

Intro to Robotics with Raspberry Pi!

Section 1. General Concepts – Linux fundamentals

Outline

Linux Fundamentals

Getting Started with Linux

Desktop Environments and Shells

Remote Login with SSH

Remote Login with VNC

Navigating Linux and Using Python Within

Using Python on the Raspberry Pi

From the Mac OS Terminal

From VNC Using the LXTerminal

From VNC Using an IDE

Python Applications

Python Web Application Using Flask

Python Dataviz Application

Python Programs to Control Hardware

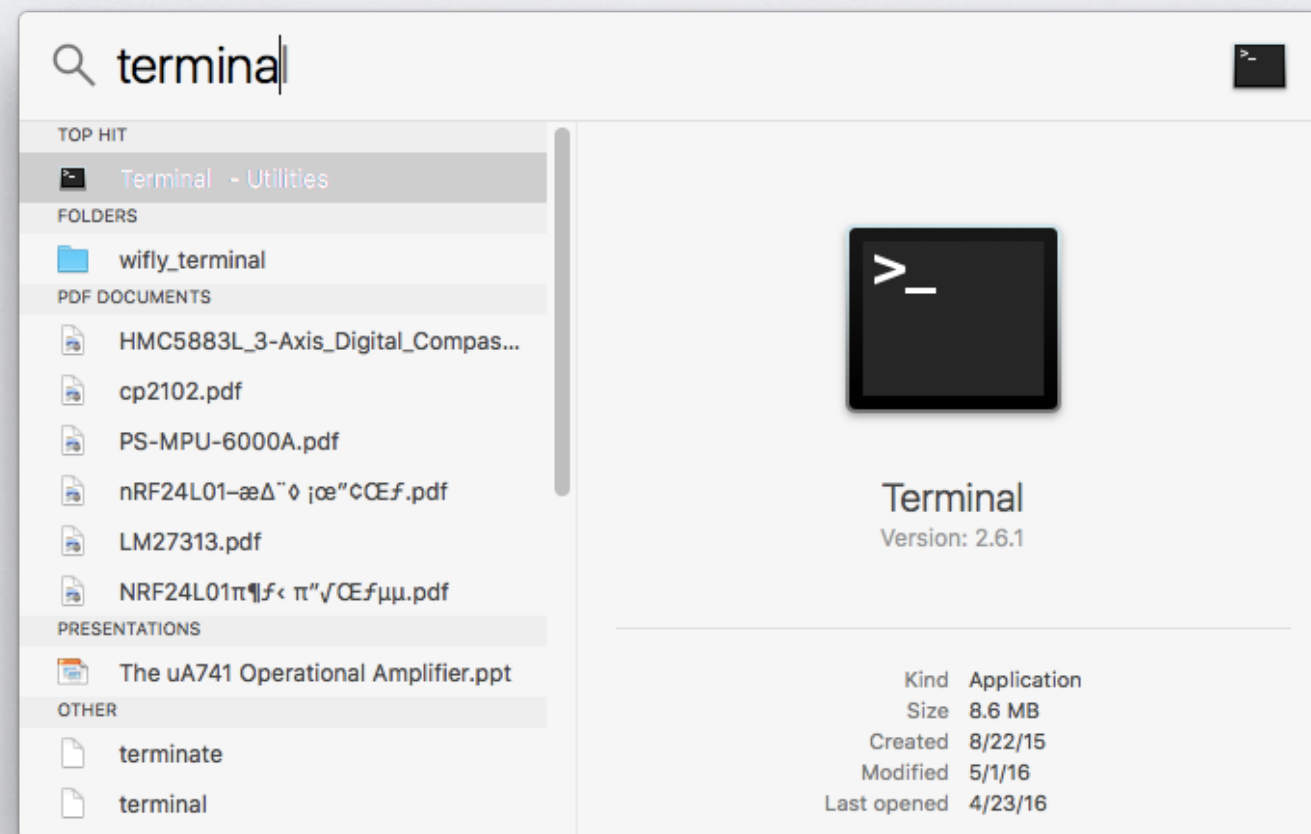
Blinking an LED

Blinking multiple LEDs

Getting Started with Linux

Desktop Environments and Shells

- A **desktop environment** is a collection of software that provides a standard look and feel: Mac OS, Windows, GNOME.
- A **shell** is a user interface for access to an operating system's services.
- Shells can either be **graphical** or **text-based**.
- OS X's **Terminal.app** allows us to access the system's text-based shell.



Example Uses of Text Shells

- Applications (programs) can be used via a graphical or text-based **shell**.
- A **terminal emulator** is an application that allows us to interact with the text-based shell.
- Commonly used programs inside a terminal emulator include:

```
say Hello Disney Interactive!
```

```
vi
```

```
ssh
```

```
wget
```

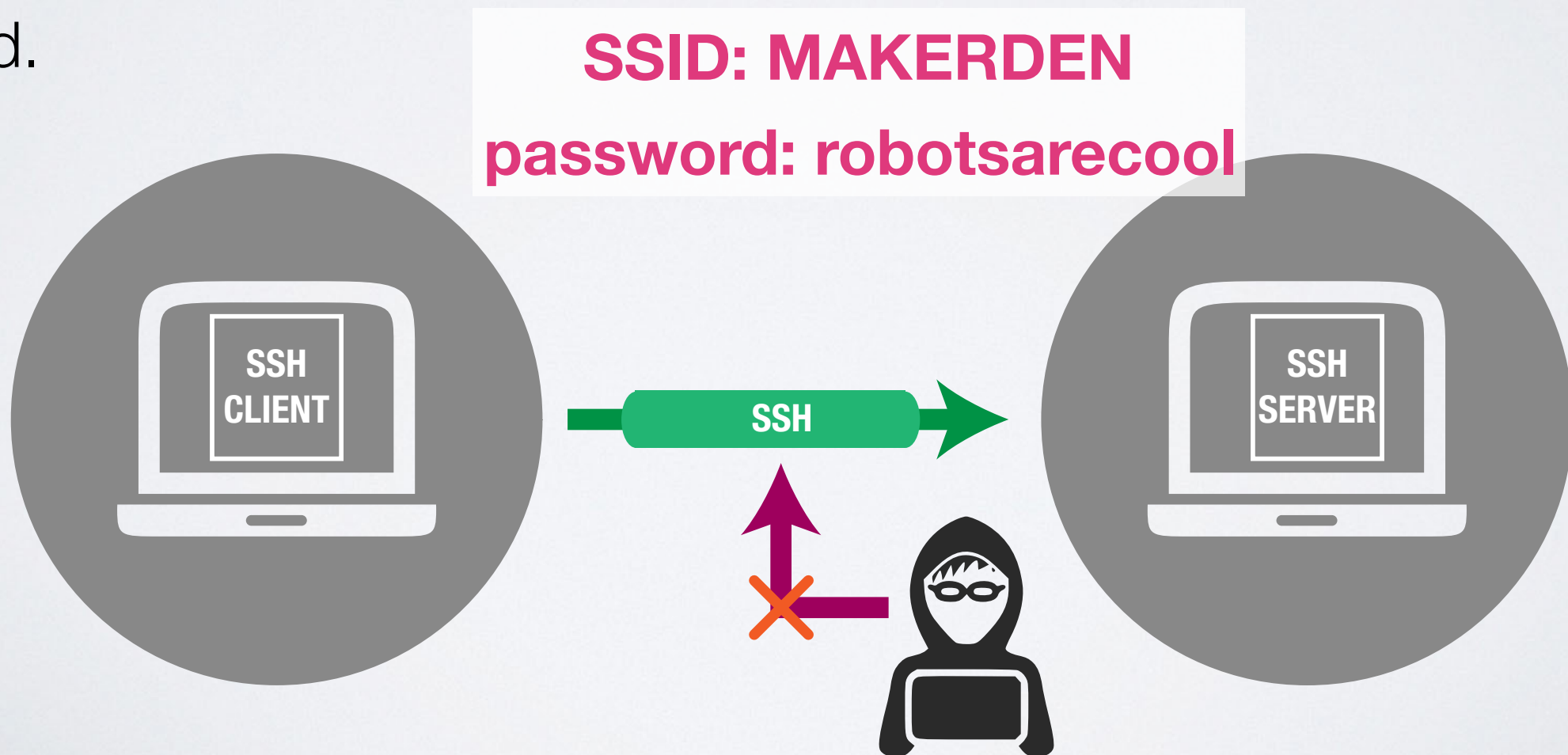
```
python
```

```
python filename.py
```

Remote Login with SSH

ssh

- Secure Shell (SSH) is an encrypted network protocol that allows remote login and other network services to operate securely over an unsecured network.
- Both OS X and the Raspberry Pi OS have the necessary SSH programs installed.

