MECH5311/6311 : ADVANCED FINITE ELEMENT ANALYSIS
PROGRAMMING BACKGROUND SETUP GUIDE

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The guide provides instructions for setting up a **programming environment** necessary for running Python codes (including advanced modules such as **FEniCsx**) that are part of this course. The language and approach has been chosen so that it is easy to follow for people with all levels of experience.

Before setting up the programming environment, it is necessary to install **Anaconda** because it allows easy creation of virtual **conda** environments from commands or **.yml** files.

This is essential for efficient package management.

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PROGRAMMING BACKGROUND SETUP GUIDE

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A. Installation for MacOS

STEP 1

Go to the Anaconda Website and download the 64-Bit Graphical Installer (688MB) or directly download the file from here. Delete the installer after installation to save space.

STEP 2

Install Anaconda using the Anaconda Graphical installer. You may follow the documentation here for installation on macOS.

STEP 3

Open **Terminal** and run the following command to switch the default shell from **zsh** to **bash**. Copy and paste the commands to the terminal for convenience. Press enter to run the command:

chsh –s /bin/bash

STEP 4

Run the following commands to create a conda environment named **advfea** and activate the environment:

conda create -n advfea

conda activate advfea

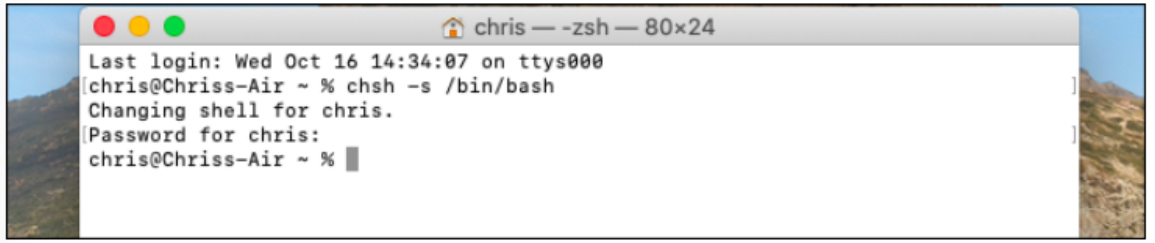
From the Terminal

To change a user account's default shell on macOS, simply run the `chsh -s` (change shell) command in a Terminal window.

Change the default shell to Bash by running the following command:

```
chsh -s /bin/bash
```

You'll have to enter your user account's password. Finally, close the Terminal window and reopen it. You'll be using Bash instead of Zsh.



Change the default shell back to Zsh by running this command:

```
chsh -s /bin/zsh
```

STEP 5

Install the necessary packages in the environment **advfea** by running the following codes consecutively:

```
conda install -c anaconda jupyter
```

```
conda install -c anaconda ipykernel
```

```
conda install -c conda-forge jax
```

```
conda install -c conda-forge matplotlib
```

```
conda install -c anaconda sympy
```

```
conda install -c conda-forge fenics-dolfinx mpich pyvista
```

The last installation might take a long time.

STEP 6

Include your environment in the jupyter notebook kernels using the following command :

```
python -m ipykernel install --user --name=advfea
```

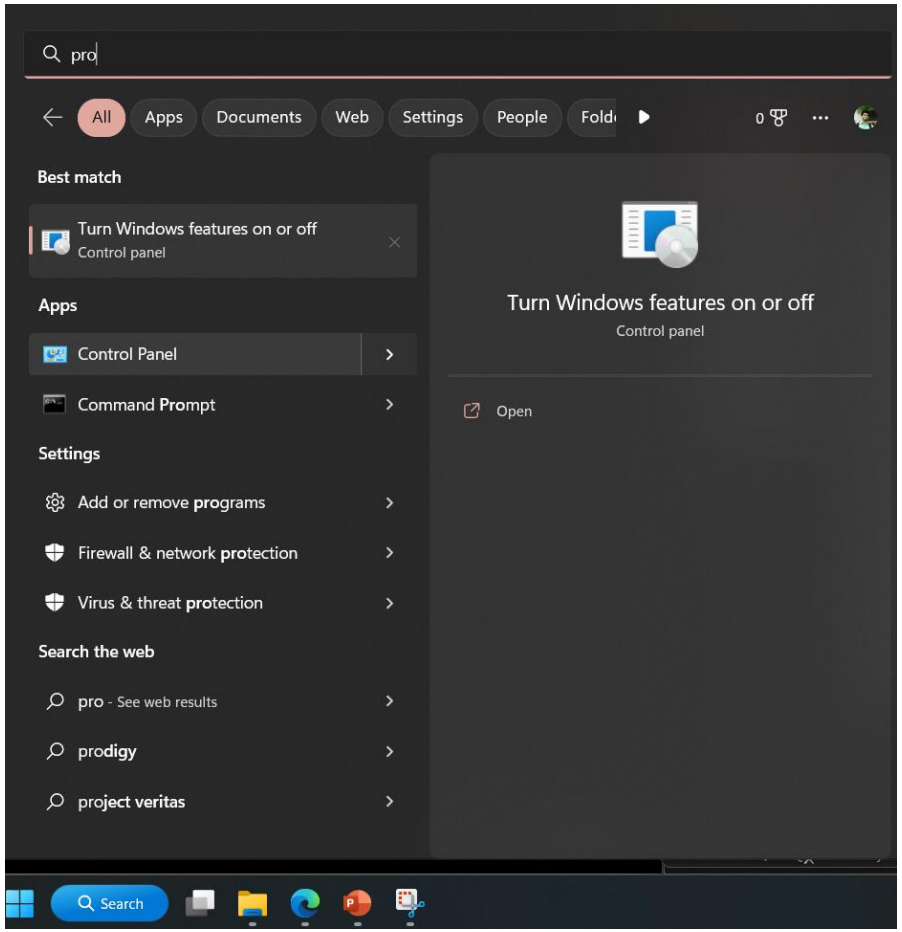
STEP 7

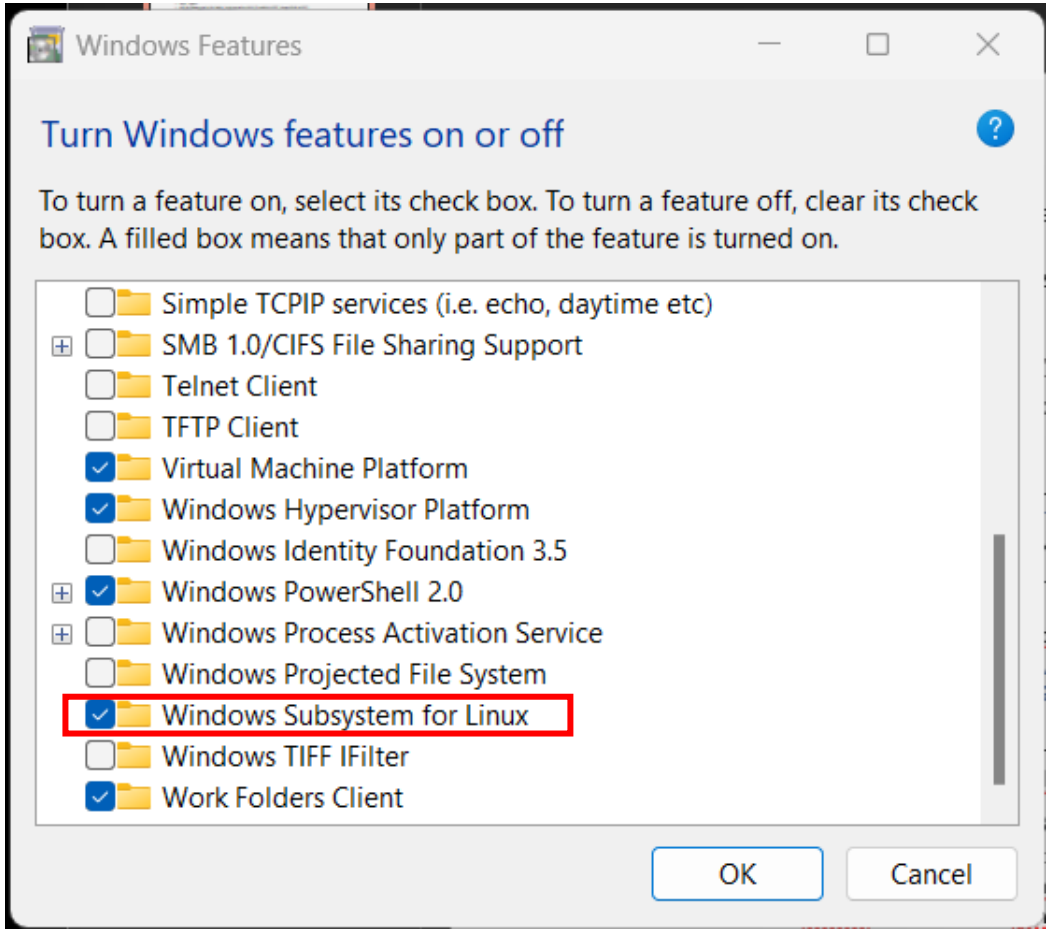
Move on to **Section C** to receive instructions on running **jupyter notebook** and test the environment

