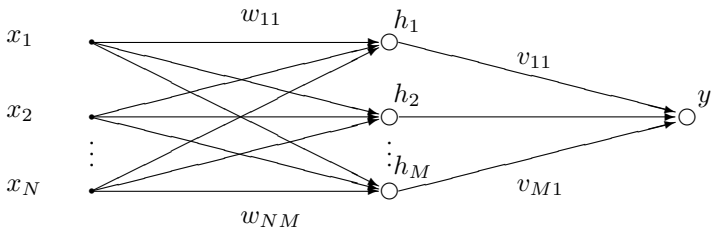
# Machine Learning
# TBMI26 / 732A55

## Computer Assignments

2023



# Contents

# General information

This compendium contains instructions for the 4 computer assignments. Additional resources are found on the LISAM course page (*lisam.liu.se*).

You have to pass all assignments to get the lab credits. The assignments will be graded (pass/fail) based on your solutions and answers, which you submit in LISAM. All files needed for the assignments are found in the zip file available on LISAM. The solved assignments should be submitted individually or in groups of two students. The submissions will be checked for plagiarism. Plagiarized submissions will be reported to the LiU disciplinary board.

The deadlines for the reports can be found in LISAM. If a report is sent in late we might not look at it until the next re-examination period. *So, submit your reports in time*!

**Important:** This year, all four assignments have gone through major updates. In case you discover any technical problems with the provided code, we would be grateful if you notified us as soon as possible so the issue can be fixed.

**Common setup:** All four assignments are written in python notebooks. This is a file type used for interactive python coding. We recommend that you use Jupyter Lab and that you install the Variable Inspector extension. This will give you a list of all current variables and their values, which will make debugging much more convenient. Once you are up and running with your first notebook, you can open the Variable Inspector by right-clicking anywhere in the notebook window and selecting ”Open Variable Inspector”. In the same way, you can also open a python console for the notebook, which can be useful when testing your code.

The step-by-steps instructions for setting up the lab environment is included at the end of this pdf.

It is also possible to run the notebooks in Visual Studio Code, but we do not provide the instructions for that environment and cannot guarantee that it will work as expected.

# Lab assignments

This course has four assignments. These are, in order:

### A1: Supervised learning

This assignment contains three notebooks. First you will implement and test the k-nearest neighbour algorithm. Then you will implement and train a simple single-layer neural network. Finally, you will implement and train a multi-layer neural network.

*Note that this assignment is often regarded as the most difficult and time consuming, since it covers three different models. Do not expect to finish this lab in the scheduled timeslot, you have to prepare in advance!*

### A2: Deep learning

Here you will use the Keras framework for deep learning to train increasingly powerful models for object classification. To get you started using Keras, we have provided a separate notebook with some explanations and examples, called `MNIST-Demo.ipynb`. It is highly recommended that you go through this demo well in advance.

*Note that this assignment requires a different Python environment than the other three (either* `tf_env` *or* `tf_gpu_env`*), due to the inclusion of several large deep learning packages. The details are in the Python setup instructions below.*

### A3: Boosting

This assignment will cover a method for supervised ensemble learning, specifically the algorithm AdaBoost, in which many weak classifiers are combined to make a single strong classifier. You will use this technique to build a face detector.

### A4: Reinforcement learning

In the last assignment you will implement and train a reinforcement learning agent to find the optimal paths through different grid worlds.

# Lab submission

### Written submission

You submit your solved assignments in Lisam. To ensure that you submit a working solution we will run your code. Therefore, you must submit both your notebook file (and any required external files), as well as an exported version of the notebook (HTML-format). In short, follow these steps to ensure a valid submission:

1. Export your notebook using the menu bar option `File -> Export Notebook As... -> Export Notebook to HTML / PDF`
2. Use the menu bar option `Kernel -> Restart Kernel and Run All...`. This ensures that all code is run from a clean state and actually works. This is for your own benefit; if the code does not run, you will get it back.
3. Make sure nothing big changed in the solution. Some variance is expected due to randomness, but you should get comparable results. If you did not you probably need to optimize your hyperparameters to get more stable solutions.
4. Zip all files *except* the exported HTML file.
5. Submit the Zip and HTML in Lisam. The exported HTML-file will be checked for plagiarism, and we will run your code.

### Oral examination

As an alternative to the default written submission, we will offer the option to instead do the lab examination orally during the scheduled lab session. If you pass the lab this way, you will not have to wait for us to correct the written report and will instead be passed directly (or within a day or two). You should still submit your solutions for reference in Lisam. In addition to a faster approval, we teachers also get the opportunity to discuss your solutions in order to clear up any misunderstandings. Although note that this examination session is not meant to help you solve the labs. You should be fully done and well prepared before you request an oral examination. In case we require you to make revisions you will have to submit them in the default written format in Lisam.

*Again note, this is only an option. We do not require you to present the labs orally if you do not want to.*

We will give more details about this before the first lab session.

# Python setup

The following pages will go through the installation process for the lab environment.

(There are more instructions after these, don’t miss them.)

# Setting up your computer for the labs

Please read fully before starting

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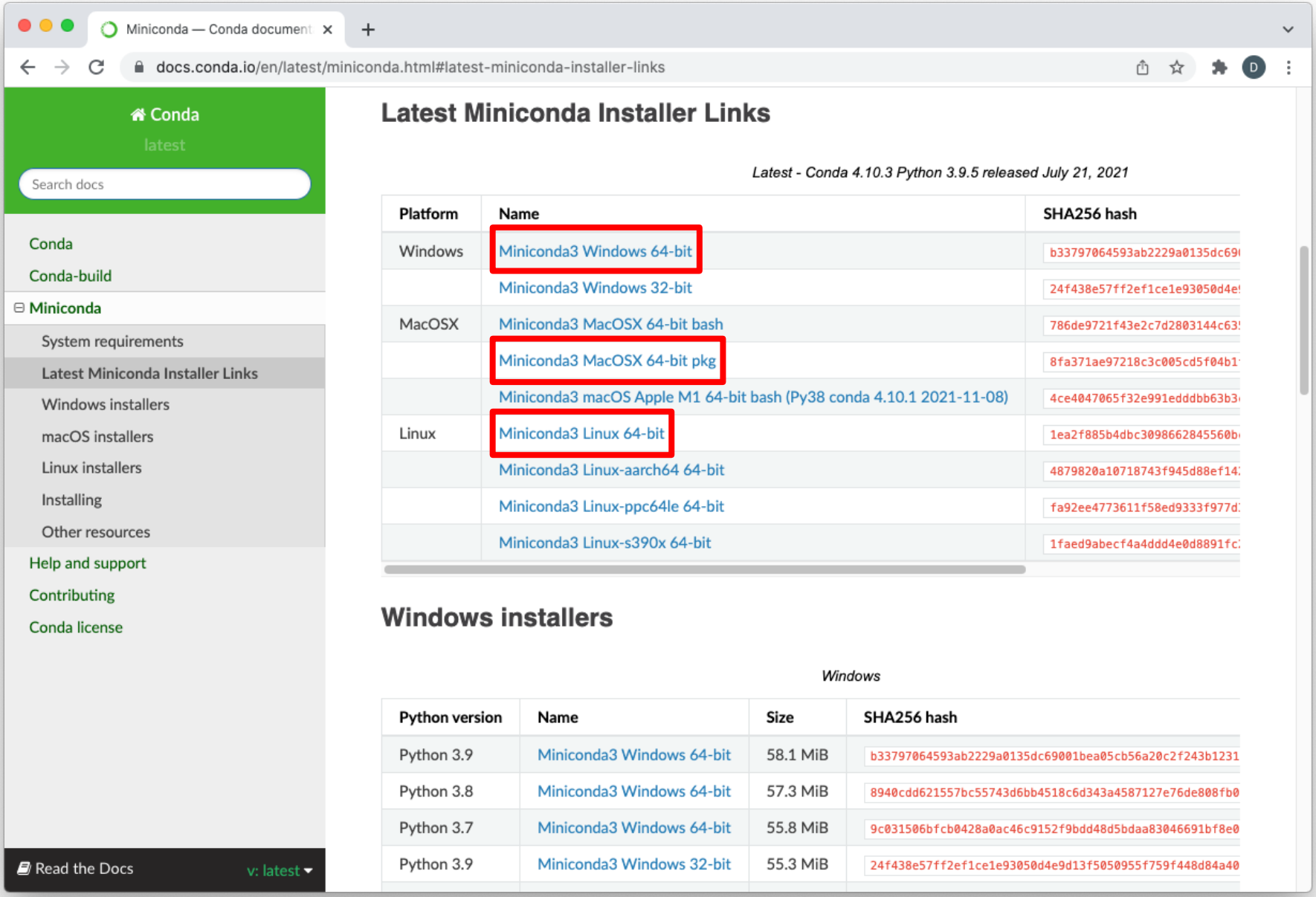
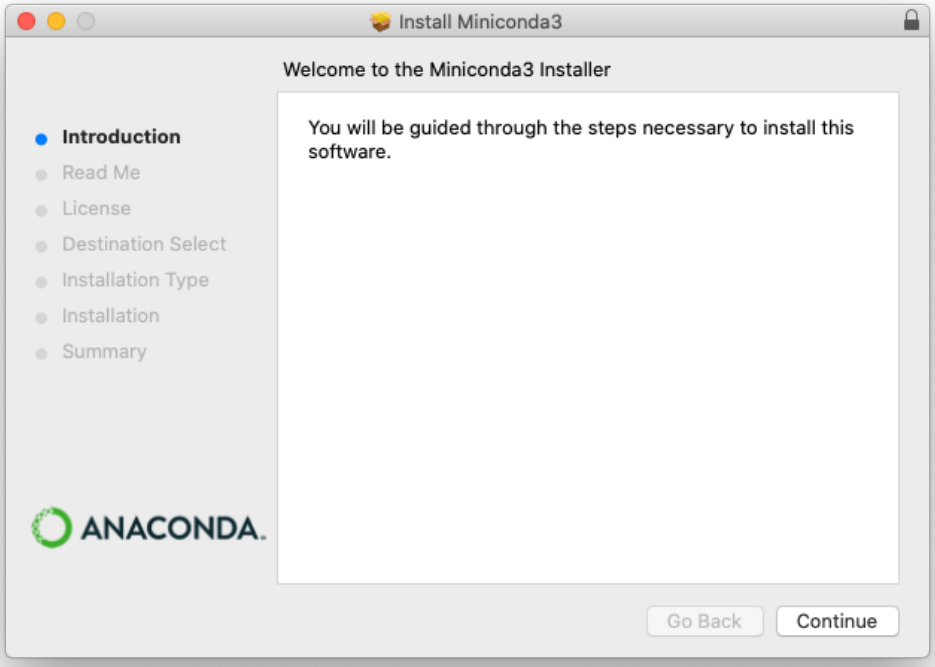
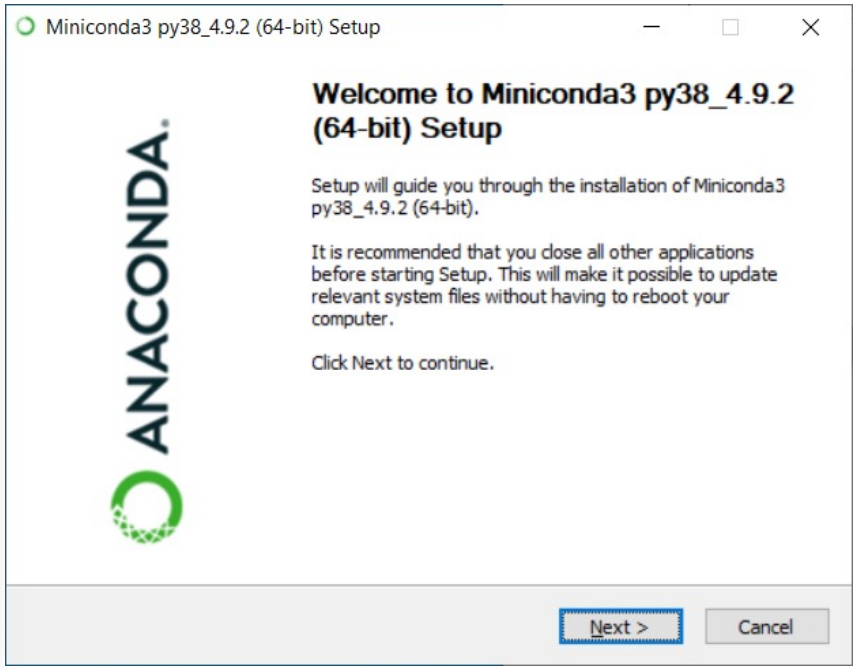
# Setting up the environment

This only needs to be done once

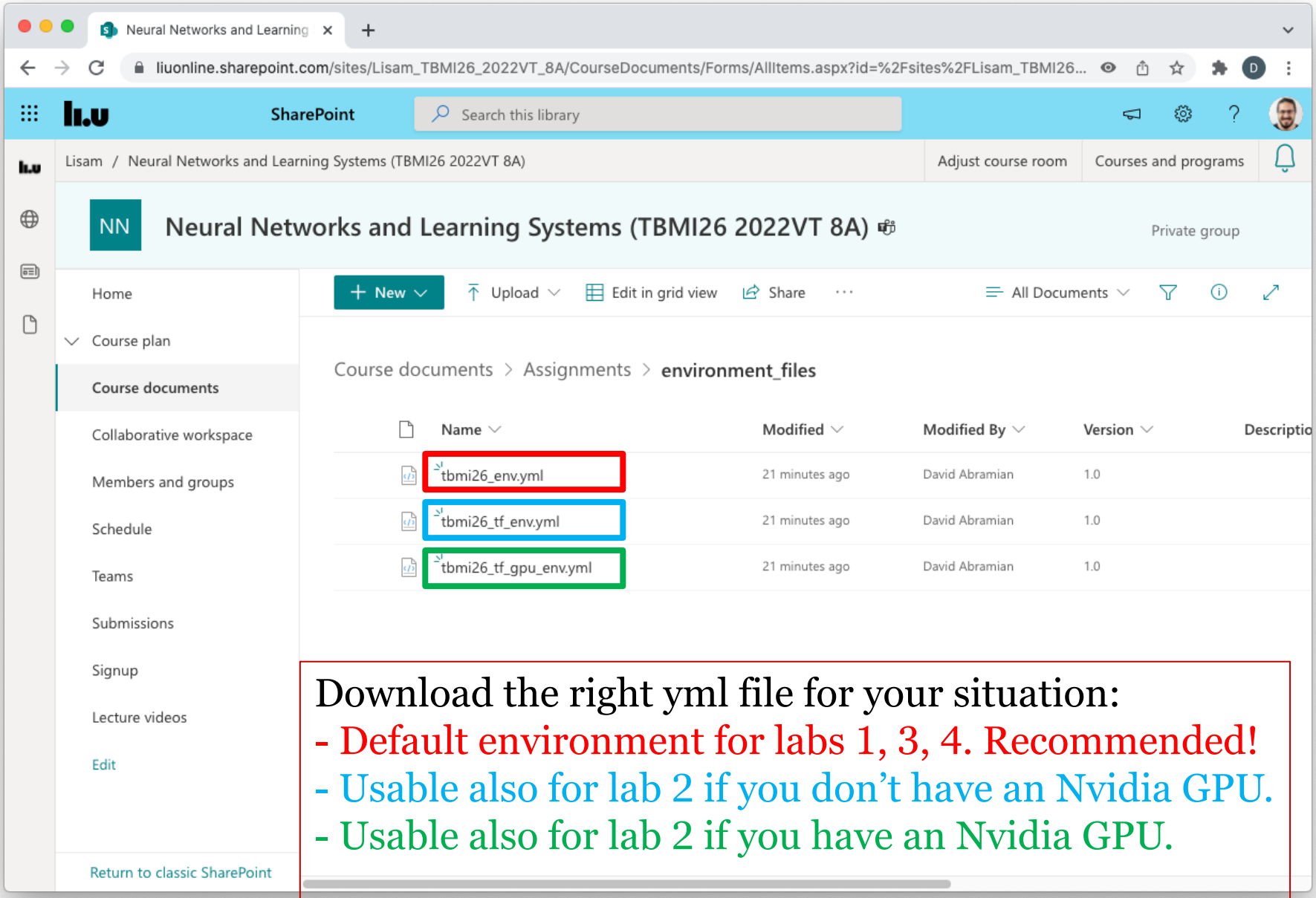



Download the right version of Miniconda for your OS.




