

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 **FEniCxx**) 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 **.yaml** files.

This is essential for efficient package management.

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- A. [Installation for MacOS](#)
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A. Installation for MacOS

STEP 1

Go to the [Anaconda Website](https://www.anaconda.com/products/distribution) 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
```

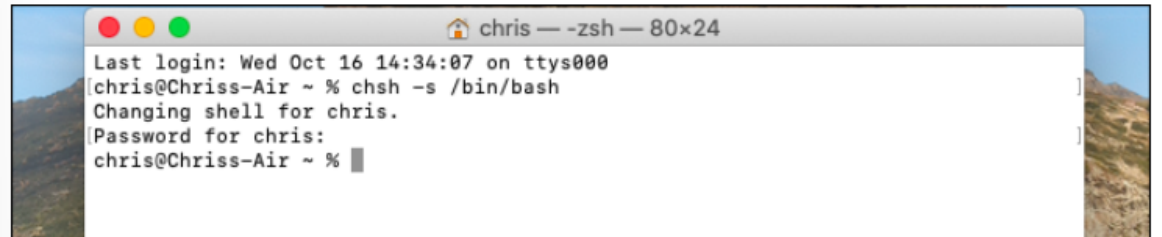
From the Terminal

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

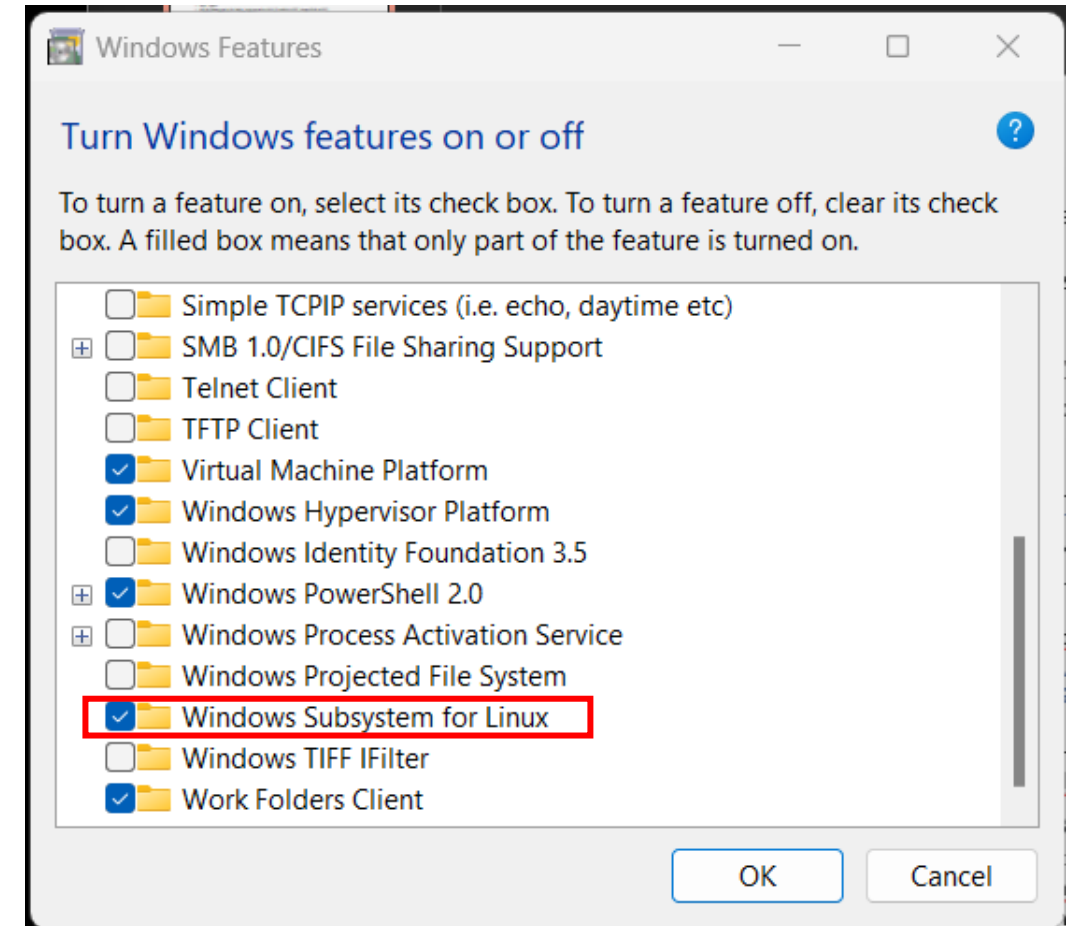
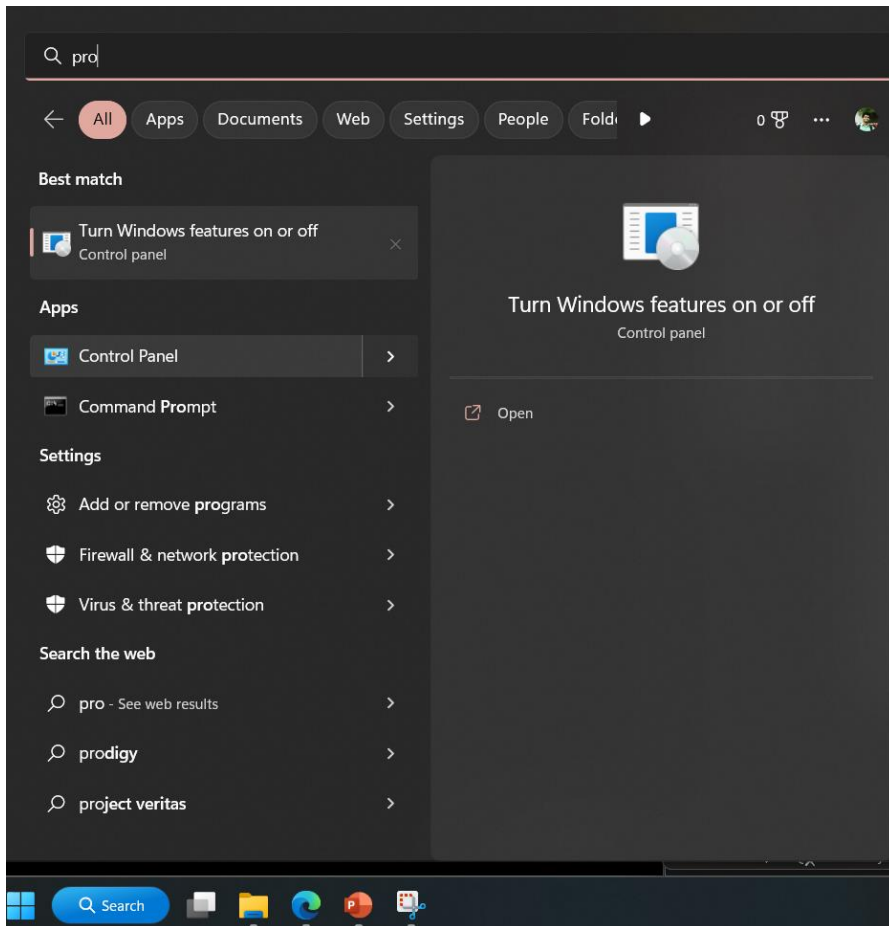