B. Installation for Windows (Linux starts from Step 7)

STEP 1

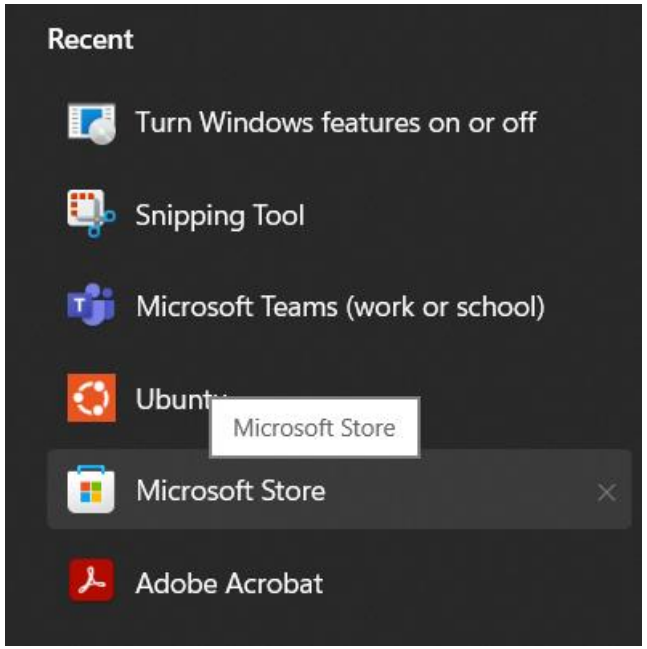
Search and click **Turn Windows Features On or Off** in the Windows search bar. Scroll down and ensure that the box next to **Windows Subsystem for Linux (WSL)** is checked.
If not**, check** the box and **Restart your Computer**.