Install Miniconda. The default settings should be fine.


Neural Networks and Learning
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SharePoint
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Courses and programs
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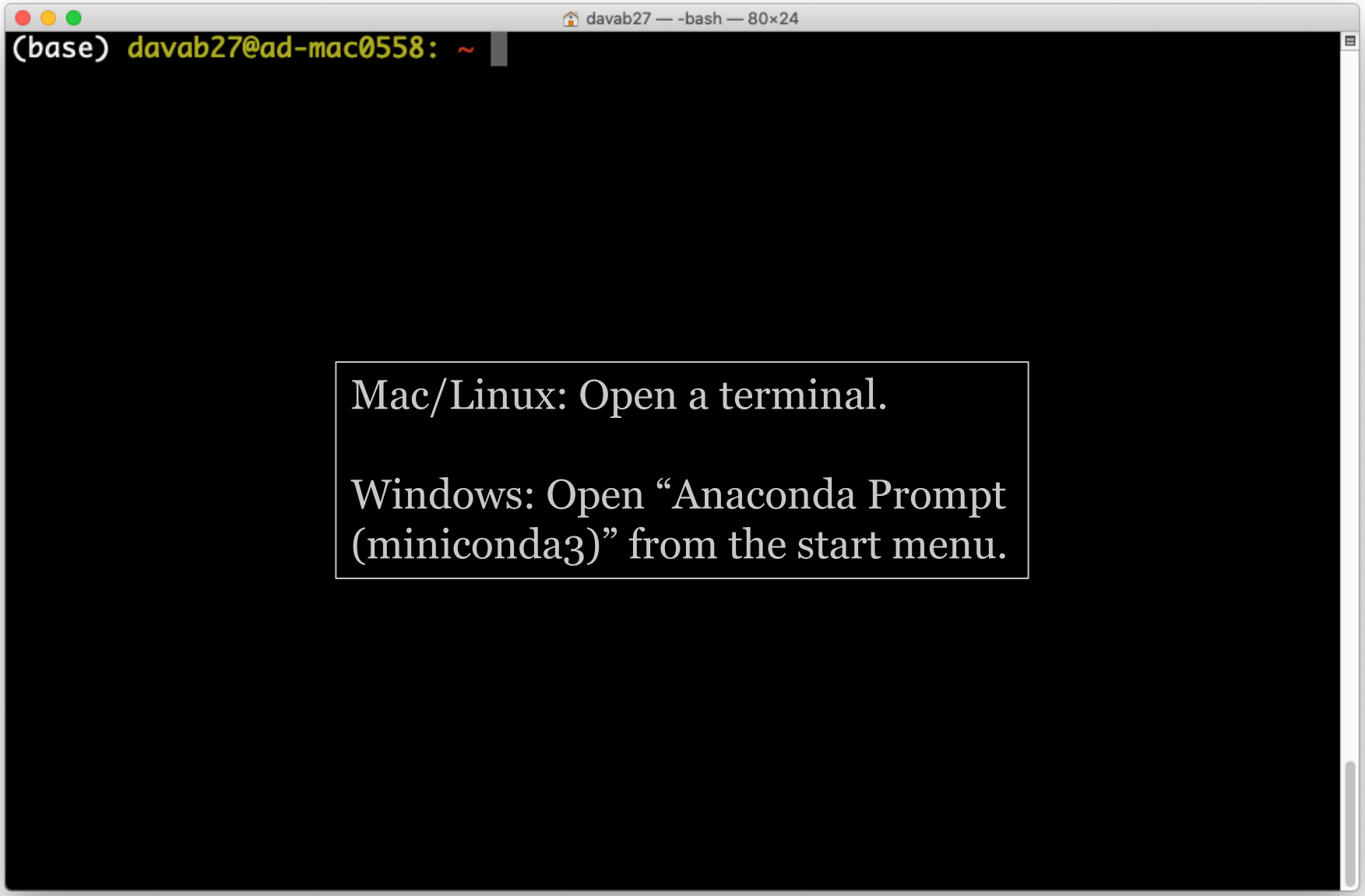
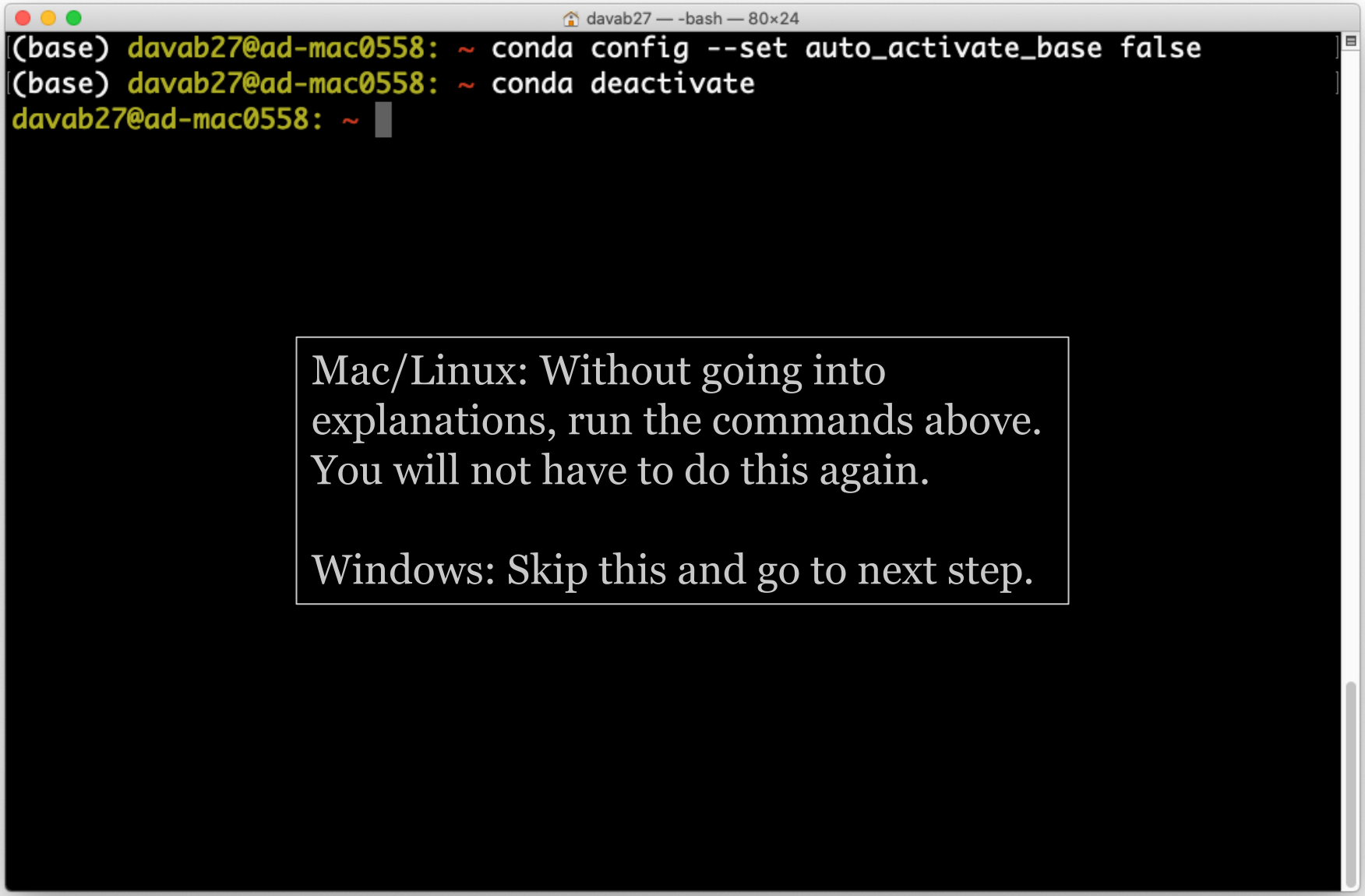
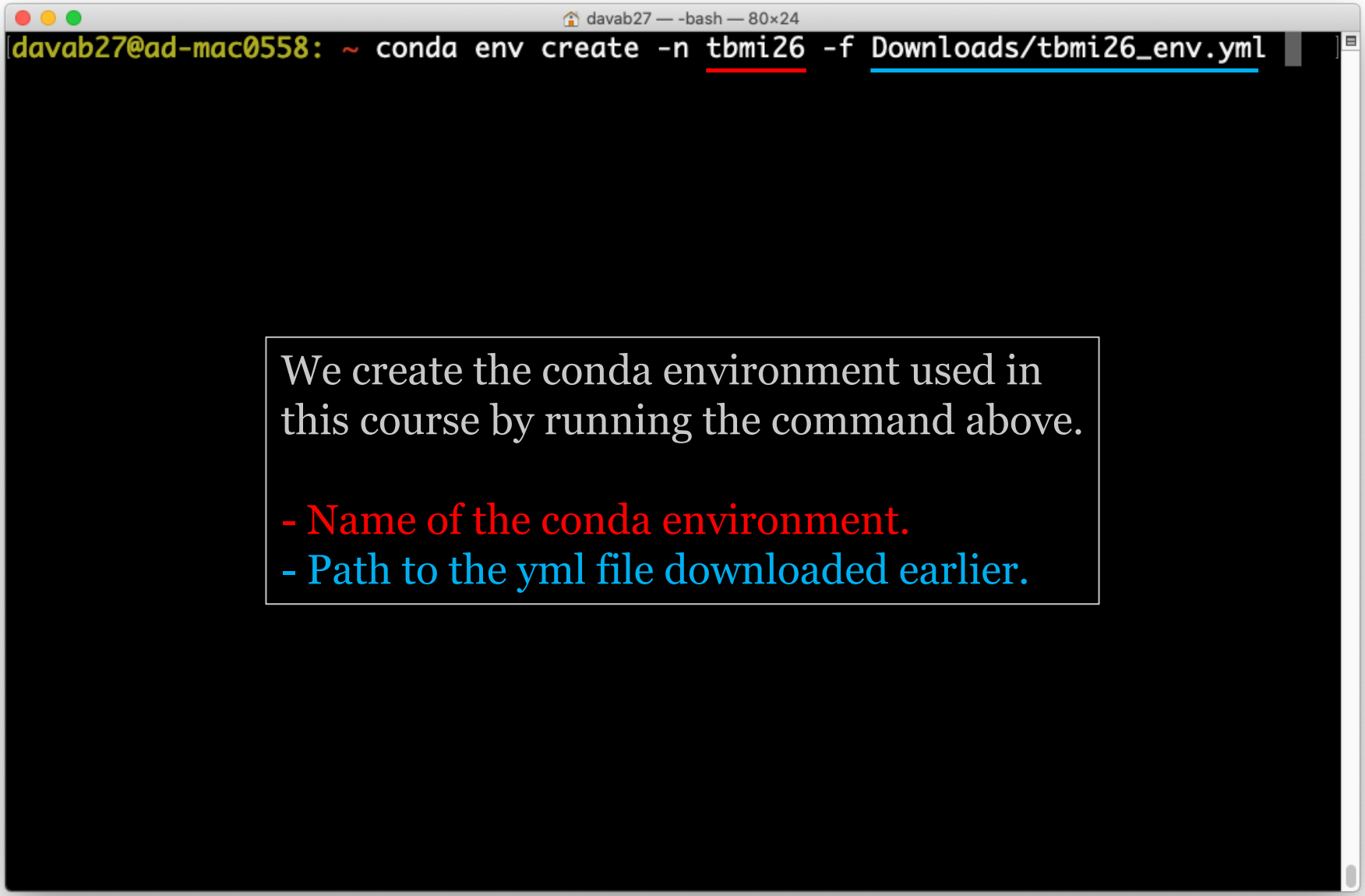
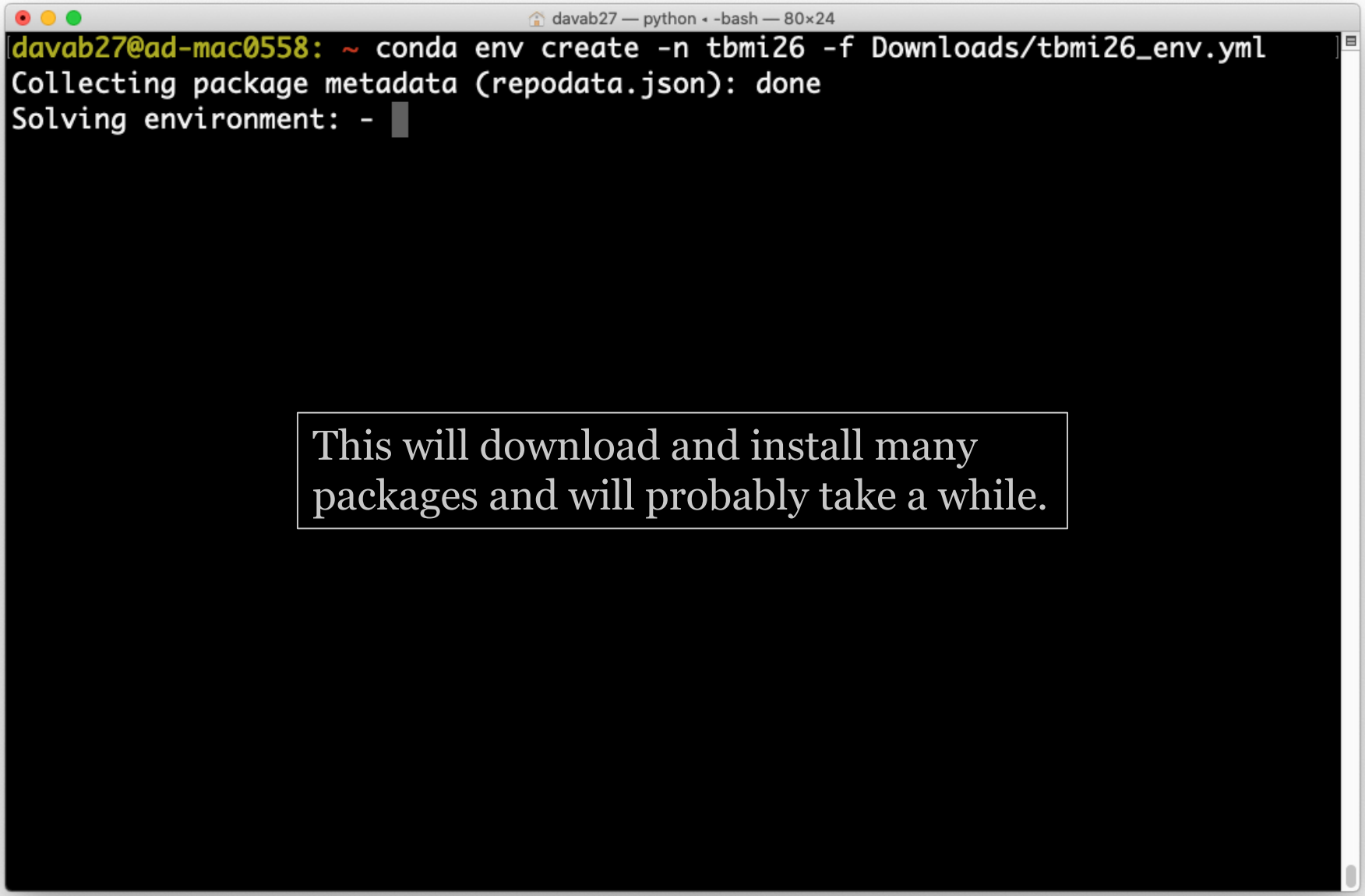
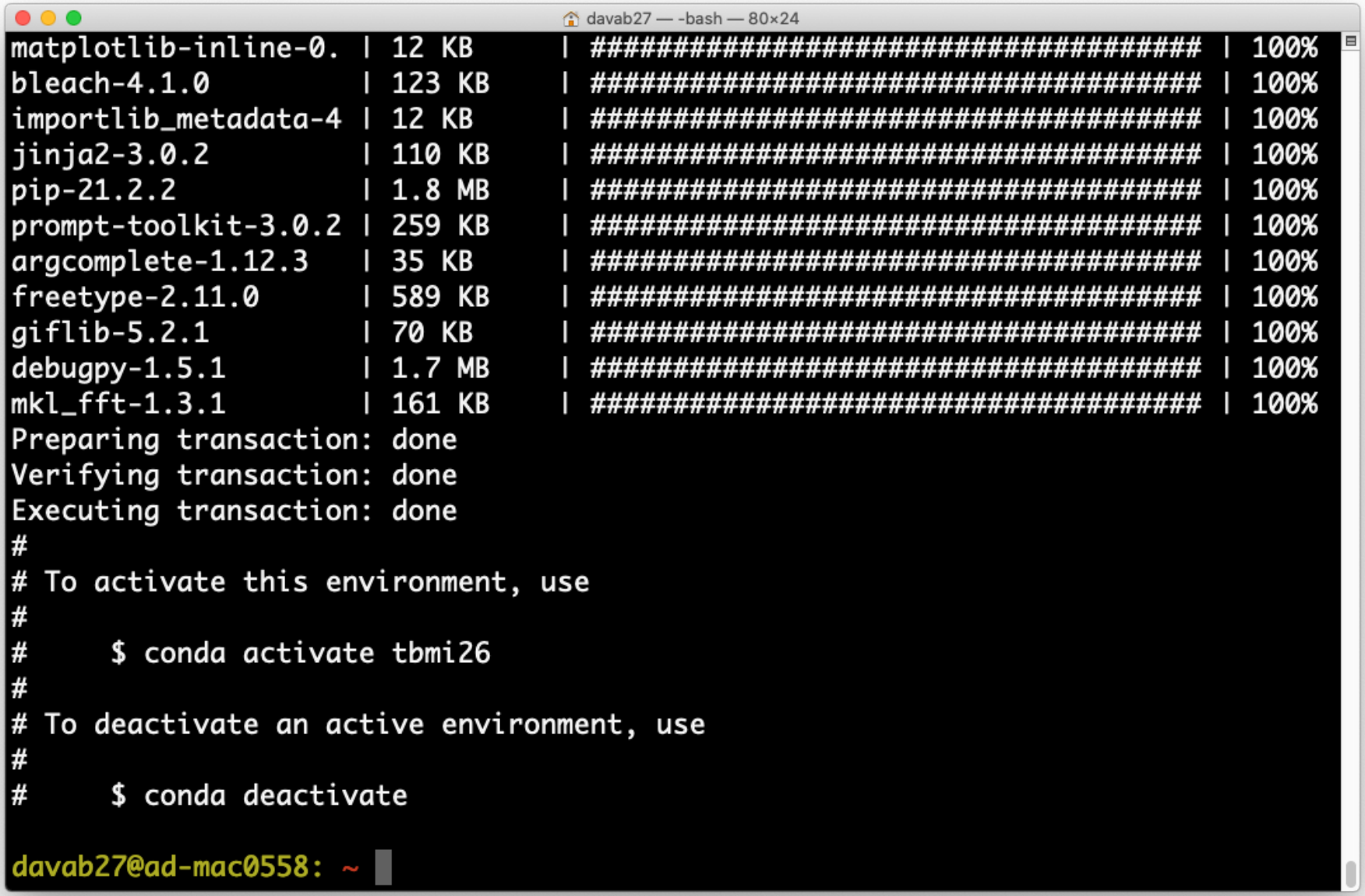
Neural Networks and Learning Systems (TBMI26 2022VT 8A)
Private group
Home
Course plan
Course documents
Collaborative workspace
Members and groups
Schedule
Teams
Submissions
Signup
Lecture videos
Edit
Return to classic SharePoint
New
Upload
Edit in grid view
Share
All Documents
Course documents > Assignments > environment_files
Name
Modified
Modified By
Version
tbmi26_env.yml
21 minutes ago
David Abramian
1.0
tbmi26_tf_env.yml
21 minutes ago
David Abramian
1.0
tbmi26_tf_gpu_env.yml
21 minutes ago
David Abramian
1.0
Download the right yml file for your situation:
- Default environment for labs 1, 3, 4. Recommended!
- Usable also for lab 2 if you don't have an Nvidia GPU.
- Usable also for lab 2 if you have an Nvidia GPU.
Only the last of these will take advantage of a GPU.
The rest will run on the CPU.