Move on to **Section C** to receive instructions on running **jupyter notebook** and test the environment

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

STEP 1

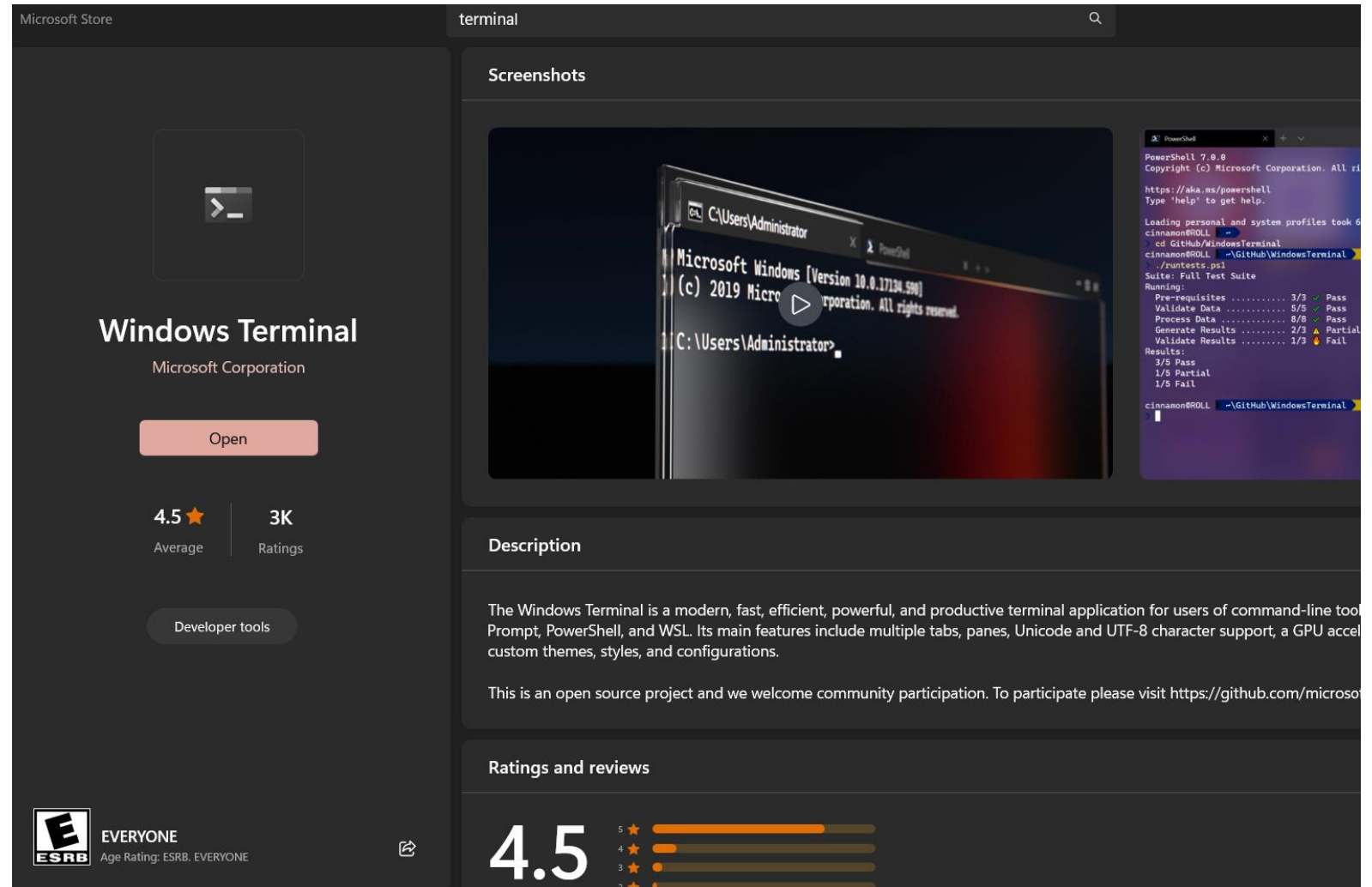
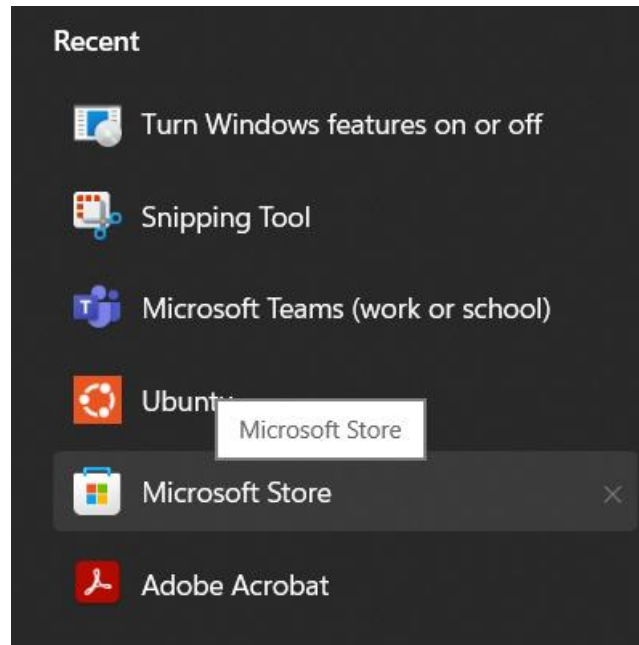
Search and click **Turn Windows Features On or Off** in the Windows search bar. Scroll down and ensure that the box next to **Windows Subsystem for Linux (WSL)** is checked.

If not, **check** the box and **Restart your Computer**.



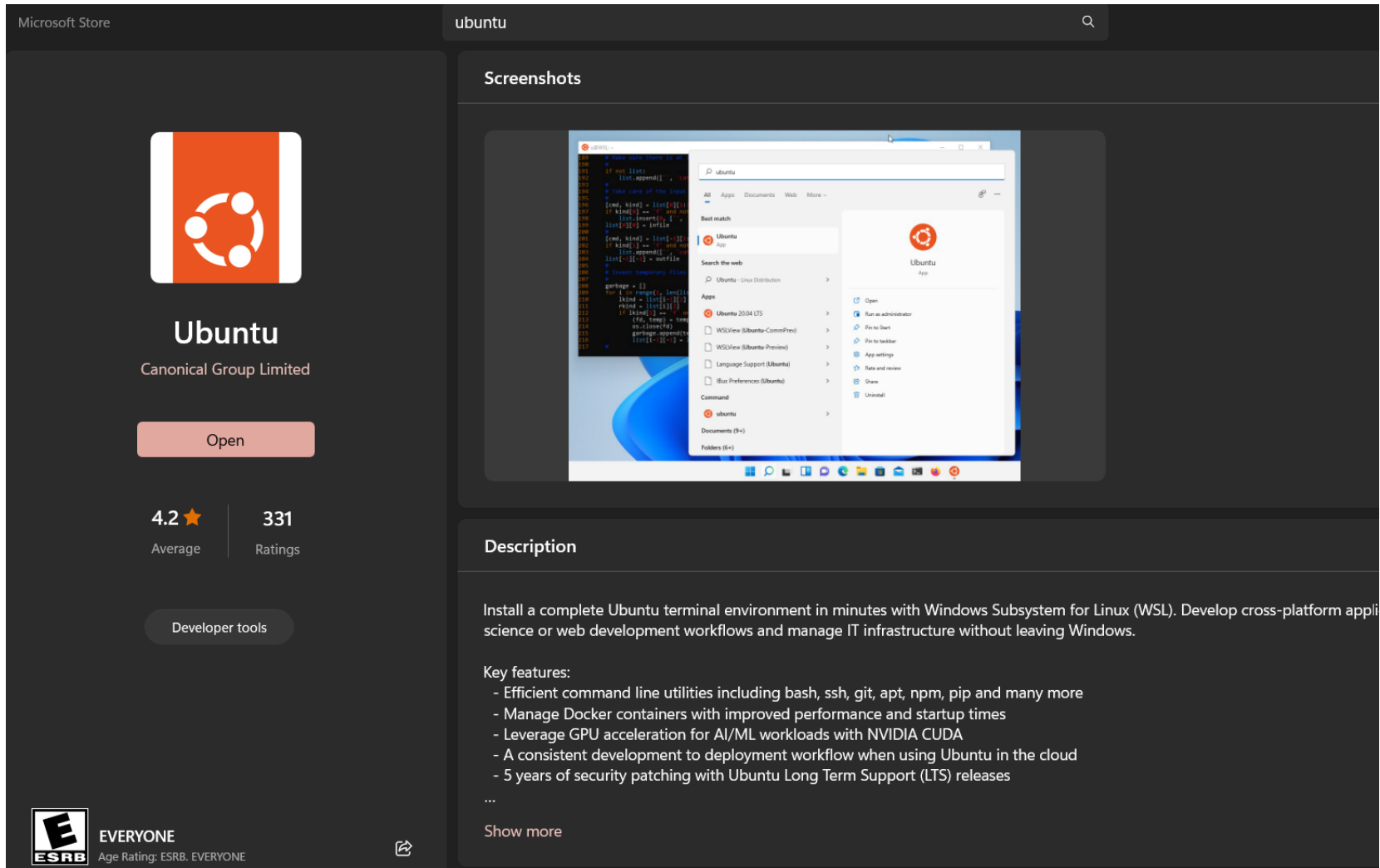
STEP 2

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.



