Practical 2: Foundations (Part 1)

Getting to grips with the 'Basics'

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This week is focussed on ensuring that you're able to run Jupyter notebooks locally (i.e. on your own computer) 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.

0.1 Learning Outcomes

- You have familiarised yourself with how to add and synchronise new files in Git/GitHub.
- You have refamiliarised yourself with Python operators and precedence.
- You have refamiliarised yourself with Python logic and lists.

These are the foundations for subsequent weeks, so if you are still confused at the end of the practical please look at Code Camp and re-run this practical from scratch if need be!

1 Starting the Practical

The process for every week will be the same: download the notebook to your `fsds` folder; `add`, `commit`, and `push` the notebook in Git; switch over to `JupyterLab` (which will be running in Podman) and get to work. When you're done for the day, save your changes to the file, then `add`, `commit`, and `push` your work to save the completed notebook.

In your GIS class you will be using the Git Desktop, and if that works for you then I won't insist you use the Terminal; however, I will note that Git only started to make sense (and problems only began to become easier to resolve) once I switched to the Terminal from Git Desktop.

1.1 Download the Notebook

So for this week, visit 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 Git 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 using `mv <name_of_practical>.ipynb.txt <name_of_practical>.ipynb` (you can even do this in JupyterLab's terminal if it's already running).

1.2 Add the Notebook to Git

1. Now you can add it to Git and synchronise it with 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).

1.3 Switch to JupyterLab

I am assuming that you are already running JupyterLab via Podman using the command that we saw in Week 1 and on the CASA Computing Platform. However, if you called `podman run ...` from the 'wrong place' then you might not be able to see the recently added practical in your work folder.

It that's the case, then you will need to stop the container so please see the section below. You need to remember that the startup command is something like:

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

The `-v` (short for *volume*) tells Podman what part of *your* computer should be connected to place in container where we store the work (`/home/jovyan/work`). `pwd` is short for 'print working directory' and is the location where you ran the startup command! So we're talking about the location on *your* computer when you access the `work` folder from Jupyter Lab:

- On a Mac, if you just opened a new Terminal and run the Podman startup command then it will 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?

Note: Docker and Podman are basically the same!

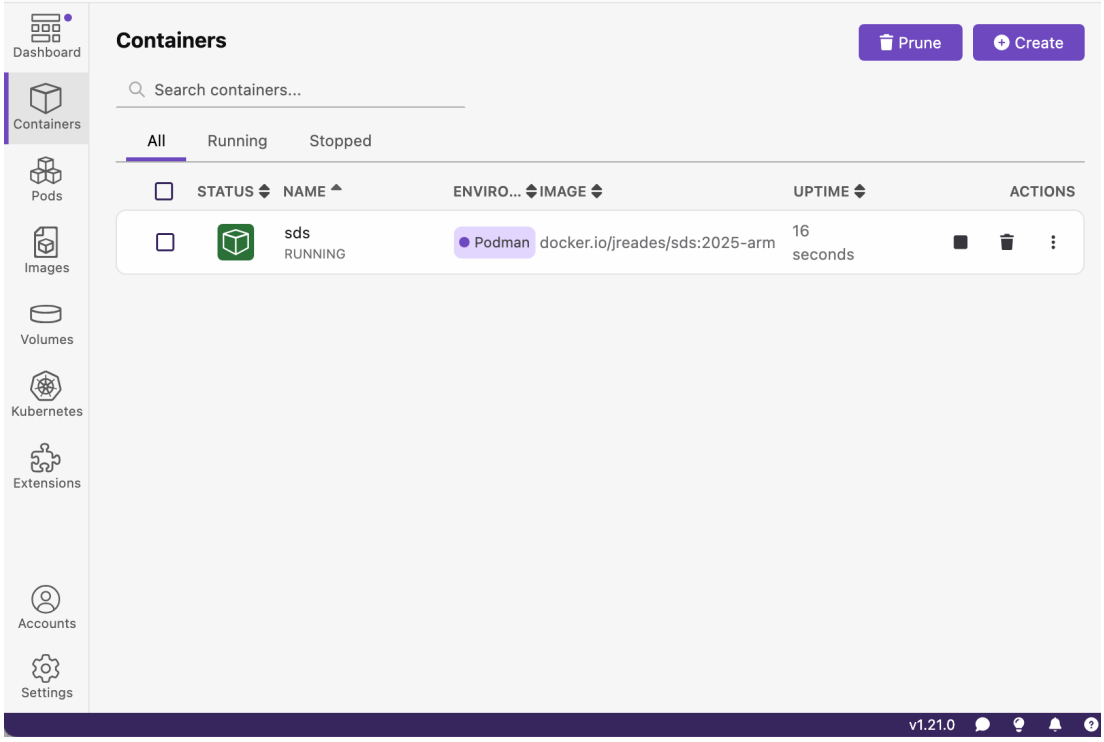
https://www.youtube.com/embed/5IkwUrYTY78