davab27 — -bash — 80×24
(base) davab27@ad-mac0558: ~
Mac/Linux: Open a terminal.
Windows: Open “Anaconda Prompt (miniconda3)” from the start menu.

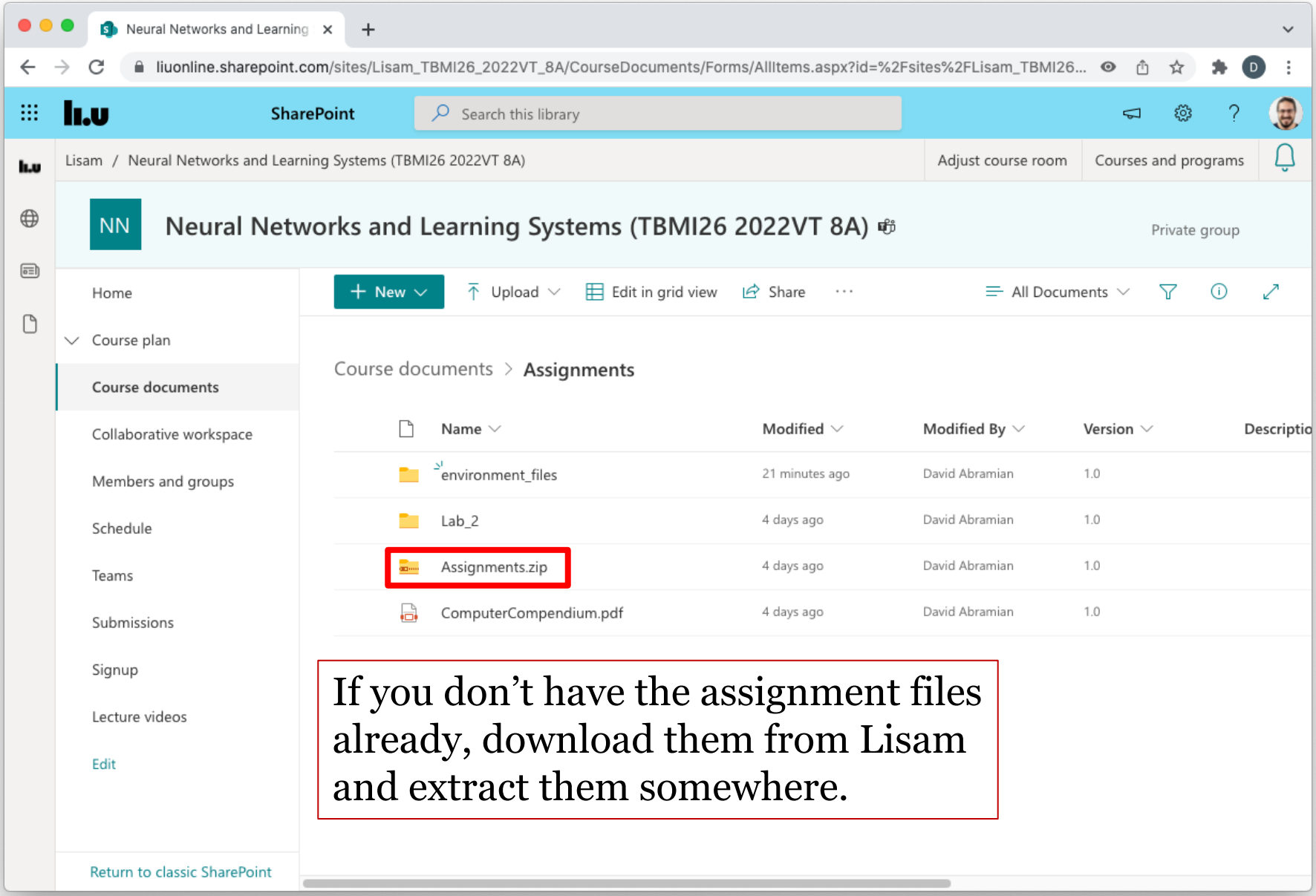

davab27 — -bash — 80×24
(base) davab27@ad-mac0558: ~ conda config --set auto_activate_base false
(base) davab27@ad-mac0558: ~ conda deactivate
davab27@ad-mac0558: ~
Mac/Linux: Without going into explanations, run the commands above. You will not have to do this again.
Windows: Skip this and go to next step.


davab27 — -bash — 80×24
davab27@ad-mac0558: ~ conda env create -n tbmi26 -f Downloads/tbmi26_env.yml
We create the conda environment used in this course by running the command above.
- Name of the conda environment.
- Path to the yml file downloaded earlier.


davab27 — python ◂ -bash — 80×24
davab27@ad-mac0558: ~ conda env create -n tbmi26 -f Downloads/tbmi26_env.yml
Collecting package metadata (repodata.json): done
Solving environment: -
This will download and install many packages and will probably take a while.




We now have an environment with Jupyter and all the other packages we will need.


Neural Networks and Learning
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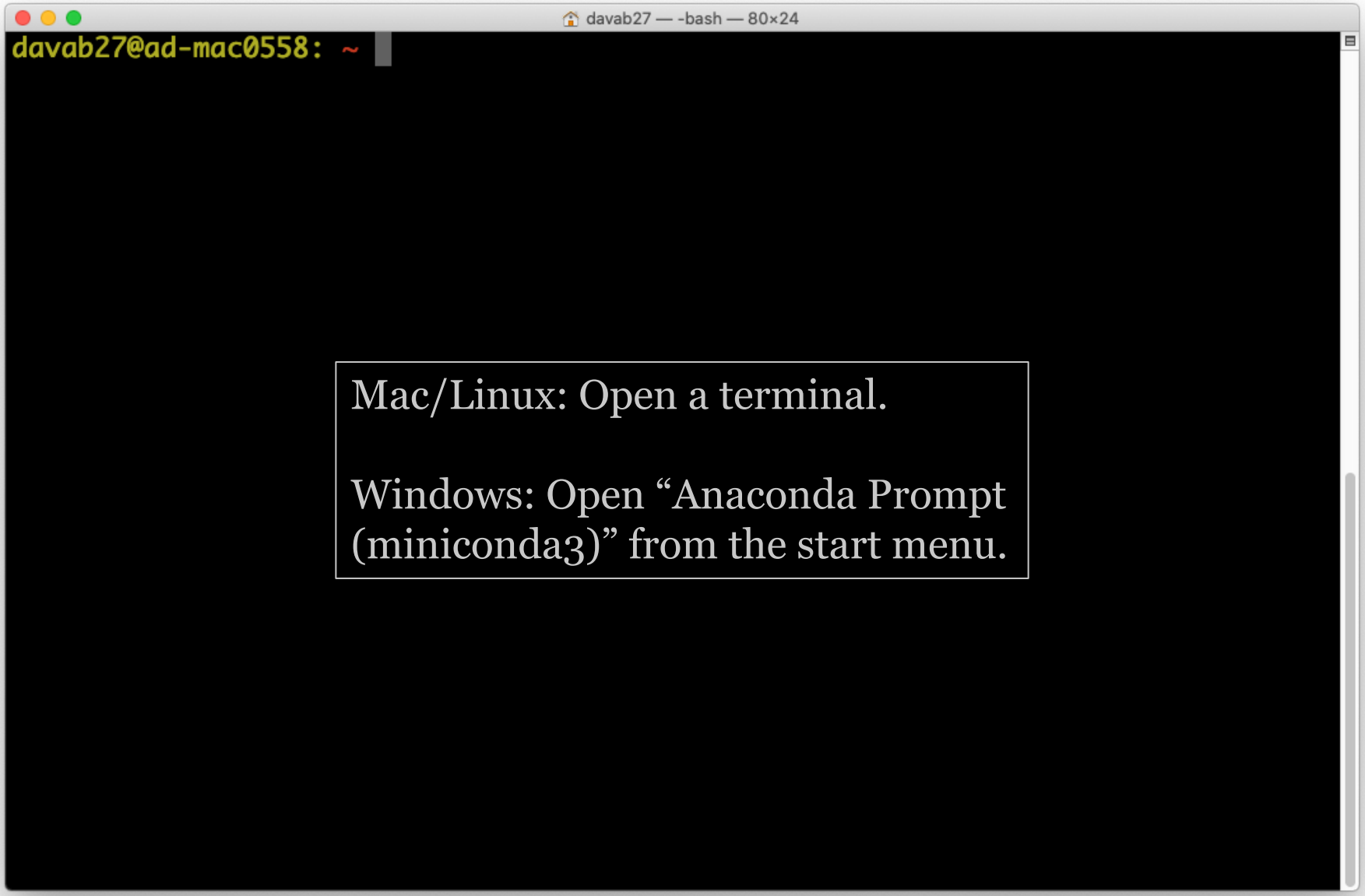
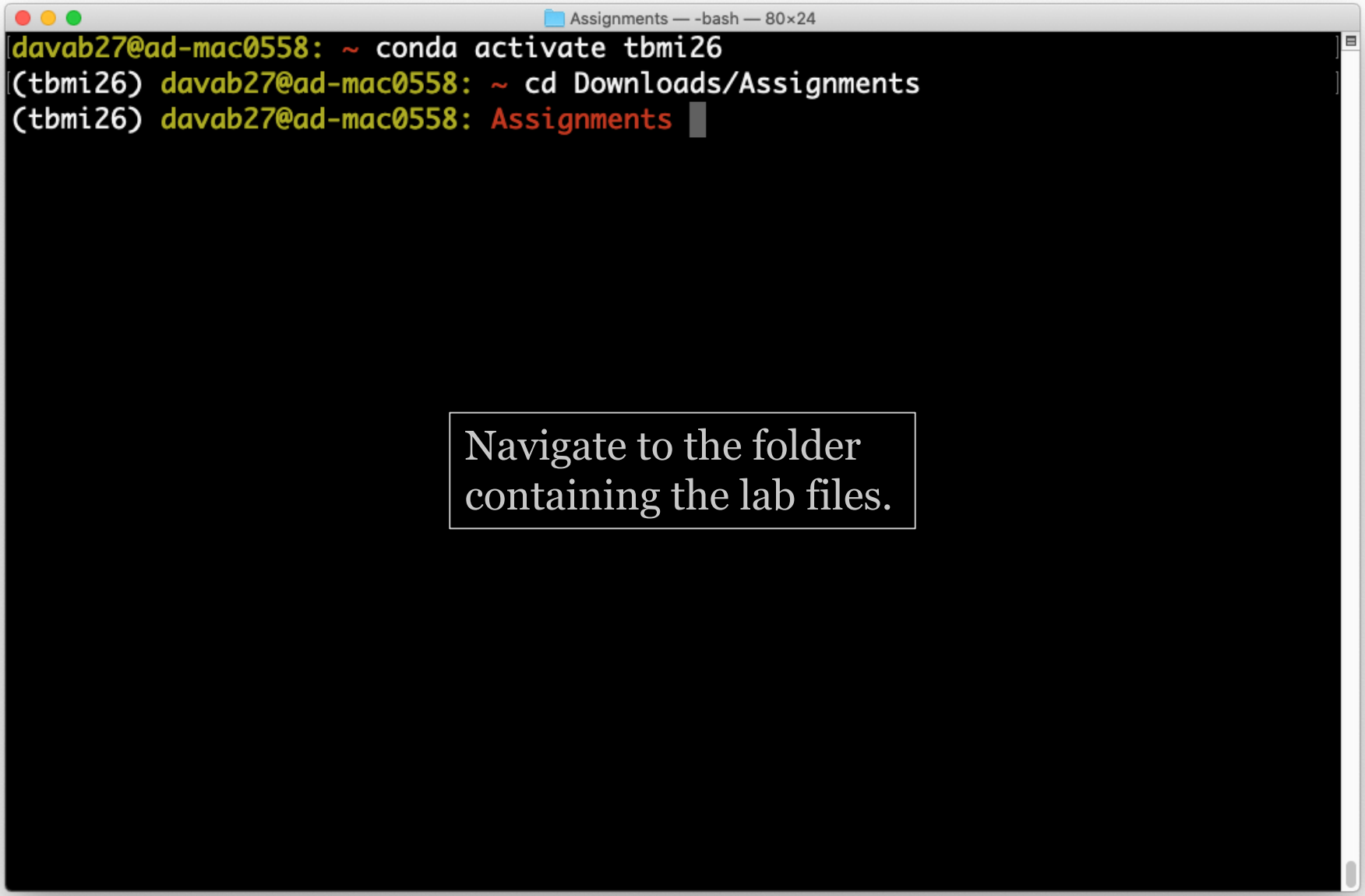
Neural Networks and Learning Systems (TBMI26 2022VT 8A)
Private group
Home
Course plan
Course documents
Collaborative workspace
Members and groups
Schedule
Teams
Submissions
Signup
Lecture videos
Edit
Return to classic SharePoint
New
Upload
Edit in grid view
Share
All Documents
Course documents > Assignments
Name
Modified
Modified By
Version
environment_files
21 minutes ago
David Abramian
1.0
Lab_2
4 days ago
David Abramian
1.0
Assignments.zip
4 days ago
David Abramian
1.0
ComputerCompendium.pdf
4 days ago
David Abramian
1.0
If you don’t have the assignment files already, download them from Lisam and extract them somewhere.