The screenshot shows the Microsoft Store interface for the Ubuntu application. The left sidebar contains the Ubuntu logo, the name 'Ubuntu', the publisher 'Canonical Group Limited', an 'Open' button, a 4.2 star average rating from 331 reviews, and a 'Developer tools' badge. The main content area is titled 'ubuntu' and features a 'Screenshots' section with a preview of the Ubuntu terminal environment. Below this is a 'Description' section with a paragraph about installing Ubuntu via WSL and a list of key features. At the bottom left, there is an ESRB rating of 'EVERYONE'.

Microsoft Store

ubuntu

Screenshots

Ubuntu

Canonical Group Limited

Open

4.2 ★ Average

331 Ratings

Developer tools

ESRB EVERYONE Age Rating: ESRB. EVERYONE

Description

Install a complete Ubuntu terminal environment in minutes with Windows Subsystem for Linux (WSL). Develop cross-platform applications or web development workflows and manage IT infrastructure without leaving Windows.

Key features:

- Efficient command line utilities including bash, ssh, git, apt, npm, pip and many more
- Manage Docker containers with improved performance and startup times
- Leverage GPU acceleration for AI/ML workloads with NVIDIA CUDA
- A consistent development to deployment workflow when using Ubuntu in the cloud
- 5 years of security patching with Ubuntu Long Term Support (LTS) releases

...

Show more

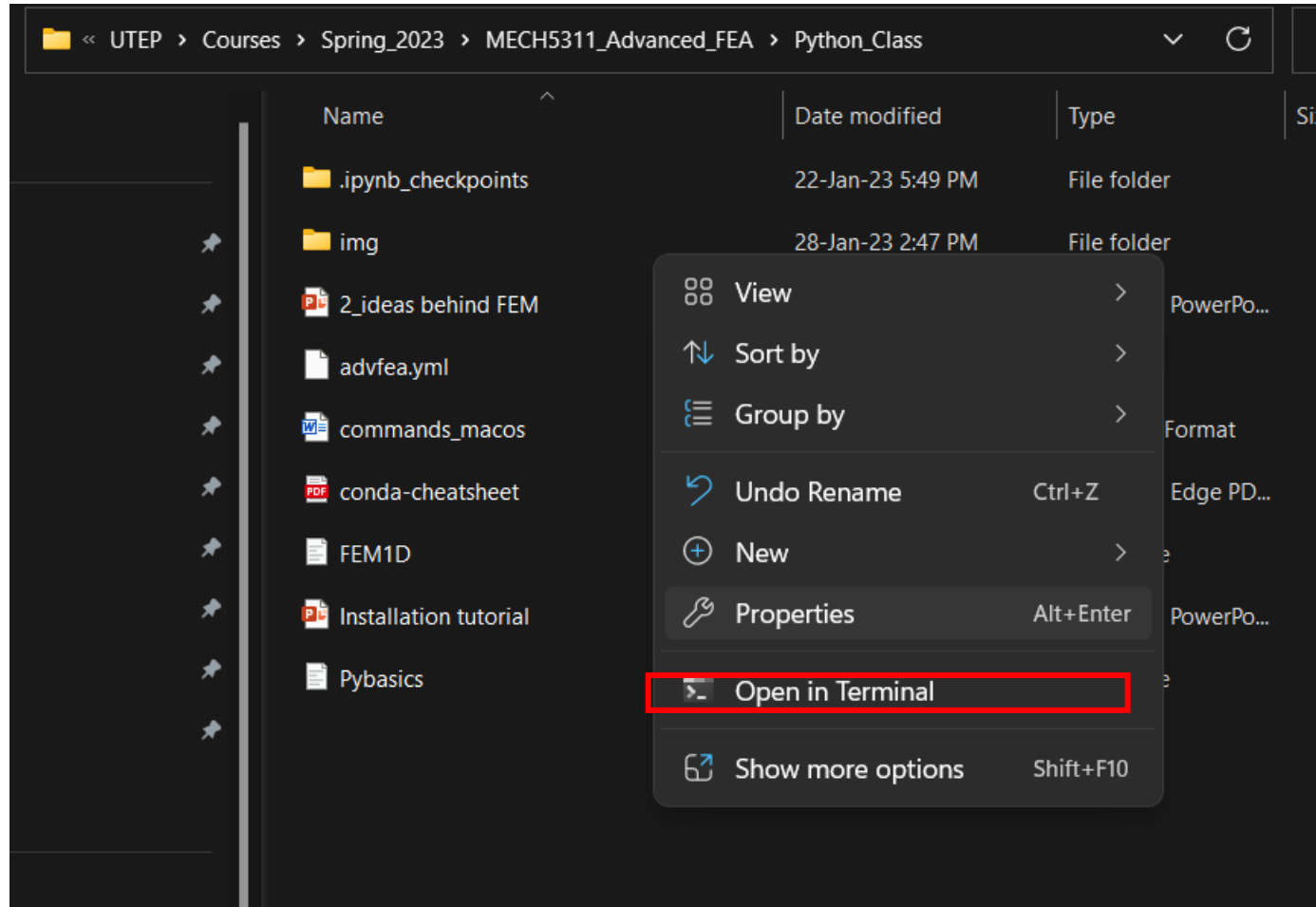
STEP 4

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.