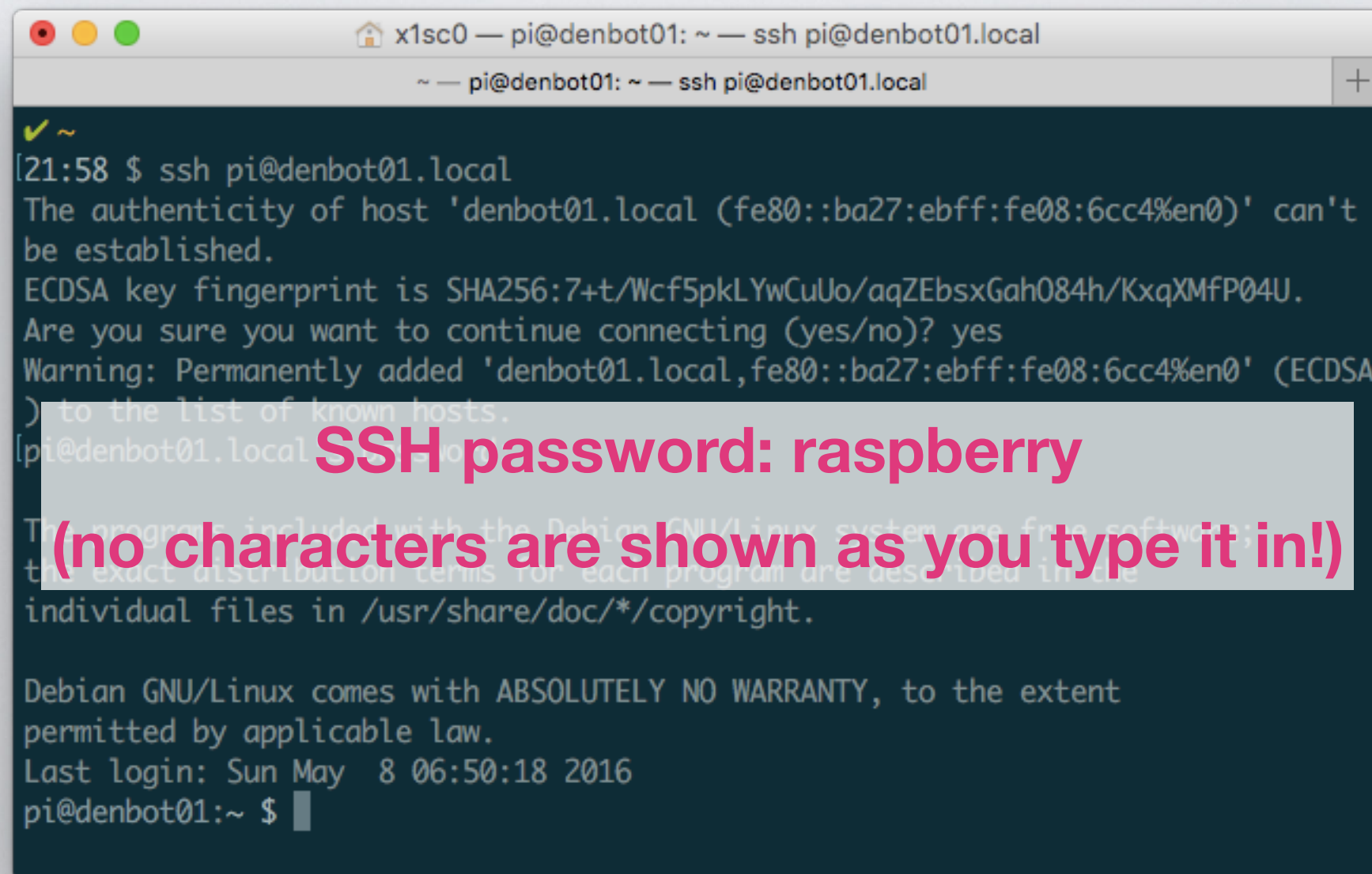


Remote Login with SSH

- Using the Terminal app let's log in to our Raspberry Pi:

```
ssh pi@denbotNN.local
```

- **pi** is the name of the default user. Default password is **raspberry**.
- **NN** should be the number of your PyDen Bot!



```
x1sc0 — pi@denbot01: ~ — ssh pi@denbot01.local
~ — pi@denbot01: ~ — ssh pi@denbot01.local

[21:58 $ ssh pi@denbot01.local
The authenticity of host 'denbot01.local (fe80::ba27:ebff:fe08:6cc4%en0)' can't
be established.
ECDSA key fingerprint is SHA256:7+t/Wcf5pkLYwCuUo/aqZEbsxGah084h/KxqXMfP04U.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'denbot01.local,fe80::ba27:ebff:fe08:6cc4%en0' (ECDSA
) to the list of known hosts.
[pi@denbot01.local ~]$
```

SSH password: raspberry
(no characters are shown as you type it in!)

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Sun May 8 06:50:18 2016
pi@denbot01:~ \$

Remote Login with SSH

- You're in! All the commands you now type are executed on the **Raspberry Pi**'s processor!
- Many of the programs we can use on our Mac's OS can also be run on the Raspberry Pi's OS.

```
vi
```

```
ssh
```

```
wget
```

```
python
```

```
python filename.py
```

- We can close the 'session' by entering:

```
exit
```

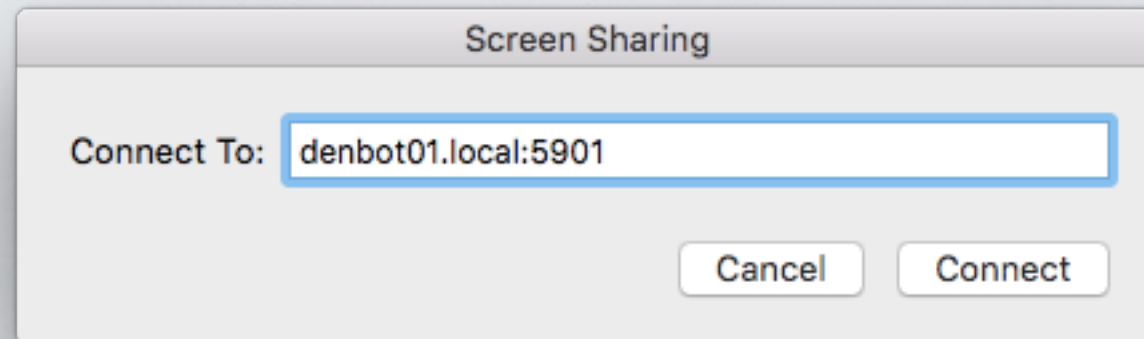

Remote Login with VNC

- Thankfully, we can also establish a GUI (Graphical User Interface)-based connection!
- Virtual Network Computing (VNC) is a graphical desktop sharing system that allows remote control another computer.
- Both OS X and the Raspberry Pi OS have the necessary VNC programs installed.
- On the terminal enter (ensure you're logged out of your Raspberry Pi!):

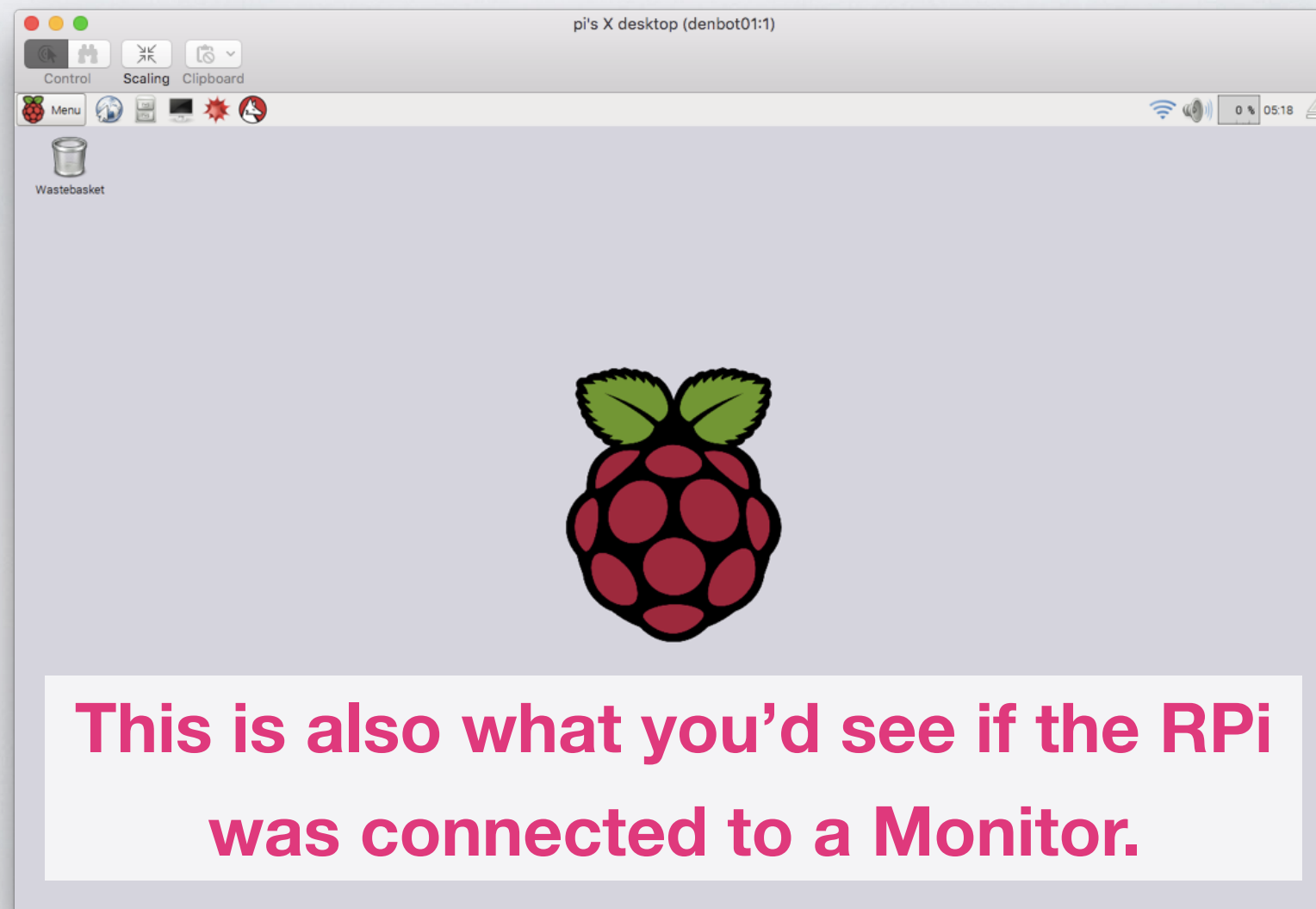
```
open -a /System/Library/CoreServices/Applications/Screen\ Sharing.app
```

Remote Login with VNC

- Inside the field enter your PyDen Bot name (e.g., denbot01.local:5901):