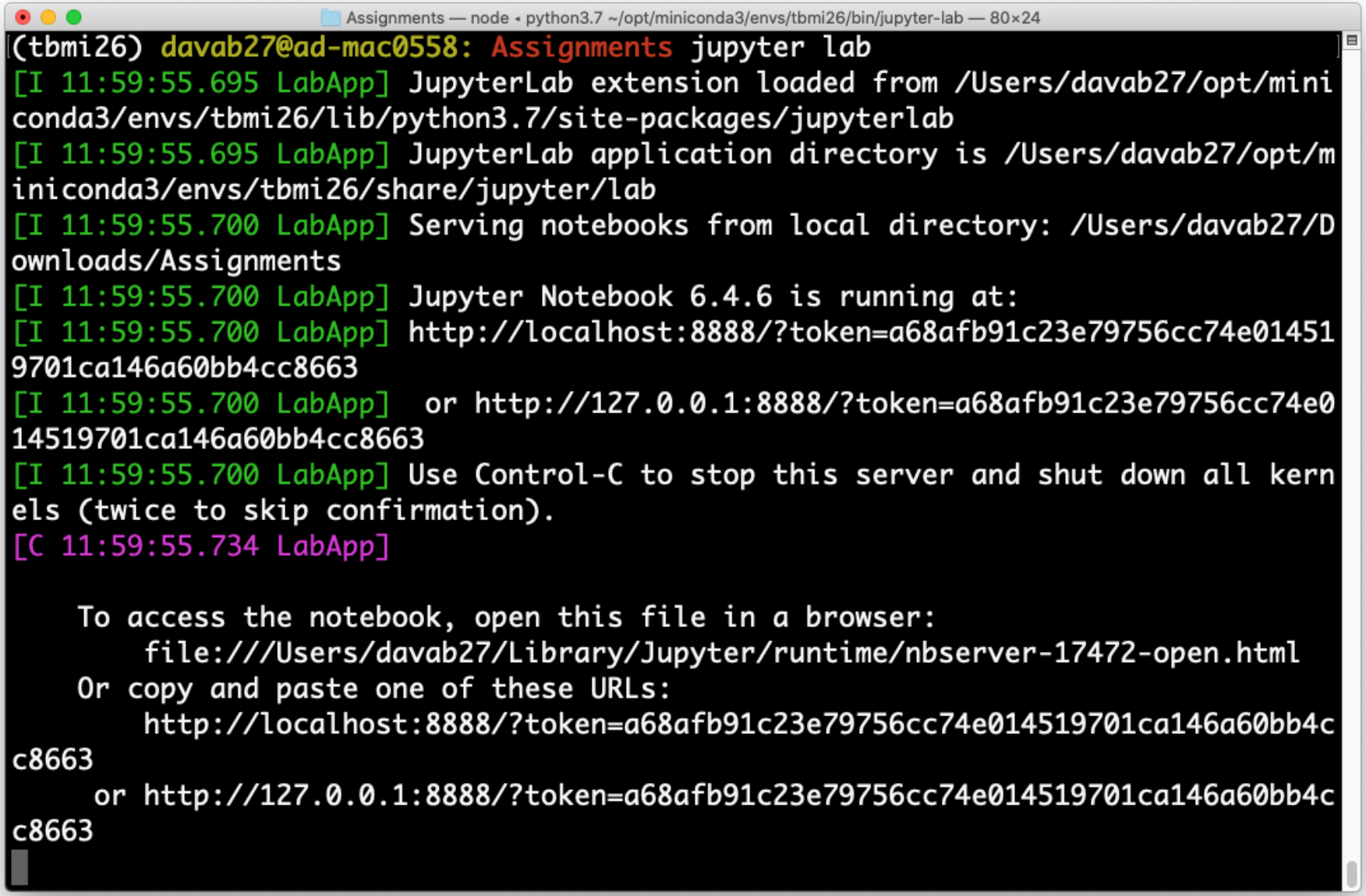
# Launching the labs

Do this every time you want to work on the lab

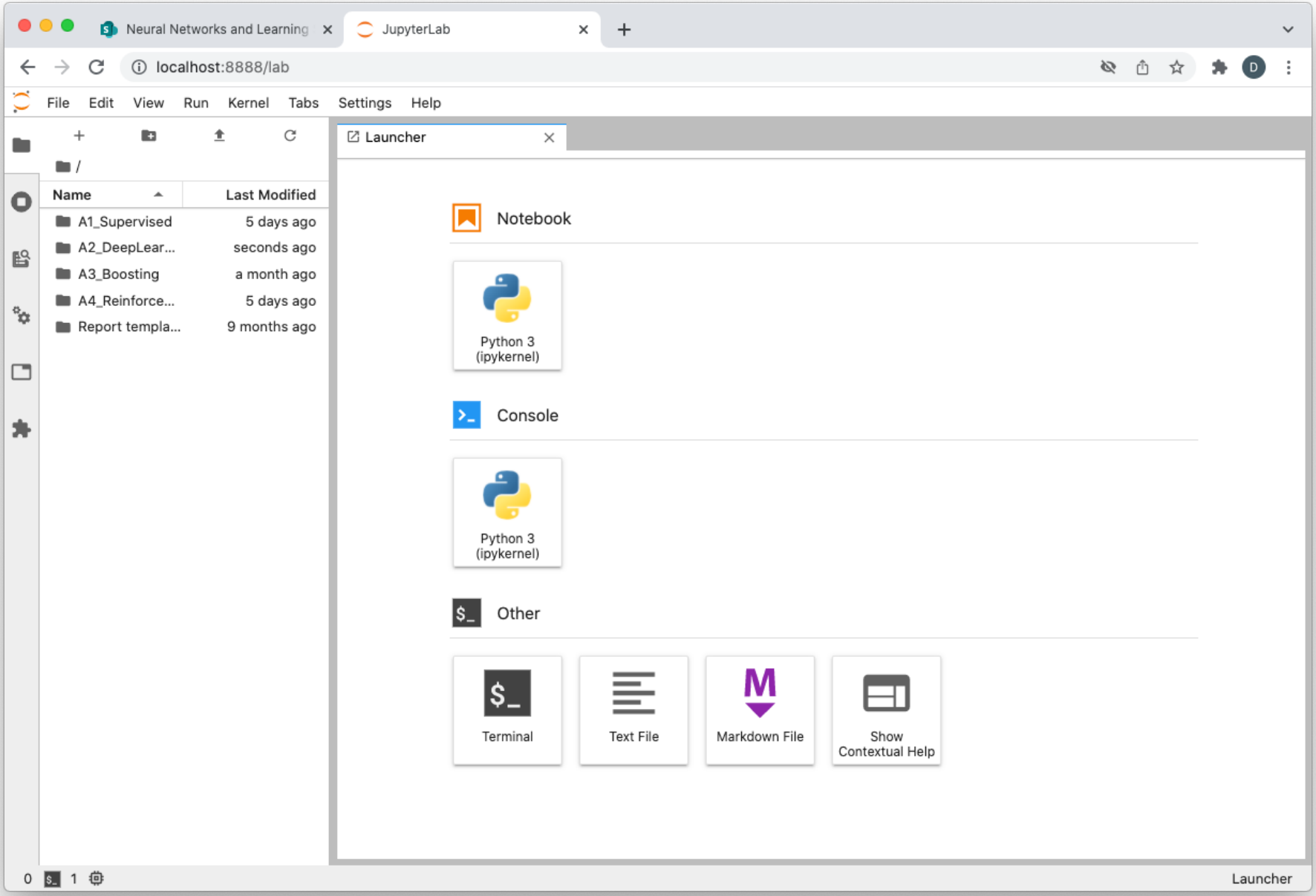

davab27 — -bash — 80×24
davab27@ad-mac0558: ~
Mac/Linux: Open a terminal.
Windows: Open “Anaconda Prompt (miniconda3)” from the start menu.


davab27 — -bash — 80×24
davab27@ad-mac0558: ~ conda activate tbmi26
(tbmi26) davab27@ad-mac0558: ~
Activate the conda environment.

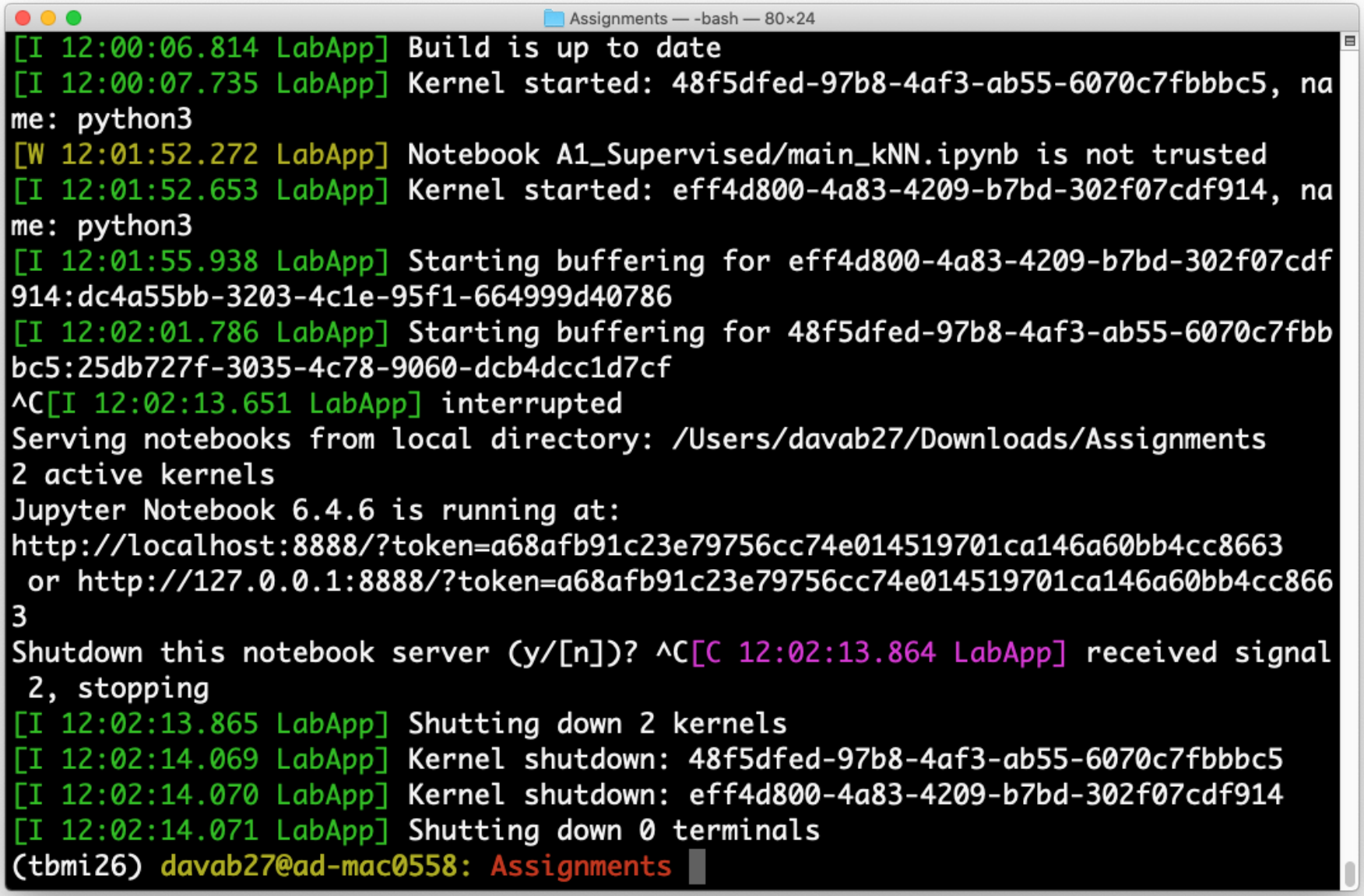

Assignments — -bash — 80×24
davab27@ad-mac0558: ~ conda activate tbmi26
(tbmi26) davab27@ad-mac0558: ~ cd Downloads/Assignments
(tbmi26) davab27@ad-mac0558: Assignments
Navigate to the folder containing the lab files.




Start Jupyter with the given command.