1.4 Is the Container Running?

Podman will happily keep a container running in the background even if you close every open window. So how do you know if the `sds2025` container is already running? There are two ways:

1. Open the Podman Desktop from the menu and make sure that you select the `Containers` tab. You *should* see something like this if the container is *running* and *available*:

Figure 1: Container running



1. From the Terminal you should be able to run: `podman ps`. This will give you output something like this:

Figure 2: Container running from Terminal

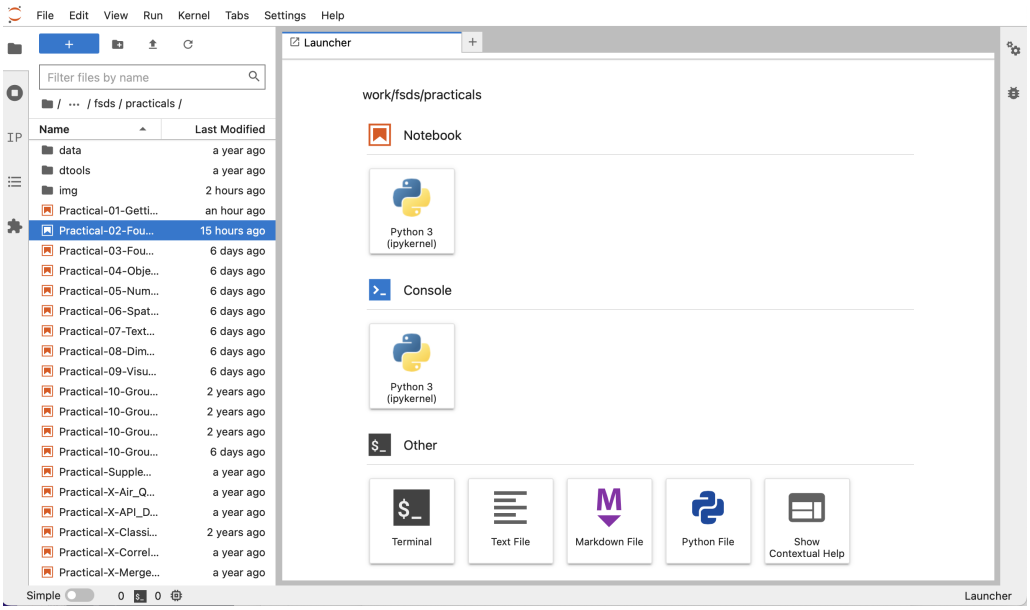
```
➜  ~ podman ps
CONTAINER ID  IMAGE                          COMMAND               CREATED        STATUS                  PORTS       NAMES
af7ee80ccf6d  docker.io/jreades/sds:2025-arm  start.sh jupyter ...  4 minutes ago  Up 4 minutes (healthy)  8888/tcp    sds
➜  ~
```

If the `sds2025` *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.

1.4.1 Connect to Jupyter Lab

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

Figure 3: Screenshot of JupyterLab



You're connected!

