Practical 2: Foundations (Part 1)

Getting to grips with the 'Basics'

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This notebook is focussed on ensuring that you're able to run Jupyter notebooks locally (i.e. on your own computer) in Docker and are comfortable with the basics of Python: if you've already done Code Camp then this will be a refresher and you'll have plenty of time to get to grips with Git and GitHub, which often presents significant practical challenges. You should find this notebook quite straightforward, but take any challenges as a sign that you need to keep practicing since subsequent weeks will build on these foundational concepts.



Remember

Please save your work regularly, or prepare to be disappointed. This will be my only reminder about this!

1 Setting Up

I'm going to assume that you've got Docker installed and have managed to 'pull' the jreades/sds:2025-amd or jreades/sds:2025-arm image at this point. If not, this is your most urgent priority. Please make one of us aware of your situation and we'll do our best to get you going.

1.1 Downloading the Practical

On the Week 2 of FSDS page you'll see that there is a 'preview' link and a a 'download' link in the Practical section. If you click the preview link you will be taken to the GitHub page for the notebook where it has been 'rendered' as a web page. But to make the notebook useable on your computer, you need to download the IPYNB file.

So now:

- 1. Click on the Download link.
- 2. The file should download automatically, but if you see a page of raw code, select File then Save Page As....
- 3. Make sure you know where to find the file (e.g. Downloads or Desktop).
- 4. Move the file to your GitHub repository folder (e.g. ~/Documents/CASA/fsds/)
- 5. Check to see if your browser has added .txt to the file name:
 - If no, then you can move to adding the file.
 - If yes, then you can either fix the name in the Finder/Windows Explore, or you can do this in the Terminal/PowerShell using my <name_of_practical>.ipynb.txt <name_of_practical>.ipynb (you can even do this in JupyterLab's terminal).
- 6. Now you can add it to Git and GitHub:
 - 1. git add <name_of_practical>.ipynb
 - 2. git commit -m "Adding Practical 2"
 - 3. git push

The file should now be in your GitHub repository in its 'original' format (before you write or run any code).

1.2 Running Docker

1.2.1 Making the Notebook Available to Jupyter Lab

To keep all of your notebooks and other CASA0013 content in Git/GitHub, you need to make sure that JupyterLab can access your local git repository. JupyterLab can only do this if the git folder is a child of the one where you ran docker run So if your git repo is ~/Documents/CASA/fsds/ then you need to make sure that you start Docker from ~/Documents/CASA/fsds, ~/Documents/CASA/ or ~/Documents/.

Wrong Place?

If you called docker run ... from the wrong place, then you will need to stop the container. Please see the section below.

Remember that the startup command is something like:

```
docker run ... -v "$(pwd):/home/jovyan/work" ...
```

The -v (short for volume) tells Docker what part of your computer (\$(pwd)) to connect to container (/home/jovyan/work). pwd is short-hand for 'print working directory' and is the location where you ran the Docker startup command! So we're talking

about the location on *your* computer when you access the work folder from within Docker/Jupyter Lab:

- On a Mac it will often be your \$HOME (also known as ~) directory (e.g. /Users/your_username/) because that's where new Terminal windows start by default.
- On a Windows machine it may be your \$HOME directory but we can't promise.

Perhaps a video will help clarify?

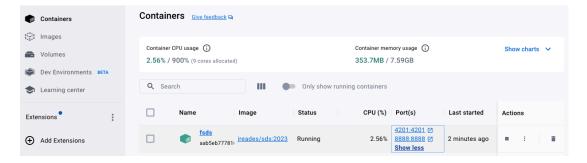
https://www.youtube.com/embed/5IkwUrYTY78

1.2.2 Is the Container Running?

Docker will happily keep a container running in the background even if you close every open window. So how do you know if the sds2024 container is already running? There are two ways:

1. Open the Docker Dashboard/Desktop from the menu and make sure that you select the Containers tab on the left (it may be hidden by a message from Docker about upcoming conferences). You should see something like this if the container is running and available:

Figure 1: Container running



2. From the Terminal/Power Shell you should be able to run: docker ps. This will give you output something like this:

Figure 2: Container running from Terminal



If the sds2024 container is not running then you'll need to run the startup command (docker run...) covered in the last practical session. If it is running but in the wrong place, then you should stop it, use cd to navigate to the correct location, and then restart it.

