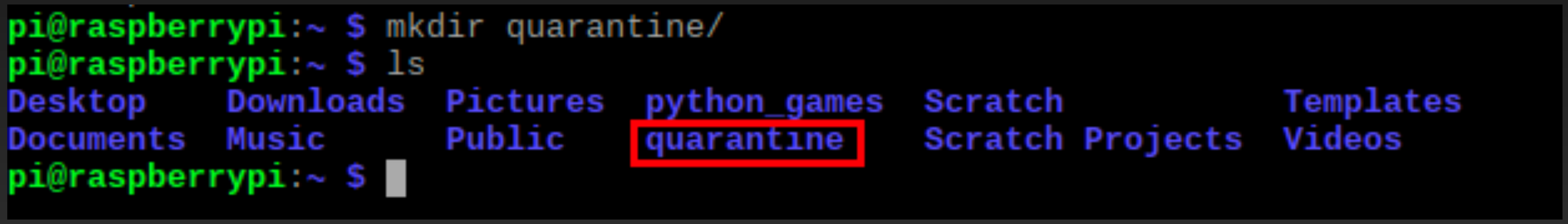
A quarantine folder isolates suspicious files so they cannot harm your computer. They are usually made automatically by antivirus software and have additional programming attached to them — you will simulate what it is like to create one.

Pac-Man treasure hunt project

First off, you will learn to create your own directories in your file system!

Next to the shell prompt, create a quarantine folder by typing `mkdir quarantine/` and pressing Enter.

`mkdir` stands for ‘make directory’. The command you typed in created a new directory called `quarantine` inside your `home` directory. In the image, you can see that I have also used the `ls` command to check that my directory exists:



Pac-Man treasure hunt project

Let’s catch our first ghost!

Navigate into the Documents directory using the commands you learned in the last step.

List all the files and directories in the Documents directory using the commands you learned in the last step.

Look at the directories. Do you see anything strange that looks like it should not be there?

Pac-Man treasure hunt project

That strange file named `sp00ky.txt` represents a virus. If you've spotted it, you have found the first ghost!

You've found Spooky!

You might have noticed that instead of being called `spooky.txt`, the virus is called `sp00ky.txt`. Hackers, both ethical and not so ethical, replace certain letters with numbers so they cannot be picked up in simple keyword searches. Keep that in mind when you are looking for the other ghosts.

Pac-Man treasure hunt project

Copying files

Copy the ghost and put it in the quarantine folder by typing:

```
cp sp00ky.txt ~/quarantine/
```

`cp` (for ‘copy’) is followed by the name of the file you want to copy and then the directory you want it copied into. Here, we copied the file `sp00ky.txt` and placed it in the `quarantine` folder in the `home` directory (`~`).

Pac-Man treasure hunt project

Removing files

Now remove the ghost by typing:

```
rm sp00ky.txt
```

Note: be careful with using `rm` — it deletes things from your computer permanently! There isn't an 'undelete' command, so once you delete something with `rm`, it's gone forever. This is why we copied the file into a new directory before removing it.

You're now ready to safely catch all the ghosts!

Pac-Man treasure hunt project

Catch all the ghosts

Now use all the commands you have learned in the last two steps to move around your Raspberry Pi’s file system and find, catch, and quarantine as many ghosts as you can.

Here’s a reminder of all the commands you need to navigate the terminal:

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Essential commands

Here is a summary of basic commands for navigating the command line:

- `ls` lists the contents of the folder (directory) you're currently in:

```
ls
```

- `pwd` stands for 'print working directory' and tells you what directory you are currently in:

```
pwd
```

- `cd` stands for 'change directory' and navigates to the directory you want to move into:

```
cd directoryname/
```

- `cd ..` navigates up one directory, meaning it moves you from a subfolder into its parent folder:

```
cd ..
```

Additional commands

These are useful for creating and removing directories and files.

- `mkdir` stands for 'make directory' and creates a new directory in the directory you are currently in:

```
mkdir directoryname/
```

- `cp` is followed by the name of the file to copy and then the directory you want it copied into:

```
cp filename.filetype path/to/directory
```

- `rm` stands for 'remove' and deletes files (careful with this one, you cannot undo it):

```
rm filename.filetype
```

Pac-Man treasure hunt project

Tips:

Remember to copy the ghosts to the quarantine folder before removing them

Navigate to your quarantine folder to see how many ghosts you've caught

If you want to navigate into a directory with a name that has more than one word in it (for example `My Movies`), use a `\` before each blank space in the name (`cd My\ Movies`)

There are seven ghosts in total — can you catch them all?

Pac-Man treasure hunt project

Find the treasure

Now that you have found all the ghosts and put them in a safe folder so they cannot damage your computer, you will look inside the files to collect your treasure.

Here is all the treasure you can collect and the points you get when you find the treasure:

Treasure		Points
	Cherry	100
	Strawberry	300
	Peach	500
	Apple	700
	Grapes	1000
	Galaxian Boss	2000
	Bell	3000
	Key	5000

Pac-Man treasure hunt project

Navigate to your `quarantine/` directory, and then list the contents of the directory to see all the ghosts you have caught.

Treasure		Points
	Cherry	100
	Strawberry	300
	Peach	500
	Apple	700
	Grapes	1000
	Galaxian Boss	2000
	Bell	3000
	Key	5000

Pac-Man treasure hunt project

Collect your treasure

See what treasure you got from catching Spooky!

To view a text file, type `cat` followed by the full name of the file into the terminal window, and then press Enter:

```
cat sp00ky.txt
```

You should see some treasure.

```
pi@raspberrypi:~ $ cd quarantine/
pi@raspberrypi:~/quarantine $ ls
sp00ky.txt
pi@raspberrypi:~/quarantine $ cat sp00ky.txt
galaxian boss
grapes
cherry
pi@raspberrypi:~/quarantine $
```

Treasure		Points
	Cherry	100
	Strawberry	300
	Peach	500
	Apple	700
	Grapes	1000
	Galaxian Boss	2000
	Bell	3000
	Key	5000

Pac-Man treasure hunt project

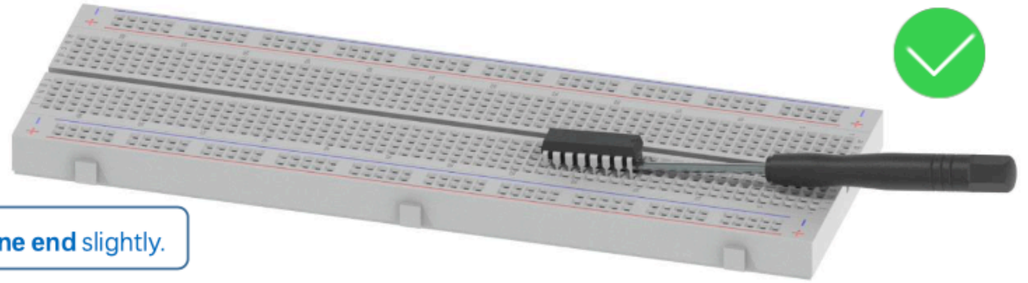
Challenge: get rid of the quarantine folder

Now that you have finished finding all the ghosts, you must clear your computer of any harmful files.

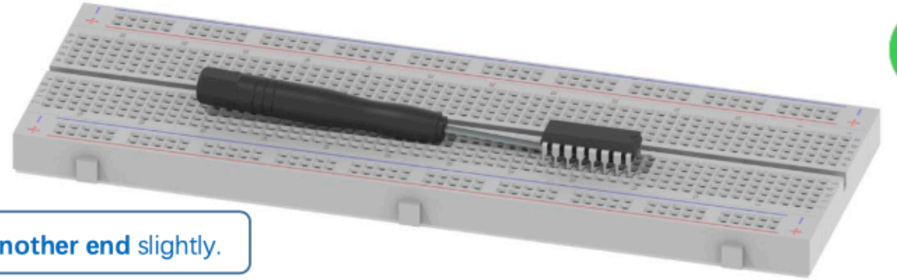
- Delete the whole `quarantine` folder without copying any of the files in it. Use this link www.raspberrypi.org/documentation/linux/usage/commands.md or look up online how to recursively remove a directory.
- Check the folder has been deleted by listing the contents of your `home` directory.

Remove the Chips

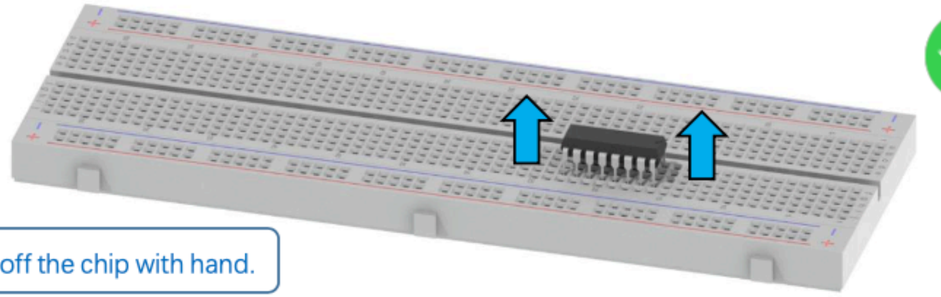
Some chips and modules are inserted into the breadboard to protect their pins.
You need to remove them from breadboard before use. (There is no need to remove GPIO Extension Board.)
Please find a tool (like a little screw driver) to handle them like below:



Step 1, lift **one end** slightly.

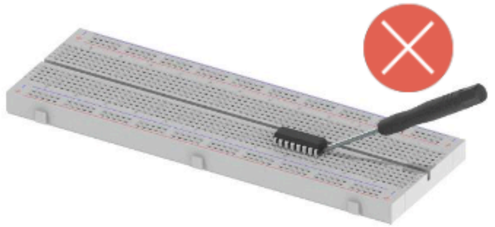


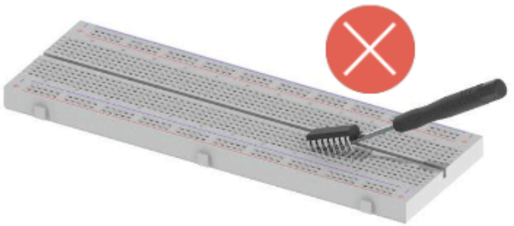
Step 2, lift **another end** slightly.