2 Running the 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 3` 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 ( ); it's in the area between the clipboard (for copying) and the ■ (for stopping running code).

So when you run:

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

Hopefully, the following appears directly *below* the code:

```
Hello World!
```

> **Tip**
>
> You can always click the 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. Starting from the `work` folder, navigate to your repo folder where you saved this notebook (`Practical-02-Foundations_1.ipynb`).
2. Double-click the notebook file and the notebook should appear on the right-hand side. If all you see is reams of plain text then there is probably still a `.txt` extension on your notebook file that hasn't been removed.

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**:

Question

```
Pi = 3.14159      # Valid Python
pi = 3.14159      # ??
3pi = 3.14159*3   # ??
pi_2 = 3.14159**2 # ??
```

```
pi^2 = 3.14159**2 # ??
my radius = 5     # ??
My_Radius = 5     # ??
class = 5         # ??
```

3.2 Variable Types

Using only the values for `x`, `y`, and `z`, what operations allow you to print the following?

```
6
22
22
125
0.4
```

Question

```
x = '2'
y = 2
z = 3

print(y ?? ) # 6
print(x ?? ) # 22
print(x ?? ) # 22 (but a different way!)
print((y+z) ?? ) # 125
print(y ?? ) # 0.4
```

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.

Question

```
x = 12
y = 10

z = x + y # ??
x = x + y # ??
y = z + y # ??

print(x)
print(y)
print(z)
```

Once you have worked out what you think `x`, `y` and `z` are, run the code 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!

Question

By adding parentheses adjust the equations below to output the following:

```
2.5
2.25
2.5
```

```
# Add parentheses to get the outputs above
print(1 + 2 * 3 / 4)
print(1 + 2 * 3 / 4)
print(1 + 2 * 3 / 4)
```

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.

Question

```
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:

> Tip
>
> 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.

Question

```
from math import ??
v = ??
print(f"{v:0.3f} cm3")
```

I get an answer of 904.779cm^3.

3.6.2 Calculate the Radius of a Sphere

Now, given a sphere of volume 14,137cm^3 calculate its radius as a **whole number**. The formula for this can be worked out as:

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

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?

Question

```
from math import pi
v = 14137
r = ??
print(??)
```

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!`

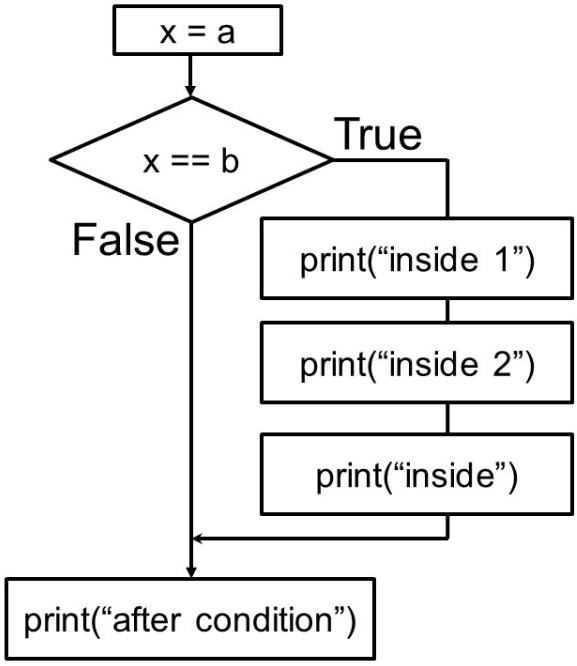
> **Hint**
>
> You will *also* need to think about the order in which these conditions are tested.

Question

```
hours = 2

if hours ??:
    print(" ")
elif hours ??:
    print(" ")
else:
    print(" ")
```

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



Question