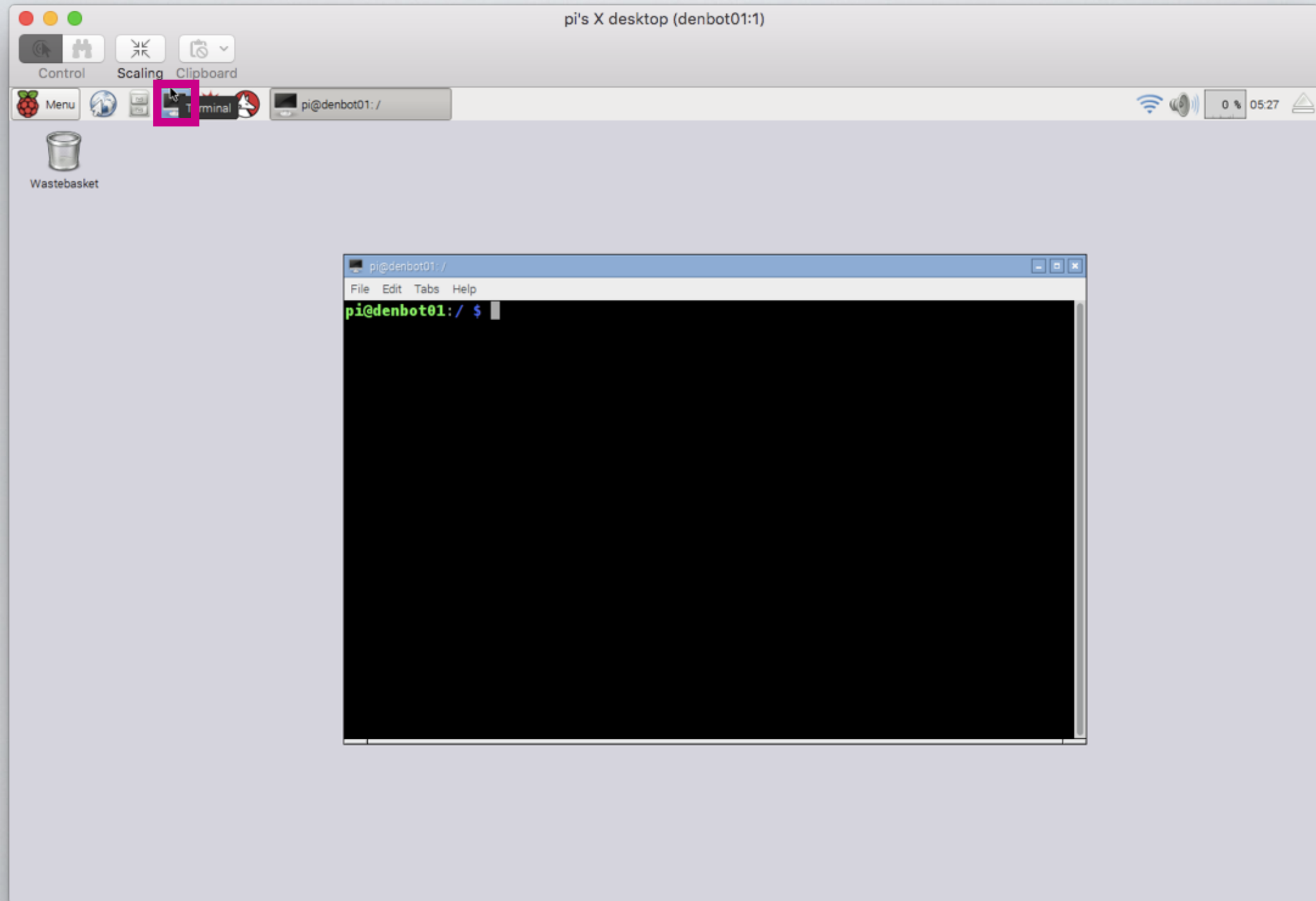


*5901 is the port where the Raspberry Pi listens for incoming VNC connections. Default password is **pidenbot**.



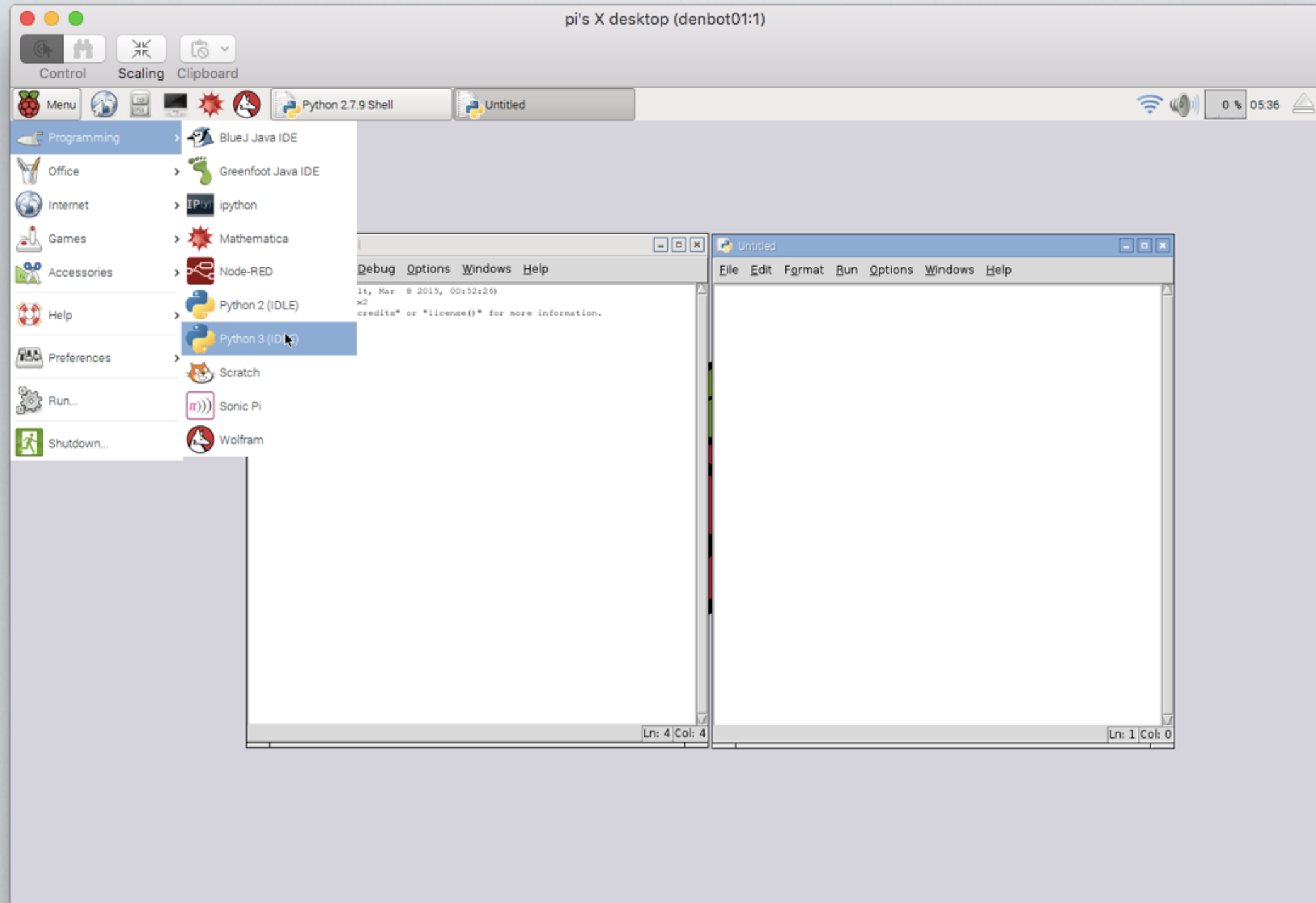
Linux Fundamentals

- The Raspberry Pi OS (Raspbian) also has a **Terminal emulator** (**LXTerminal**) we can use!



Using Python in Raspbian

- An Integrated Development Environment for Python (IDLE) is pre-installed in Raspbian (though not used in this class (-:).



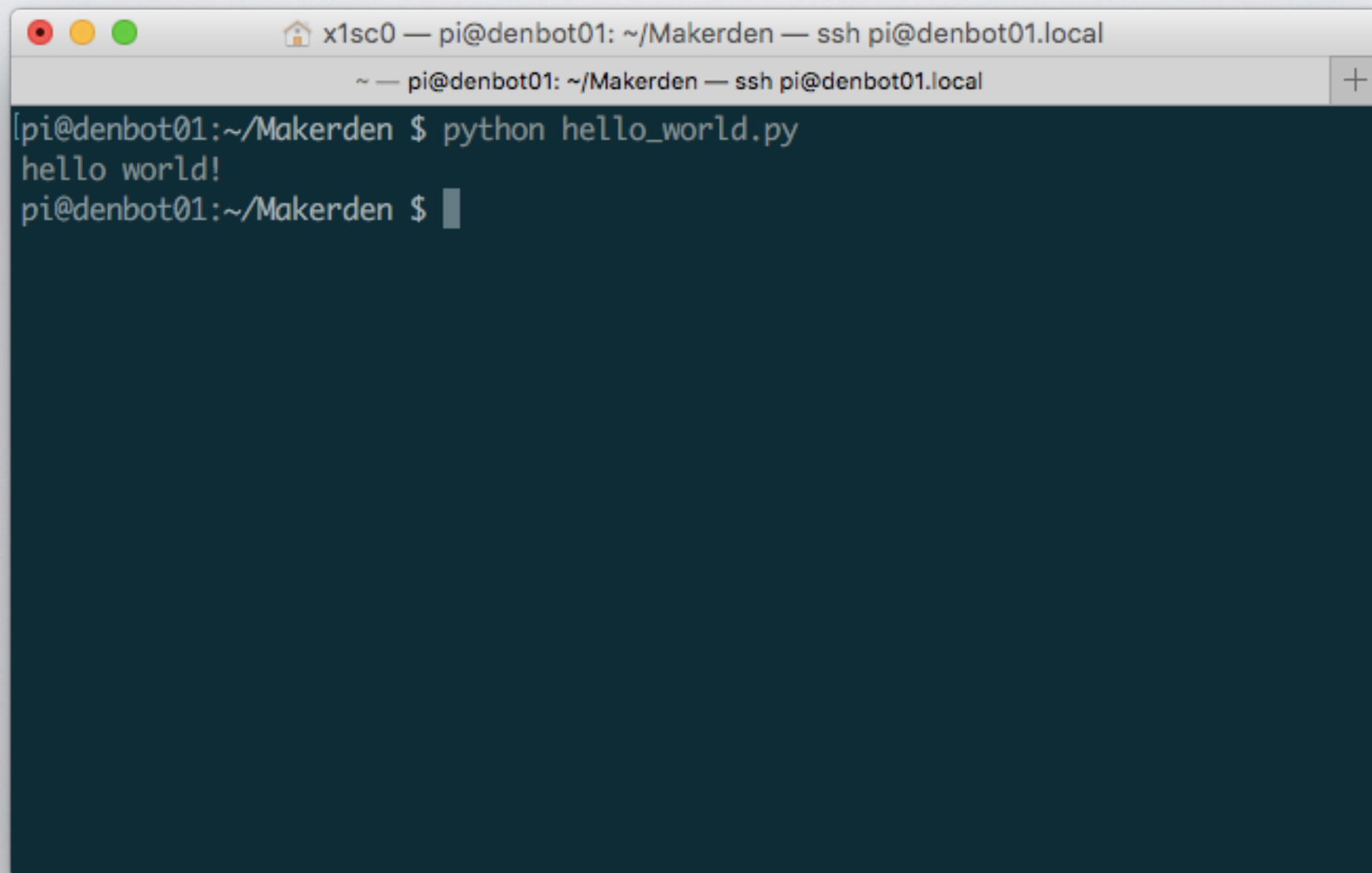
Using Python on the Raspberry Pi

Using Python On The Raspberry Pi

- We've got many options for writing and running Python scripts on the Pi.
 1. Connecting via **SSH** and using command-line tools (Mac OS Terminal).

```
cd ~/Makerden
```

```
nano hello_world.py
```



The screenshot shows a Mac OS Terminal window with a dark blue background. The title bar at the top reads 'x1sc0 — pi@denbot01: ~/Makerden — ssh pi@denbot01.local'. Below the title bar, the terminal shows the command 'python hello_world.py' being executed, followed by the output 'hello world!'. The prompt 'pi@denbot01:~/Makerden \$' is visible at the bottom of the terminal window.