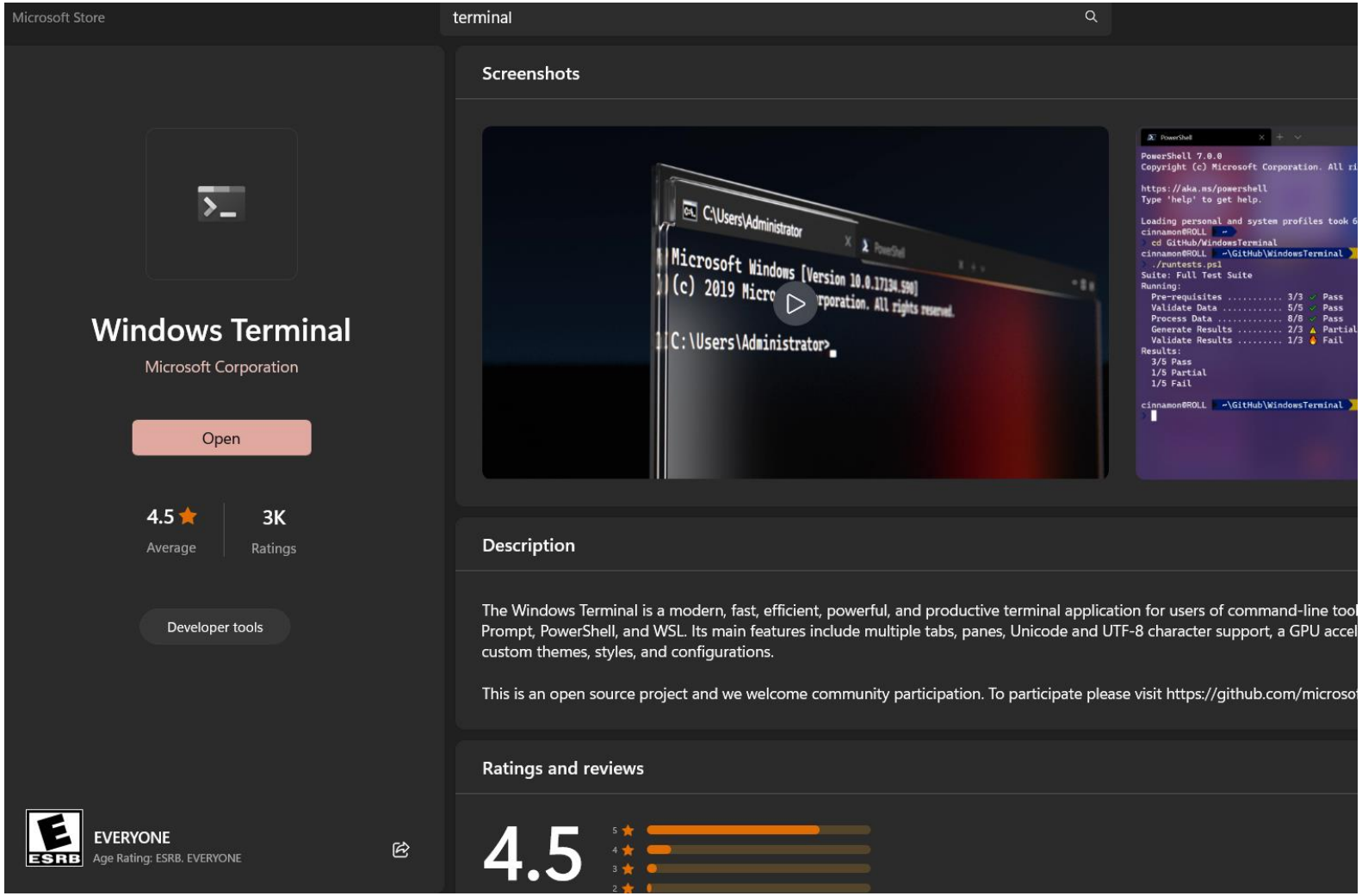




STEP 2

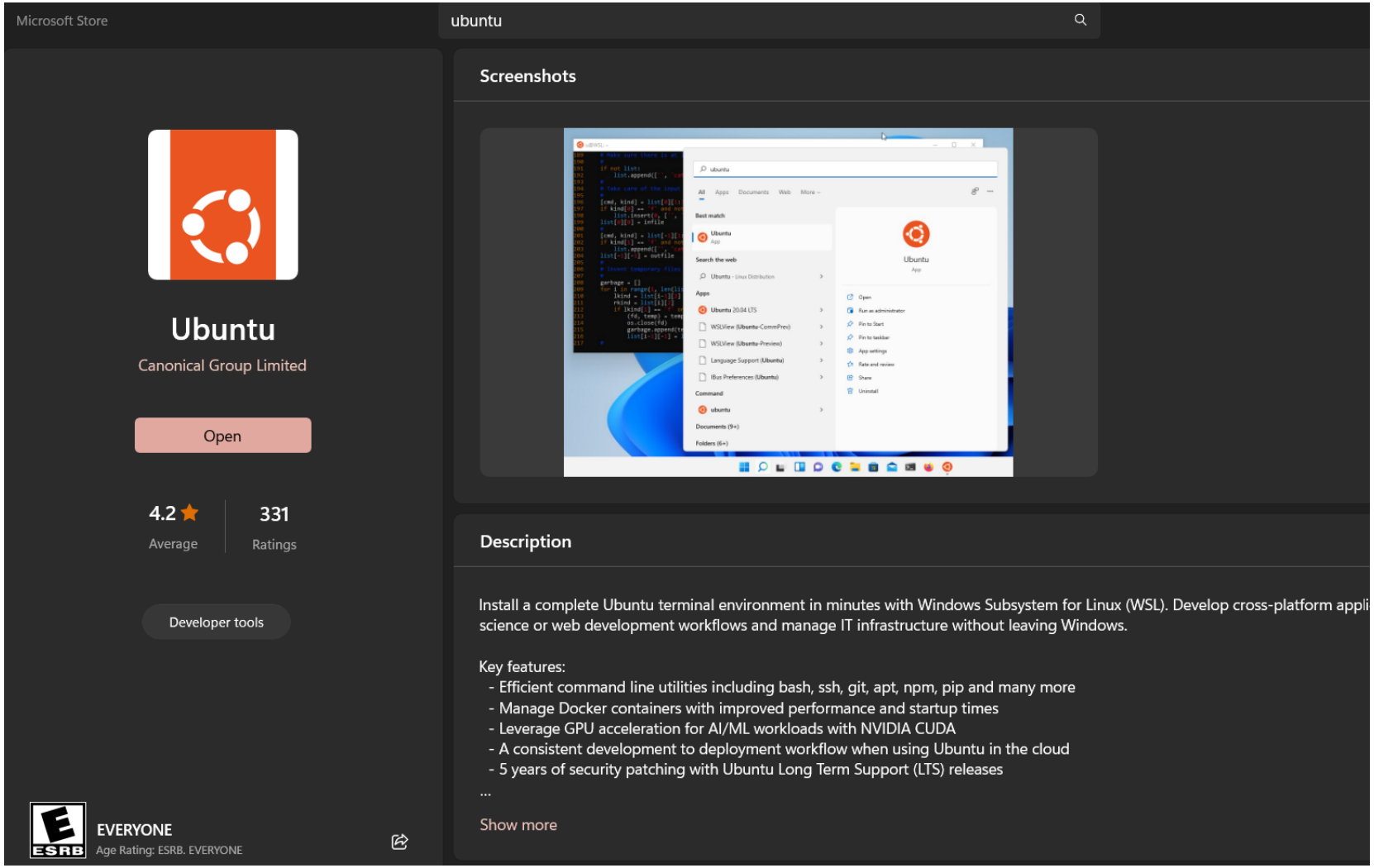
Visit **Microsoft Store** and download the **Windows Terminal** app. This is just a fancy program that allows us to easily open **Windows Powershell** in any windows folder.





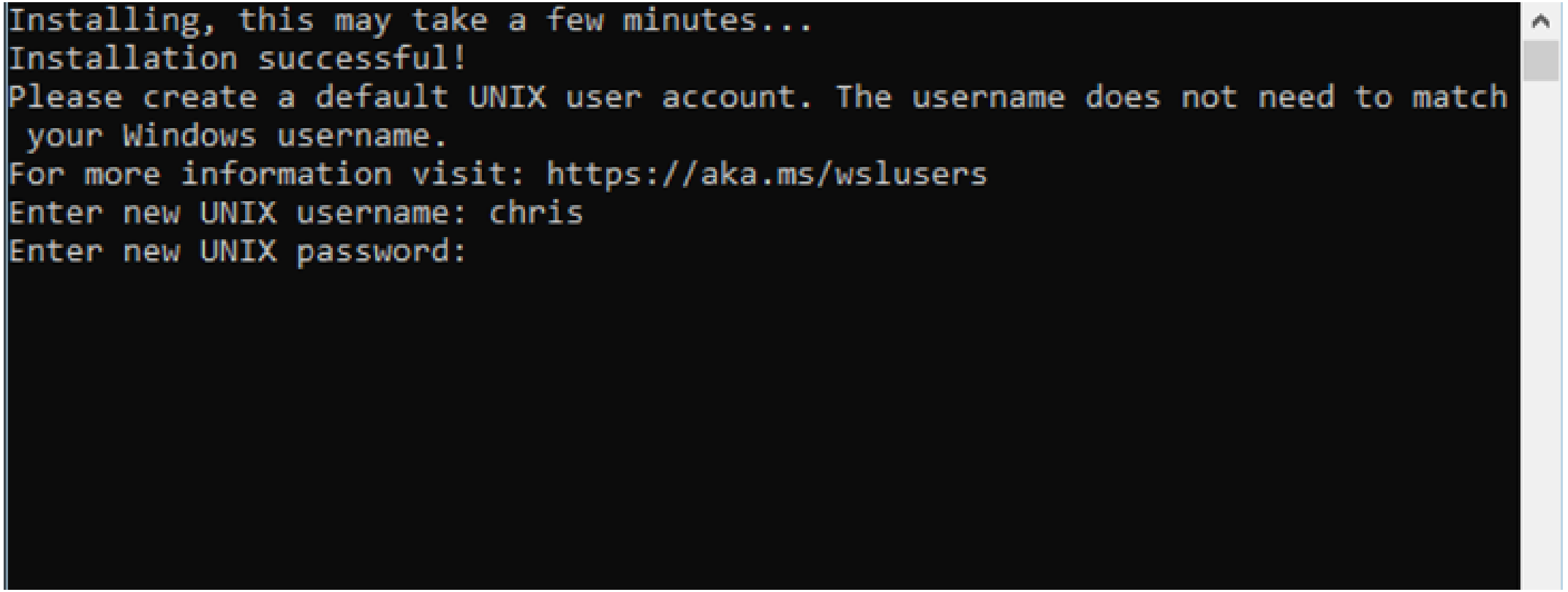
STEP 3

Visit **Microsoft Store** and download the **Ubuntu** app. This installs the Ubuntu-22.04 distribution to your WSL.