```
a = 1
b = 1

# <your code here>
??
```

5 Python Logic

> **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 `x` and running the code below, try to answer the following questions:

Question

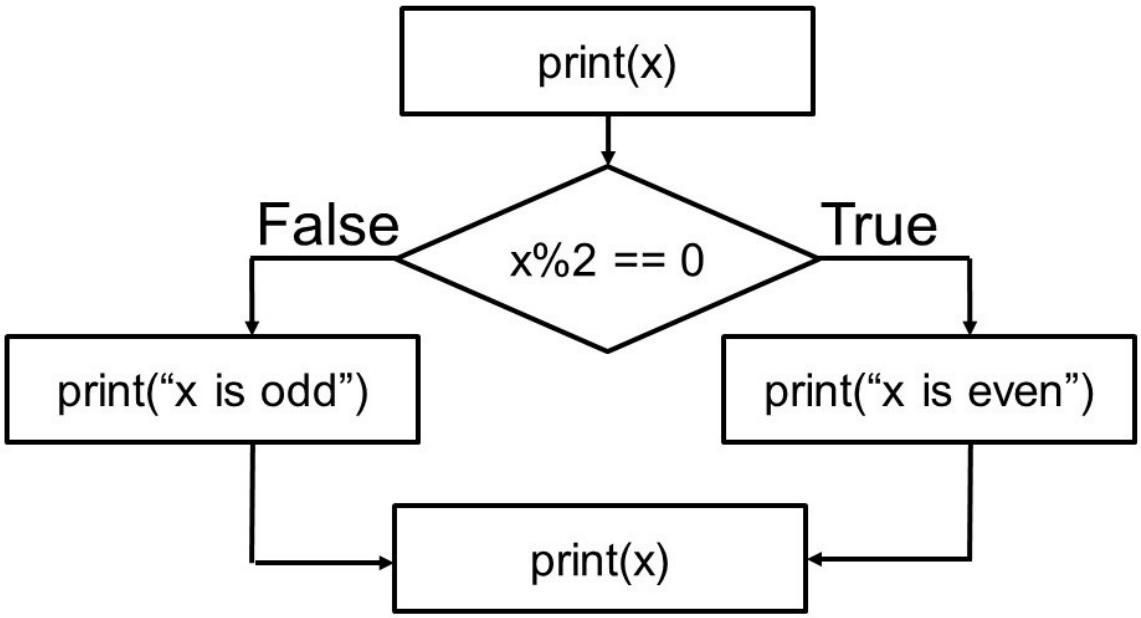
1. What names are name(s) are printed when `x = 5`?
2. What value(s) can `x` be when the names `Joe` and `Aled` are printed?
3. What name(s) are printed when `x = -1`?

4. Is there any value for which all three names will be printed?

```
x = ??

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

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

if not(x > 0):
    print("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 `x` between 0 and 9.

Question

```
for x in range(0,9):
    #... do something...
    ??
```

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.

Question

```
x = 5
y = 4

if x != y:                                  #line 1
    print("x is not equal to y")

    if(x > y):                              #line 4
        print("x is greater than y")

    else:                                   #line 7
        print("x is less than y")

else:
    print("<insert conclusion here>")
```

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.

Question

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

# Print out London from cities:
print( ?? )

# Print out Tokyo using *negative* indexing:
print( ?? )

# Print out Beijing *and* Tokyo using a list slice
print( ?? )

# Print out London to Delhi using a slice
print( ?? ) # 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( ?? )

# Print out the index for New York by searching for it (i.e. you can't just type 0)
print( ?? )
```

6.2 Manipulating Lists

Let's break a few things…

6.2.1 Create an IndexError

Question

```
# Cause an 'IndexError: list index out of range' errr
??
```

6.2.2 Create a ValueError

Question

```
# Cause a ValueError using the city of 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

Question

```
??
print(cities)
```

The output from this should be: [‘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.

Question

```
# Just in case you make a mistake...
cities = ['Tokyo', 'New York', 'London', 'Delhi', 'Beijing']

??
print(cities)
```

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…

Question

```
??
print(p)
print(cities)
```

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?

Question

```
if ??
    ??
else:
    ??
```

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 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!