1.2.3 Connect to Jupyter Lab

Once you know the container is running you can connected to Jupyter Lab on local-host:8888 and should see something like this:

File Edit View Run Kernel Tabs Settings Help + **t** C ☑ Launcher Filter files by name work/fsds/practicals m / ... / fsds / practicals / Last Modified Notebook data a vear ago dtools a year ago 2 hours ago Practical-01-Getti.. an hour ago ■ Practical-02-Fou Python 3 (ipykernel) Practical-03-Fou.. Practical-04-Obie.. 6 days ago >_ Console Practical-05-Num... 6 days ago Practical-06-Spat... Practical-07-Text... 6 days ago Practical-08-Dim... 6 days ago 6 days ago Practical-10-Grou... 2 years ago ■ Practical-10-Grou... 2 years ago Practical-10-Grou... 2 years ago \$_ Other 6 days ago Practical-10-Grou... Practical-Supple... a vear ago Practical-X-Air_Q... a year ago M \$_ \Box ■ Practical-X-API_D... a year ago ■ Practical-X-Classi... 2 years ago Practical-X-Correl... a year ago Practical-X-Merge... a year ago Simple 0 **8** 0 **9**

Figure 3: Screenshot of JupyterLab

You're connected!

2 Running a Notebook

2.1 Hello World!

Nearly every introduction to programming course starts with the famous 'Hello World!', so why do anything different?

From within Jupyter Lab you should now able to create a new notebook:

- 1. Click on the Python (base) tile in the Notebook section.
- 2. You should see a new tab open with a new notebook (title: Untitled.ipynb).
- 3. In the first cell type print('Hello World!').
- 4. Click the Run button () in the menu above the notebook.
- 5. You should see Python output Hello World! below the cell.

Any time you want to run code you click on the right-triangle ($|\cdot|$); it's in the area between the clipboard $|\cdot|$ (for copying) and the $|\cdot|$ (for stopping running code).

So when you run:

```
print('Hello World!')
```

Hopefully, the following appeare directly below the code:

Hello World!



Tip

You can always click the $\frac{1}{2}$ icon above, but it will be much faster to get into the habit of type Ctrl+Enter instead when you have placed your cursor in a code cell. This is also how to turn a Markdown cell back into display text.

You can now close this notebook. Unless you created this notebook in the work folder, you will not be able to save it permanently. That's fine.

2.2 Starting the Practical Notebook

Now from within Jupyter Lab you should start the Practical 2 notebook:

- 1. Make sure Jupyter Lab is showing (/work/) in the left-hand menu.
- 2. Navigate to your git repo (where you saved Practical-02-Foundations_1.ipynb).
- 3. Double-click the file and the notebook should appear on the right-hand side.

Now you can run code directly in your browser, so let's try it!

3 Python Variables

Connections

This is a short recap of materials covered in this week's video on Python: the Basics as well as Code Camp's The Basics

3.1 Variable Names

Look closer!

Pay attention to the colour of the code, while it might be subtle (a single character in a different colour), it is giving you clues as to where problems might be found because it means the Python 'interpreter' is reading what you wrote differently from how you probably meant it...

Some of the lines of code below are valid Python, but others may have a problem that will cause Python to generate an error. Each error can be fixed by changing one character. See if you can work out which ones you need to fix before running the code:

```
Pi = 3.14159  # Valid Python

pi = 3.14159  # Valid Python

pi3 = 3.14159*3  # Invalid, variable starts with a number

pi_2 = 3.14159**2  # Valid Python

pi2 = 3.14159**2  # Invalid, 'hat' character in variable name

my_radius = 5  # Invalid, space in variable name

My_Radius = 5  # Valid Python

mclass = 5  # Invalid, reserved word
```

3.2 Variable Types

Before running the code below, work out what the output will be for *each* of the print commands below when the code is executed. Write them as comments on the same line as the code (after the #, see example).