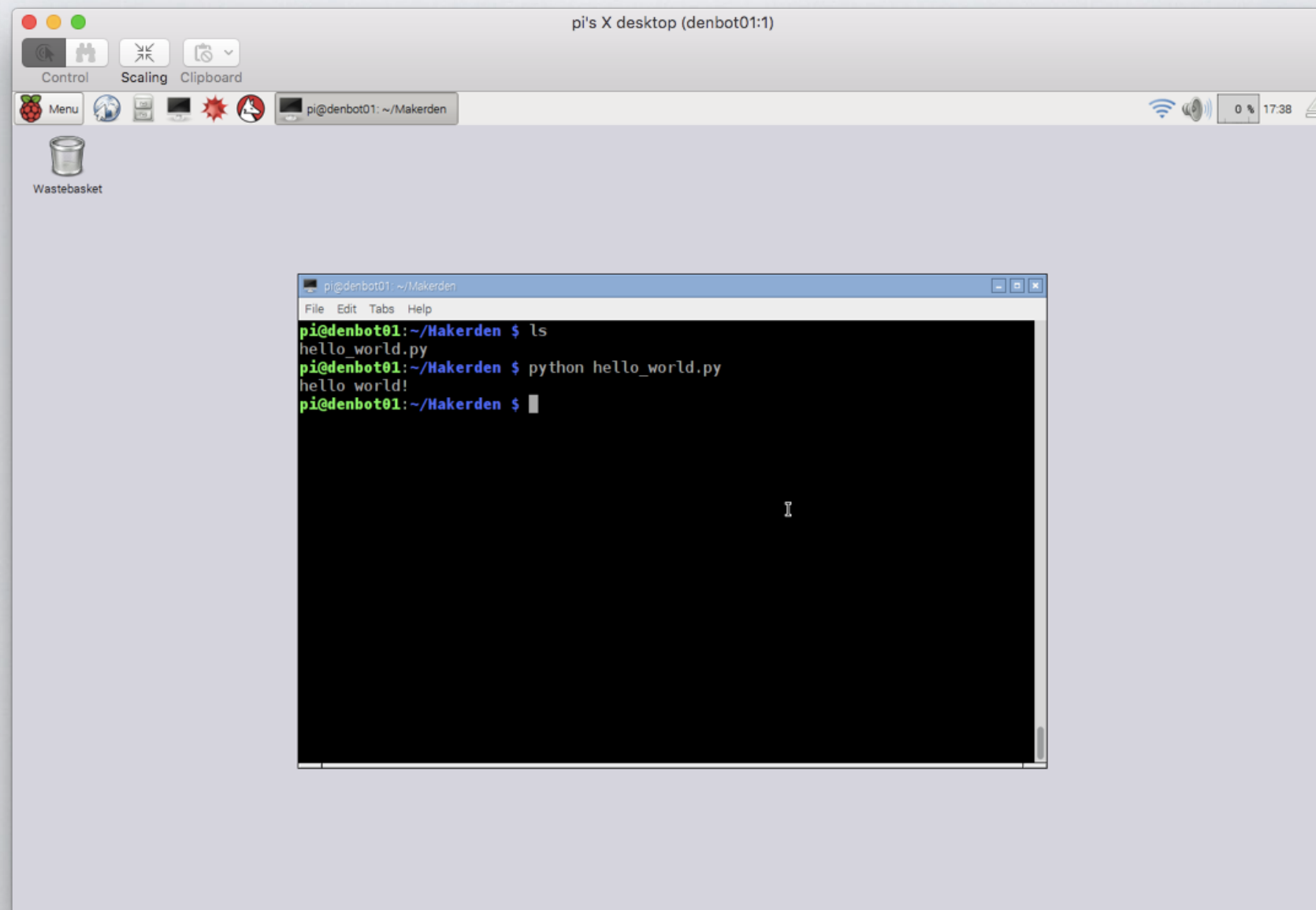
```
x1sc0 — pi@denbot01: ~/Makerden — ssh pi@denbot01.local  
~ — pi@denbot01: ~/Makerden — ssh pi@denbot01.local  
[pi@denbot01:~/Makerden $ python hello_world.py  
hello world!  
pi@denbot01:~/Makerden $
```


Using Python On The Raspberry Pi

- We've got many options for writing and running Python scripts on the Pi.
 1. Connecting via VNC and using graphical tools (Raspbian Desktop).
 2. Connecting via VNC and using command-line tools (Raspbian Terminal).

```
cd ~/Makerden
```

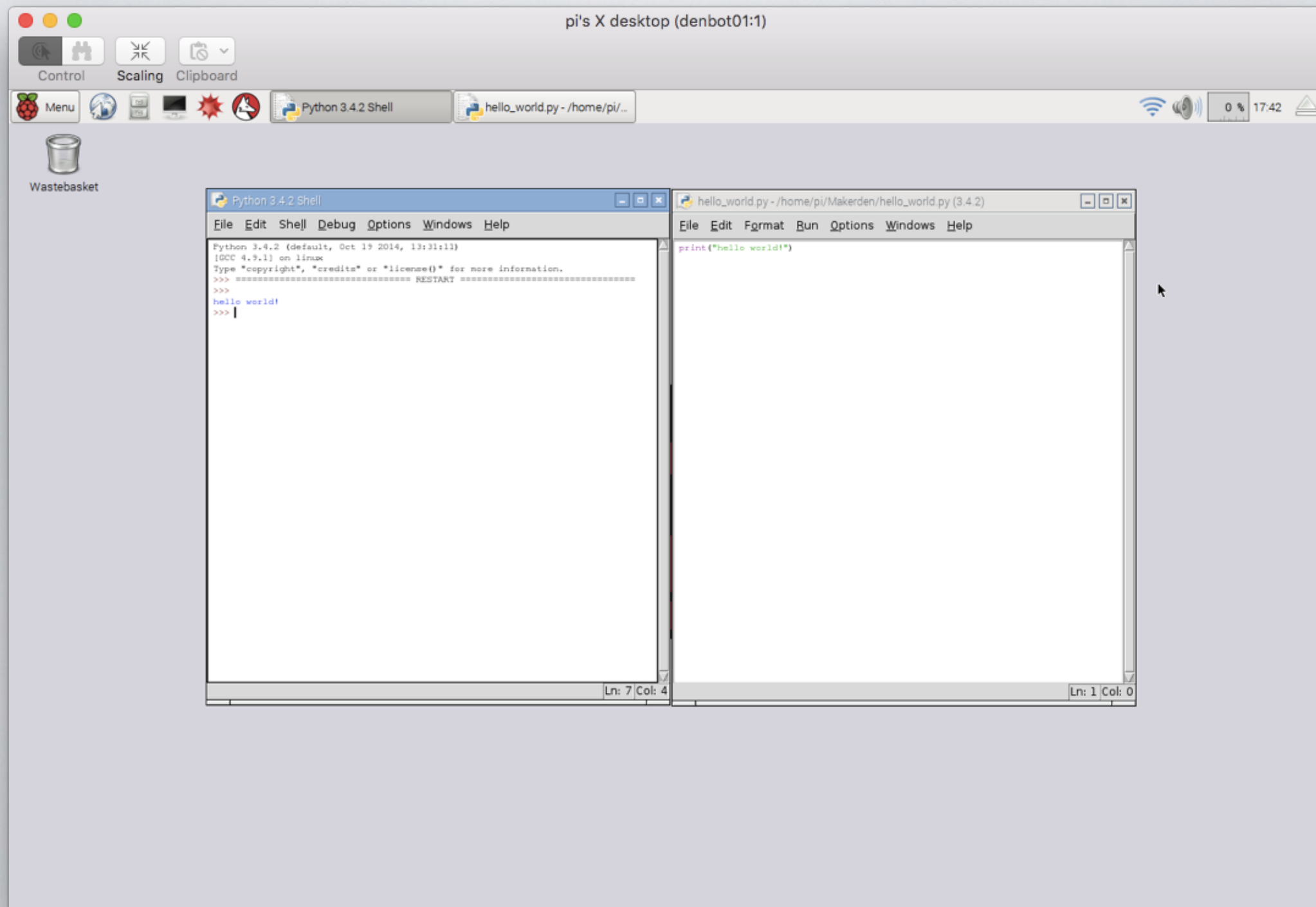
```
nano hello_world.py
```



Using Python On The Raspberry Pi

- We've got many options for writing and running Python scripts on the Pi.

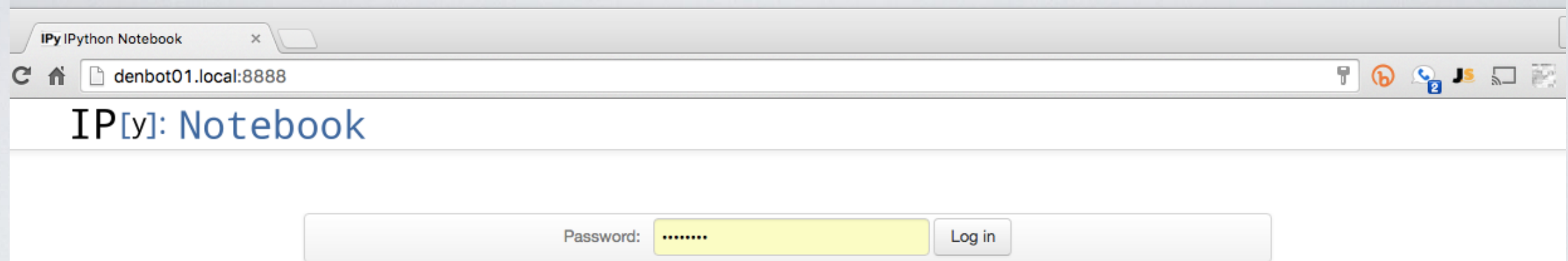
3. Connecting via VNC and using **Python IDE** (Raspbian).



Using Python On The Raspberry Pi

- We've got many options for writing and running Python scripts on the Pi.

4. Using iPython notebook server! (what we'll be using)

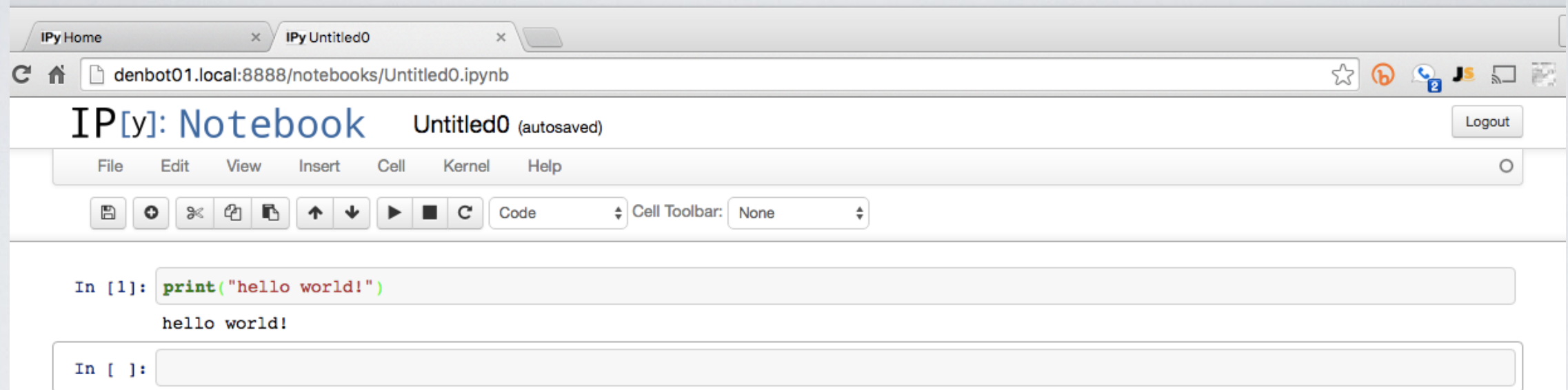


Navigate to: <http://denbotNN.local:8888>

Default password: pidenbot

Using Python On The Raspberry Pi

- iPython notebook will work with its own file format (extension .ipynb)
- Choose **File** → **Download as** → **Python (.py)** to convert.