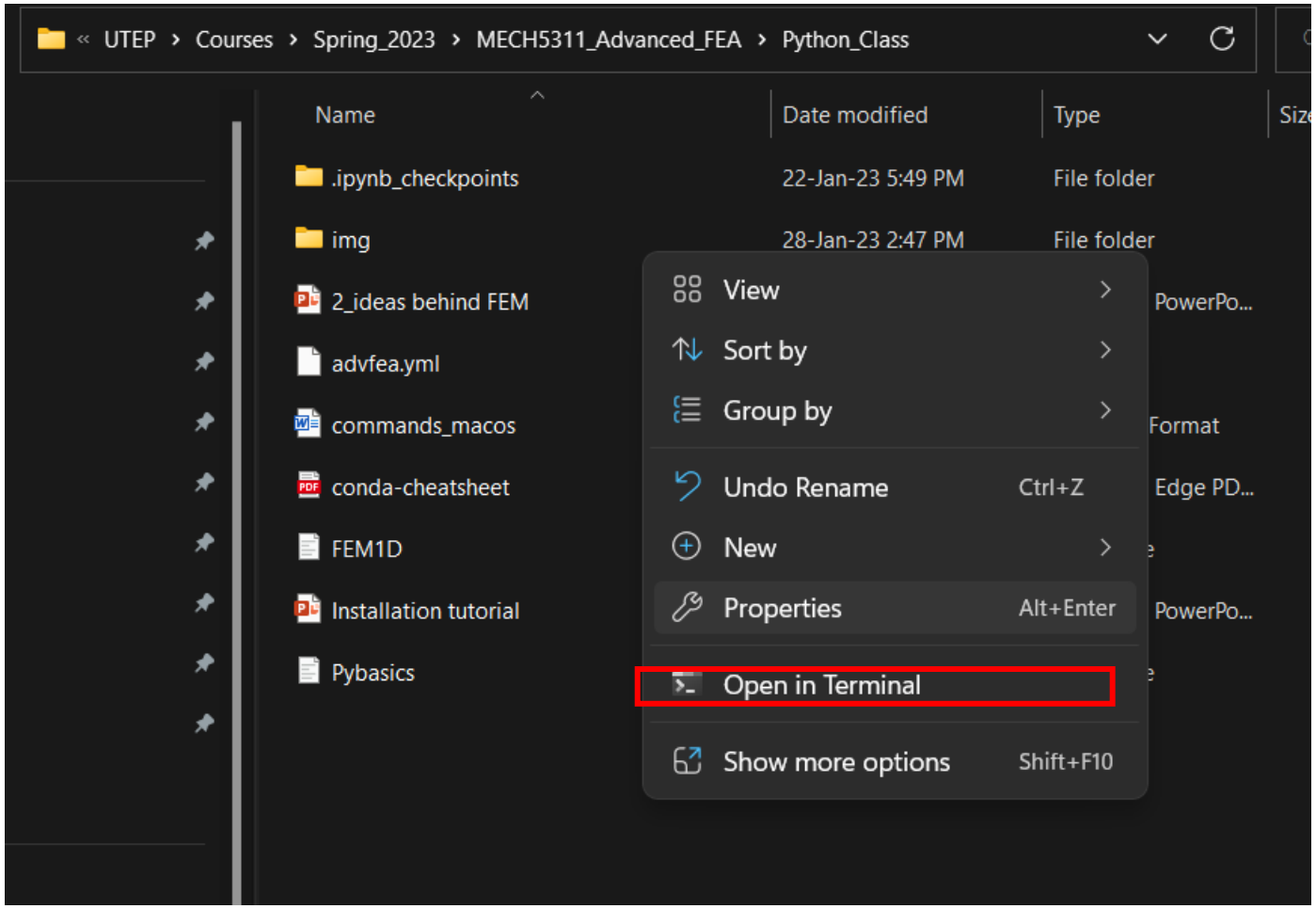
STEP 4

Open the **Ubuntu** application. The application prompts you to enter a **username** and **password** for your Ubuntu user profile. Enter an username and press **Enter**. Enter an easy password . The password will not show on the screen when you are typing it. Press **Enter** when you are done and retype the password when prompted. Once an user has been setup, you are done. Close the terminal or type **exit** and Press Enter to close the application.



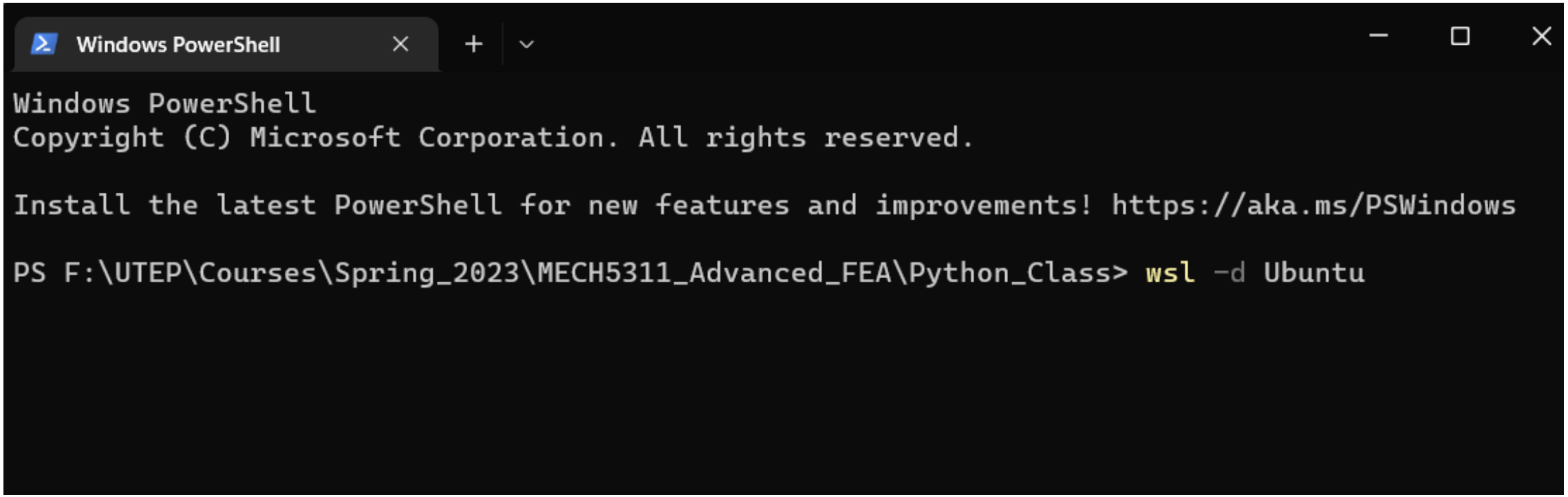
STEP 5

Go to the folder where you have **Pybasics_demo** file downloaded. **Right click** and click **Open in Terminal** to directly open **Windows Powershell** with the directory mounted.



STEP 6

Run the following command to start **Ubuntu**. The linux environment starts under the **username** you just created mounted with the directory.

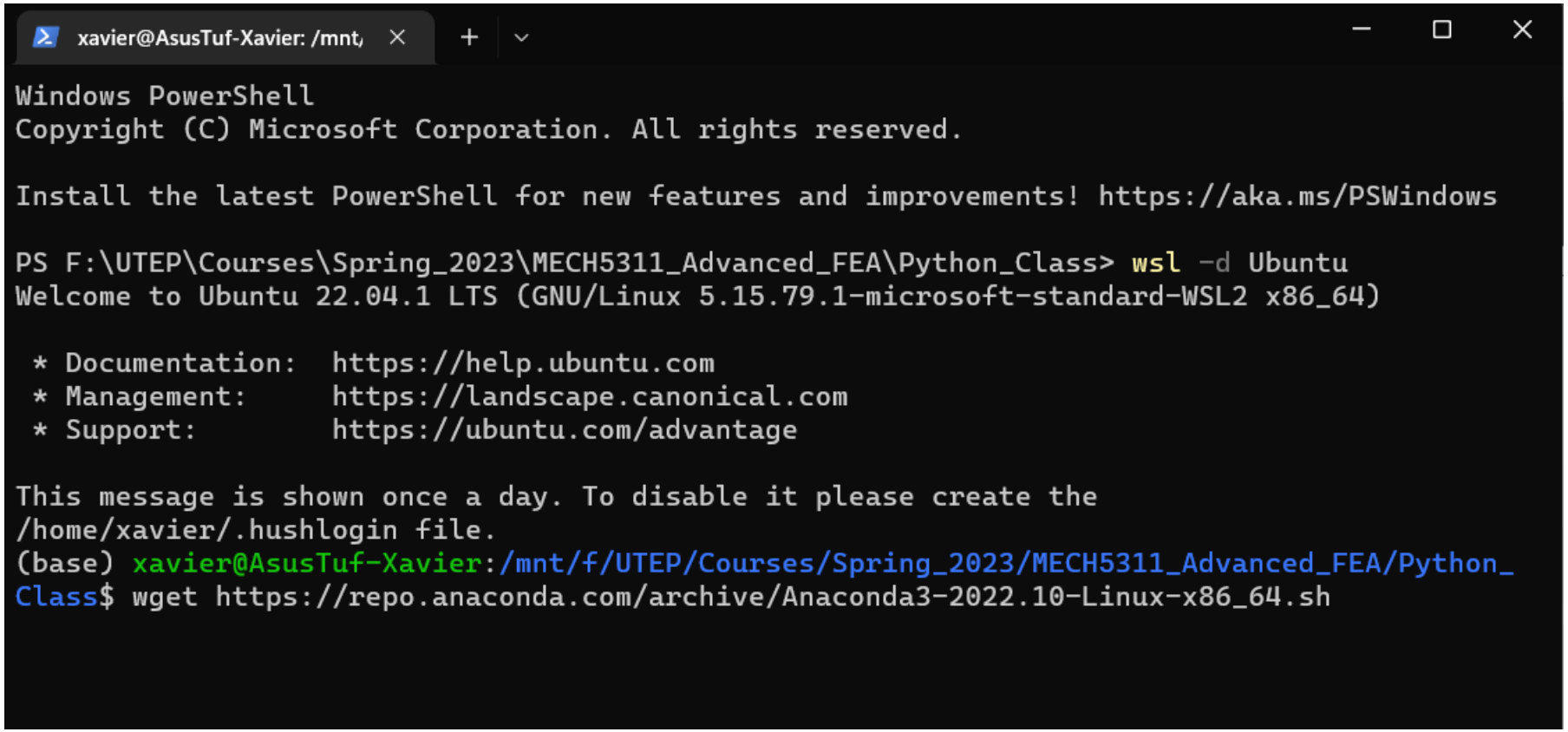


STEP 7

Run the following command to start **Ubuntu**. The **linux environment** starts under the **username** you just created mounted with the directory. For more details, you may follow this link.