Answer

```
x = '2'
y = z = 2

print(y * z)  # 4
print(x * y)  # ??
print(x + x)  # ??
print((y+z)**z)  # ??
print((y+z)**z)  # ??
print((y/(y+z))  # ??

print((type(x * y))  # ??
print((type(y * z))  # ??
print((type((y+z)**z))  # ??
print((type(y/(y+z)))  # ??
```

```
4
22
22
16
0.5
<class 'str'>
<class 'int'>
<class 'int'>
<class 'int'>
```

3.3 Assignment

Before running the code, work out what the values of x, y and z will be after every line of code in the block has been executed.

Answer

```
x = 12
y = 10
z = x + y
x = x + y
print(x)
print(y)
print(z)
```

22 32 22

Once you have worked out what you think x, y and z are, add print(...) statements to the code above to check your answers!

Make sure you understand the results you find. Ask someone if you need help to understand.

3.4 Operators & Precedence

Before running the code, work out what the values of x, y and z will be after every line of code in the block has been executed. Feel free to use a calculator.



🅊 Tip

This question is about what operations (i.e. multiplication, division, powers, etc.) are done first based on the type of operation and the presence of parentheses... it's the same as it would be for a maths problem!

Answer

```
x = 1 + (2 * 3) / 4
y = (1 + 2) * (3 / 4)
z = 1 + 2 * (3 / 4)
print(x) # x is
print(y) # y is
print(z) # z is
```

2.5

2.25

2.5

Once you have calculated what you think x, y and z are, run the code to check.

3.5 Test Your Operator Knowledge

Now let's look at some of the stranger operators. Many of these can be very useful in more complex code but can seem a little pointless now.

Work out what operator should replace the ?? in each of the lines of code below to produce the output I've shown in the comments. I've mixed in ones you have seen above with ones that we've not seen before.

Answer

```
x = 10
y = 3

print( x % y ) # 1
print( x + y ) # 13
print( x == y ) # False
print( x ** y ) # 1000
print( x - y ) # 7
print( x // y ) # 3
```

3.6 Applying What We've Learned

Now we are going to take what we've learned and apply it in a more 'abstract' way: how do we translate some well-known mathematical formulae *into code*? In particular, I'm interested in the formula for the volume of a sphere (and this gives me a chance to show that Notebooks can show formulae as well!):

$$V = \frac{4}{3}\pi r^3$$

3.6.1 Calculate the Volume of a Sphere

So, given a sphere with a **diameter** of 12cm, calculate its volume:



I would strongly advise you to Google: python constant pi and look for code that will save you having to write down the value of π .

Answer

```
from math import pi
v = (4/3) * pi * (12/2)**3
print(f"{v:0.3f}")
```

904.779

I get an answer of 904.779cm³.

3.6.2 Calculate the Radius of a Sphere

Now, given a sphere of volume 14,137cm³ calculate its radius as a **whole number**. The formula for this can be worked out as:

$$\frac{\frac{3}{4}V = \pi r^3}{\frac{3}{4}\frac{V}{\pi}} = r^3$$
$$(\frac{3}{4}\frac{V}{\pi})^{1/3} = r$$

If you can't remember how to rearrange formulae this would be a good skill to refresh!



Tip

There are three ways to get a "whole number" from a float:

- 1. When you're starting out, the easiest is to change the variable's type
- 2. The next step up is to make use of Google to find out if there are ways of rounding to the nearest integer
- 3. The third step is to change what's visible to the user without altering the actual number

I get an answer of either 14 or 15... can you work out why?

```
from math import pi
\vee = 14137
r = ((3 * v) / (4 * pi))**(1/3)
print("1. " + str(int(r)) + " cm")
print("2. " + str(round(r)) + " cm")
print("3. " + f"{r:0.0f} cm")
```

```
1. 14 cm
```

- 2. 15 cm
- 3. 15 cm

4 Python Conditions

Connections

This is a short recap of material covered in Code Camp's Truth & Conditions and, to some extent, the Iteration lecture.

4.1 Working with Conditions

Use if, elif, and else so that you get the following output:

- 1. When hours is 10 or more, then the code prints At least 10 hours worked!
- 2. When hours is exactly 2, then the code prints Exactly 2 hours worked.
- 3. When hours is 9 or less but not 2, then the code prints Less than 10 hours worked!



You will also need to think about the order in which these conditions are tested.