Click the 'play' button to run a cell!

Writing Python Programs On iPython Notebook

The Python Package Index (PyPI)

- The Python Package Index is a repository of software for the Python programming language.

<https://pypi.python.org/pypi>



» Package Index

PACKAGE INDEX »

[Browse packages](#)
[Package submission](#)
[List trove classifiers](#)
[List packages](#)
[RSS \(latest 40 updates\)](#)
[RSS \(newest 40 packages\)](#)
[Python 3 Packages](#)
[PyPI Tutorial](#)
[PyPI Security](#)
[PyPI Support](#)
[PyPI Bug Reports](#)
[PyPI Discussion](#)
[PyPI Developer Info](#)

[ABOUT](#) »

[NEWS](#) »

[DOCUMENTATION](#) »

[DOWNLOAD](#) »

[COMMUNITY](#) »

[FOUNDATION](#) »



[CORE DEVELOPMENT](#) »

PyPI - the Python Package Index

The Python Package Index is a repository of software for the Python programming language. There are currently **67937** packages here.

To contact the PyPI admins, please use the [Support](#) or [Bug reports](#) links.

Not Logged In

[Login](#)
[Register](#)
[Lost Login?](#)
Use [OpenID](#)  

Status

[Nothing to report](#)

Get Packages

To use a package from this index either "[pip](#) install *package*" ([get pip](#)) or download, unpack and "[python setup.py install](#)" it.

Package Authors

Submit packages with "[python setup.py upload](#)". The index [hosts package docs](#). You may also use the [web form](#). You must [register](#). Testing? Use [testpypi](#).

Infrastructure

To interoperate with the index use the [JSON](#), [OAuth](#), [XML-RPC](#) or [HTTP](#) interfaces. Use [local mirroring or caching](#) to make installation more robust.

Updated	Package	Description
2015-10-21	toil 3.1.0a1.dev48	Pipeline management software for clusters.
2015-10-21	django-knob 1.1	A Django reusable application that performs remote configurations on multiple devices, distributing the operations using Celery.
2015-10-20	song2 0.1.0	Typesafe/Immutable schema for dict object
2015-10-20	django-influxdb-metrics 1.2.1	A reusable Django app that sends metrics about your project to InfluxDB
2015-10-20	luigi-monitor 0.2.2	Send summary messages of your Luigi jobs to Slack.
2015-10-20	flask-autorouter 0.1.1	a utility for generating flask URL routing
2015-10-20	django-templatetags 1.1	Custom template tags for notification
2015-10-20	djangorecipe 2.1.2	Buildout recipe for Django
2015-10-20	SciSalt 1.6.1	Tools to make scientific data analysis easier

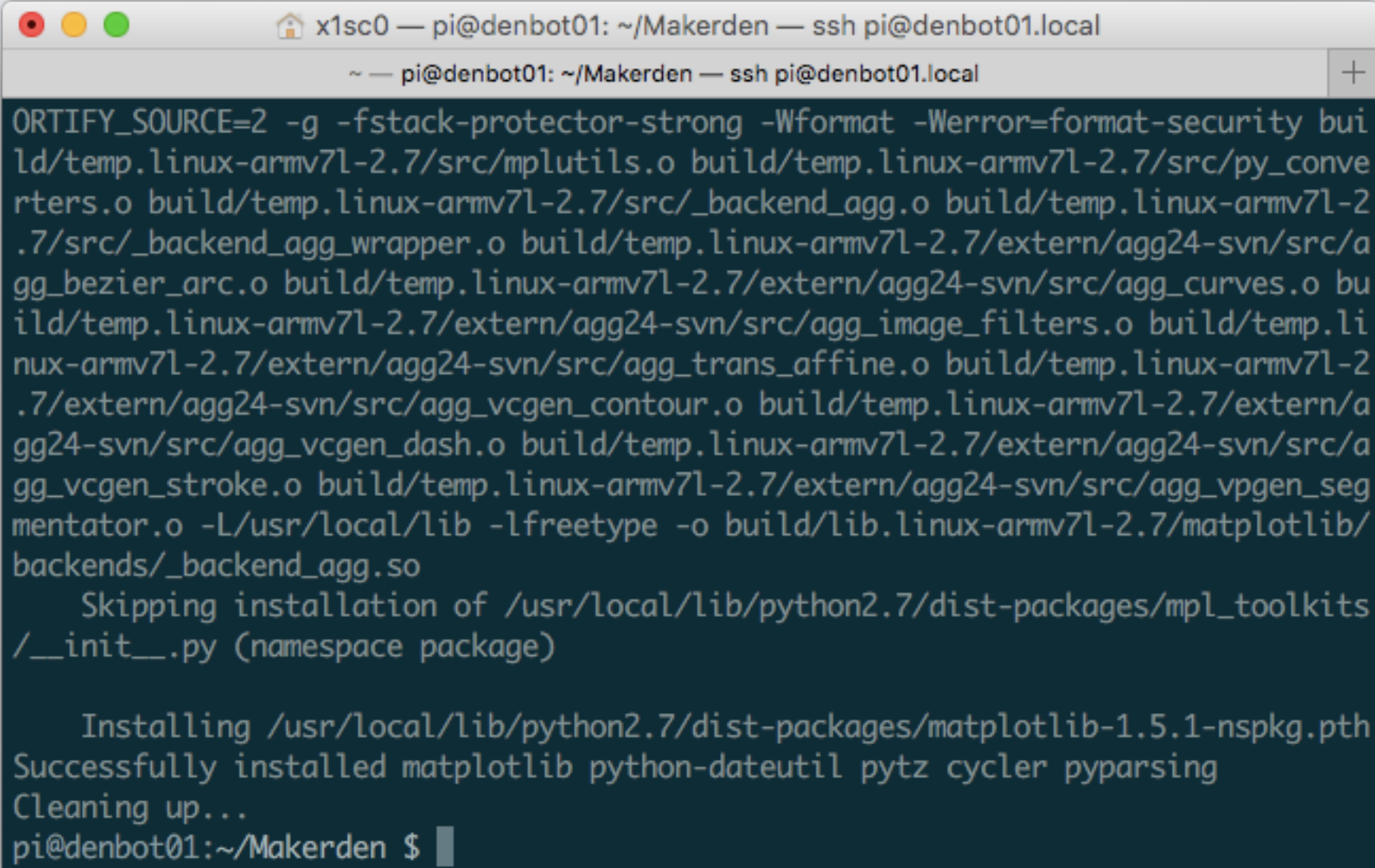
The Python Package Index (PyPI)

- Let's install a couple of 3rd-party modules using the program **pip**.

```
sudo apt-get update && sudo apt-get install python-dev python-pip
```

```
sudo pip install flask matplotlib werkzeug itsdangerous jinja2
```

*These steps might've already been completed by your instructor (-:

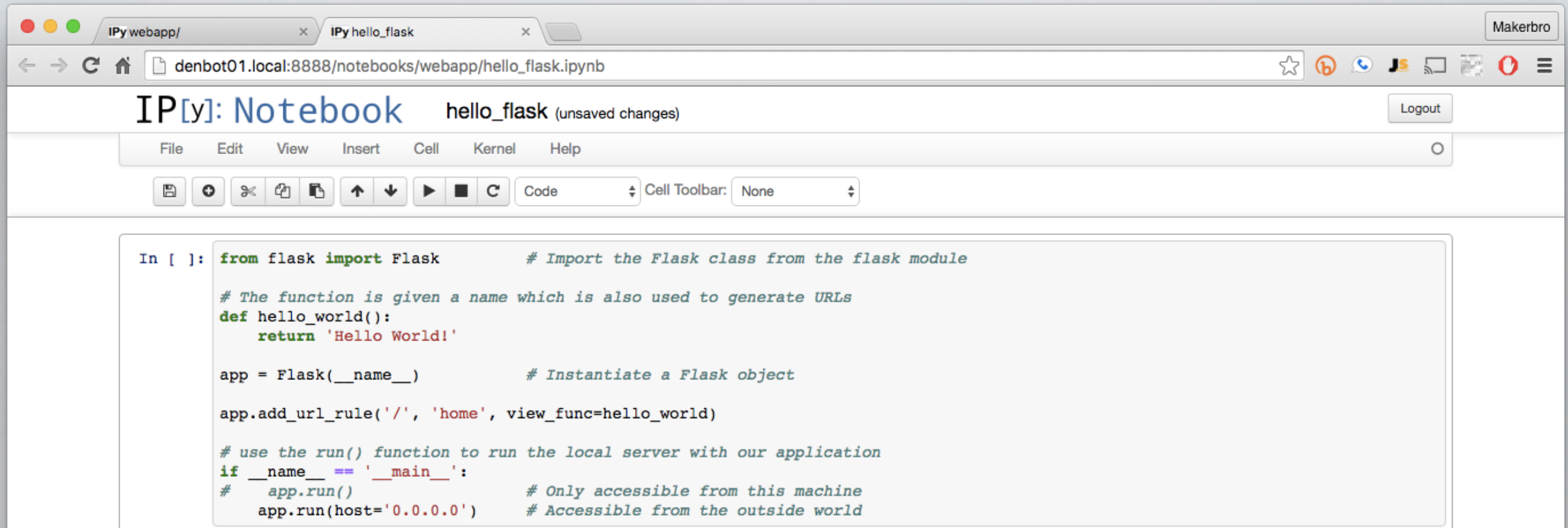


```
x1sc0 — pi@denbot01: ~/Makerden — ssh pi@denbot01.local
~ — pi@denbot01: ~/Makerden — ssh pi@denbot01.local
ORTIFY_SOURCE=2 -g -fstack-protector-strong -Wformat -Werror=format-security bui
ld/temp.linux-armv7l-2.7/src/mplutils.o build/temp.linux-armv7l-2.7/src/py_conve
rters.o build/temp.linux-armv7l-2.7/src/_backend_agg.o build/temp.linux-armv7l-2
.7/src/_backend_agg_wrapper.o build/temp.linux-armv7l-2.7/extern/agg24-svn/src/a
gg_bezier_arc.o build/temp.linux-armv7l-2.7/extern/agg24-svn/src/agg_curves.o bu
ild/temp.linux-armv7l-2.7/extern/agg24-svn/src/agg_image_filters.o build/temp.li
nux-armv7l-2.7/extern/agg24-svn/src/agg_trans_affine.o build/temp.linux-armv7l-2
.7/extern/agg24-svn/src/agg_vcgen_contour.o build/temp.linux-armv7l-2.7/extern/a
gg24-svn/src/agg_vcgen_dash.o build/temp.linux-armv7l-2.7/extern/agg24-svn/src/a
gg_vcgen_stroke.o build/temp.linux-armv7l-2.7/extern/agg24-svn/src/agg_vpgen_seg
mentator.o -L/usr/local/lib -lfreetype -o build/lib.linux-armv7l-2.7/matplotlib/
backends/_backend_agg.so
  Skipping installation of /usr/local/lib/python2.7/dist-packages/mpl_toolkits
/__init__.py (namespace package)

  Installing /usr/local/lib/python2.7/dist-packages/matplotlib-1.5.1-nspkg.pth
Successfully installed matplotlib python-dateutil pytz cyclr pyparsing
Cleaning up...
pi@denbot01:~/Makerden $
```