Step 3, take off the chip with hand.

Avoid lifting one end with big angle directly.

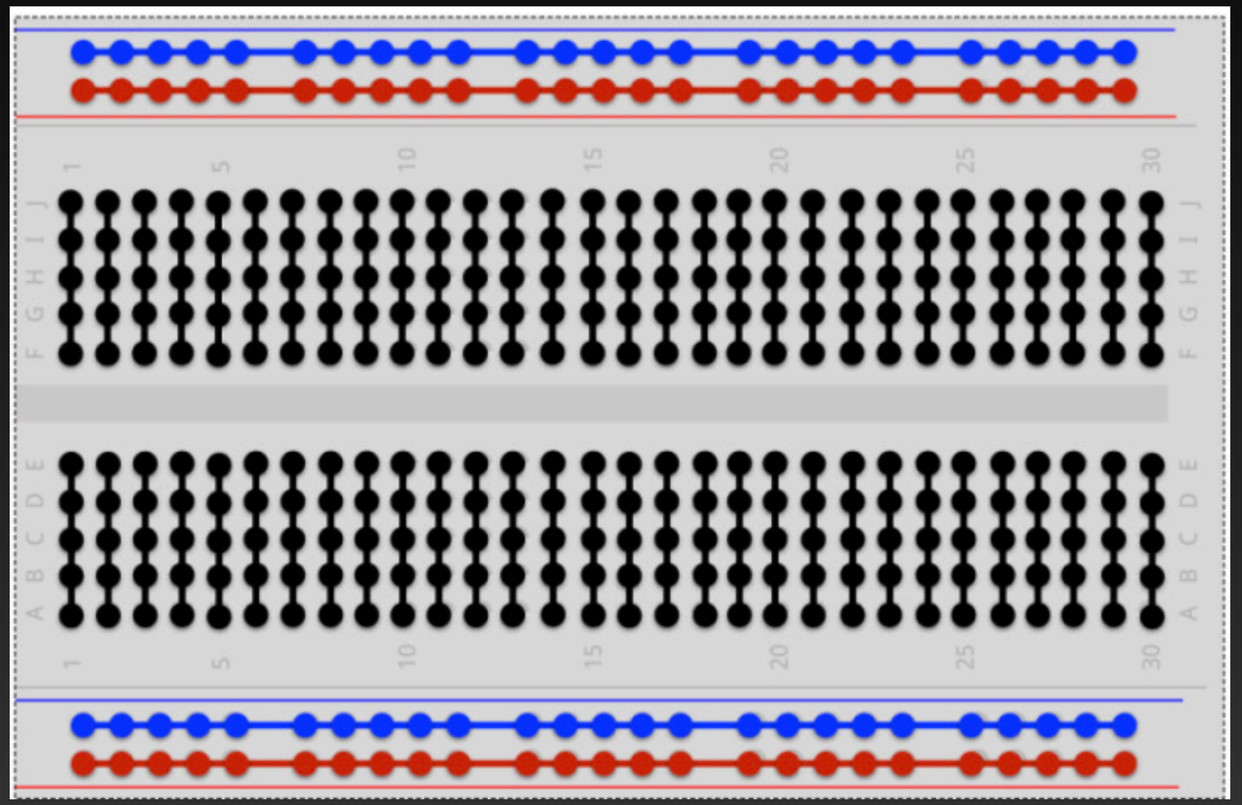




Introducing Breadboard

Most of our projects are tested using a small piece of plastic known as a breadboard. Officially, it's known as a 'solderless breadboard' because it enables you to use circuit parts without soldering them together.

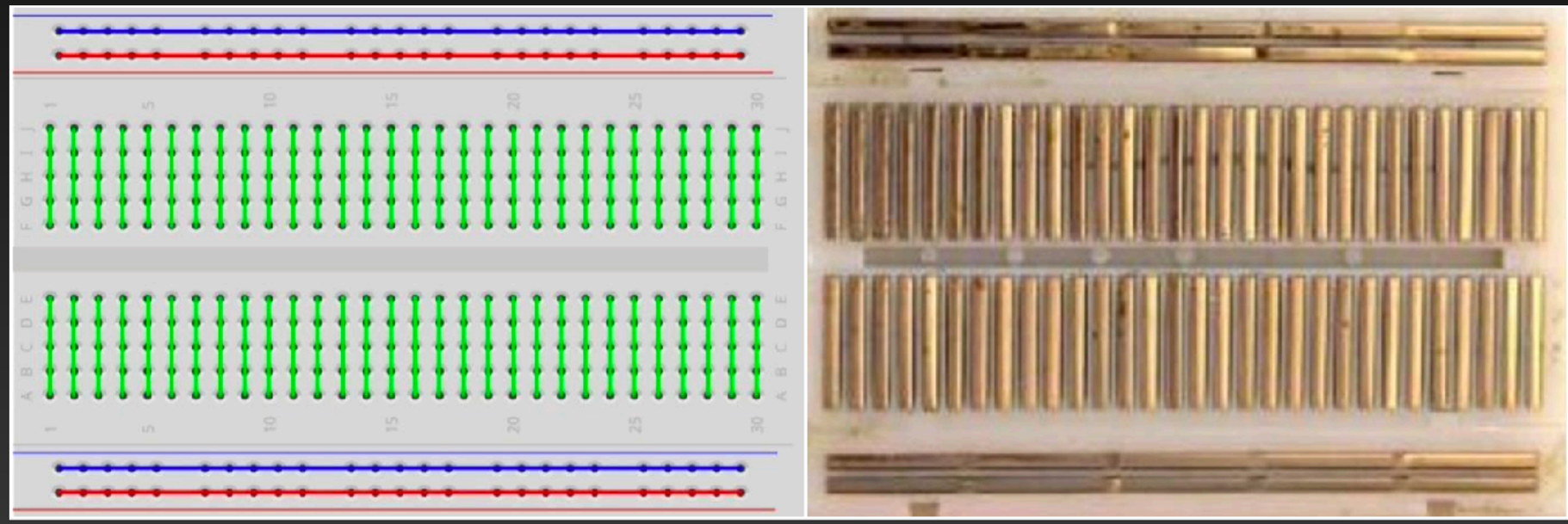
Electrical components are connected by pushing them into the holes in a breadboard. These holes are connected in strips, as shown in the main image. If you push a wire, or a different component, into one hole in a strip, and another wire into the hole next to it, it's as if you'd physically joined (or soldered) the two wires.



Introducing Breadboard

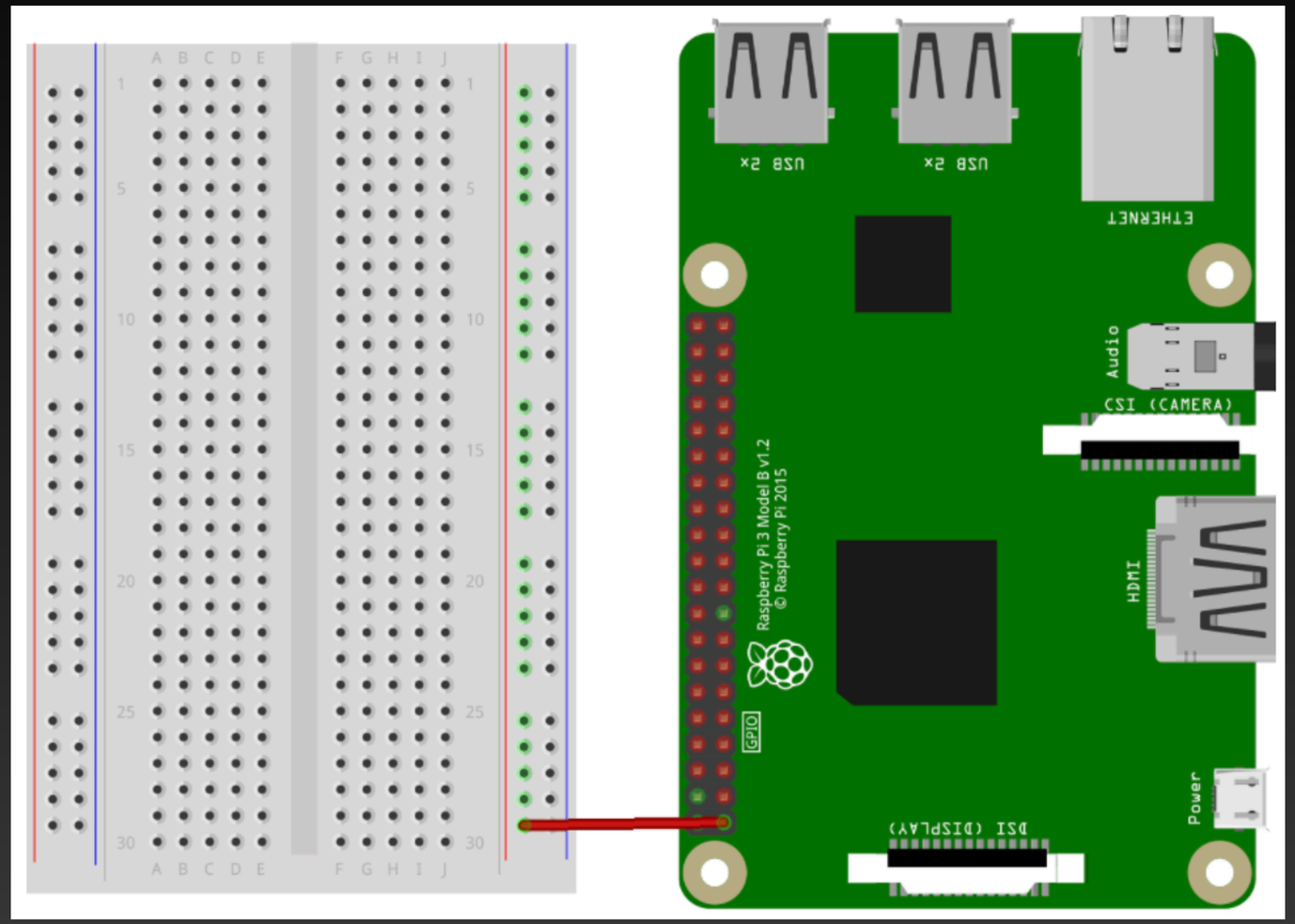
Breadboard

Here we have a small breadboard as an example of how the rows of holes (sockets) are electrically attached. The left picture shows the ways the pins have shared electrical connection and the right picture shows the actual internal metal, which connect these rows electrically.