Answer

```
hours=2

if hours == 2:
    print("Exactly 2 hours worked")

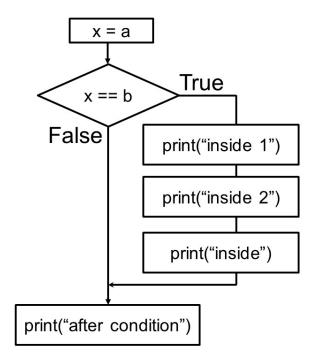
elif hours < 10:
    print("Less than 10 hours worked!")

else:
    print("At least 10 hours worked!")</pre>
```

Exactly 2 hours worked

4.2 Flow Control

Using the flow chart shown in the image below as a model, write the code to make this condition work. You will need to complete the code such that it produces the following: 1. When a = 2 and b = 2 four lines of output will be written 2. When a = 1 and b = 2 one line of output will be written



Answer

```
a = 1
b = 1

x = a

if x == b:
    print("inside 1")
    print("inside 2")
    print("inside")

print("after condition")
```

inside 1
inside 2
inside
after condition

5 Python Logic

i Connections

This is a short recap of Code Camp's Boolean Logic session and the Pthon: the Basics lecture.

5.1 It's All Quite Logical...

Before adding a value for \times and running the code below, try to answer the following questions:

Answer

- 1. What names are name(s) are printed when x = 5? **Answer**: Aled
- 2. What value(s) can ${\bf x}$ be when the names Joe and Aled are printed? Answer: $x \in [1,4]$
- 3. What name(s) are printed when x = -1? Answer: Aled and Sarah
- 4. Is there any value for which all three names will be printed? NO

```
x = 0

if x > 0 and x < 5:
    print("Joe")

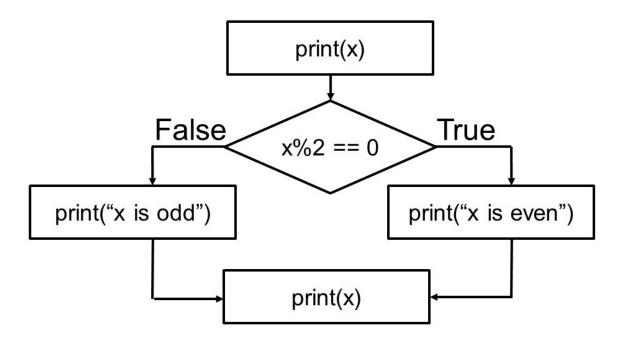
if x > 0 or x < 5:
    print("Aled")

if not(x > 0):
    print("Sarah")
```

Aled Sarah

5.2 Logic (Cont'd)

Study the flow chart below.



Tip

This will require you to combine logic with one of the operators that we saw earlier. Also note the *new* iterator that we've got here: range(<start>, <stop>) to create a range of numbers between two other numbers.

In the cell below, use the for loop *already set up* to as a starting point for implementing the flow chart shown above for values of \times between 0 and 9.

Answer

```
for x in range(0,9):
    #... do something...
    if x%2==0:
        print("x is even.")
    else:
        print("x is odd")
    print(x)
```

```
x is even.
0
x is odd
1
x is even.
2
x is odd
3
x is even.
4
x is odd
5
x is even.
6
x is odd
7
x is even.
8
```

5.3 'Nested' Conditionals

Conditional statements can be nested within one another. That is, Python evaluates the first, or 'outer', condition and can then evaluate secondary, or 'inner', conditions. The code below shows an example of this.

```
x is not equal to y
x is less than y
```

Note how the indentation makes it easier to work out which 'level' (outer or inner condition) the code is operating on. In the code above, lines 4 and 7 are at the same indentation meaning that *both will be skipped* if the initial condition (on line 1) is False.

To check you understand how the code above works:

- 1. Change <insert conclusion here> to a string that explains the condition of x and y
- 2. For x = 2 and y = 3, type what line(s) will be output here: ...

Great! You should now have a pretty good understanding of how conditional and logical operators work. This understanding will be handy in future as we work through other computational concepts.

6 Python Lists

Connections

This is a short recap of material covered in the Lists lecture and Code Camp's Lists session.