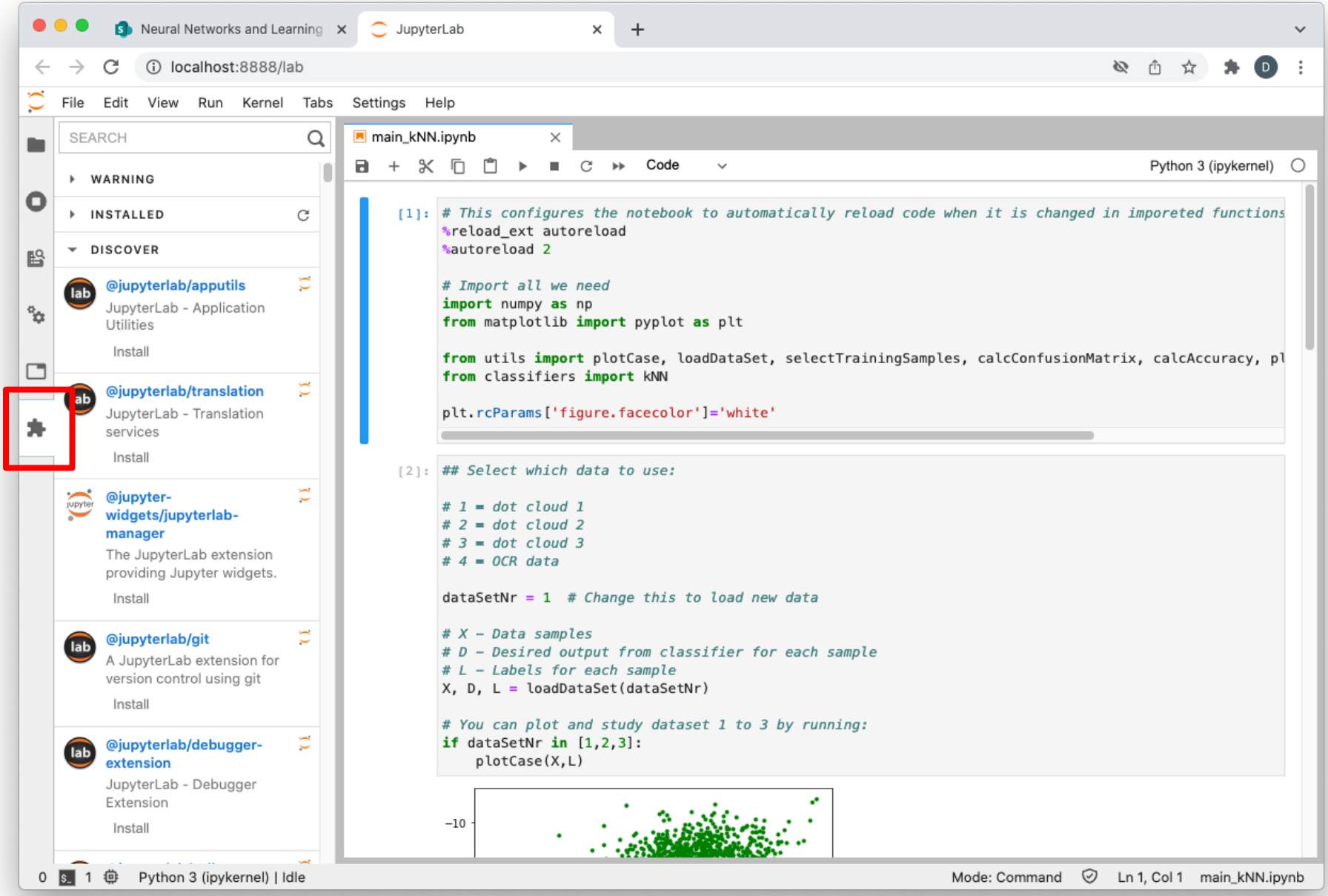

Jupyter will launch in a browser window automatically.



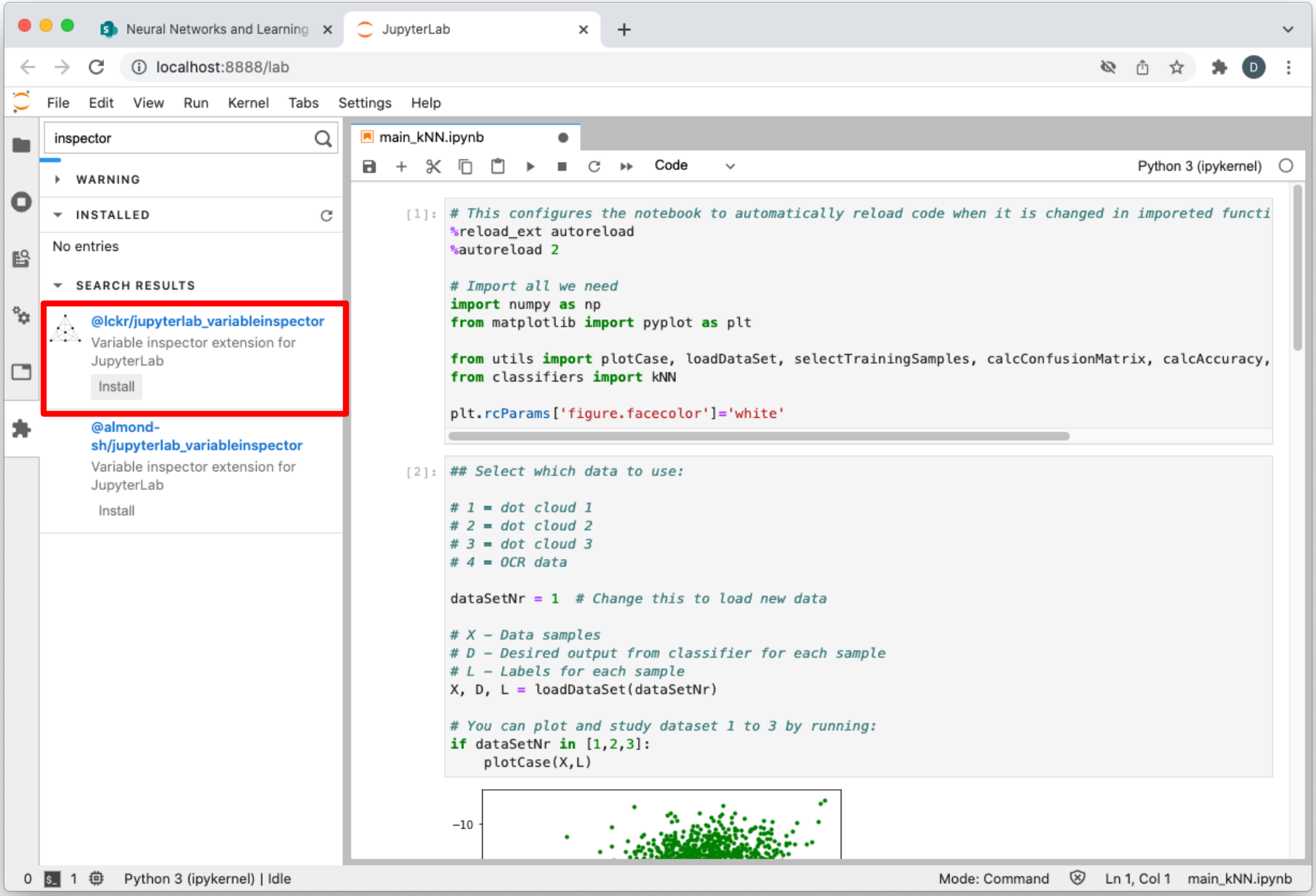

You can shutdown Jupyter by pressing [Ctrl + C] twice in the terminal.

# Install Jupyter variable inspector

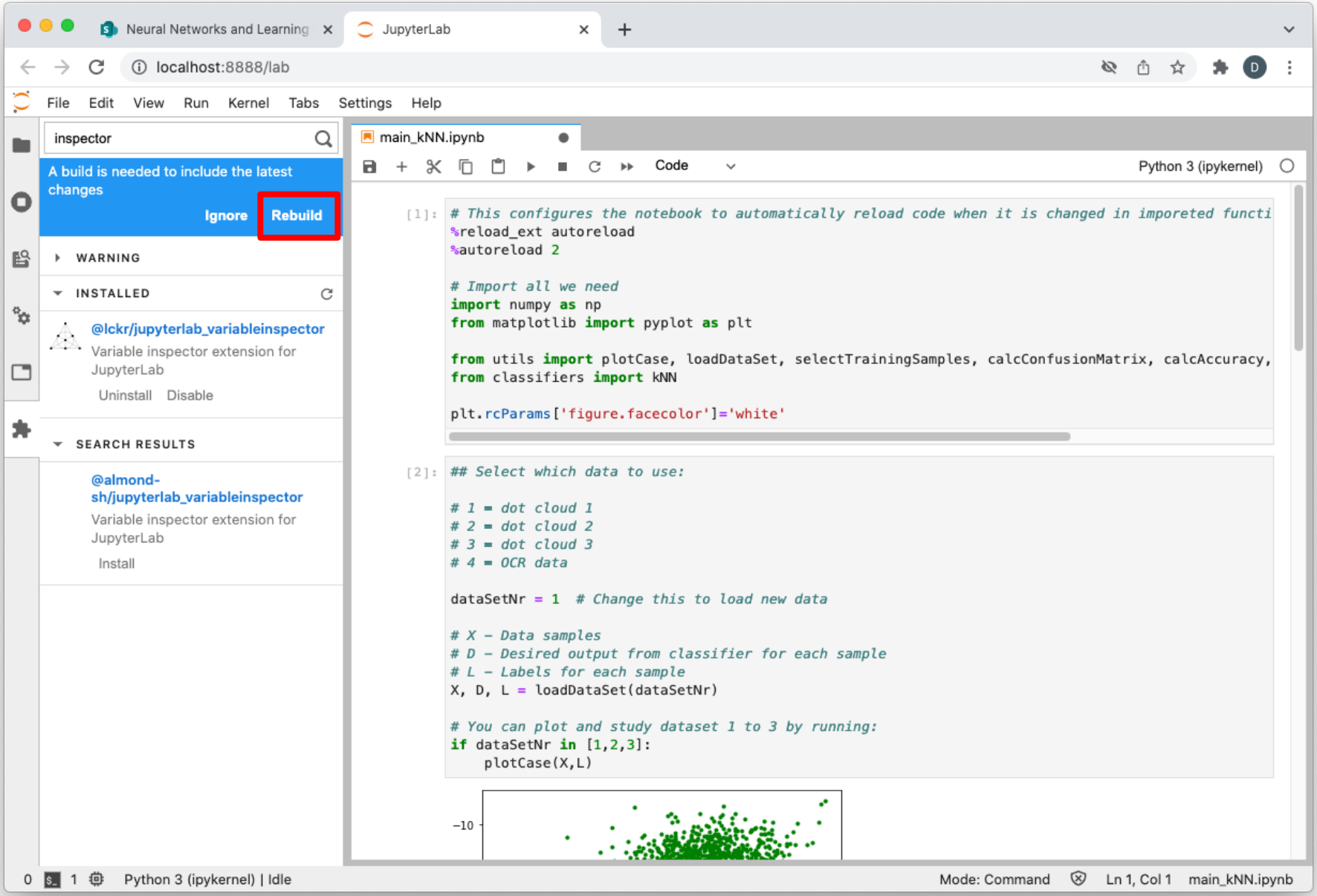
This is strongly recommended!



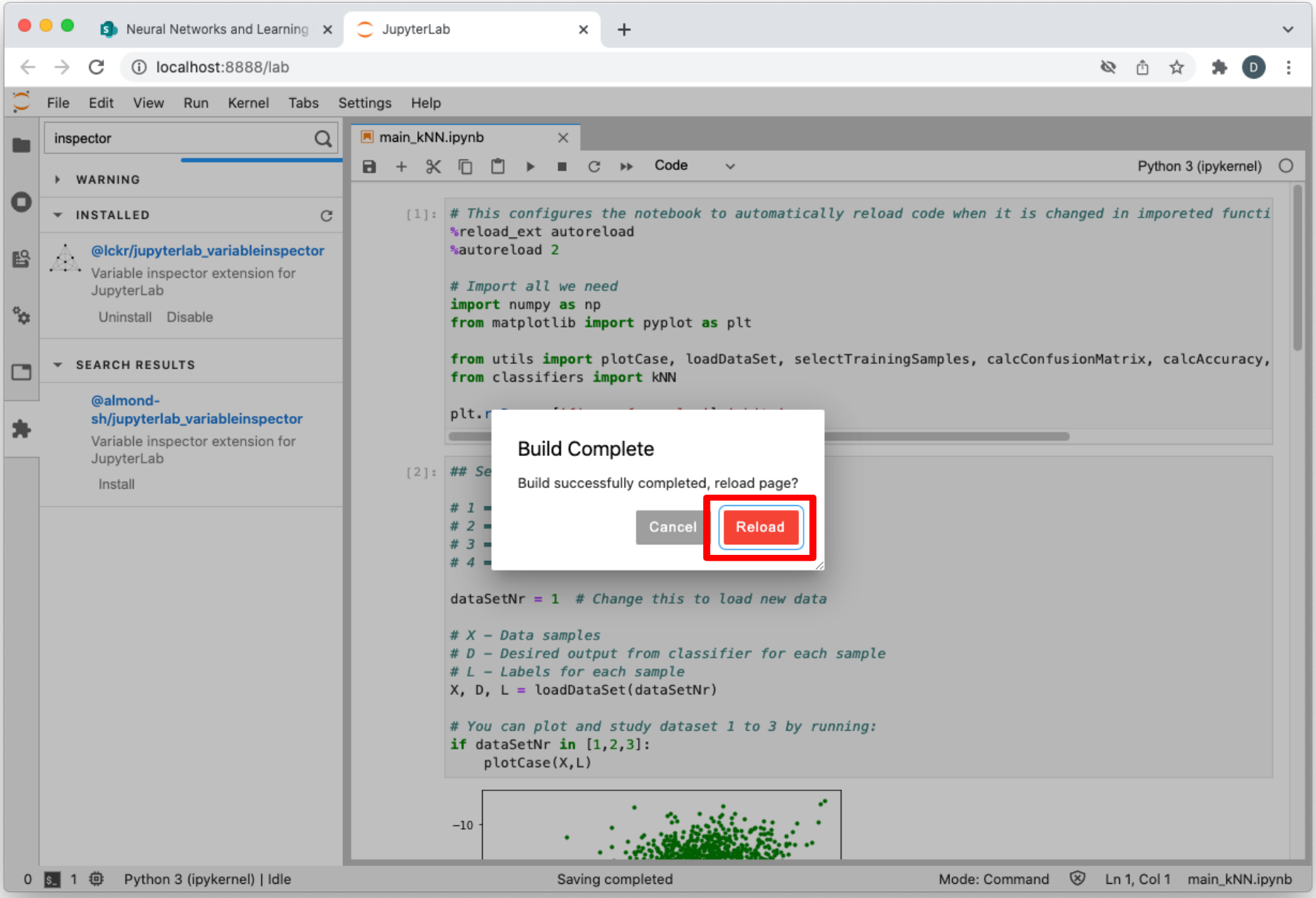

Open the Extensions tab.