Test your circuit! An LED project

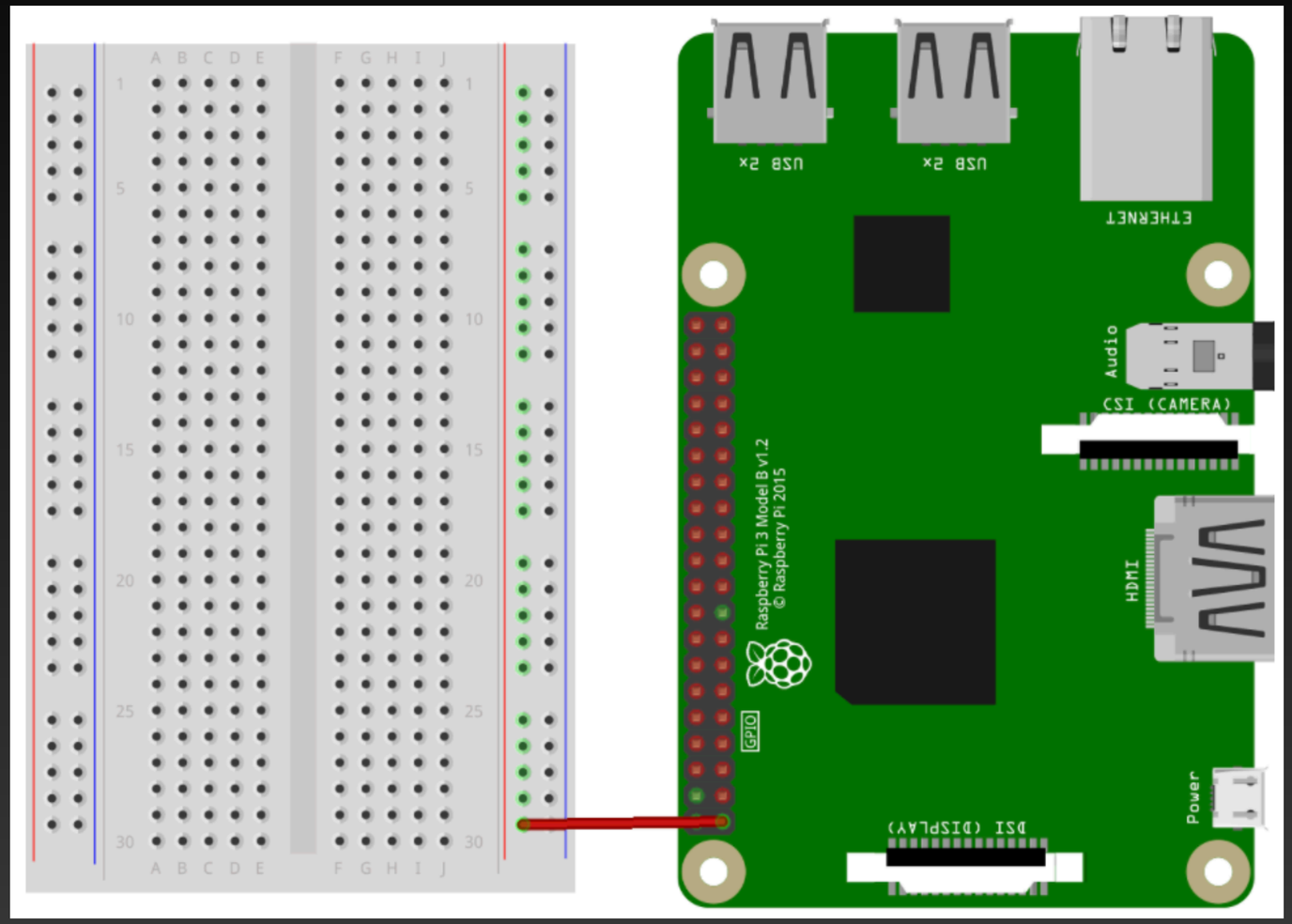
- Using a breadboard. Breadboard, LED light, Resistor, Male-to-female jumper leads, Male-to-male jumper leads



Test your circuit! An LED project

The breadboard's live rail

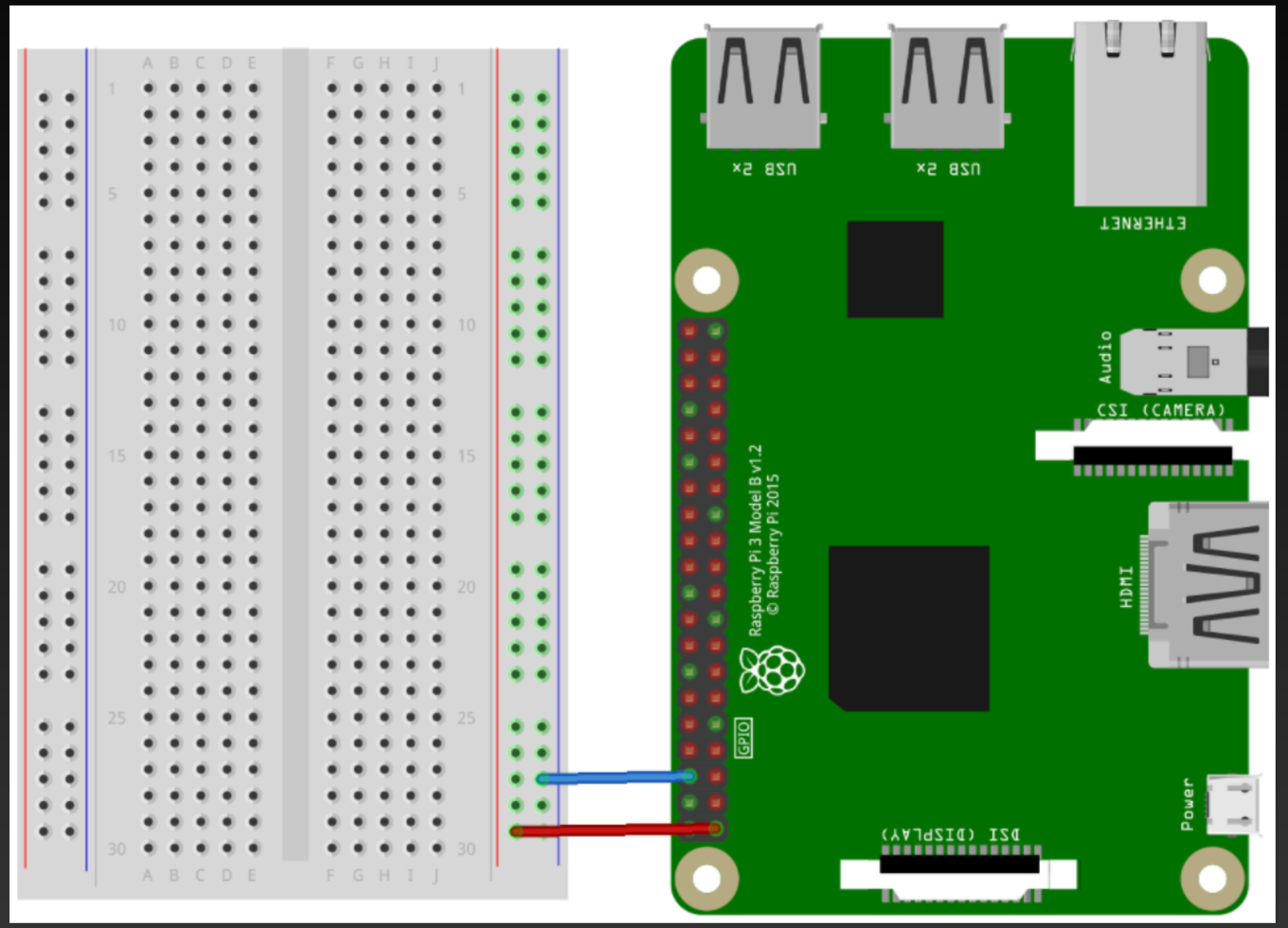
Take a female-to-male jumper lead (the colour of the wire doesn’t matter) and connect the female end to a 3.3V pin on the Raspberry Pi. Place the male end of the lead into a hole on the red rail on the breadboard.