```
Installing, this may take a few minutes...
Installation successful!
Please create a default UNIX user account. The username does not need to match
your Windows username.
For more information visit: https://aka.ms/wslusers
Enter new UNIX username: chris
Enter new UNIX password:
```

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.

A screenshot of a Windows PowerShell terminal window. The title bar at the top shows 'Windows PowerShell' with a blue icon on the left and standard window controls (minimize, maximize, close) on the right. The terminal content is as follows:
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Install the latest PowerShell for new features and improvements! <https://aka.ms/PSWindows>

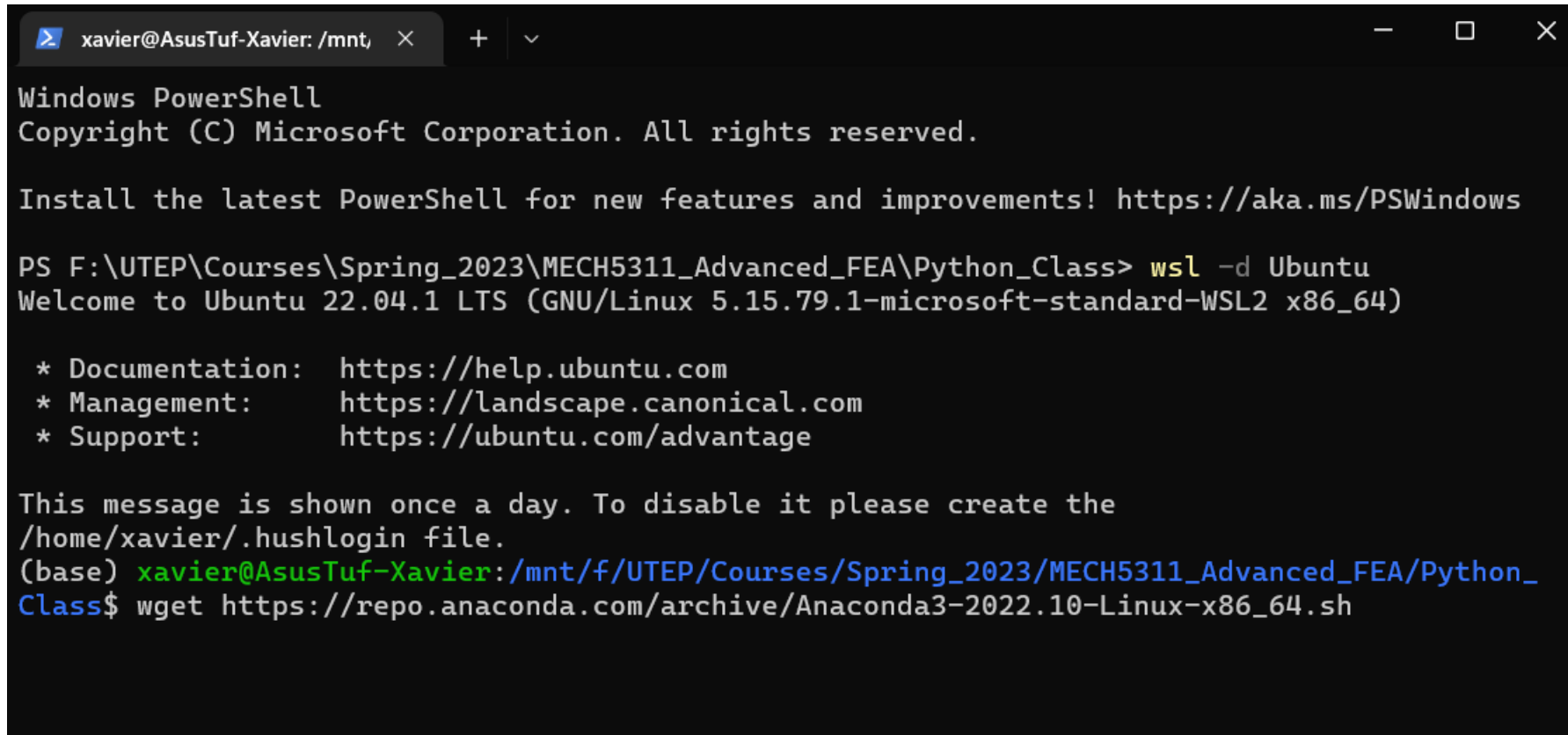
PS F:\UTEP\Courses\Spring_2023\MECH5311_Advanced_FEA\Python_Class> wsl -d Ubuntu

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
```



```
xavier@AsusTuf-Xavier: /mnt  ×  +  ▾  
Windows PowerShell  
Copyright (C) Microsoft Corporation. All rights reserved.  
  
Install the latest PowerShell for new features and improvements! https://aka.ms/PSWindows  
  
PS F:\UTEP\Courses\Spring_2023\MECH5311_Advanced_FEA\Python_Class> wsl -d Ubuntu  
Welcome to Ubuntu 22.04.1 LTS (GNU/Linux 5.15.79.1-microsoft-standard-WSL2 x86_64)  
  
* Documentation:  https://help.ubuntu.com  
* Management:    https://landscape.canonical.com  
* Support:        https://ubuntu.com/advantage  
  
This message is shown once a day. To disable it please create the  
/home/xavier/.hushlogin file.  
(base) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_  
Class$ 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.