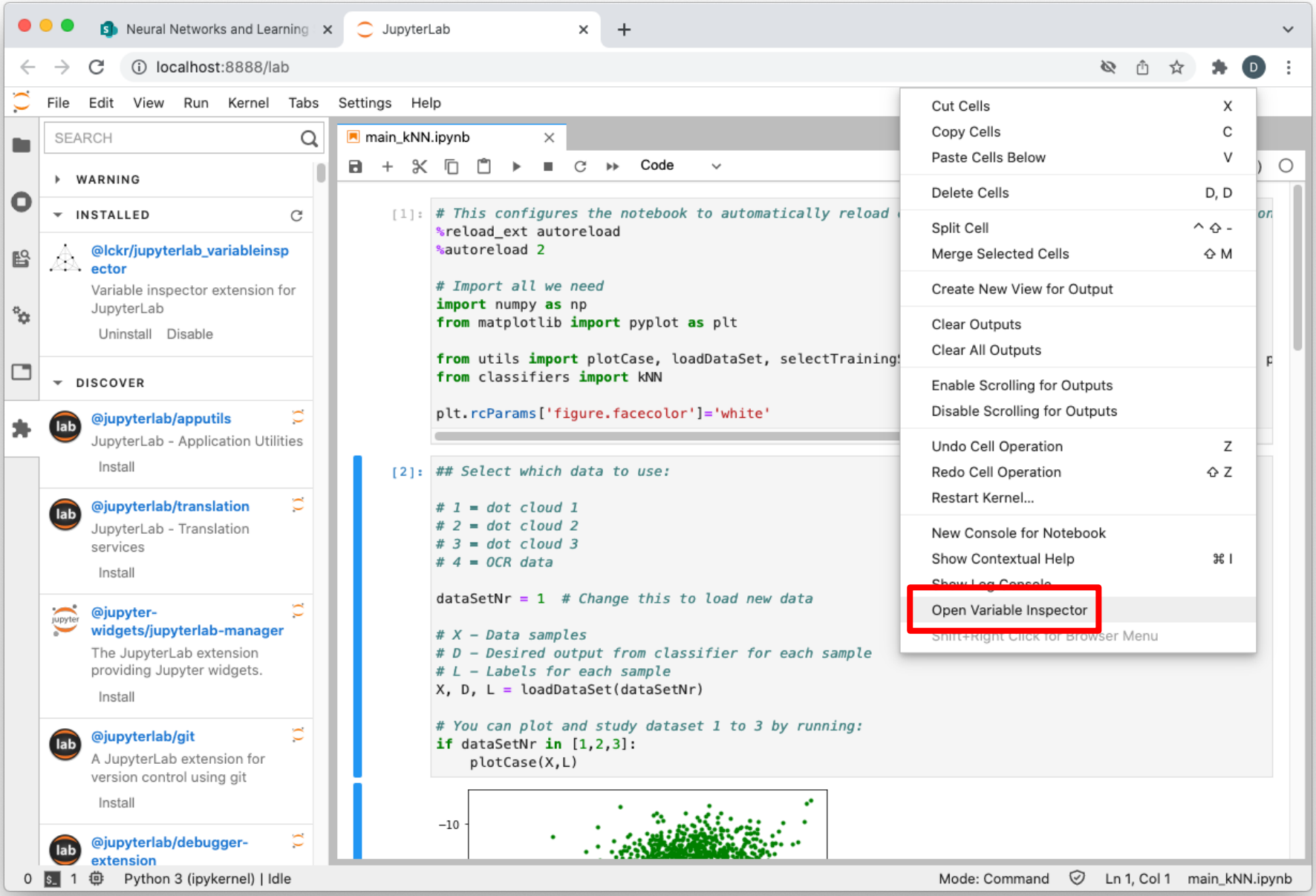

Search for and install the variable inspector extension (make sure to get the indicated one). This will take some time.



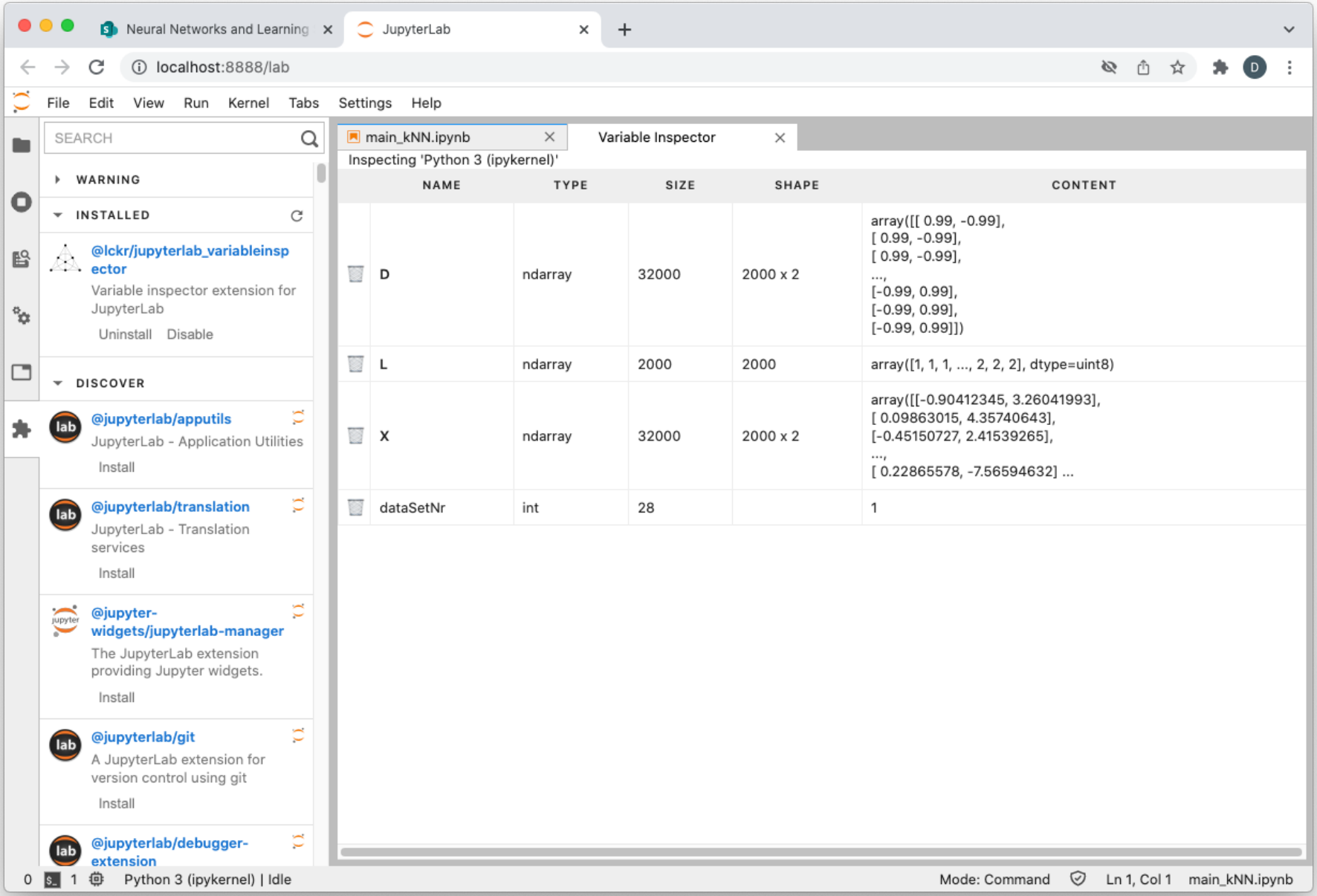

After installation you will need to rebuild Jupyter. This will take some time.



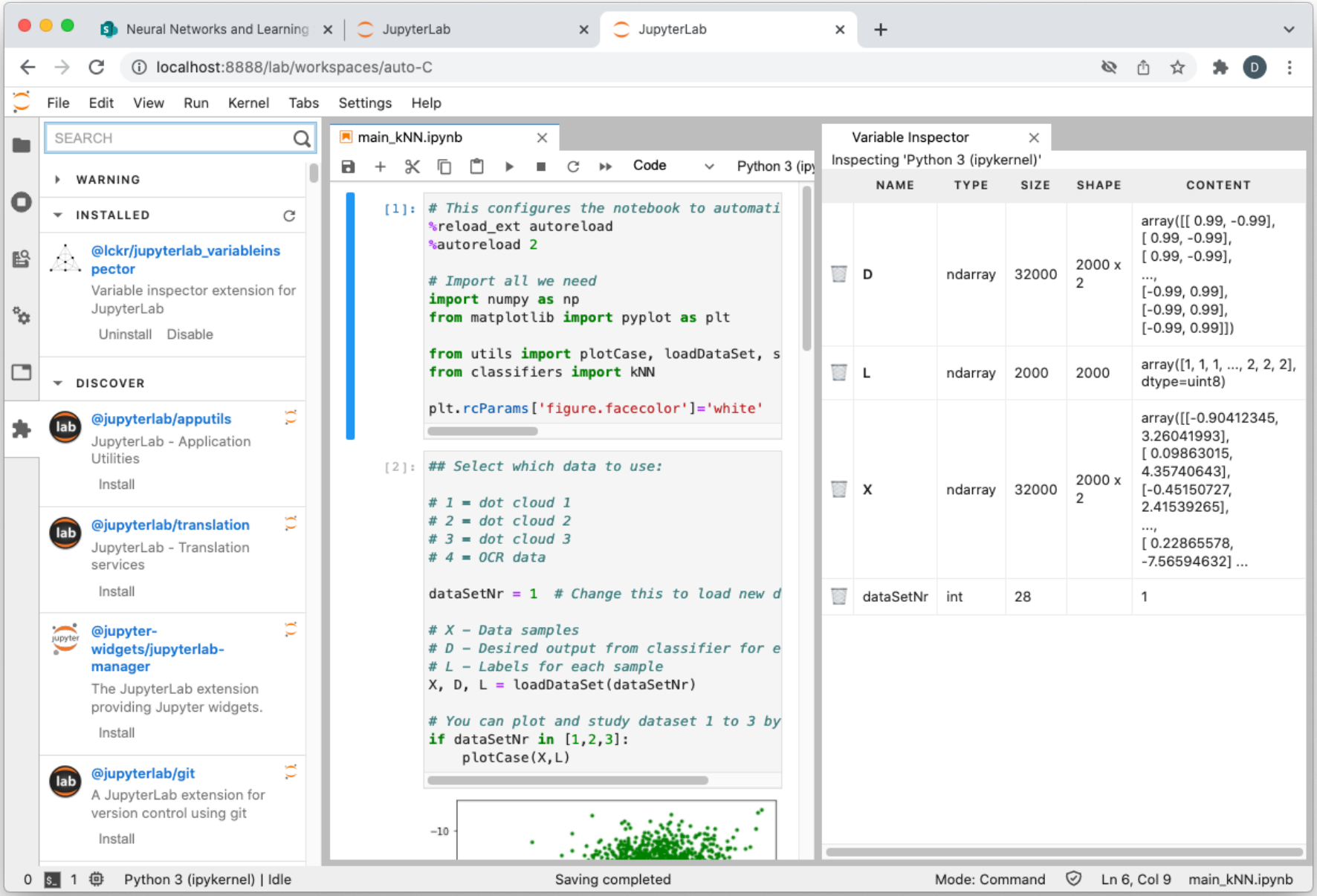

Reload the page.




You can right click anywhere to open the variable inspector.



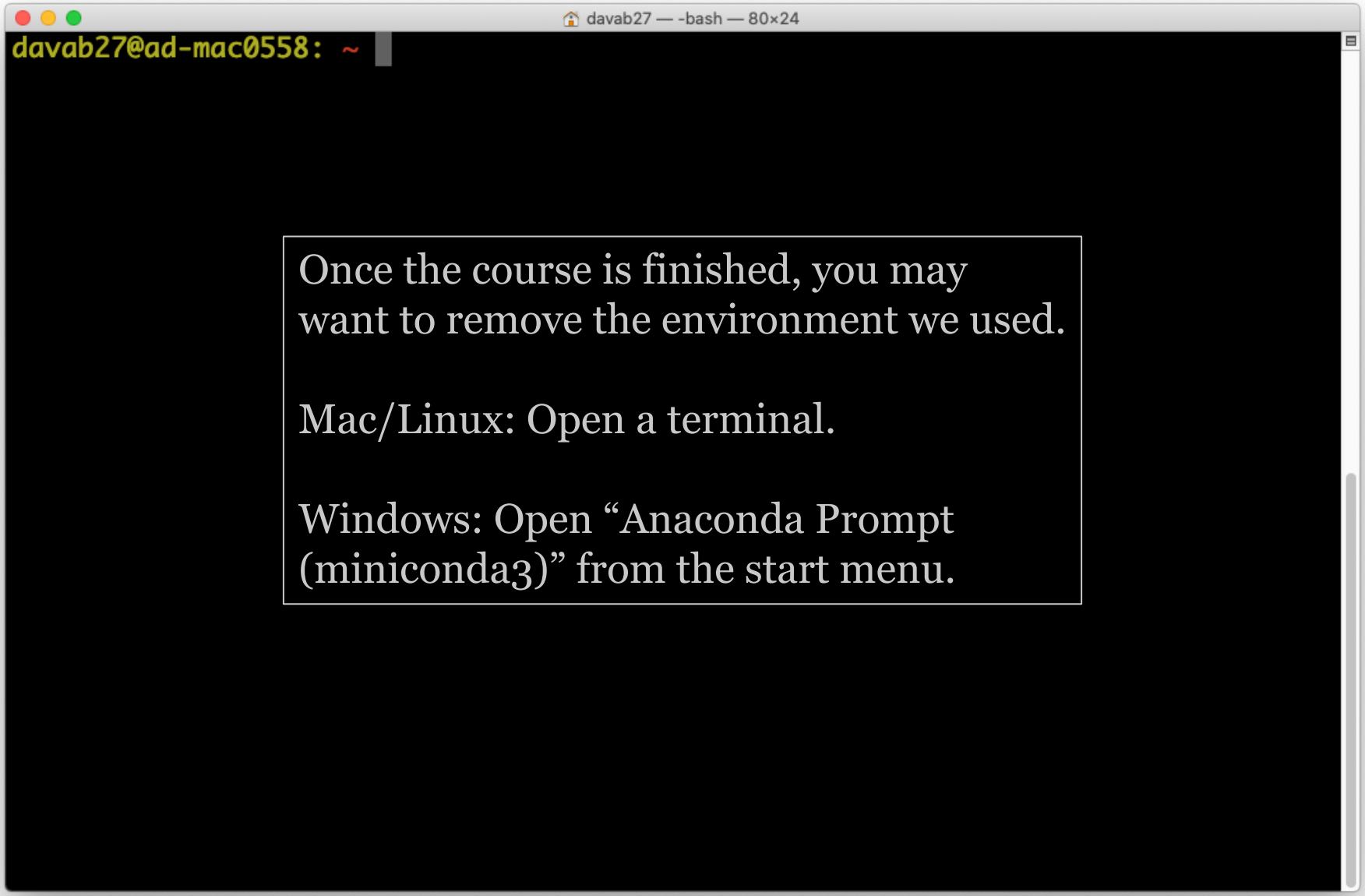

This will allow you to examine the defined variables and their shapes (the "size" column is not so useful, as it gives the size of the variable in bytes).



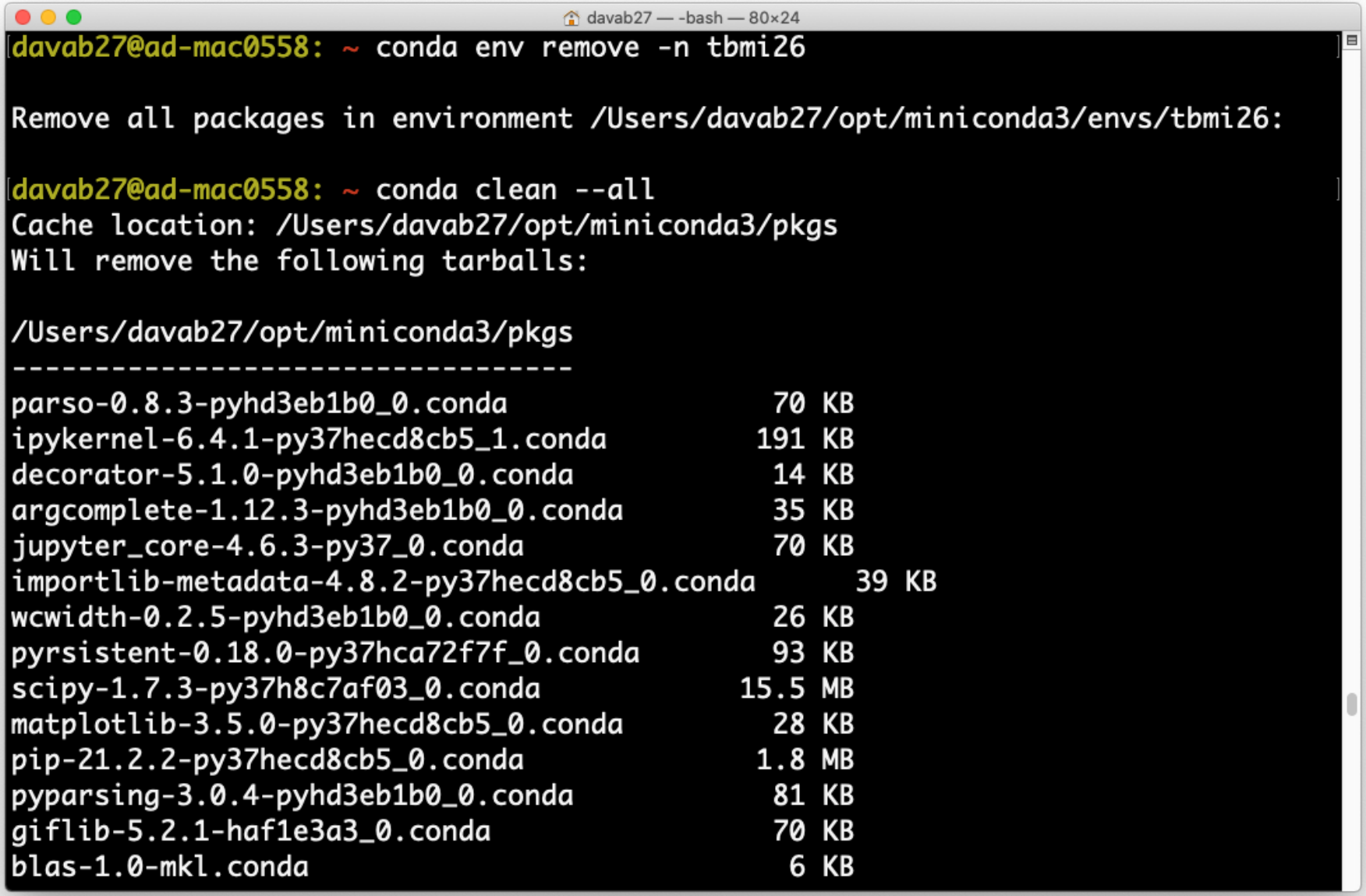

You can also view it side-by-side with the code by dragging the tab to the right.