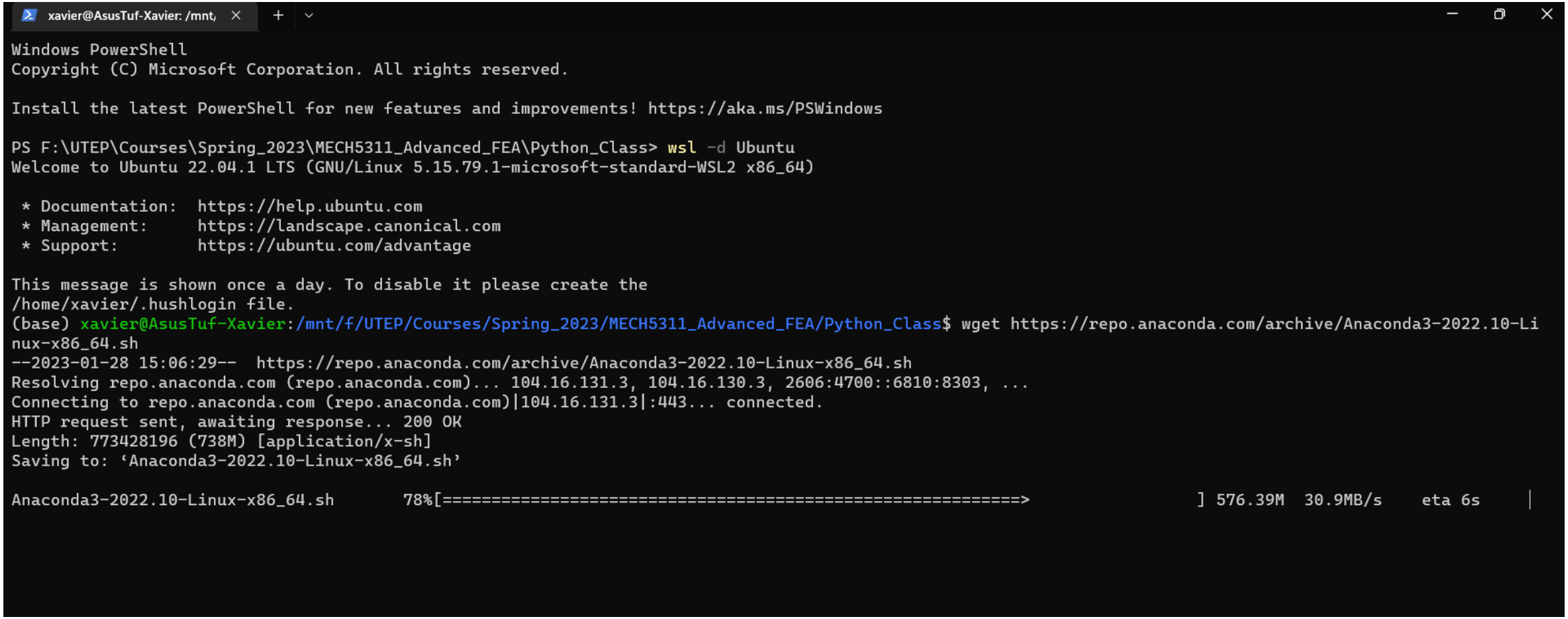
Run the following command to download the linux installer for anaconda. You may delete the file from the folder after **STEP 13.** Copy and paste to the terminal and press enter:

```
wget https://repo.anaconda.com/archive/Anaconda3-2022.10-Linux-x86_64.sh
```



STEP 7 (Continued)

Wait for the installer to finish downloading. Proceed to Step 8 when the “**username@your_computer_name:**” comes back on screen.



STEP 8

Type **ls** and press Enter to **list** the files in the directory. The installer should be there as an **sh** file.

```
(base) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class$ ls
'2_ideas behind FEM.pptx'            FEM1D.ipynb                  Pybasics.ipynb   commands_macos.rtf     img
 Anaconda3-2022.10-Linux-x86_64.sh  'Installation tutorial.pptx'   advfea.yml       conda-cheatsheet.pdf  '~$Installation tutorial.pptx'
```

STEP 9

Copy and paste the following command and press Enter to make the installer **sh** file executable.

```
chmod +x Anaconda3-2022.10-Linux-x86_64.sh
```

Running `chmod –v +x Anaconda3-2022.10-Linux-x86_64.sh` shows the mode of the file.

```
(base) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class$ chmod +x Anaconda3-2022.10-Linux-x86_64.sh
(base) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class$ chmod -v +x Anaconda3-2022.10-Linux-x86_64.sh
mode of 'Anaconda3-2022.10-Linux-x86_64.sh' retained as 0777 (rwxrwxrwx)
```

STEP 10

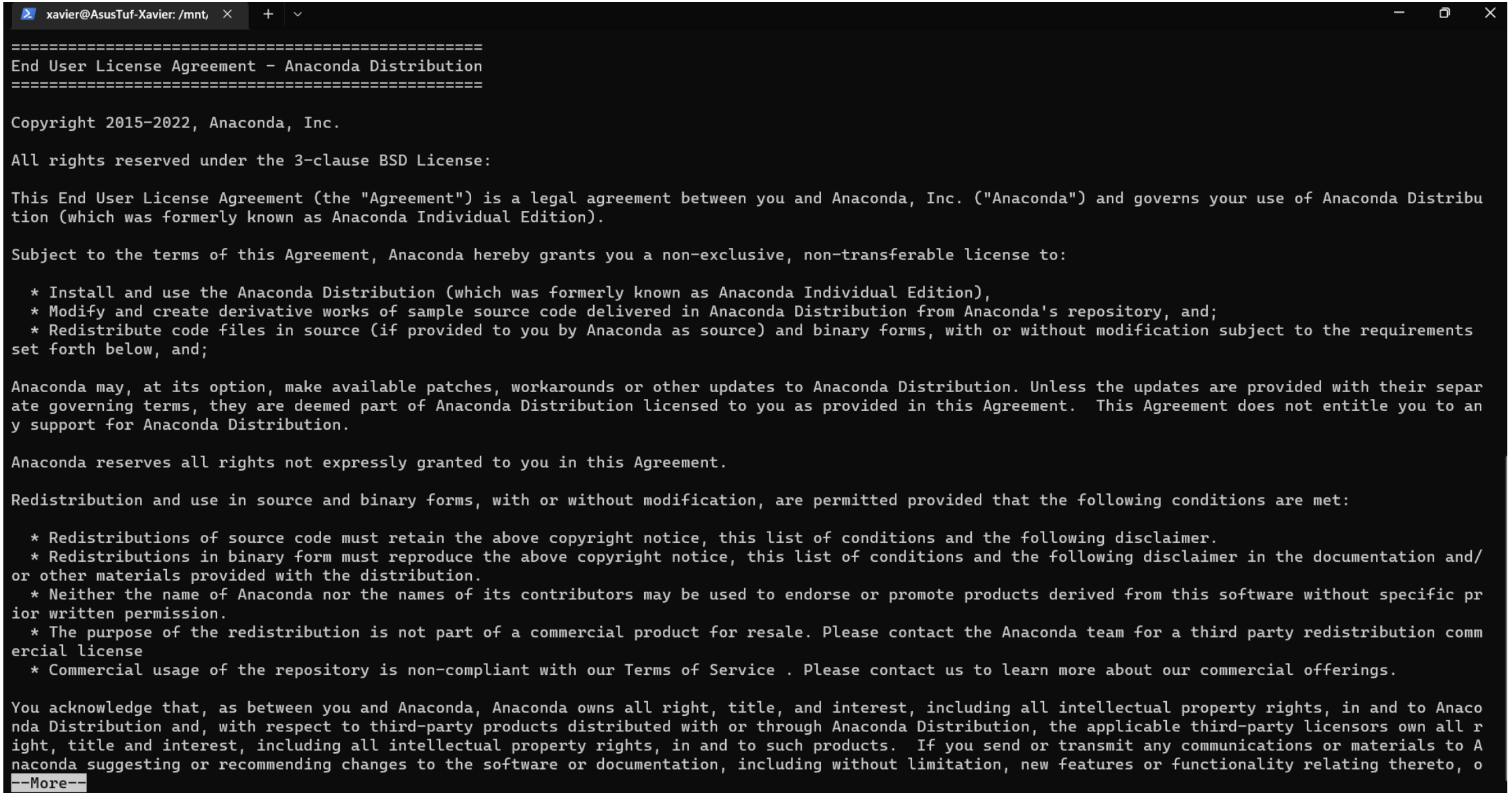
Copy and paste the following command and press Enter to run the installer for **Anaconda**.

```
./Anaconda3-2022.10-Linux-x86_64.sh
```

```
(base) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class$ ./Anaconda3-2022.10-Linux-x86_64.sh

Welcome to Anaconda3 2022.10

In order to continue the installation process, please review the license
agreement.
Please, press ENTER to continue
>>>
```

STEP 11

Press and hold Enter to reach the bottom of the license agreement.