6.1 Who's in the List?

Here we are looking to interact with lists in a straightforward way that will help you to understand accessing them using indexes and slices, and searching.

```
cities = ['New York', 'London', 'Beijing', 'Tokyo', 'Delhi']

# Print out London from cities:
print( cities[1] )

# Print out Tokyo using *negative* indexing:
print( cities[-2] )

# Print out Beijing and Tokyo using a list slice
print( cities[2:4] )

# Print out London to Delhi using a slice
print( cities[1:] ) # You could also do cities[1:5] but this way is neater

# Combine positive and negative indexing to print out London, Beijing and Tokyo usin print( cities[1:-1] )

# Print out the position of New York in the list by searching for it (i.e. you can't print( cities.index('New York') )
```

```
London
Tokyo
['Beijing', 'Tokyo']
['London', 'Beijing', 'Tokyo', 'Delhi']
['London', 'Beijing', 'Tokyo']
```

6.2 Manipulating Lists

Let's break a few things...

6.2.1 Create an IndexError

Answer

```
```{python}
cities[7]
```
```

6.2.2 Create a ValueError

```
```{python}
cities.index('Toronto')
```
```

6.2.3 Sort the List

Sort the list *in place* in reverse alphabetical order (i.e. z...a) and then print the sorted list

Answer

```
# The approach does _not_ sort the original list,
# it returns a copy of the list that is sorted:
print(sorted(cities, reverse=True)) # <- what is printed is sorted
print(cities) # <- but the list is not

# This is the 'in place' option
cities.sort(reverse=True) # <- list is now sorted
print(cities)</pre>
```

```
['Tokyo', 'New York', 'London', 'Delhi', 'Beijing']
['New York', 'London', 'Beijing', 'Tokyo', 'Delhi']
['Tokyo', 'New York', 'London', 'Delhi', 'Beijing']
```

6.3 Adding/Removing Values

6.3.1 Inserting into a List

Add the city of Toronto to the list after New York in the sorted list.

Answer

```
# Just in case you make a mistake...
cities = ['Tokyo', 'New York', 'London', 'Delhi', 'Beijing']
cities.insert(2,'Toronto')
print(cities)
```

```
['Tokyo', 'New York', 'Toronto', 'London', 'Delhi', 'Beijing']
```

The output should be: ['Tokyo', 'New York', 'Toronto', 'London', 'Delhi', 'Beijing']

6.3.2 Removing from a List

Now pop New York from the list without specifying its index (i.e. the number 1 should not appear in your code). Print out the value that you popped and the print out the cities list to check you've done the right thing...

```
p = cities.pop( cities.index('New York') )
print(p)
print(cities)
```

```
New York
['Tokyo', 'Toronto', 'London', 'Delhi', 'Beijing']
```

The output should be:

- New York
- ['Tokyo', 'Toronto', 'London', 'Delhi', 'Beijing']

6.3.3 Checking Lists

Finally, how can you check if the city of Moscow is in the list and let the user know if it is or is not?

Answer

```
if 'Moscow' in cities:
    print("Moscow is in the cities list.")
else:
    print("Moscow is not in the cities list.")
```

Moscow is not in the cities list.

6.4 You're Done!

This is quite a lot to get through. If you've managed it in under 2 hours then *congratulations*! Either you must have paid a lot of attention when doing Code Camp, or you might want to check in with us as to whether you should really be doing this module...

6.4.1 No Wait, One More Thing...

You now want to add/commit/push your completed notebook to your GitHub reposistory. Using the Terminal (macOS or from with Jupyter/Docker) or Git Bash (Windows) you need to:

- 1. Navigate to your repository (e.g.\$HOME/Documents/CASA/<your repository>).
- 2. Check the status of your notebooks using git status (you should see that Practical-02-Foundations_1.ipynb has been modified).
- **3. Add the changes to Git using** git add Practical-02-Foundations_1.ipynb
- 4. Commit this changed notebook with a message using git commit -m "<your message here...>"
- 5. Push this change to GitHub using: git push

You should now be able to visit your repository on GitHub and see that your changes are now stored there as well!

i Note

If you are using Docker then you can also save your work as a PDF using: File > Export Notebook As... (this does not work for notebooks with lots of complex formatting).

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