# Deleting the environment

Do this if you want once the course is finished


davab27 — -bash — 80×24
davab27@ad-mac0558: ~
Once the course is finished, you may want to remove the environment we used.
Mac/Linux: Open a terminal.
Windows: Open “Anaconda Prompt (miniconda3)” from the start menu.


davab27 — -bash — 80×24
davab27@ad-mac0558: ~ conda env remove -n tbmi26
Remove all packages in environment /Users/davab27/opt/miniconda3/envs/tbmi26:
davab27@ad-mac0558: ~
Remove the conda environment. This will not delete the downloaded packages.




Delete the conda packages used in the environment, freeing up some hard drive space.

# Azure setup

The following pages will go through the process for running Lab 2 on Microsoft Azure. Lab 2 (deep learning) requires a computer with GPU to to train the models in a reasonable time. If you have a decent home computer you can run it on your own machine and skip these instructions.

# Starting lab 2 in Azure

Please read fully before starting

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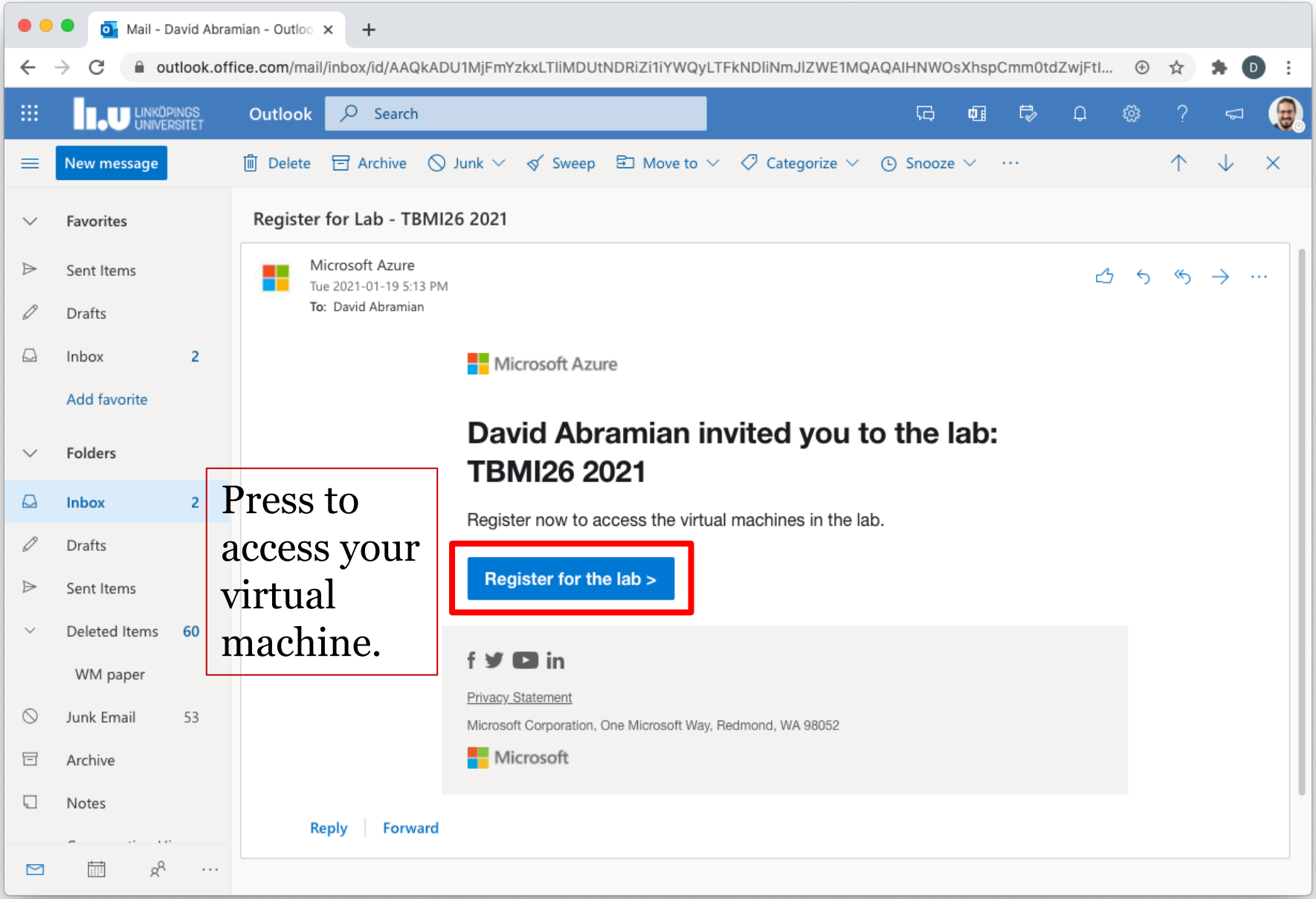
# Joining the lab and starting the machines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Outlook
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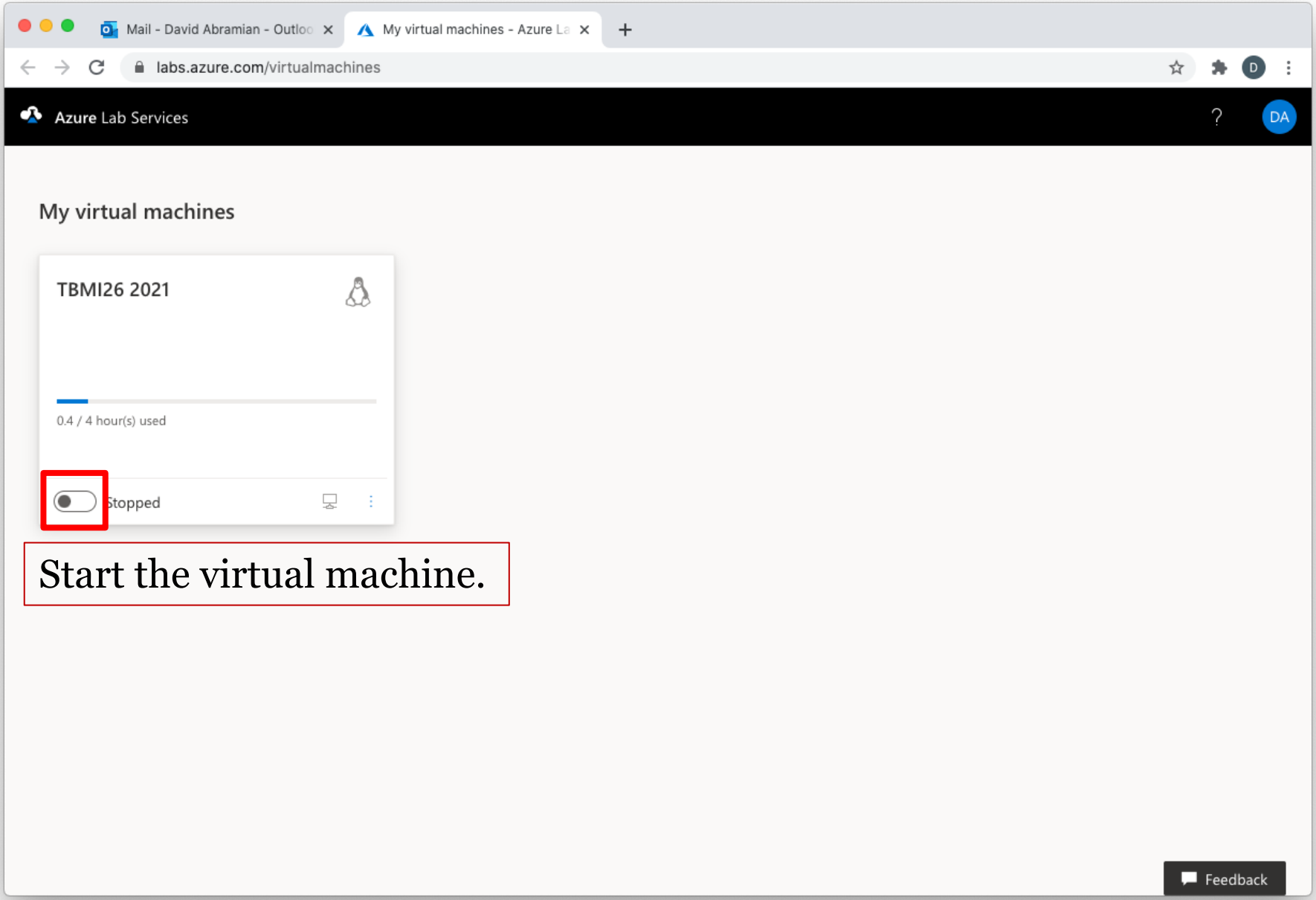
New message
Delete
Archive
Junk
Sweep
Move to
Categorize
Snooze
Favorites
Sent Items
Drafts
Inbox 2
Add favorite
Folders
Inbox 2
Drafts
Sent Items
Deleted Items 60
WM paper
Junk Email 53
Archive
Notes
Register for Lab - TBMI26 2021
Microsoft Azure
Tue 2021-01-19 5:13 PM
To: David Abramian
Microsoft Azure
David Abramian invited you to the lab: TBMI26 2021
Register now to access the virtual machines in the lab.
Register for the lab >
Privacy Statement
Microsoft Corporation, One Microsoft Way, Redmond, WA 98052
Microsoft
Reply
Forward
Press to access your virtual machine.