Test your circuit! An LED project

The breadboard's ground rail

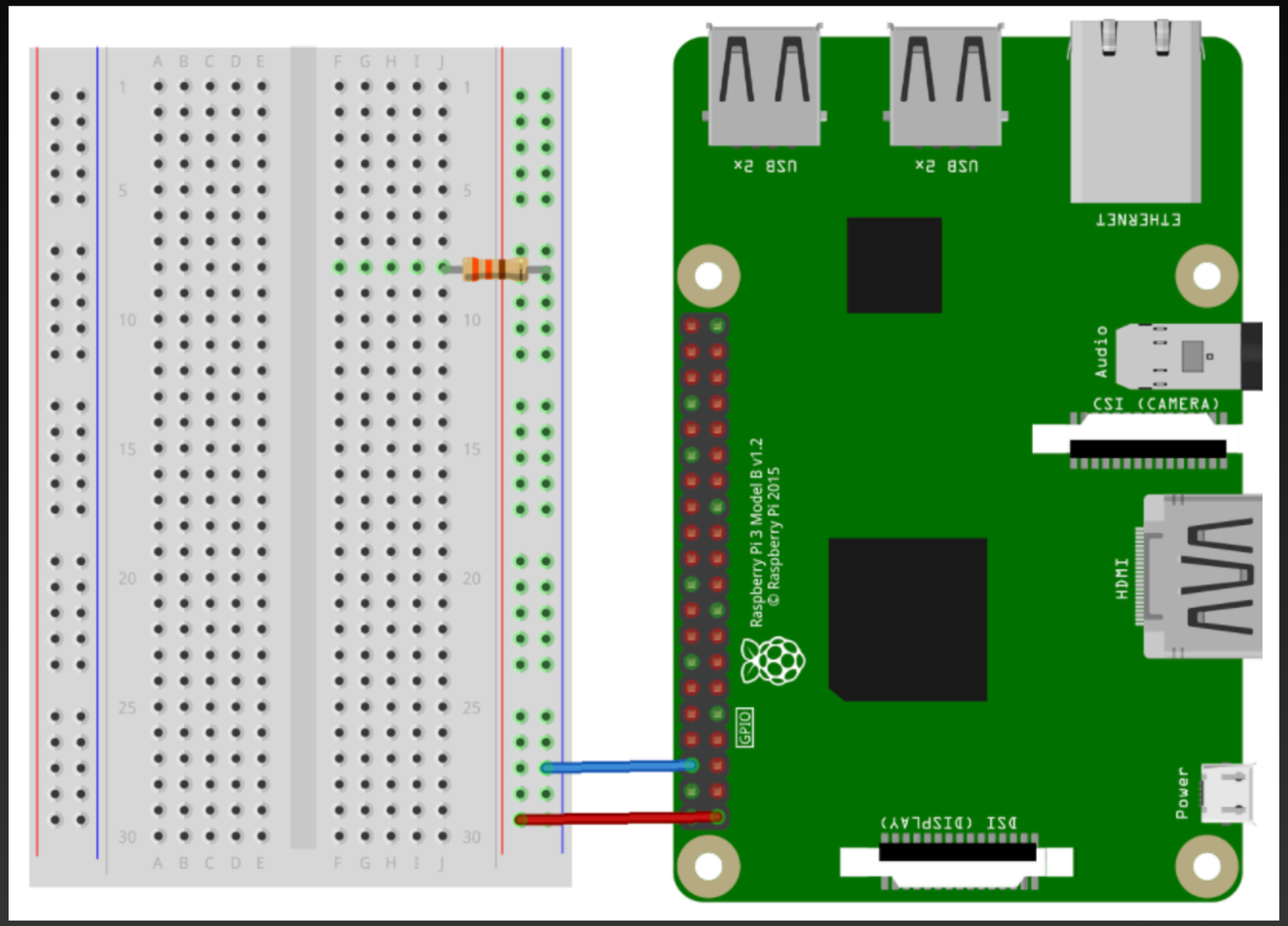
Take another female-to-male jumper and connect the female end to a ground (GND) pin on the Raspberry Pi. The male end goes into a hole on the blue (ground) rail. All blue holes now act as a ground pin.



Test your circuit! An LED project

Add a resistor to the breadboard

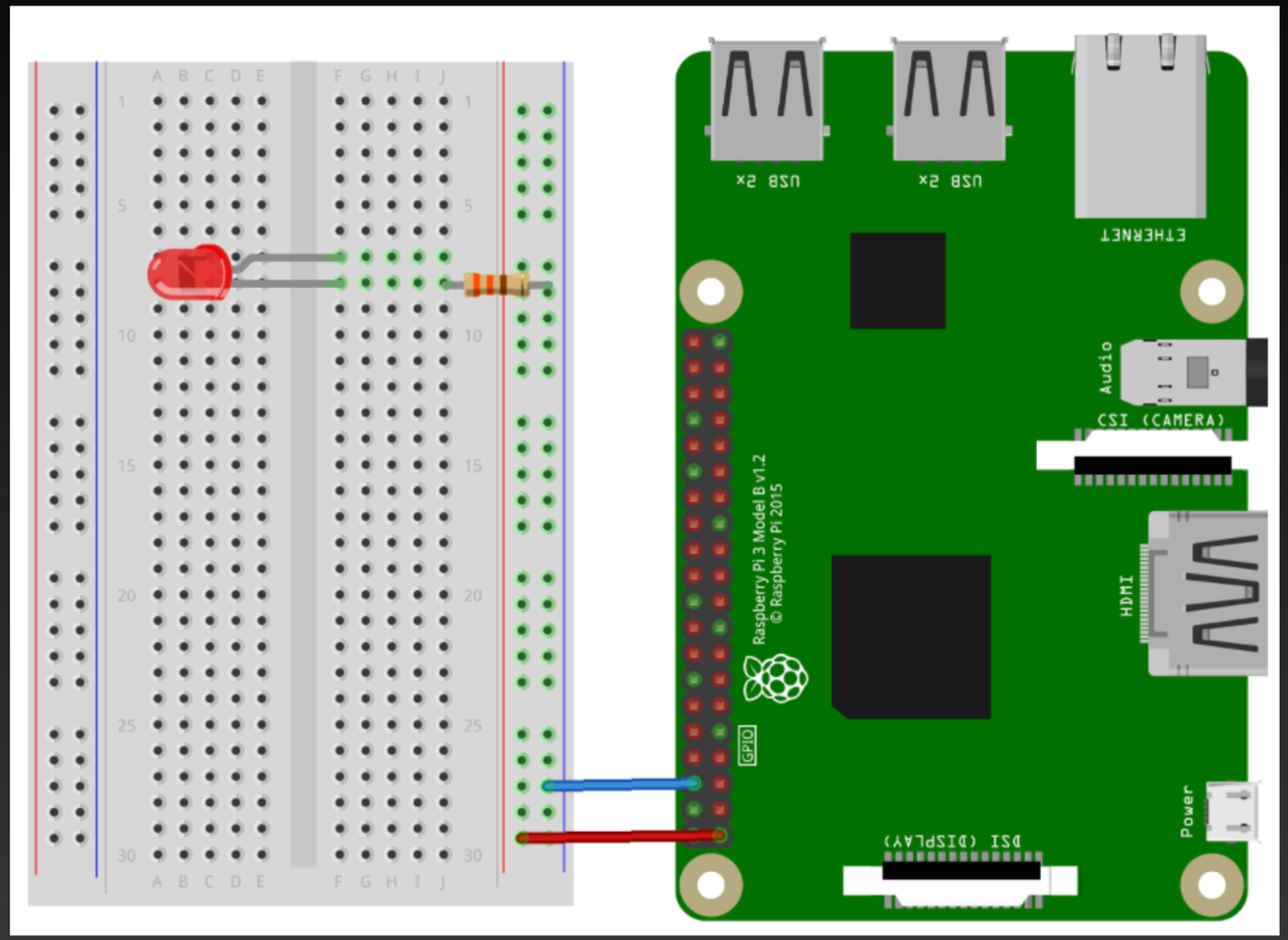
Take a resistor and connect one leg of it to a hole on the ground rail of the breadboard. It’s now linked to the ground pin of the Raspberry Pi (via the jumper lead we used in the previous step). Take the other leg and connect it to a hole on the main breadboard.



Test your circuit! An LED project

Add the LED to the breadboard

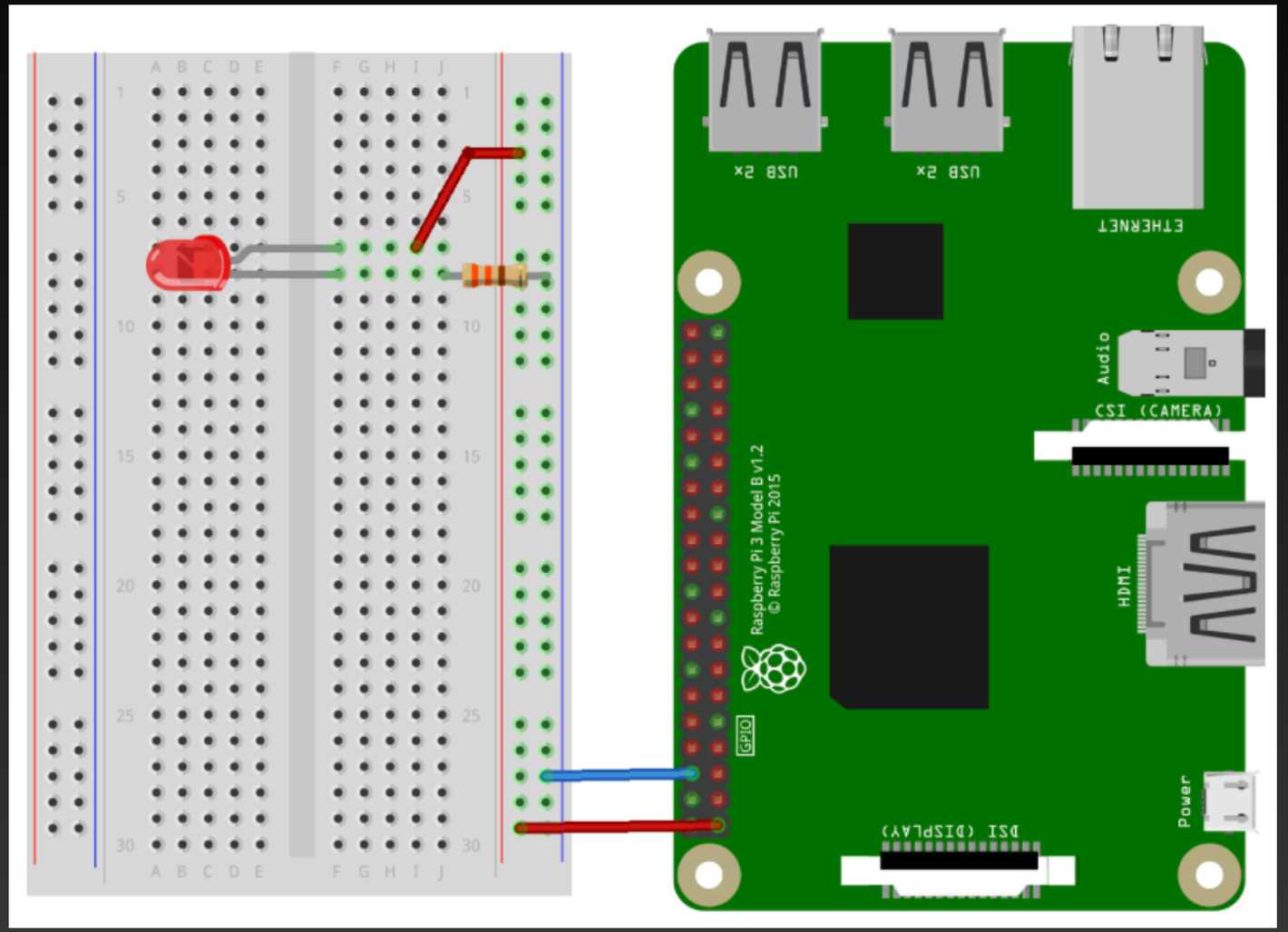
Take an LED component and look at the legs. Notice that one of the legs is shorter than the other. Place the shorter leg in a hole on the same row as the resistor. This leg is now connected to the resistor (which is linked to the ground rail, and therefore to the ground pin on the Raspberry Pi).