Python Web Application Using Flask

- With the necessary modules installed, let's use them to build a simple **web application!**



The screenshot shows a web browser window with two tabs: 'IPy webapp/' and 'IPy hello_flask'. The address bar shows the URL 'denbot01.local:8888/notebooks/webapp/hello_flask.ipynb'. The notebook interface has a title bar 'IP[y]: Notebook hello_flask (unsaved changes)' with a 'Logout' button. Below the title bar is a menu bar with 'File', 'Edit', 'View', 'Insert', 'Cell', 'Kernel', and 'Help'. A toolbar contains icons for saving, opening, and running cells, along with a 'Code' dropdown and a 'Cell Toolbar' dropdown set to 'None'. The main area displays a code cell with the following Python code:

```
In [ ]: from flask import Flask          # Import the Flask class from the flask module

# The function is given a name which is also used to generate URLs
def hello_world():
    return 'Hello World!'

app = Flask(__name__)          # Instantiate a Flask object

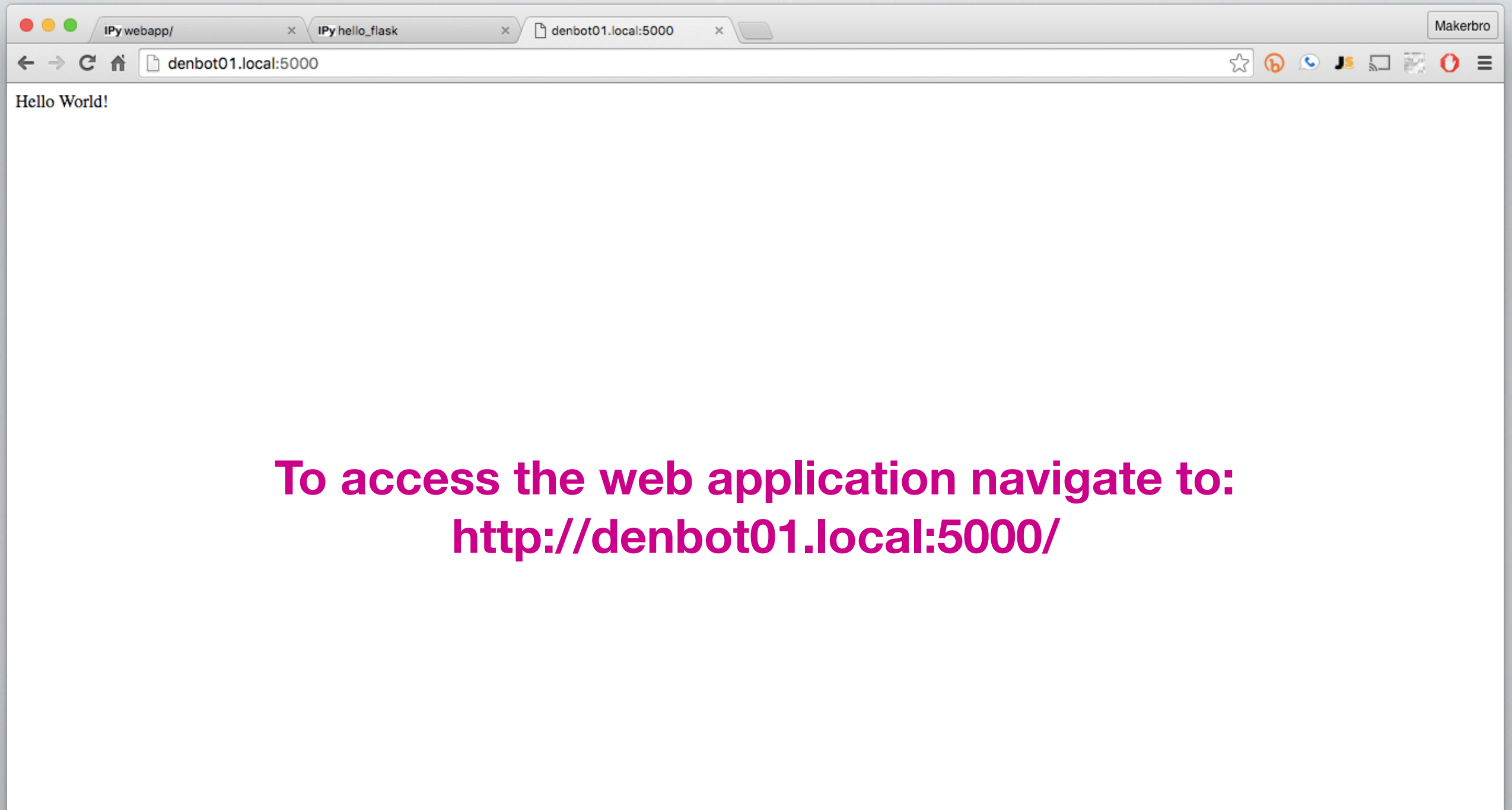
app.add_url_rule('/', 'home', view_func=hello_world)

# use the run() function to run the local server with our application
if __name__ == '__main__':
    # app.run()                # Only accessible from this machine
    app.run(host='0.0.0.0')    # Accessible from the outside world
```

Create a new notebook “hello_flask”
inside the webapp folder.

Python Web Application Using Flask

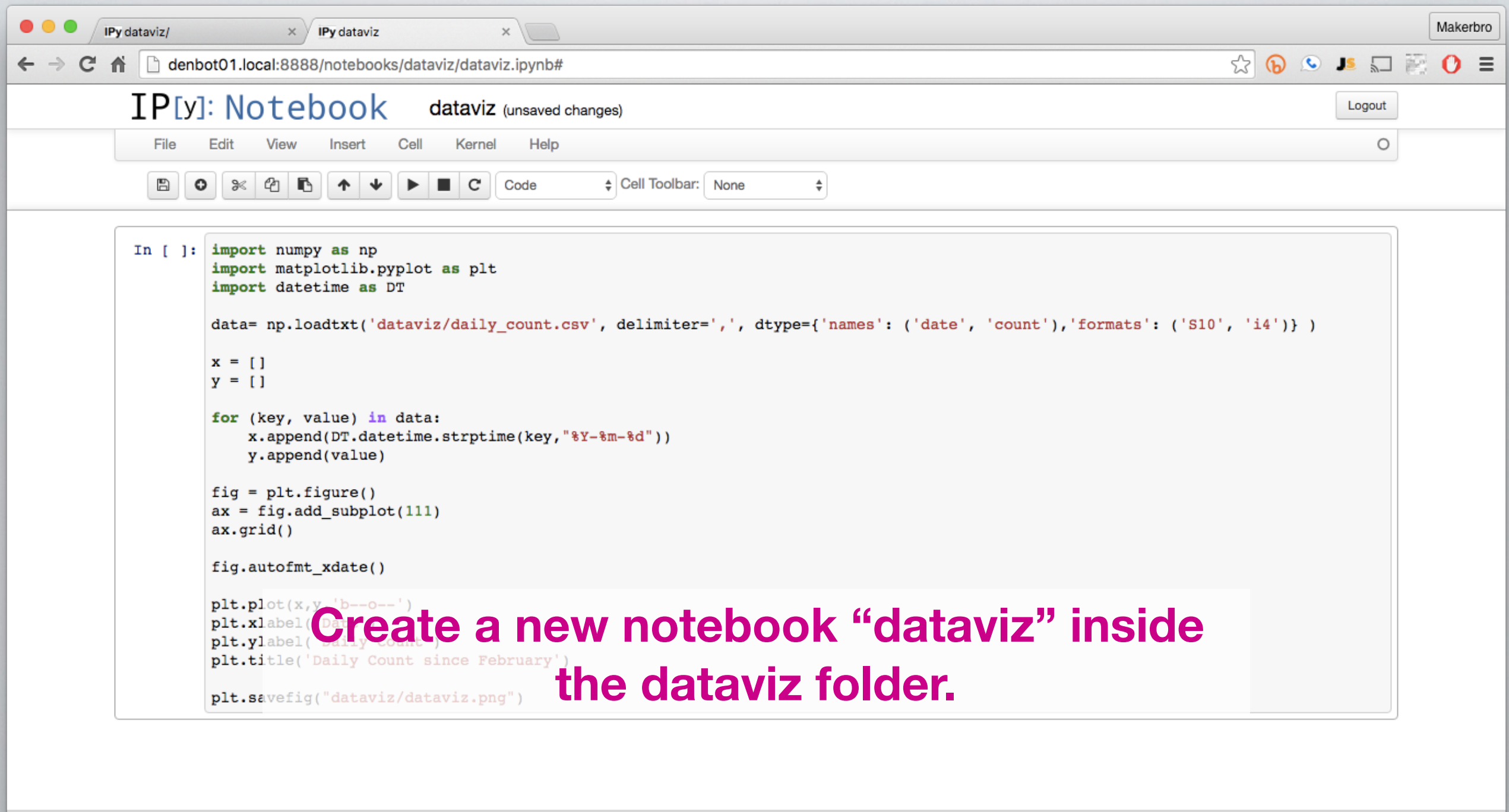
- With the necessary modules installed, let's use them to build a simple **web application**!



To access the web application navigate to:
<http://denbot01.local:5000/>

Python Dataviz Application Using Matplotlib

- With the necessary modules installed, let's use them to **plot data** in a **.csv** file!