```
xavier@AsusTuf-Xavier: /mnt, x + v
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Install the latest PowerShell for new features and improvements! https://aka.ms/PSWindows

PS F:\UTEP\Courses\Spring_2023\MECH5311_Advanced_FEA\Python_Class> wsl -d Ubuntu
Welcome to Ubuntu 22.04.1 LTS (GNU/Linux 5.15.79.1-microsoft-standard-WSL2 x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

This message is shown once a day. To disable it please create the
/home/xavier/.hushlogin file.
(base) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class$ wget https://repo.anaconda.com/archive/Anaconda3-2022.10-Linux-x86_64.sh
--2023-01-28 15:06:29-- https://repo.anaconda.com/archive/Anaconda3-2022.10-Linux-x86_64.sh
Resolving repo.anaconda.com (repo.anaconda.com)... 104.16.131.3, 104.16.130.3, 2606:4700::6810:8303, ...
Connecting to repo.anaconda.com (repo.anaconda.com)|104.16.131.3|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 773428196 (738M) [application/x-sh]
Saving to: 'Anaconda3-2022.10-Linux-x86_64.sh'

Anaconda3-2022.10-Linux-x86_64.sh      78%[=====] 576.39M  30.9MB/s  eta 6s
```

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.

```
xavier@AsusTuf-Xavier: /mnt  X + v
=====
End User License Agreement - Anaconda Distribution
=====

Copyright 2015-2022, Anaconda, Inc.

All rights reserved under the 3-clause BSD License:

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    * Modify and create derivative works of sample source code delivered in Anaconda Distribution from Anaconda's repository, and;
    * Redistribute code files in source (if provided to you by Anaconda as source) and binary forms, with or without modification subject to the requirements set forth below, and;

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--More--
```

STEP 11 (Continued)

Type in yes and press Enter to continue.

[illegible]

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

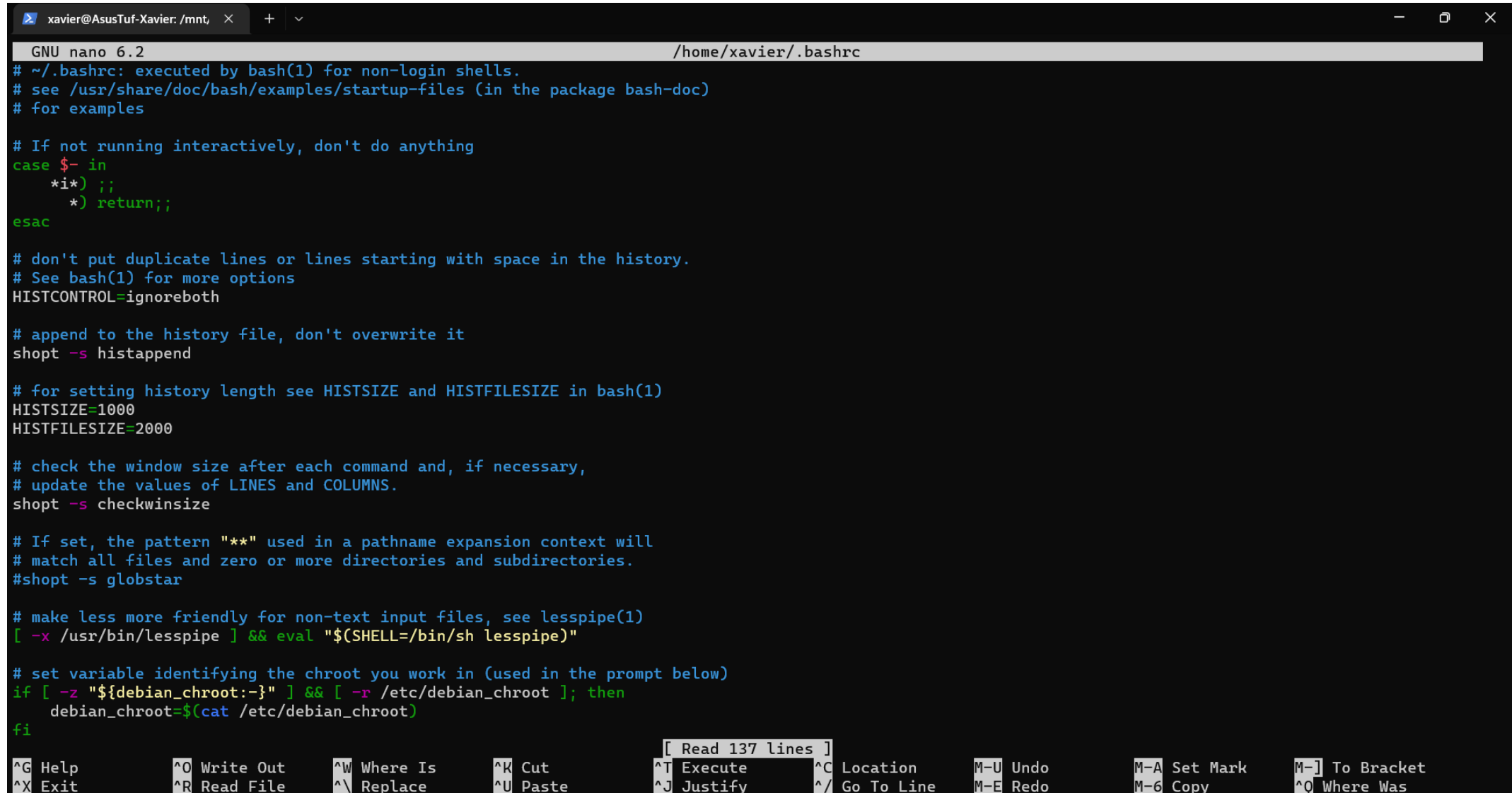
After completing anaconda installation, run the following command to edit the **bashrc** file:

```
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.



```
GNU nano 6.2 /home/xavier/.bashrc
# ~/.bashrc: executed by bash(1) for non-login shells.
# see /usr/share/doc/bash/examples/startup-files (in the package bash-doc)
# for examples

# If not running interactively, don't do anything
case $- in
  *i*) ;;
  *) return;;
esac

# don't put duplicate lines or lines starting with space in the history.
# See bash(1) for more options
HISTCONTROL=ignoreboth

# append to the history file, don't overwrite it
shopt -s histappend

# for setting history length see HISTSIZE and HISTFILESIZE in bash(1)
HISTSIZE=1000
HISTFILESIZE=2000

# check the window size after each command and, if necessary,
# update the values of LINES and COLUMNS.
shopt -s checkwinsize

# If set, the pattern "**" used in a pathname expansion context will
# match all files and zero or more directories and subdirectories.
#shopt -s globstar

# make less more friendly for non-text input files, see lesspipe(1)
[ -x /usr/bin/lesspipe ] && eval "$(SHELL=/bin/sh lesspipe)"

# set variable identifying the chroot you work in (used in the prompt below)
if [ -z "${debian_chroot:-}" ] && [ -r /etc/debian_chroot ]; then
  debian_chroot=$(cat /etc/debian_chroot)
fi

[ Read 137 lines ]
^G Help      ^O Write Out  ^W Where Is   ^K Cut        ^T Execute    ^C Location   M-U Undo      M-A Set Mark  M-] To Bracket
^X Exit      ^R Read File  ^\ Replace    ^U Paste      ^J Justify    ^/ Go To Line  M-E Redo      M-6 Copy      ^Q Where Was
```

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
```

```
# enable programmable completion features (you don't need to enable
# this, if it's already enabled in /etc/bash.bashrc and /etc/profile
# sources /etc/bash.bashrc).
if ! shopt -oq posix; then
    if [ -f /usr/share/bash-completion/bash_completion ]; then
        . /usr/share/bash-completion/bash_completion
    elif [ -f /etc/bash_completion ]; then
        . /etc/bash_completion
    fi
fi
if ! [[ $PATH =~ "$HOME/anaconda3/bin" ]]; then
    PATH="$HOME/anaconda3/bin:$PATH"
fi
```

^G Help	^O Write Out	^W Where Is	^K Cut	^T Execute	^C Location	M-U Undo	M-A Set Mark	M-] To Bracket
^X Exit	^R Read File	^N Replace	^U Paste	^J Justify	^/_ Go To Line	M-E Redo	M-6 Copy	^Q Where Was

STEP 15

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

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

```
Save modified buffer?
Y Yes
N No      ^C Cancel
```

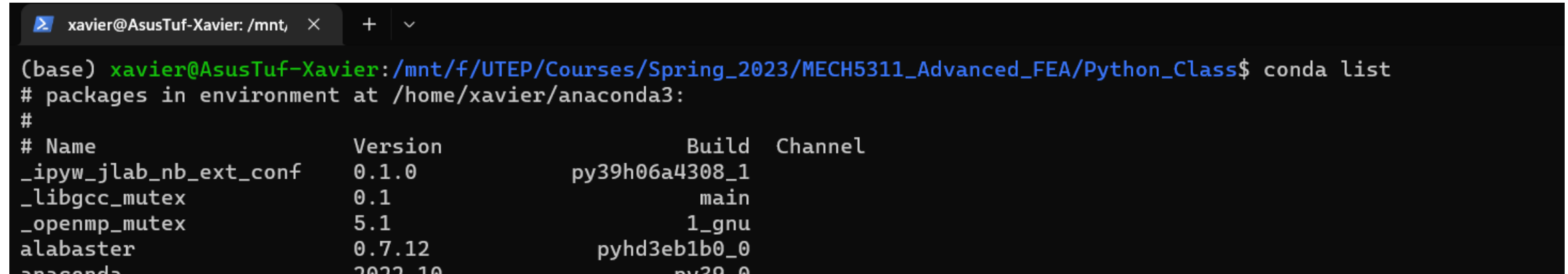
```
if ! [[ $PATH =~ "$HOME/anaconda3/bin" ]]; then
    PATH="$HOME/anaconda3/bin:$PATH"
fi
```

```
File Name to Write: /home/xavier/.bashrc
^G Help
^C Cancel      M-D DOS Format
               M-M Mac Format
```

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
```

A terminal window with a dark background. The title bar shows 'xavier@AsusTuf-Xavier: /mnt/'. The prompt is '(base) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class\$'. The command 'conda list' has been executed. The output shows the packages in the environment at /home/xavier/anaconda3. It lists several packages with their names, versions, build numbers, and channels.

```
(base) xavier@AsusTuf-Xavier:/mnt/f/UTEP/Courses/Spring_2023/MECH5311_Advanced_FEA/Python_Class$ conda list
# packages in environment at /home/xavier/anaconda3:
#
# Name                                Version                                Build      Channel
_ipyw_jlab_nb_ext_conf                0.1.0                                py39h06a4308_1
_libgcc_mutex                         0.1                                  main
_openmp_mutex                         5.1                                  1_gnu
alabaster                             0.7.12                             pyhd3eb1b0_0
anaconda                              2022.10                             py39_0
```

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

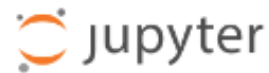
Or copy and paste one of these URLs:

<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.