Test your circuit! An LED project

Wire up the breadboard

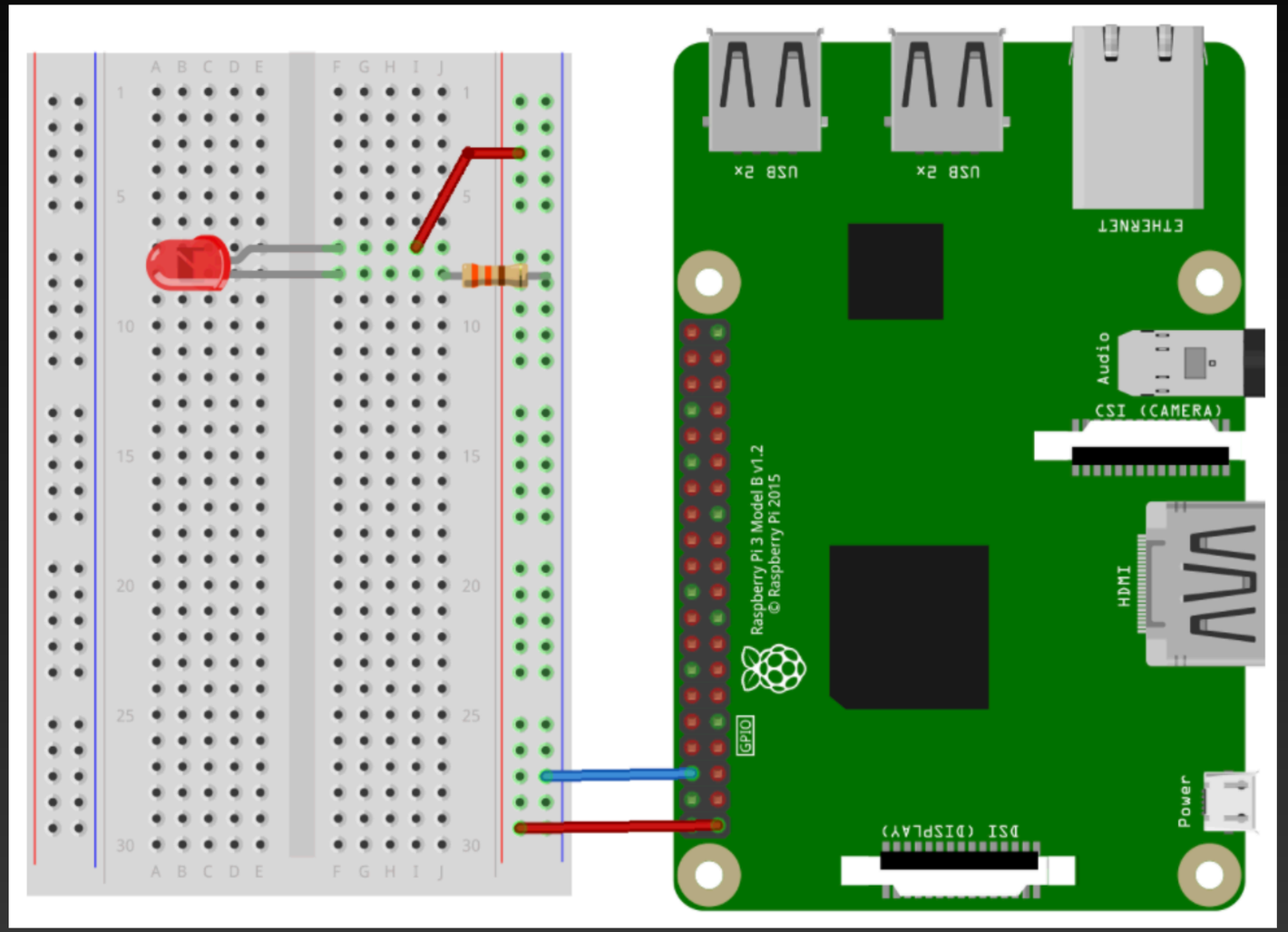
Place the longer leg in a hole on the next row along. Now take another male-to-male jumper lead and place one end in the hole next to the long leg of the LED. Place the other end in a hole on the red live rail to complete the circuit. The LED lights up.



Test your circuit! An LED project

Switching an LED on and off

GPIO Zero is a new Python library which provides a simple interface to everyday GPIO components. It comes installed by default in Raspbian.

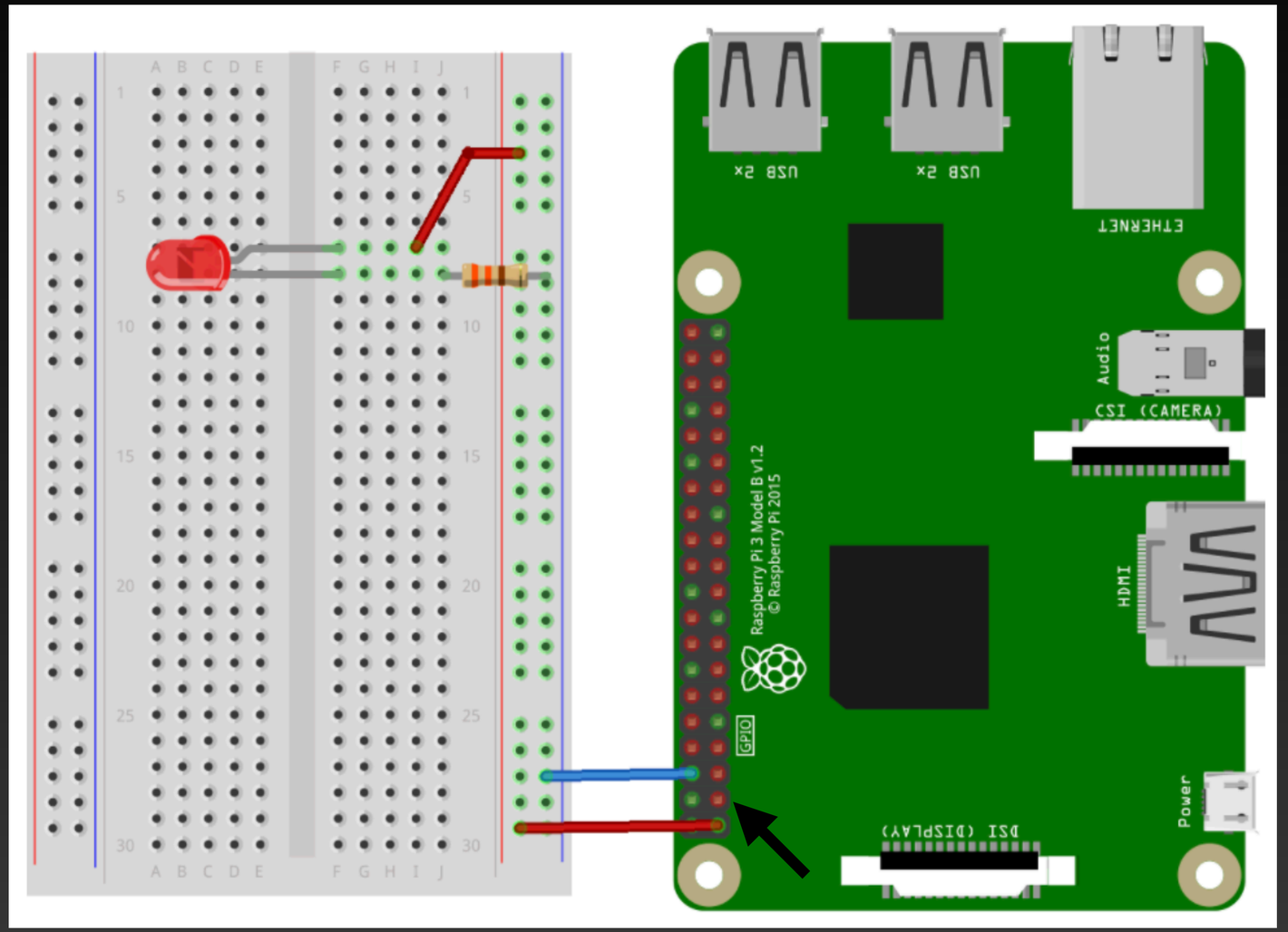


Test your circuit! An LED project

Switching an LED on and off

GPIO Zero is a new Python library which provides a simple interface to everyday GPIO components. It comes installed by default in Raspbian.