STEP 11 (Continued)

Type in yes and press Enter to continue.

STEP 12

Press Enter to allow anaconda3 to be installed in the /home/**username**/anaconda3 directory of your linux distribution.
Let anaconda install and enter **yes** or **Y** where appropriate.

```
Anaconda3 will now be installed into this location:
/home/xavier/anaconda3

  - Press ENTER to confirm the location
  - Press CTRL-C to abort the installation
  - Or specify a different location below

[/home/xavier/anaconda3] >>>
```

STEP 13

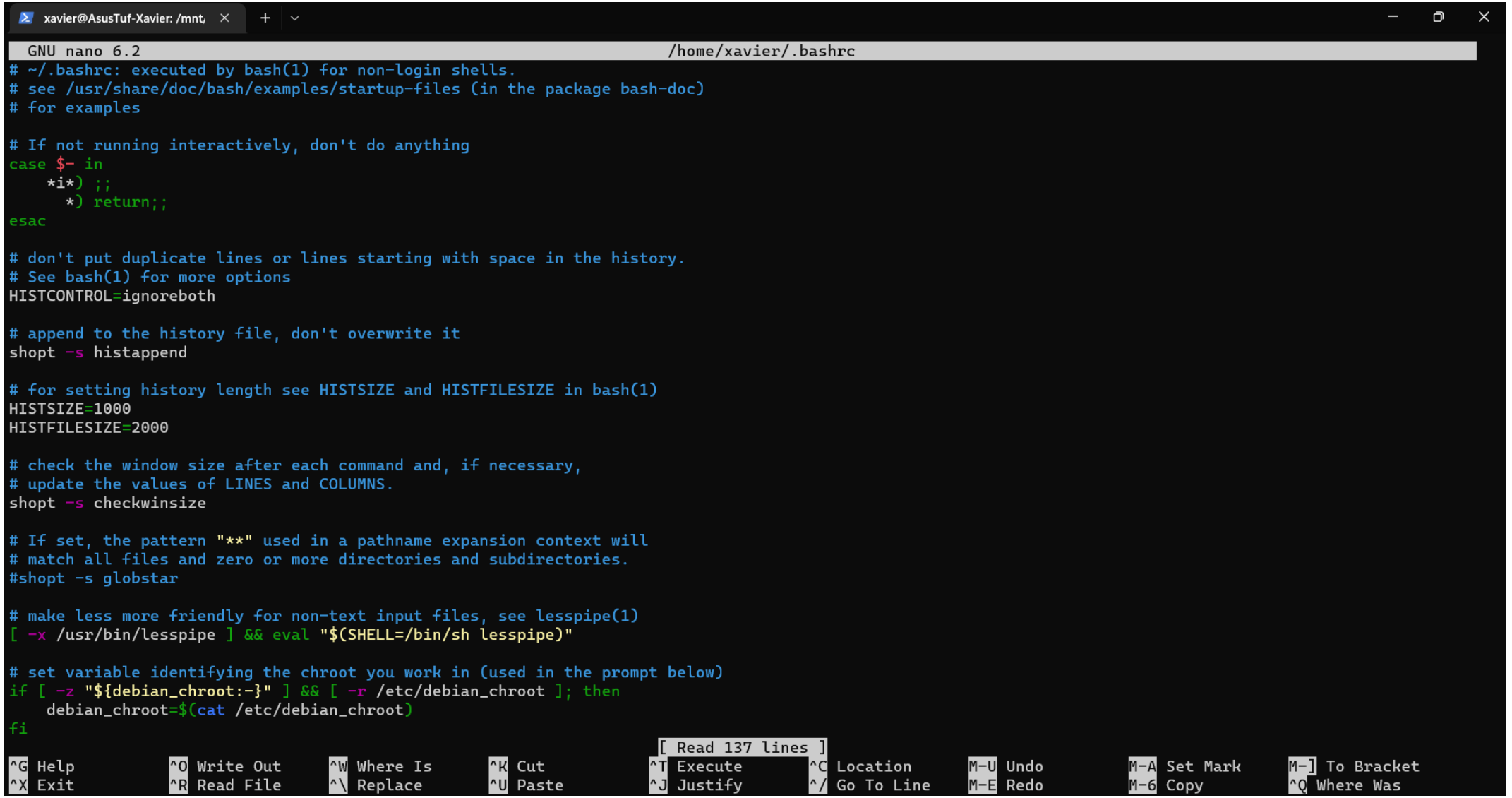
After completing anaconda installation, run the following command to edit the **bashrc** file:

nano ~/.bashrc

```
(base) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class$ nano ~/.bashrc
```

STEP 14

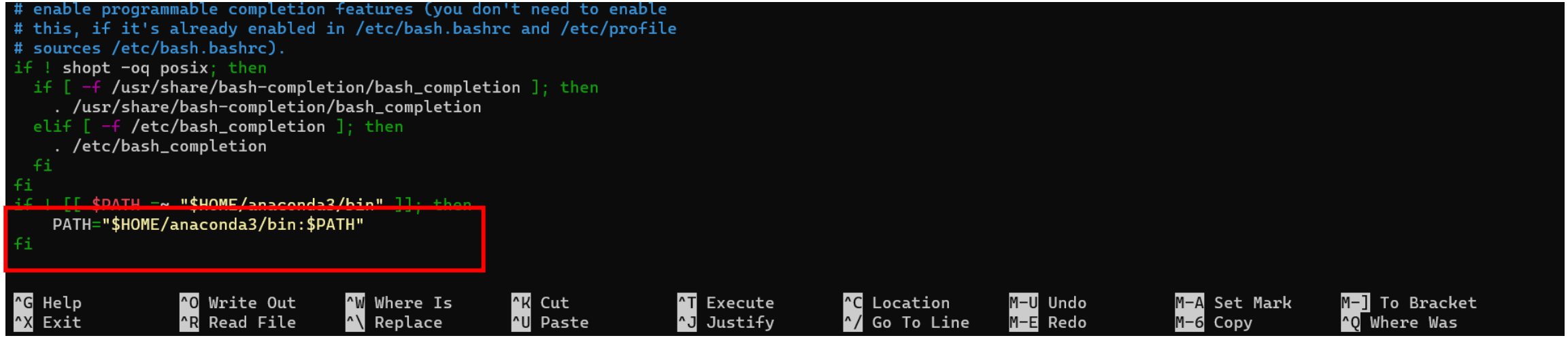
The **nano interface** looks as follows. Press down the **Down** arrow key to reach the end of the bashrc document.



STEP 14 (Continued)

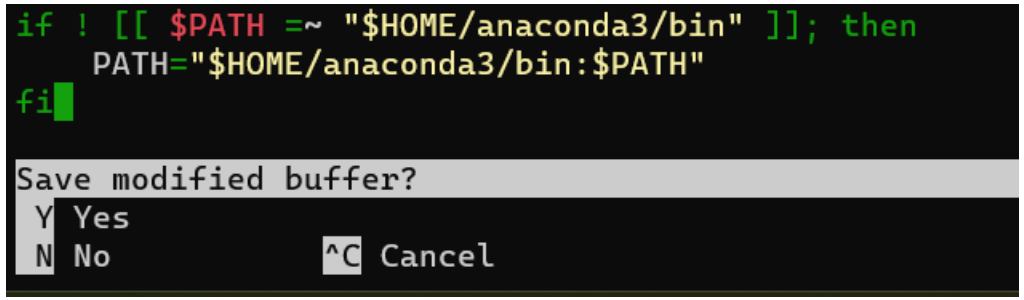
At the end of the document, Copy and paste the following lines.