  127.0.0.1:8888/tree        |   

 Quit Logout

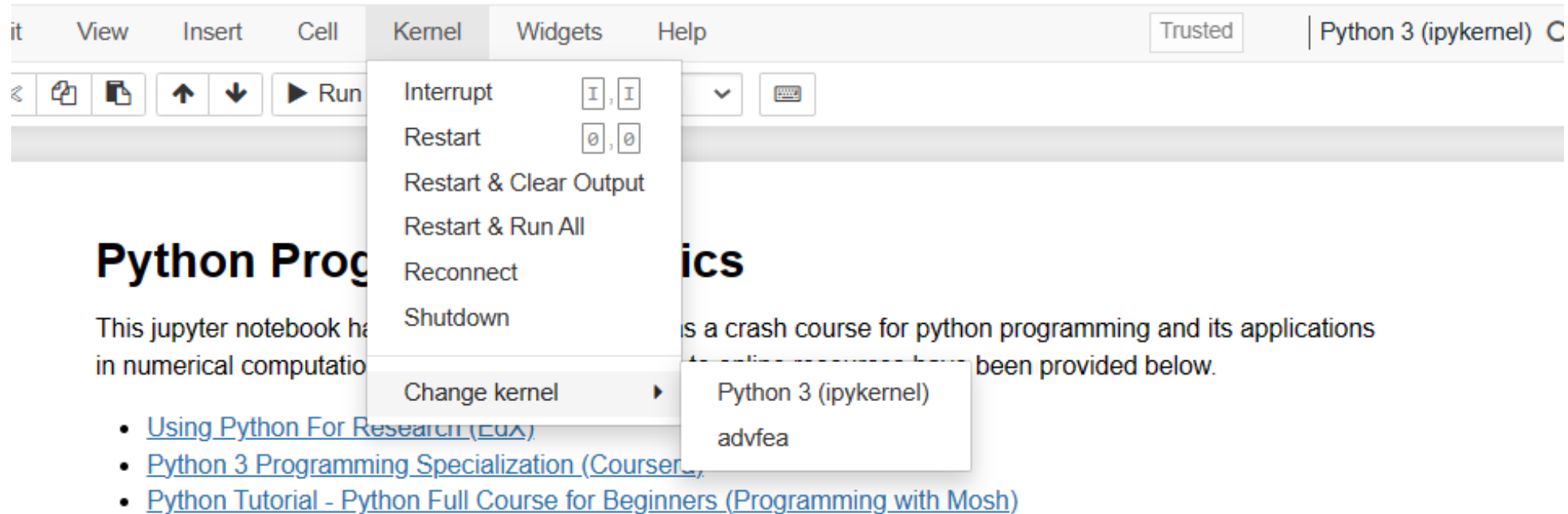
Files Running Clusters

Select items to perform actions on them. Upload New ▾ 

<input type="checkbox"/> 0 ▾  /	Name ▾	Last Modified	File size
<input type="checkbox"/>  make		4 minutes ago	
<input type="checkbox"/>  Pybasics_demo.ipynb	Running	seconds ago	1.78 kB
<input type="checkbox"/>  advfea.yml		2 days ago	10.8 kB

STEP 3

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



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`.

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 :) ")
```

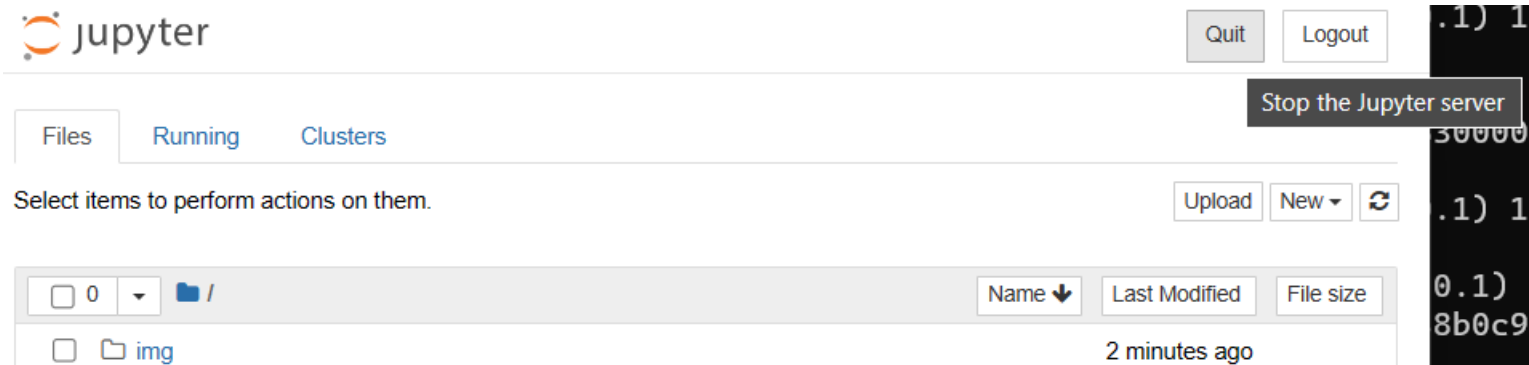
You are ready to go for this course :)

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 .yaml file: `conda env create -n advfea --file advfea.yaml`

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

Delete Conda environment: `conda env remove -n advfea`