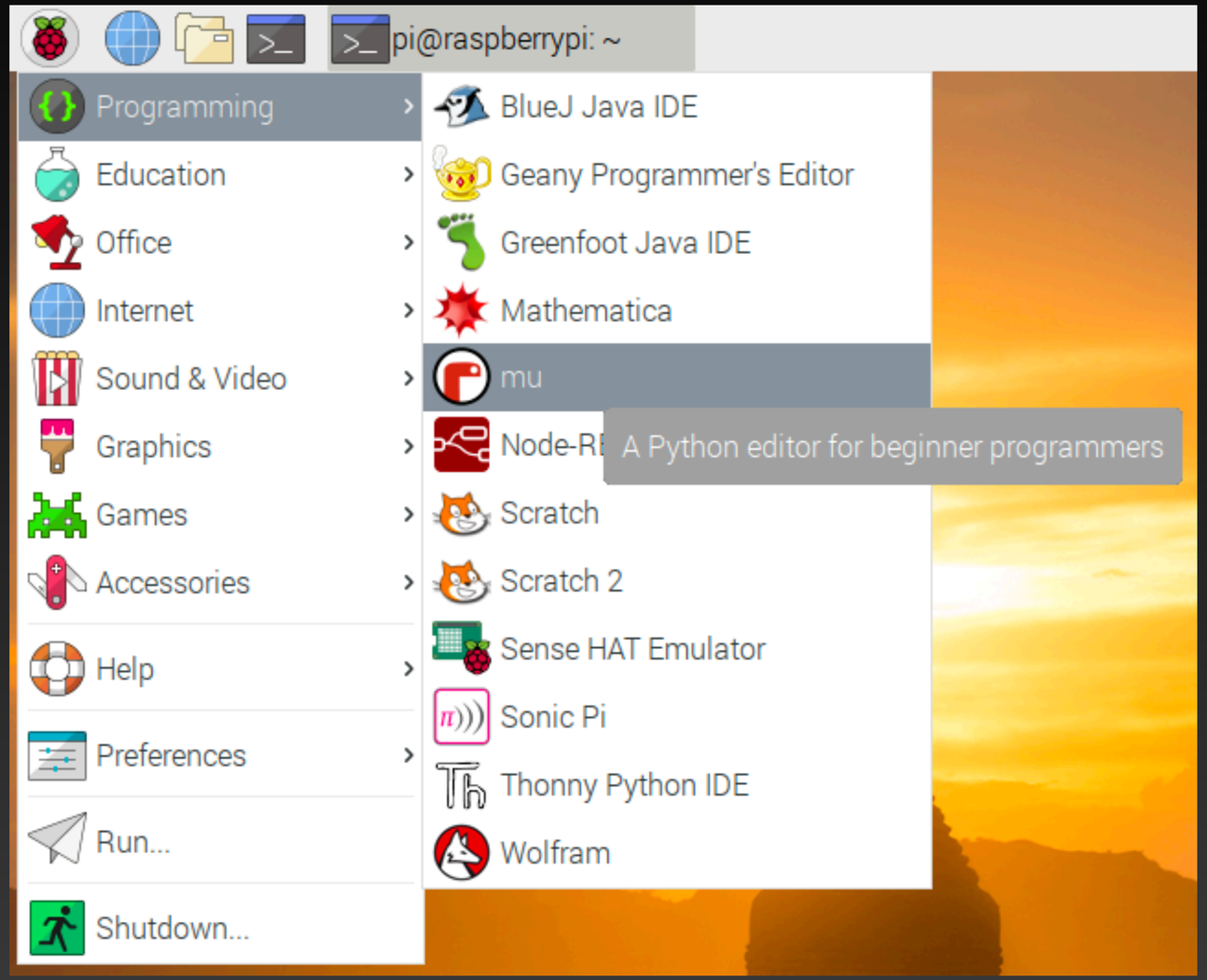
Switch your input to GPIO2



Test your circuit! GPIO Zero library

How to open Mu

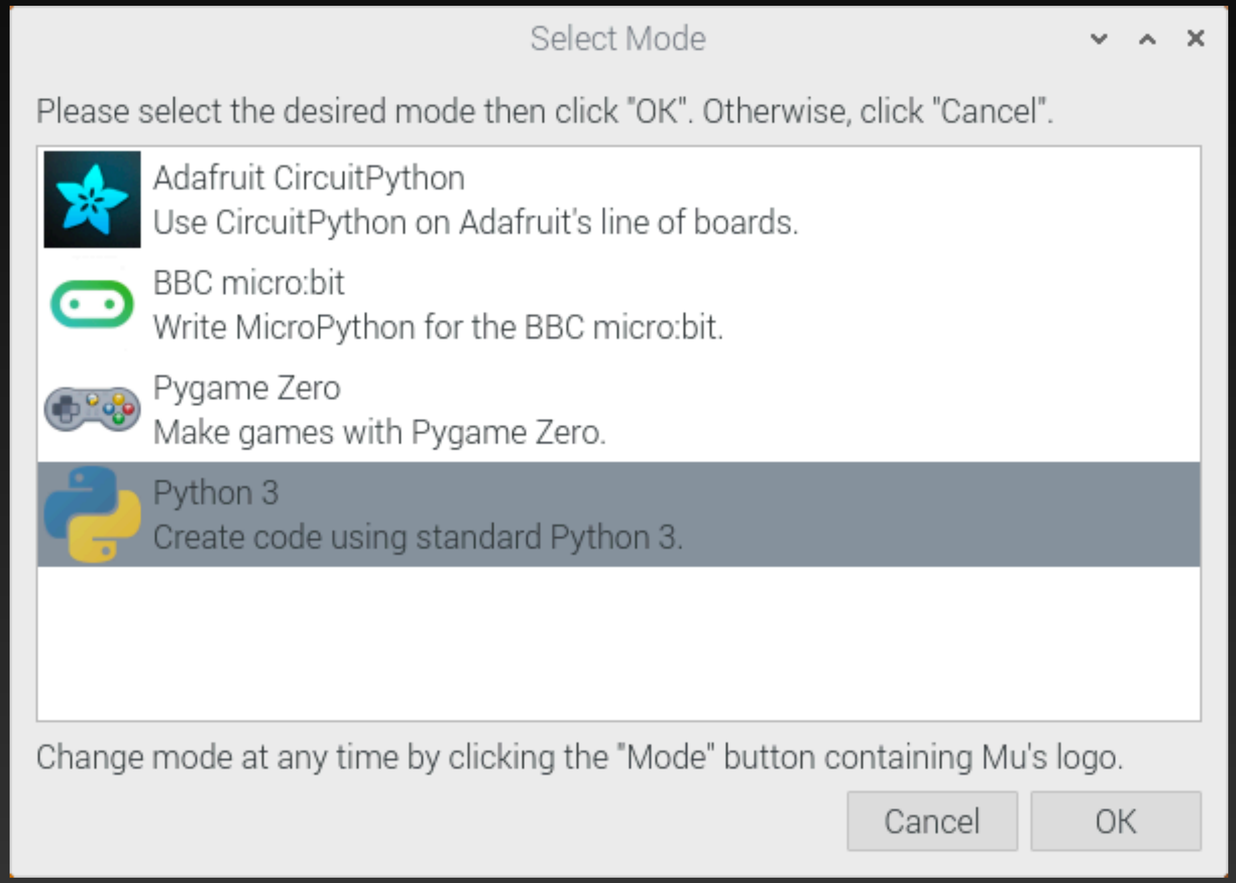
Go to the Programming menu and click on Mu.



Test your circuit! GPIO Zero library

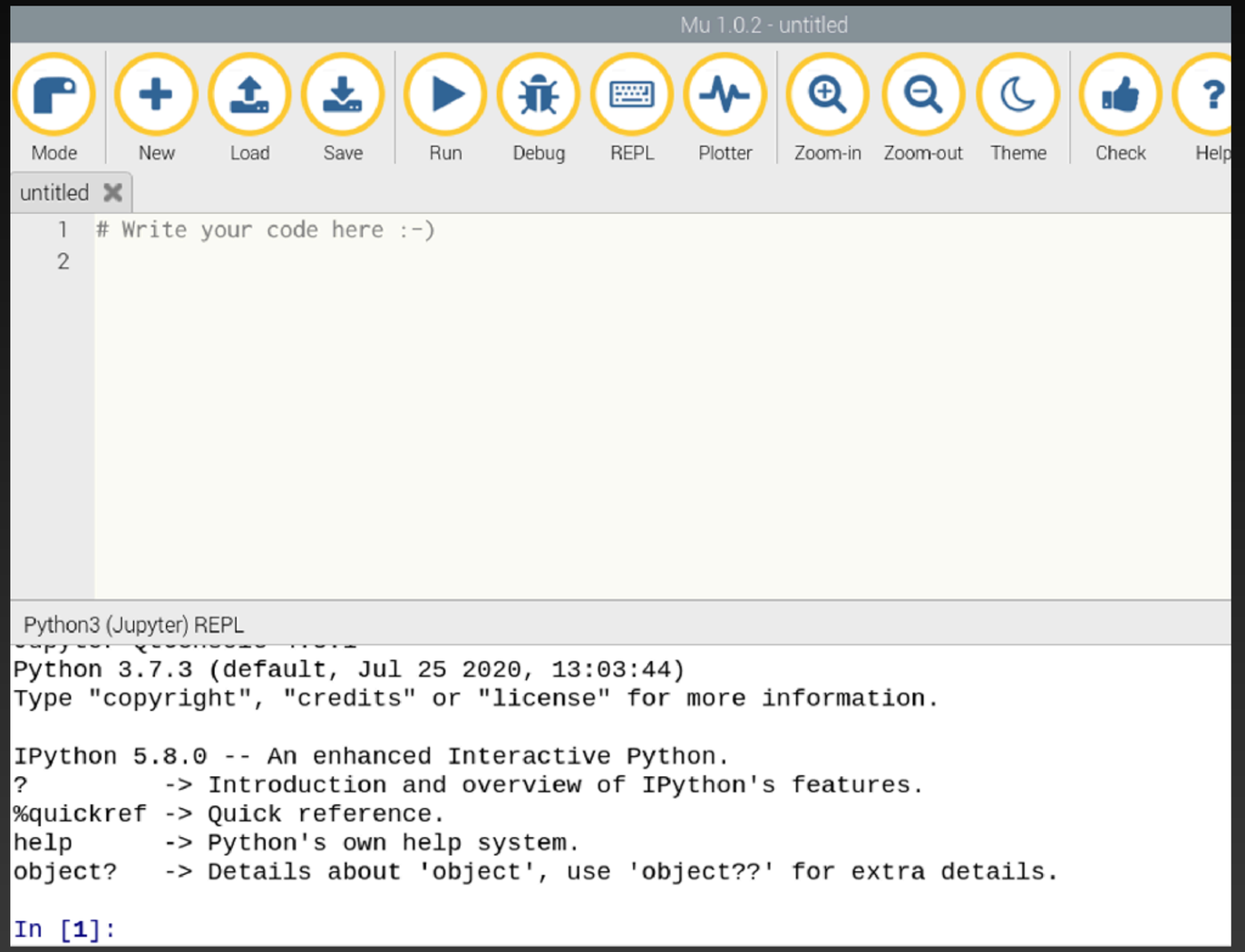
Then choose the mode in which you want to use Mu.

Choose Python 3 if you are creating a new Python script.