The screenshot shows a web-based IPython Notebook interface. The browser address bar indicates the notebook is located at `denbot01.local:8888/notebooks/dataviz/dataviz.ipynb#`. The notebook title is "IP[y]: Notebook" with a subtitle "dataviz (unsaved changes)". A "Logout" button is visible in the top right. The interface includes a menu bar (File, Edit, View, Insert, Cell, Kernel, Help) and a toolbar with icons for saving, opening, and running code. The main area contains a code cell with the following Python code:

```
In [ ]: import numpy as np
import matplotlib.pyplot as plt
import datetime as DT

data= np.loadtxt('dataviz/daily_count.csv', delimiter=',', dtype={'names': ('date', 'count'),'formats': ('S10', 'i4')})

x = []
y = []

for (key, value) in data:
    x.append(DT.datetime.strptime(key, "%Y-%m-%d"))
    y.append(value)

fig = plt.figure()
ax = fig.add_subplot(111)
ax.grid()

fig.autofmt_xdate()

plt.plot(x,y, 'b--o--')
plt.xlabel('Date')
plt.ylabel('Daily Count')
plt.title('Daily Count since February')

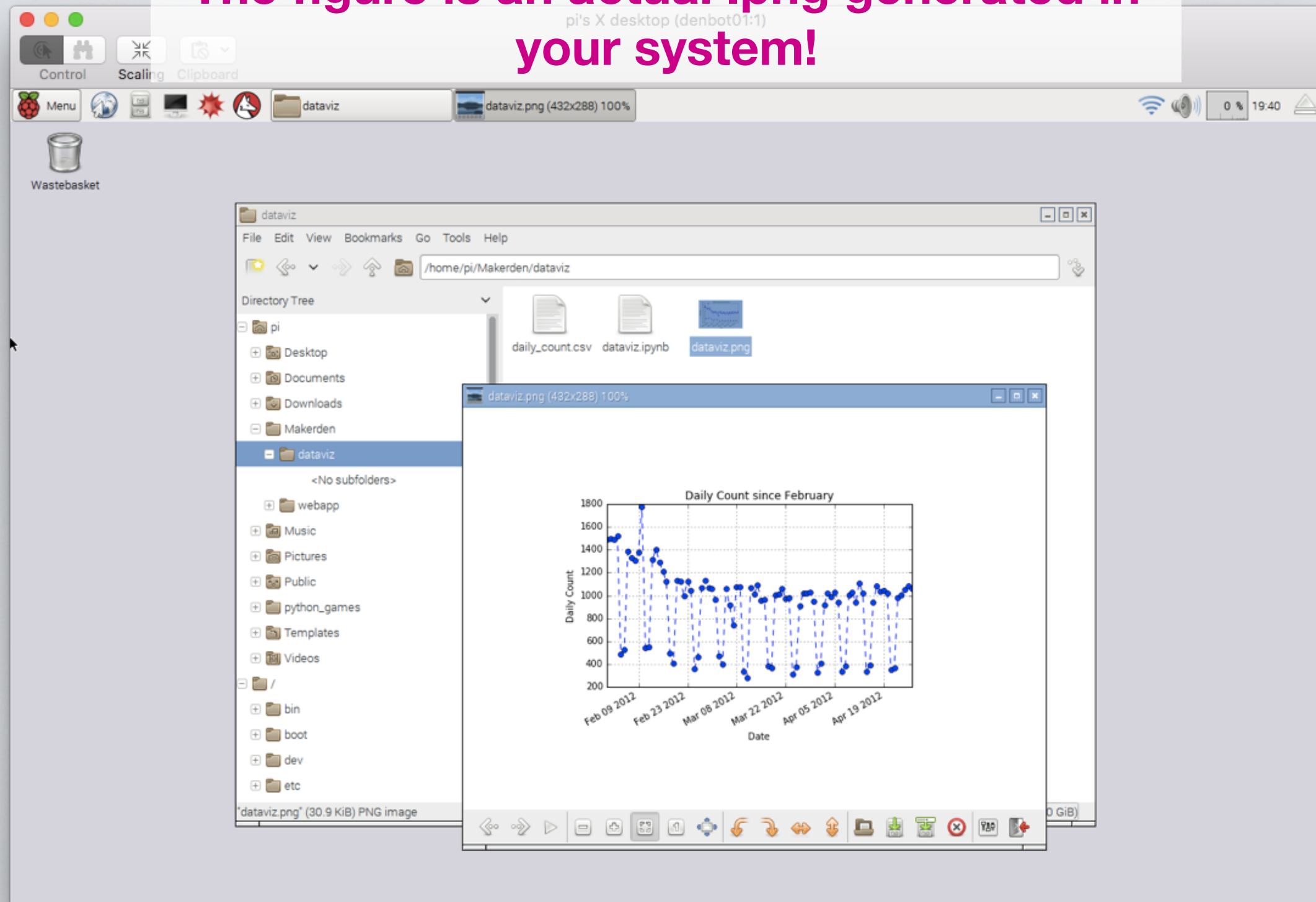
plt.savefig("dataviz/dataviz.png")
```

Overlaid on the bottom right of the code cell is a pink text box with the instruction: "Create a new notebook 'dataviz' inside the dataviz folder."

Python Dataviz Application Using Matplotlib

- With the necessary modules installed, let's use them to **plot data** in a **.csv** file!

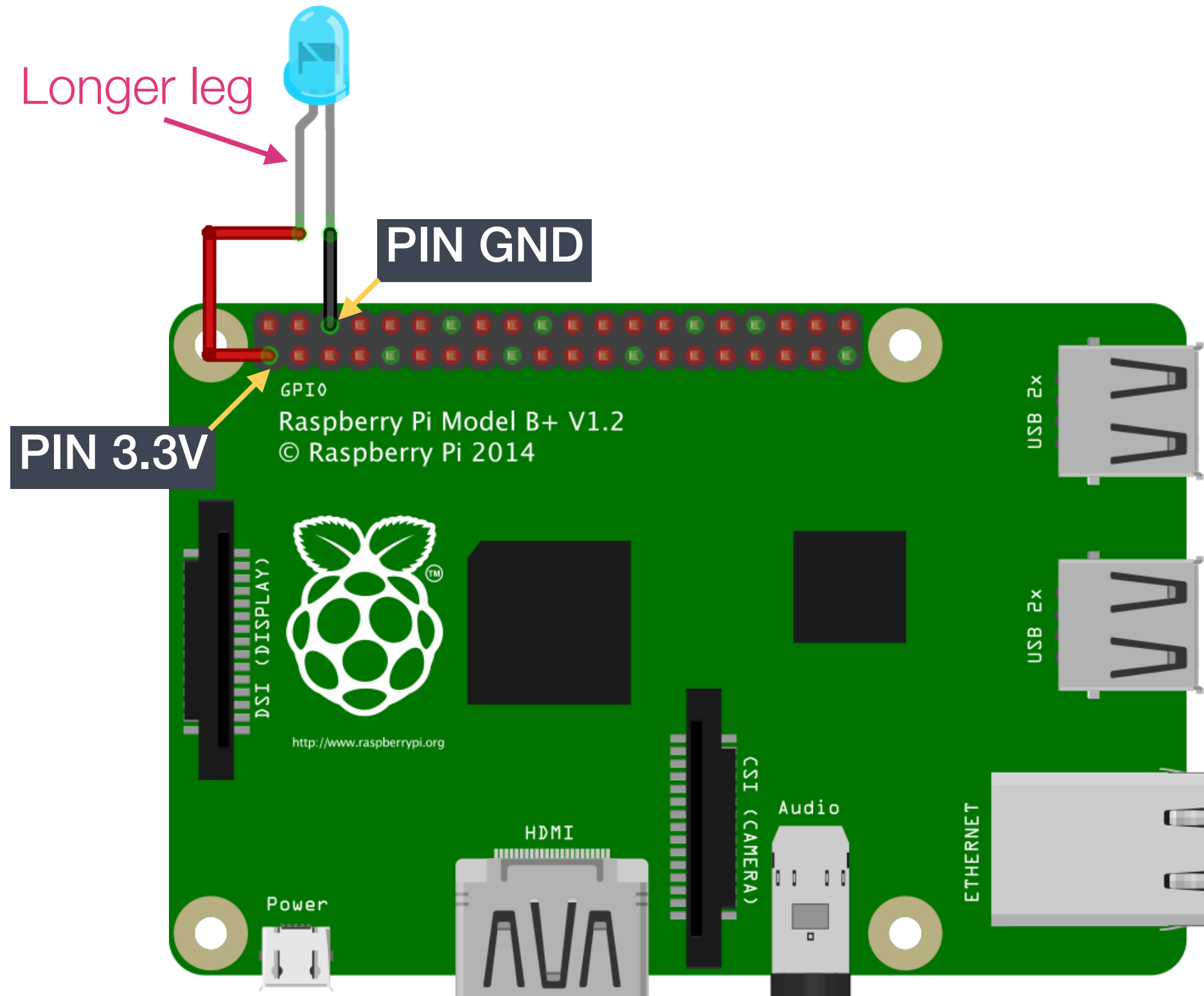
The figure is an actual .png generated in your system!