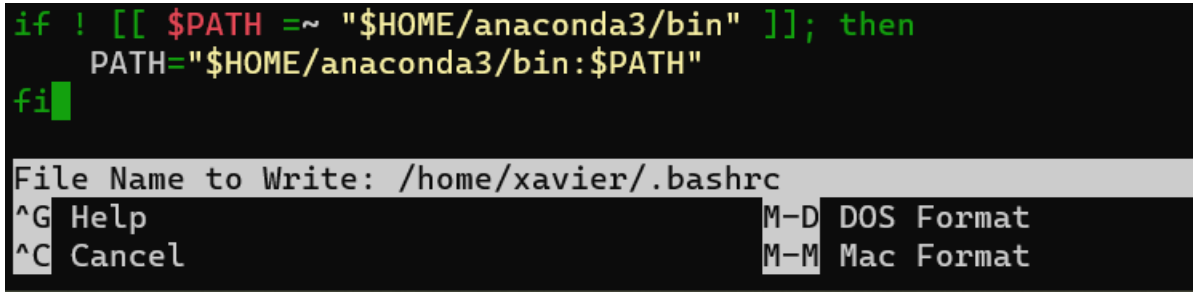
```
if ! [[ $PATH =~ "$HOME/anaconda3/bin" ]]; then
    PATH="$HOME/anaconda3/bin:$PATH"
fi
```



STEP 15

Press **Ctrl + X** to exit. Press **Y** to save and then **Enter** to continue. This takes you back to the bash terminal.

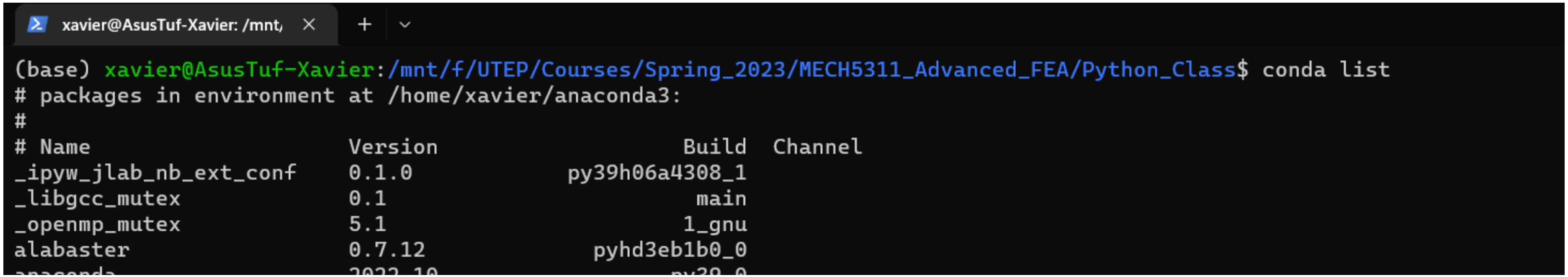




STEP 16

Restart the terminal by closing the terminal and following **STEP 5** and **STEP 6**. Run the following command to check whether Anaconda has been successfully installed and set in **PATH** . Redo **STEP 14-15** if a list does not show.

conda list



STEP 17

Run the following commands similar to **STEP 4-6** of **MACOS** to create **advfea** environment and install packages. The fenics package installation will take some time.

conda create -n advfea

conda activate advfea

conda install -c anaconda jupyter

conda install -c anaconda ipykernel

STEP 17 (Continued)

```
conda install -c conda-forge jax
```

```
conda install -c conda-forge matplotlib
```

```
conda install -c anaconda sympy
```

```
conda install -c conda-forge fenics-dolfinx mpich pyvista
```

STEP 18

Include your environment in the jupyter notebook kernels using the following command :

```
python -m ipykernel install --user --name=advfea
```

STEP 19

Move on to **Section C** to receive instructions on running **jupyter notebook** and test the environment

C. Test the Environment

STEP 1

macOS

In the terminal, go to the directory containing the code files using cd *filedirectory* and then run the command jupyter notebook To start the jupyter notebook server. Copy one of the links shown below and open them in a browser to use jupyter notebook.

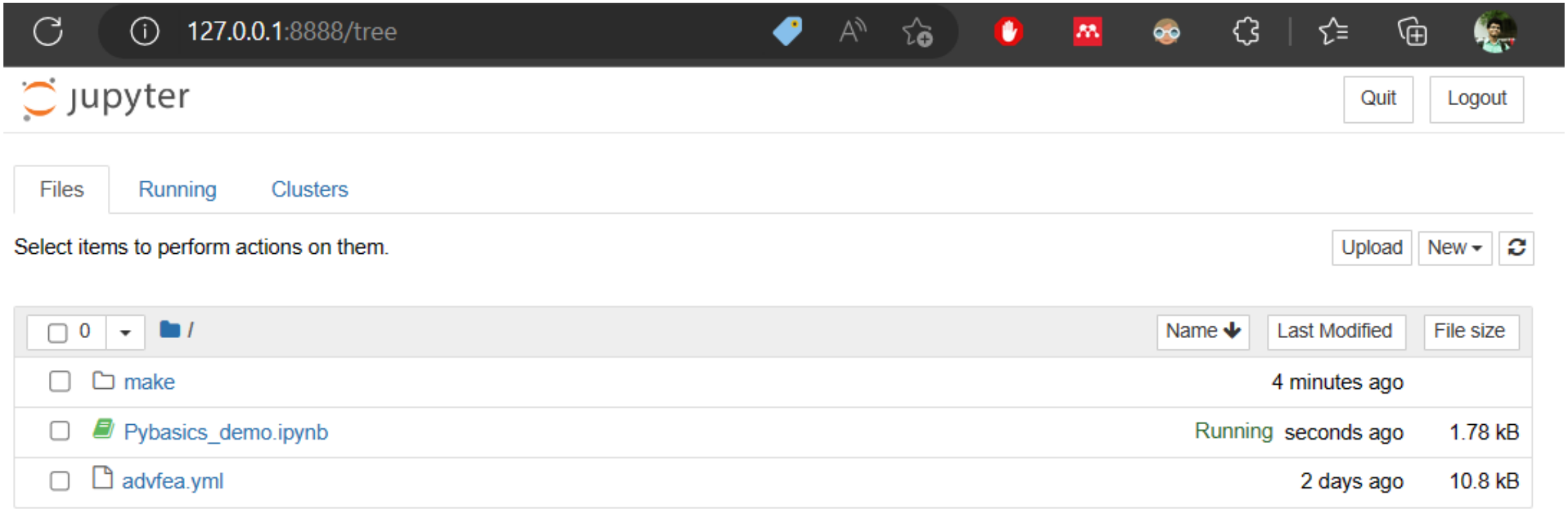
Windows/Linux

In the terminal, run the command jupyter notebook to start the jupyter notebook server. Copy one of the links shown below and open them in a browser to use jupyter notebook or **Ctrl + Click** one of the links.

```
(advfea) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class$ jupyter notebook
[I 15:46:08.739 NotebookApp] Serving notebooks from local directory: /mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class
[I 15:46:08.739 NotebookApp] Jupyter Notebook 6.5.2 is running at:
[I 15:46:08.739 NotebookApp] http://localhost:8888/?token=3eedee328e69d09c331e9f03743c5193fa51599169a22cb8
[I 15:46:08.739 NotebookApp]  or http://127.0.0.1:8888/?token=3eedee328e69d09c331e9f03743c5193fa51599169a22cb8
[I 15:46:08.739 NotebookApp] Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).
[W 15:46:13.258 NotebookApp] No web browser found: could not locate runnable browser.
[C 15:46:13.258 NotebookApp]

    To access the notebook, open this file in a browser:
        file:///home/xavier/.local/share/jupyter/runtime/nbserver-4087-open.html
    Or copy and paste one of these URLs:
        http://localhost:8888/?token=3eedee328e69d09c331e9f03743c5193fa51599169a22cb8
     or http://127.0.0.1:8888/?token=3eedee328e69d09c331e9f03743c5193fa51599169a22cb8
```