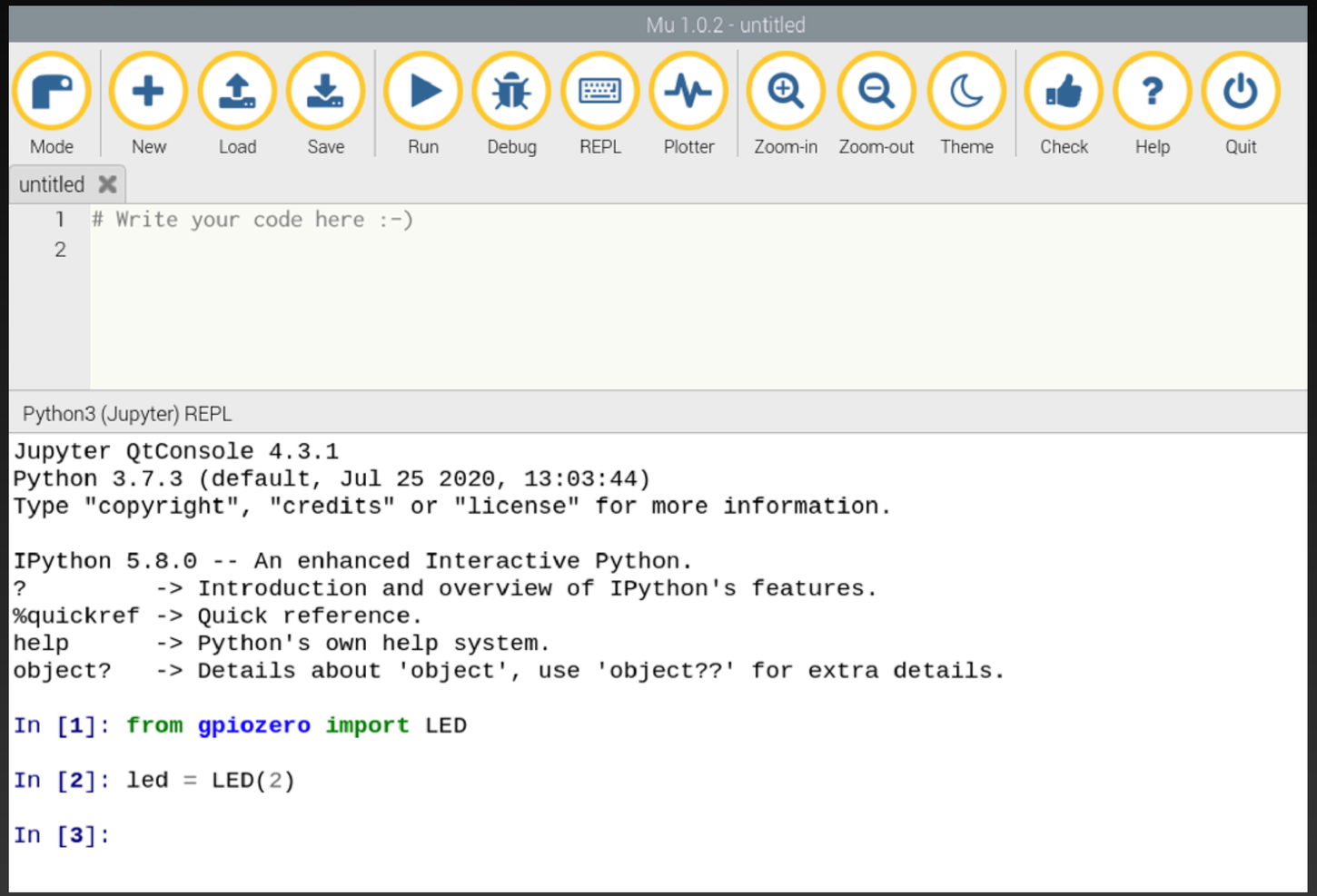
Test your circuit! GPIO Zero library

You can switch an LED on and off by typing commands directly into the REPL. Click on the REPL button in the menu bar.



Test your circuit! GPIO Zero library

First import the GPIO Zero library, and tell the Pi which GPIO pin you are using - in this case pin 2.



Test your circuit! GPIO Zero library

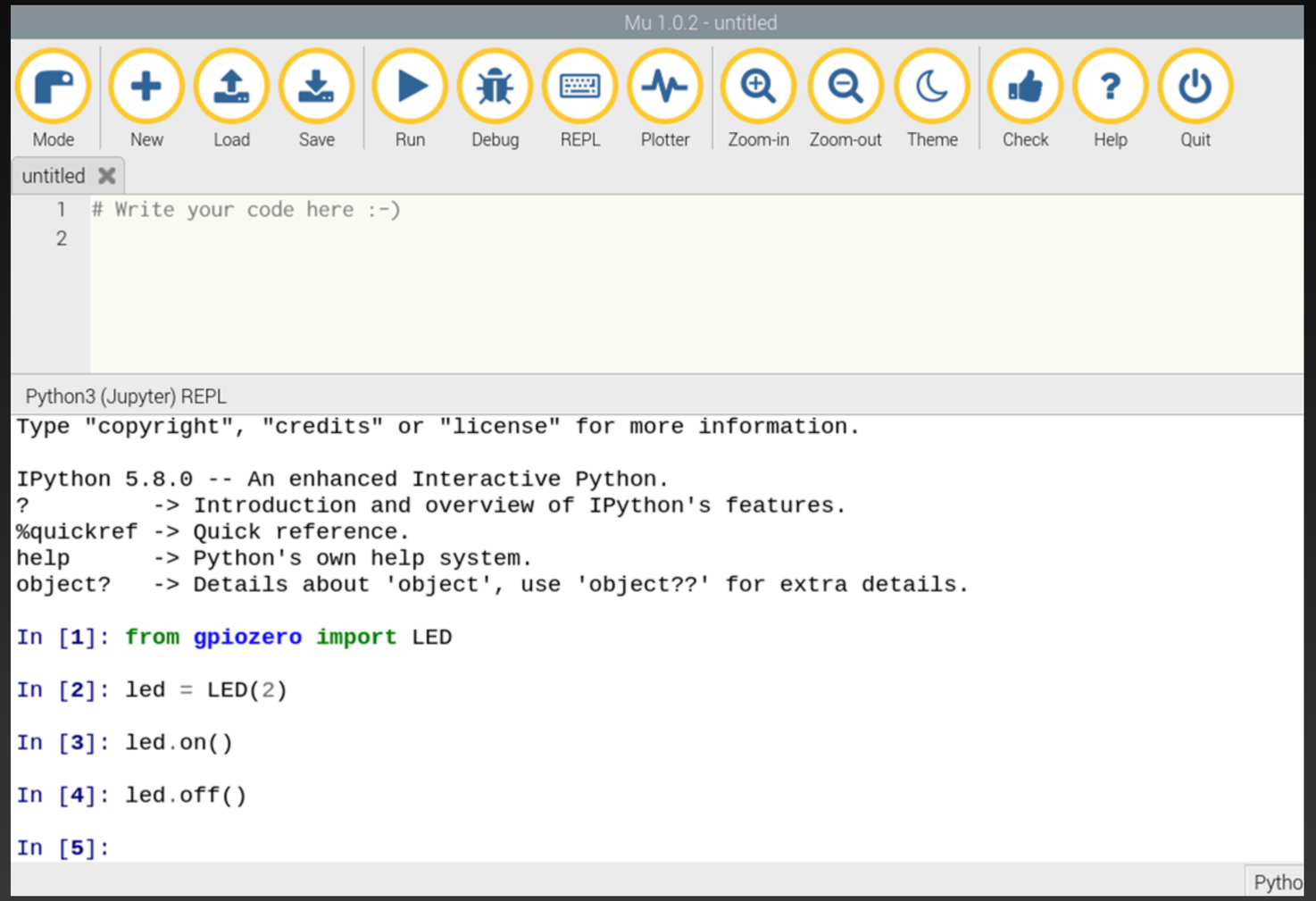
To make the LED switch on, type the following and press Enter:

```
led.on()
```

To make it switch off you can type:

```
led.off()
```

Your LED should switch on and then off again. But that's not all you can do.