Writing Python Programs To Control Low-Level Hardware

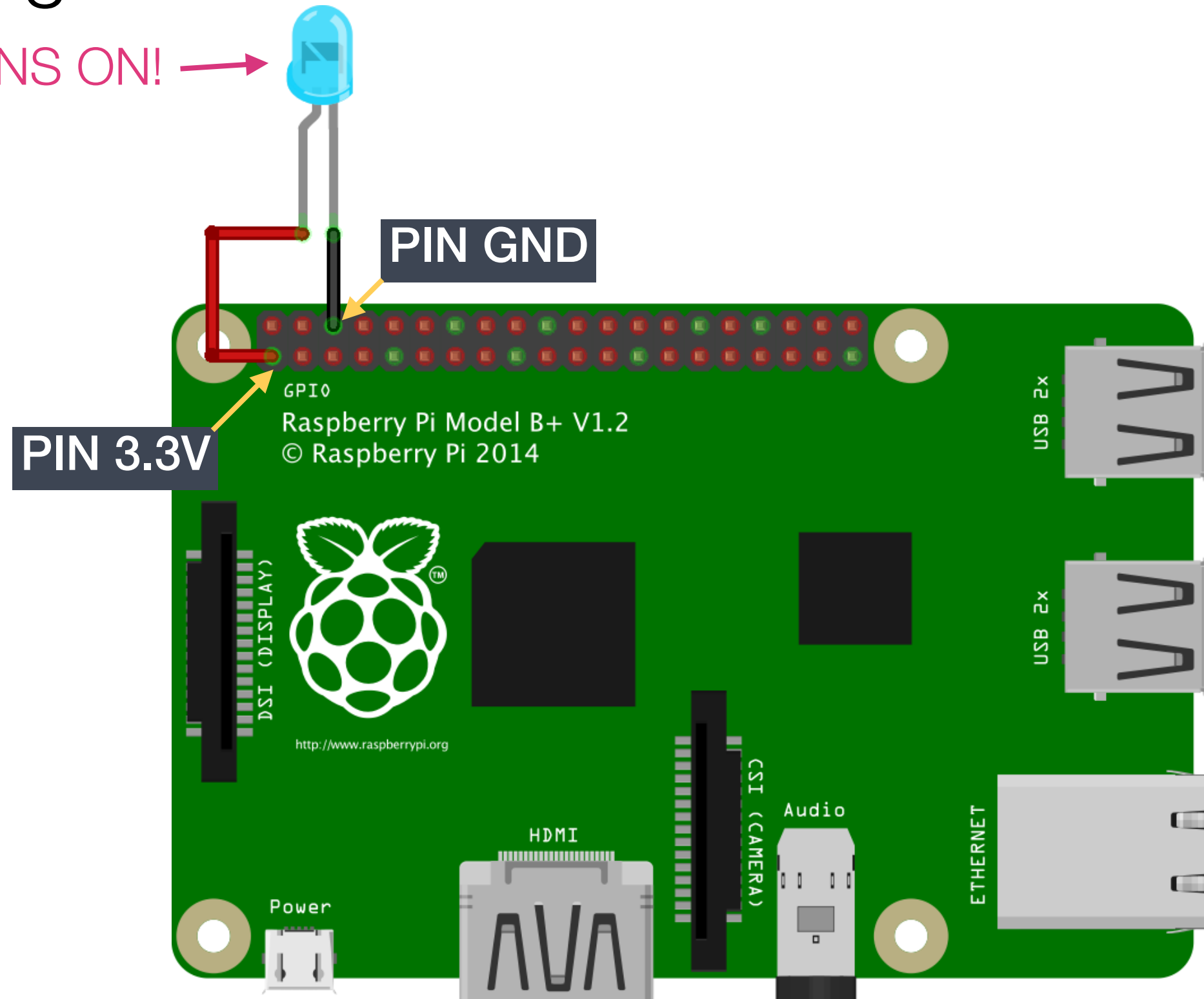
Wiring Your First Circuit

- Let's jump right into the deep-end and wire our first circuit!



Wiring Your First Circuit

TURNS ON! →



- We're using the power of the Raspberry Pi to turn on an LED!

Raspberry Pi2 GPIO Header

Pin#	NAME		NAME	Pin#
01	3.3v DC Power	⬜⬜	DC Power 5v	02
03	GPIO02 (SDA1 , I ² C)	⬜⬜	DC Power 5v	04
05	GPIO03 (SCL1 , I ² C)	⬜⬜	Ground	06
07	GPIO04 (GPIO_GCLK)	⬜⬜	(TXD0) GPIO14	08
09	Ground	⬜⬜	(RXD0) GPIO15	10
11	GPIO17 (GPIO_GEN0)	⬜⬜	(GPIO_GEN1) GPIO18	12
13	GPIO27 (GPIO_GEN2)	⬜⬜	Ground	14
15	GPIO22 (GPIO_GEN3)	⬜⬜	(GPIO_GEN4) GPIO23	16
17	3.3v DC Power	⬜⬜	(GPIO_GEN5) GPIO24	18
19	GPIO10 (SPI_MOSI)	⬜⬜	Ground	20
21	GPIO09 (SPI_MISO)	⬜⬜	(GPIO_GEN6) GPIO25	22
23	GPIO11 (SPI_CLK)	⬜⬜	(SPI_CE0_N) GPIO08	24
25	Ground	⬜⬜	(SPI_CE1_N) GPIO07	26
27	ID_SD (I ² C ID EEPROM)	⬜⬜	(I ² C ID EEPROM) ID_SC	28
29	GPIO05	⬜⬜	Ground	30
31	GPIO06	⬜⬜	GPIO12	32
33	GPIO13	⬜⬜	Ground	34
35	GPIO19	⬜⬜	GPIO16	36
37	GPIO26	⬜⬜	GPIO20	38
39	Ground	⬜⬜	GPIO21	40

Rev. 1
26/01/2014

<http://www.element14.com>

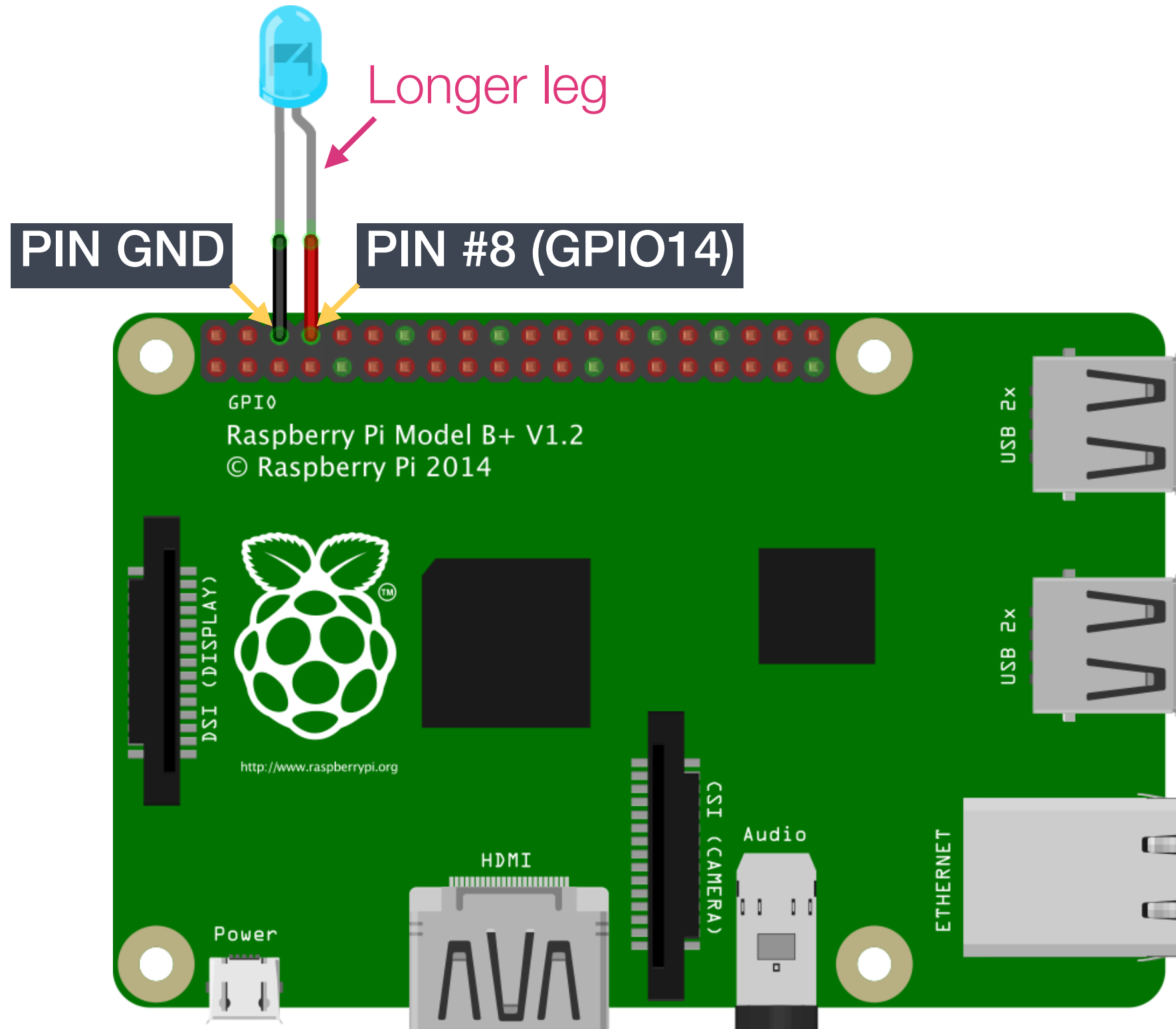


ACROBOTIC

Reference Labels PCB

- The 40 metal pins on the Raspberry Pi have different names related to their function!

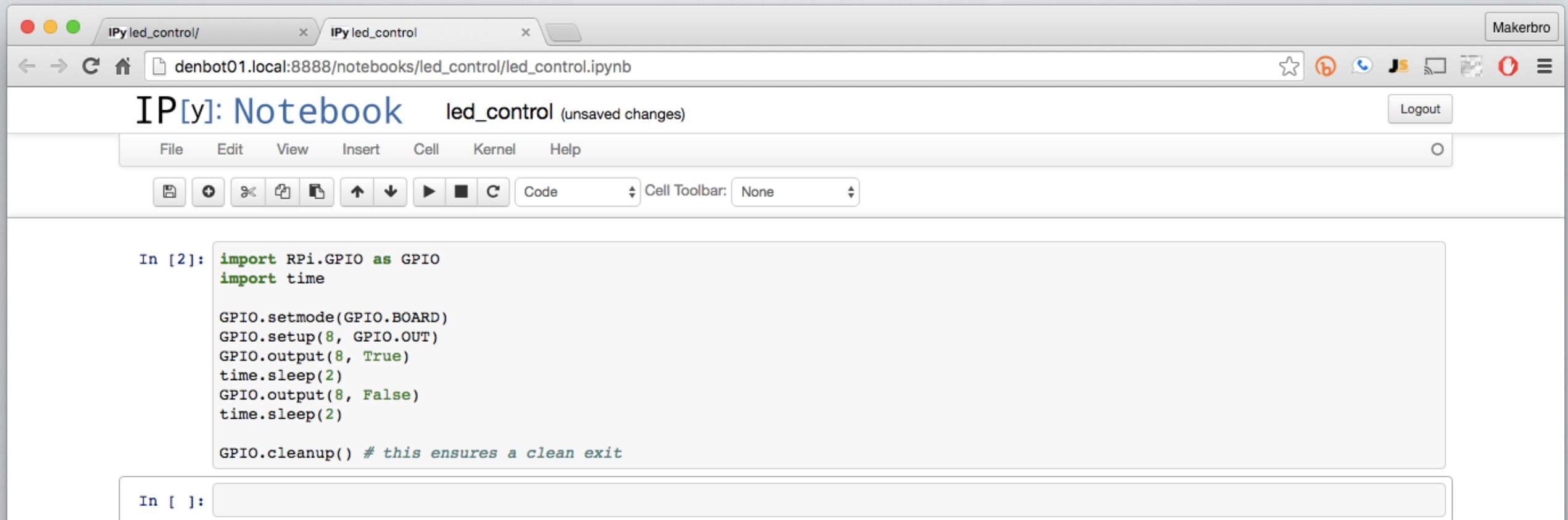
Wiring Your First Circuit



- Other pins (e.g., pin #8) can be controlled using Python!

Python LED Control Using RPi.GPIO

- Let's use the **RPi.GPIO module** to blink an LED!



The screenshot shows a web browser window with a Jupyter Notebook titled "led_control". The notebook contains a single code cell with the following Python code:

```
In [2]: import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BOARD)
GPIO.setup(8, GPIO.OUT)
GPIO.output(8, True)
time.sleep(2)
GPIO.output(8, False)
time.sleep(2)

GPIO.cleanup() # this ensures a clean exit
```

Below the code cell is an empty input field for the next command, labeled "In []:".

Create a new notebook “led_control”
inside the led_control folder.