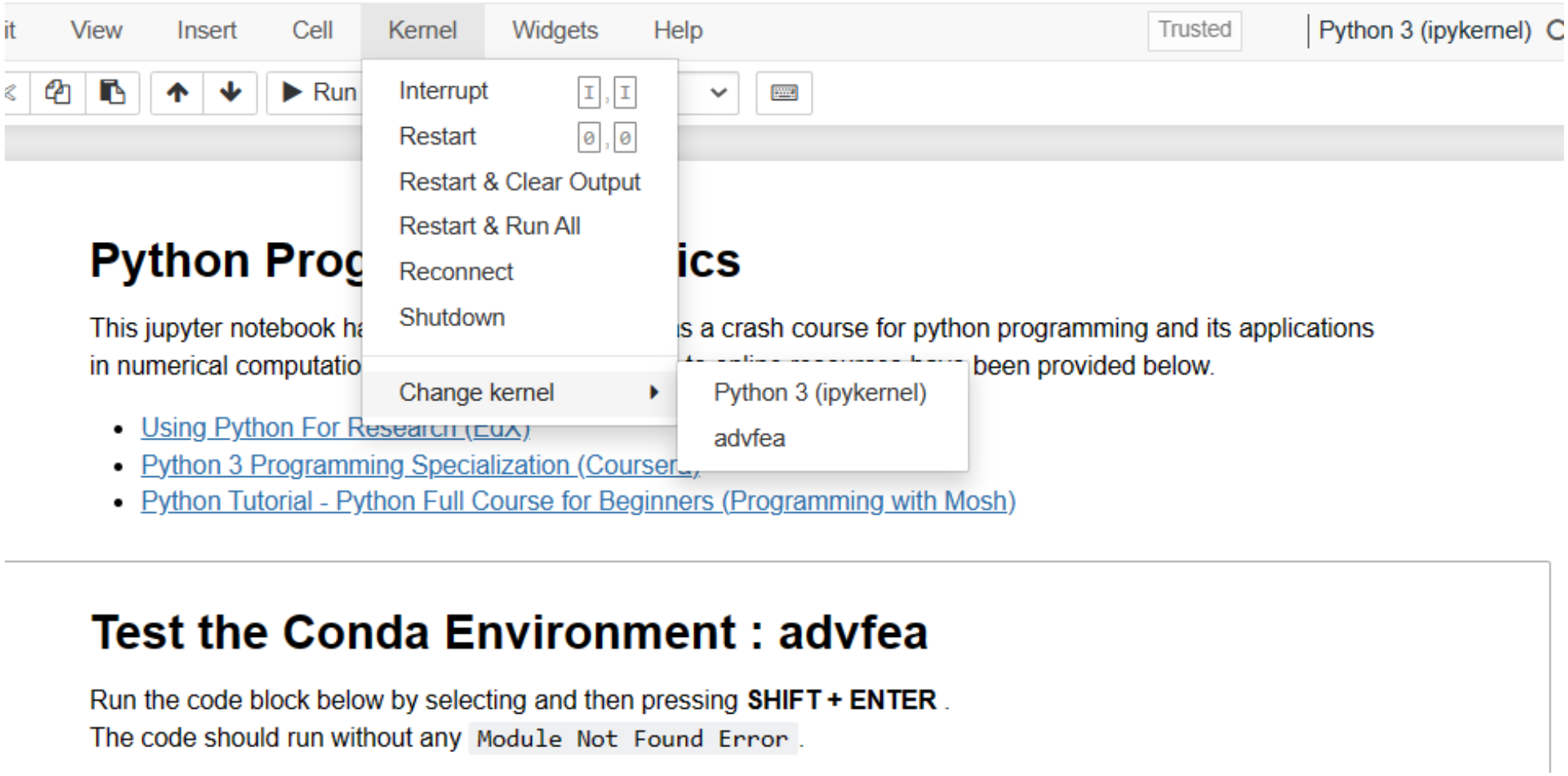
STEP 2

Choose file Pybasics_demo to run the notebook file.



STEP 3

Go to **Kernel → Change Kernel → advfea** to switch the kernel to run programs inside the **advfea** environment.



STEP 4

Run the code block by pressing **Shift + Enter** to run the import commands. If it runs without any errors, the environment is ready for the coursework.

Test the Conda Environment : advfea

Run the code block below by selecting and then pressing **SHIFT + ENTER** .
The code should run without any `Module Not Found Error` .

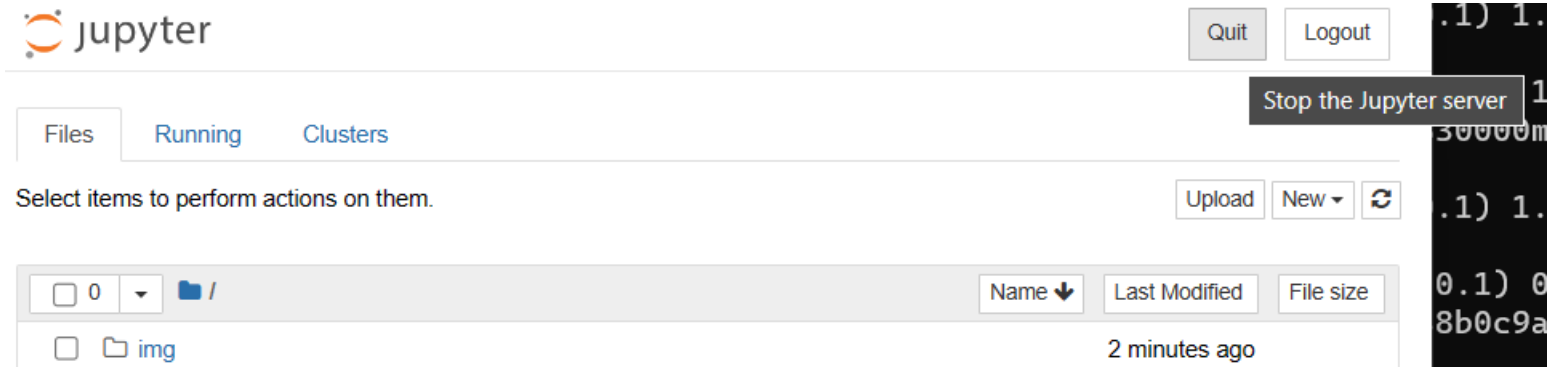
In [3]:
```
import numpy
import scipy
import matplotlib.pyplot as plt
import dolfinx
import jax
import sympy

print("You are ready to go for this course :) ")
```

```
You are ready to go for this course :)
```

D. (Optional) Tips and Commands

Closing Jupyter Notebook

Close the jupyter notebook file. Press Quit as shown below.
Alternatively, you may close the browser and then press **Ctrl+C** to interrupt the server. Input **y** to shutdown server.
Input command conda deactivate to exit the environment.




```
^C[I 15:52:37.037 NotebookApp] interrupted
Serving notebooks from local directory: /mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class
0 active kernels
Jupyter Notebook 6.5.2 is running at:
http://localhost:8888/?token=a4bb789bcf60215cd842689cb6024de0fd9ef4f4ab522116
 or http://127.0.0.1:8888/?token=a4bb789bcf60215cd842689cb6024de0fd9ef4f4ab522116
Shutdown this notebook server (y/[n])? y
[C 15:52:40.555 NotebookApp] Shutdown confirmed
[I 15:52:40.555 NotebookApp] Shutting down 0 kernels
[I 15:52:40.555 NotebookApp] Shutting down 0 terminals
(advfea) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class$ conda deactivate
(base) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class$ exit
```

Move WSL to a different drive

It may be useful to move WSL to a different drive if C drive is full (WSL with ubuntu takes about 6GB of space minimum). Input the following commands in windows powershell or cmd to move WSL. Change D:\ to a drive of your choice.

```
cd D:\

mkdir WSL

cd WSL wsl --export Ubuntu ubuntu.tar

wsl --unregister Ubuntu mkdir Ubuntu

wsl --import Ubuntu Ubuntu ubuntu.tar
```

Follow this link for more details.

Commands for Conda Environments

These commands may prove to be useful when handling conda environments. For the cheatsheet, follow this link.

Create Conda environment: conda create --name advfea

Delete Conda environment: conda env remove -n advfea

Activate conda environment: conda activate advfea

Deactivate conda environment: conda deactivate

Import Conda environment from .yml file: conda env create -n advfea --file advfea.yml

Export Conda environment to .yml file: conda env export > advfea.yml

Delete Conda environment: conda env remove -n advfea