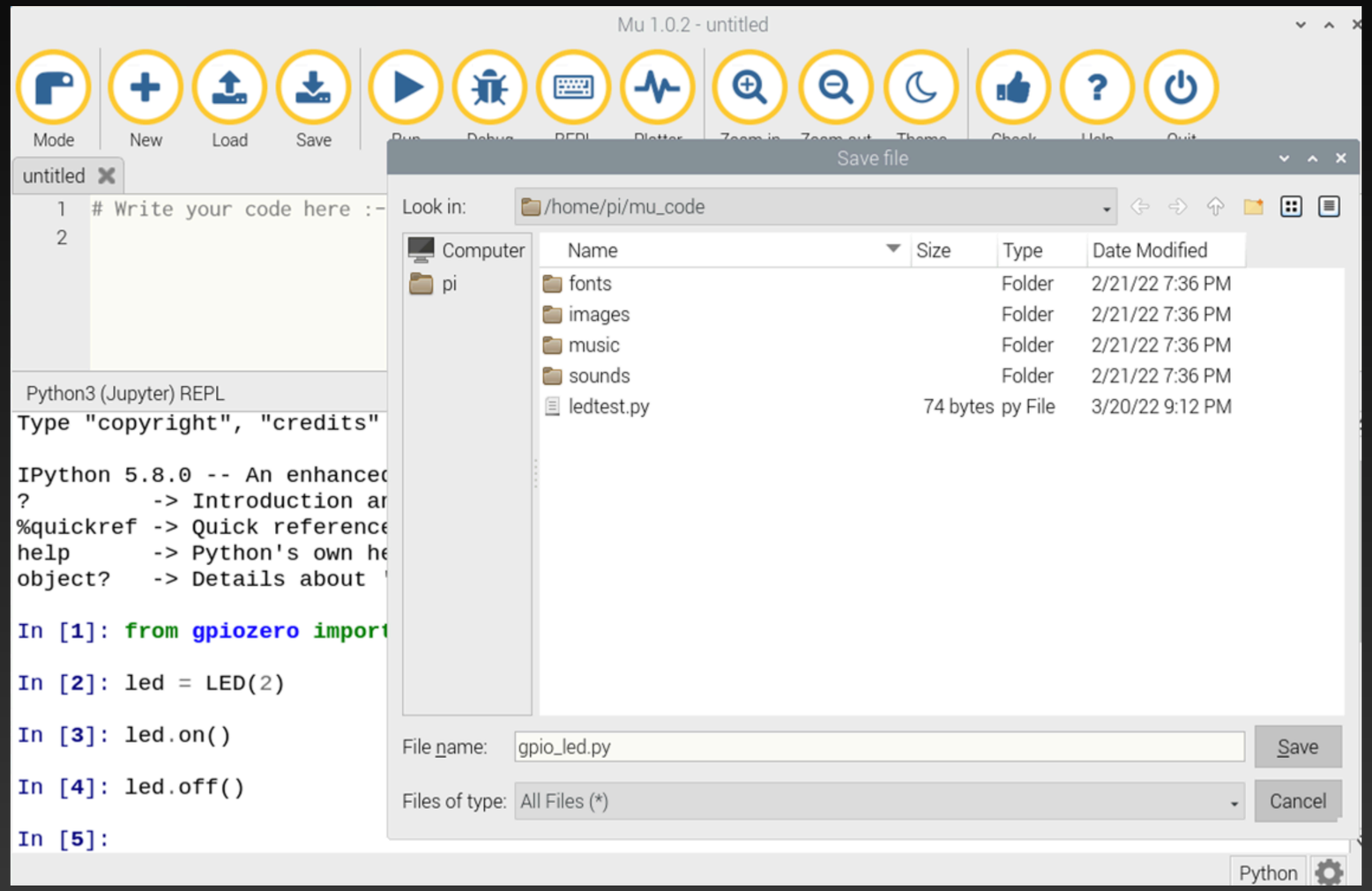


Test your circuit! Flashing an LED

With the help of the time library and a little loop, you can make the LED flash.

Create a new file by clicking New.

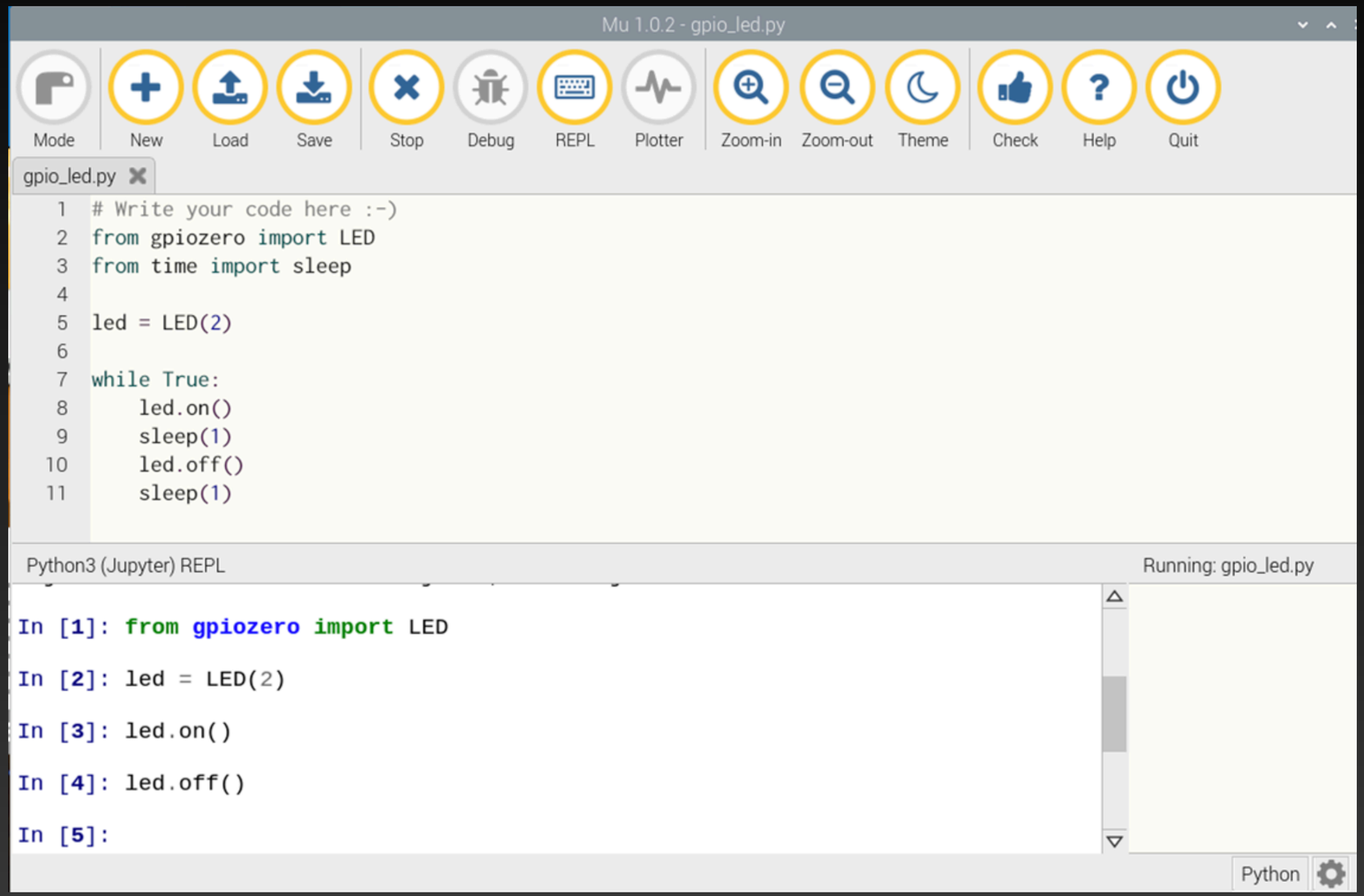
Save the new file by clicking Save. Save the file as gpio_led.py.



Test your circuit! Flashing an LED

Enter the following code to get started:

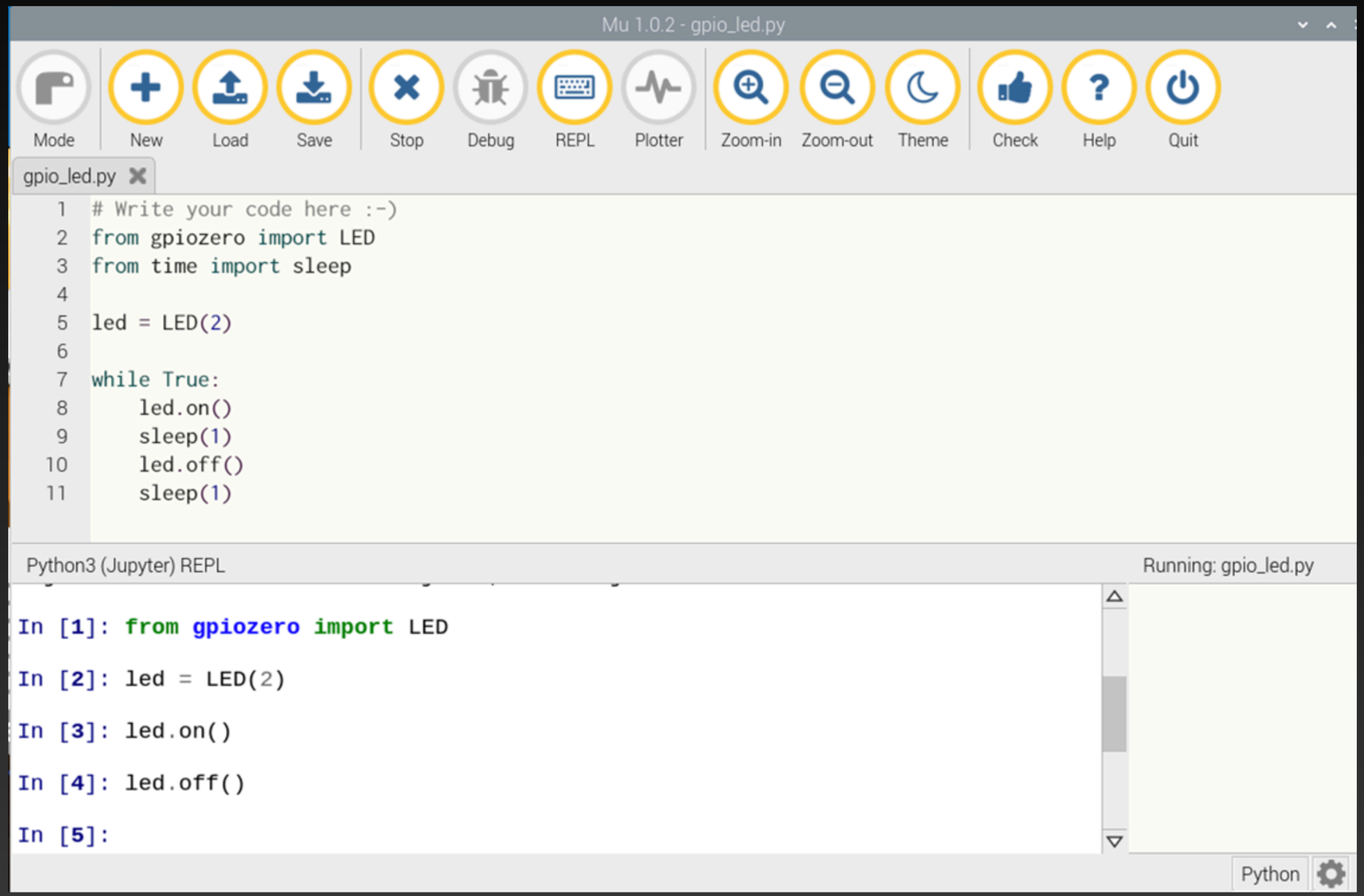
```
from gpiozero import LED
from time import sleep

led = LED(2)

while True:
    led.on()
    sleep(1)
    led.off()
    sleep(1)
```



Test your circuit! Flashing an LED

Save the file and run the code with by clicking on Run.

The LED should be flashing on and off. To exit the program click Stop.



Home project

1. Please redo “Test your circuit! An LED project”.

2. Connect three LEDs using your breadboard, control them through the Python LED Library.

IoT with MIT App Inventor

Office hour