Mail - David Abramian - Outlo
My virtual machines - Azure La
labs.azure.com/virtualmachines
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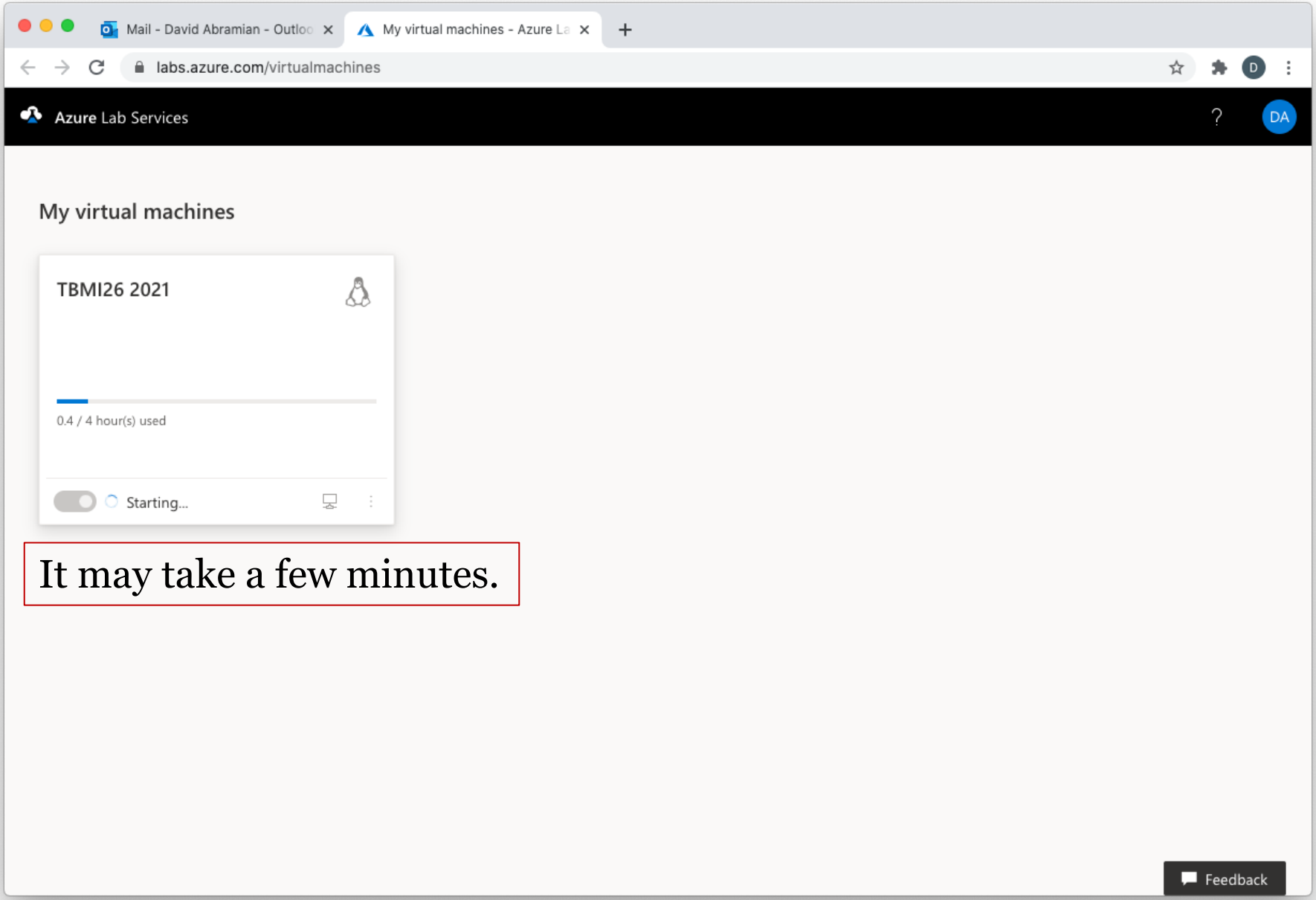
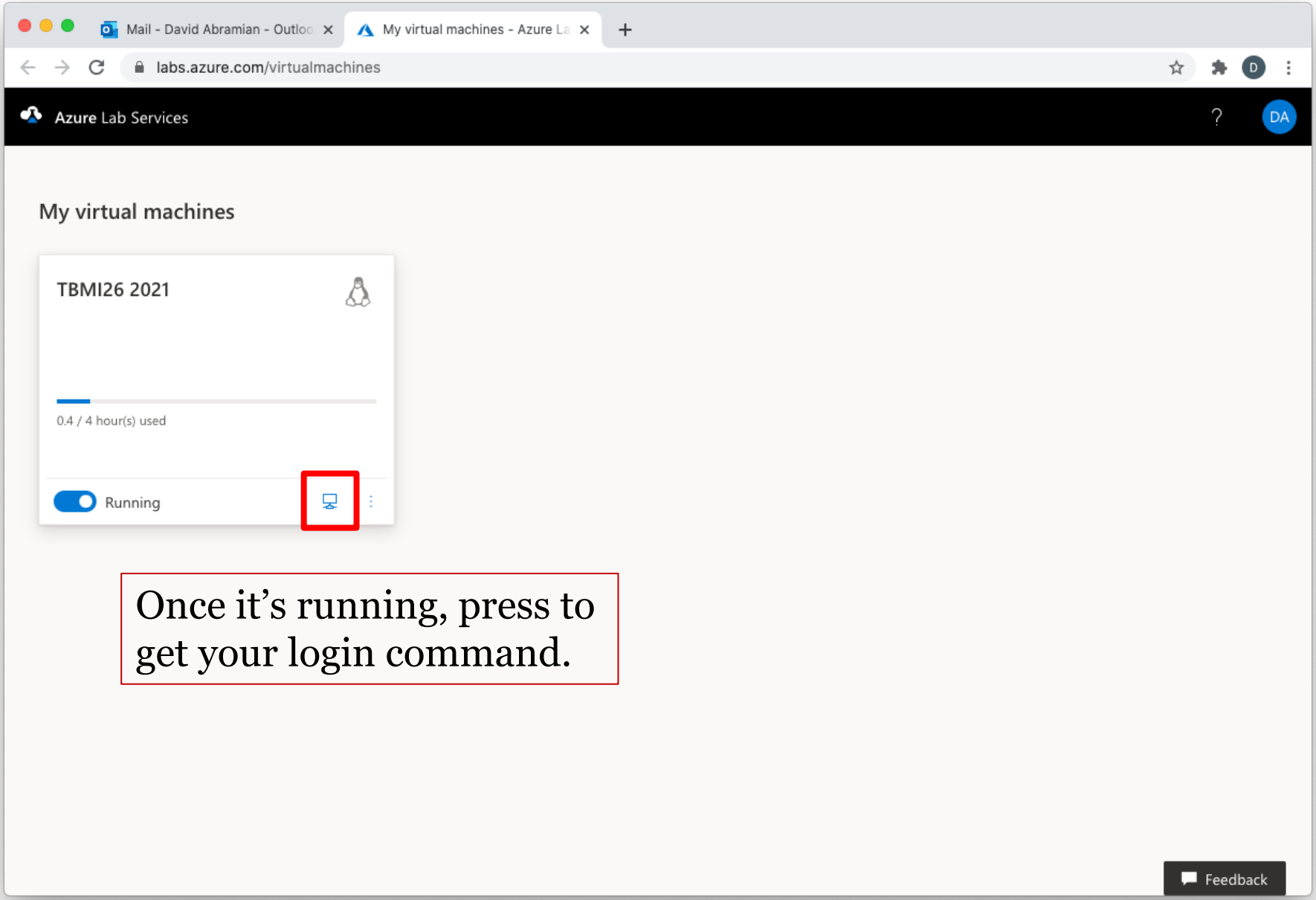
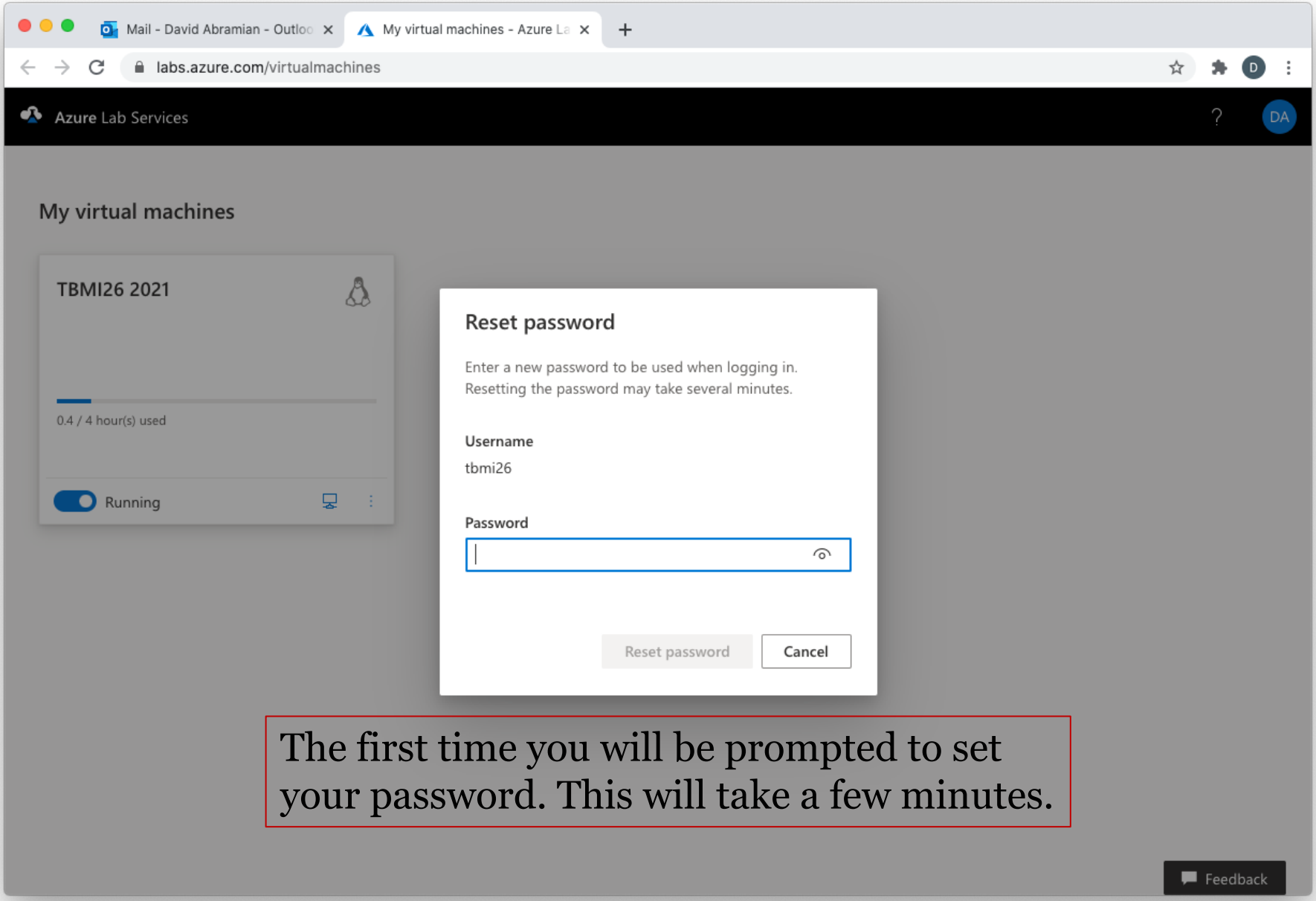
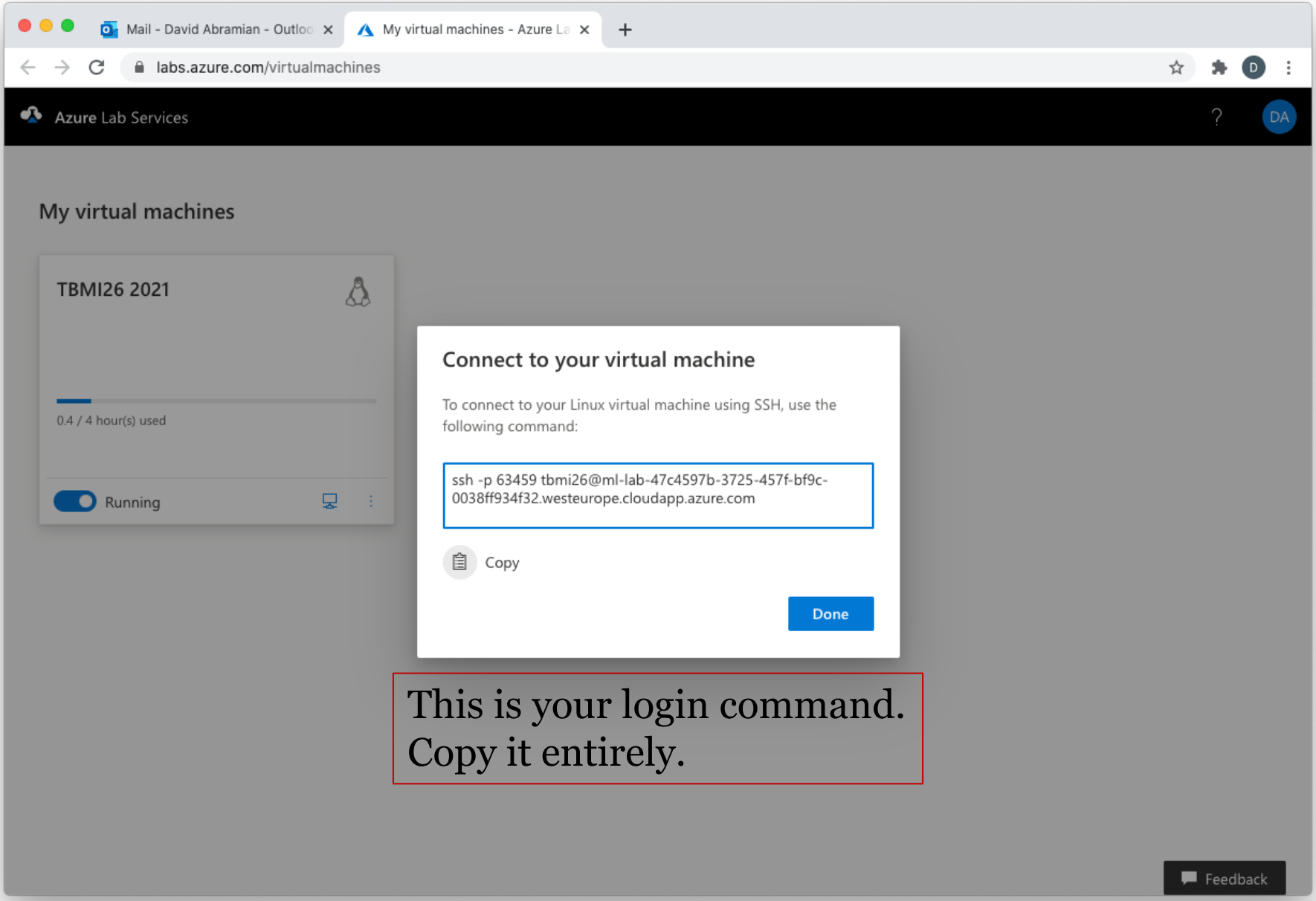
DA
My virtual machines
TBMI26 2021
0.4 / 4 hour(s) used
Stopped
Start the virtual machine.
Feedback



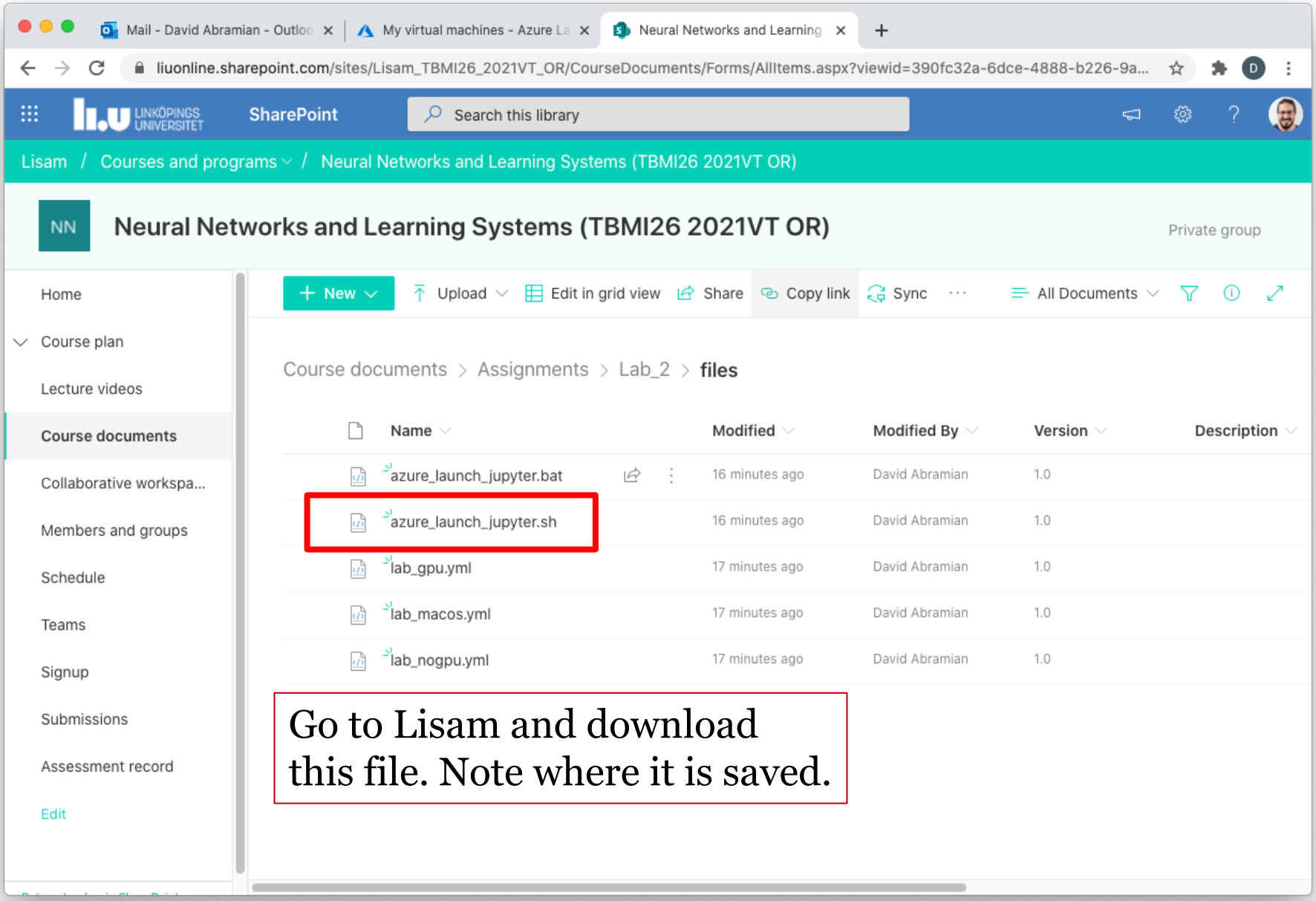

It may take a few minutes.


Mail - David Abramian - Outlo
My virtual machines - Azure La
labs.azure.com/virtualmachines
Azure Lab Services
DA
My virtual machines
TBMI26 2021
0.4 / 4 hour(s) used
Running
Once it's running, press to get your login command.
Feedback


Mail - David Abramian - Outloo
My virtual machines - Azure La
labs.azure.com/virtualmachines
Azure Lab Services
DA
My virtual machines
TBMI26 2021
0.4 / 4 hour(s) used
Running
Reset password
Enter a new password to be used when logging in.
Resetting the password may take several minutes.
Username
tbmi26
Password
Reset password
Cancel
The first time you will be prompted to set your password. This will take a few minutes.
Feedback


Mail - David Abramian - Outloo
My virtual machines - Azure La
labs.azure.com/virtualmachines
Azure Lab Services
DA
My virtual machines
TBMI26 2021
0.4 / 4 hour(s) used
Running
Connect to your virtual machine
To connect to your Linux virtual machine using SSH, use the following command:
ssh -p 63459 tbmi26@ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com
Copy
Done
This is your login command.
Copy it entirely.
Feedback

# Logging in with Linux/Mac


Mail - David Abramian - Outloo
My virtual machines - Azure La
Neural Networks and Learning
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David Abramian
1.0
azure_launch_jupyter.sh
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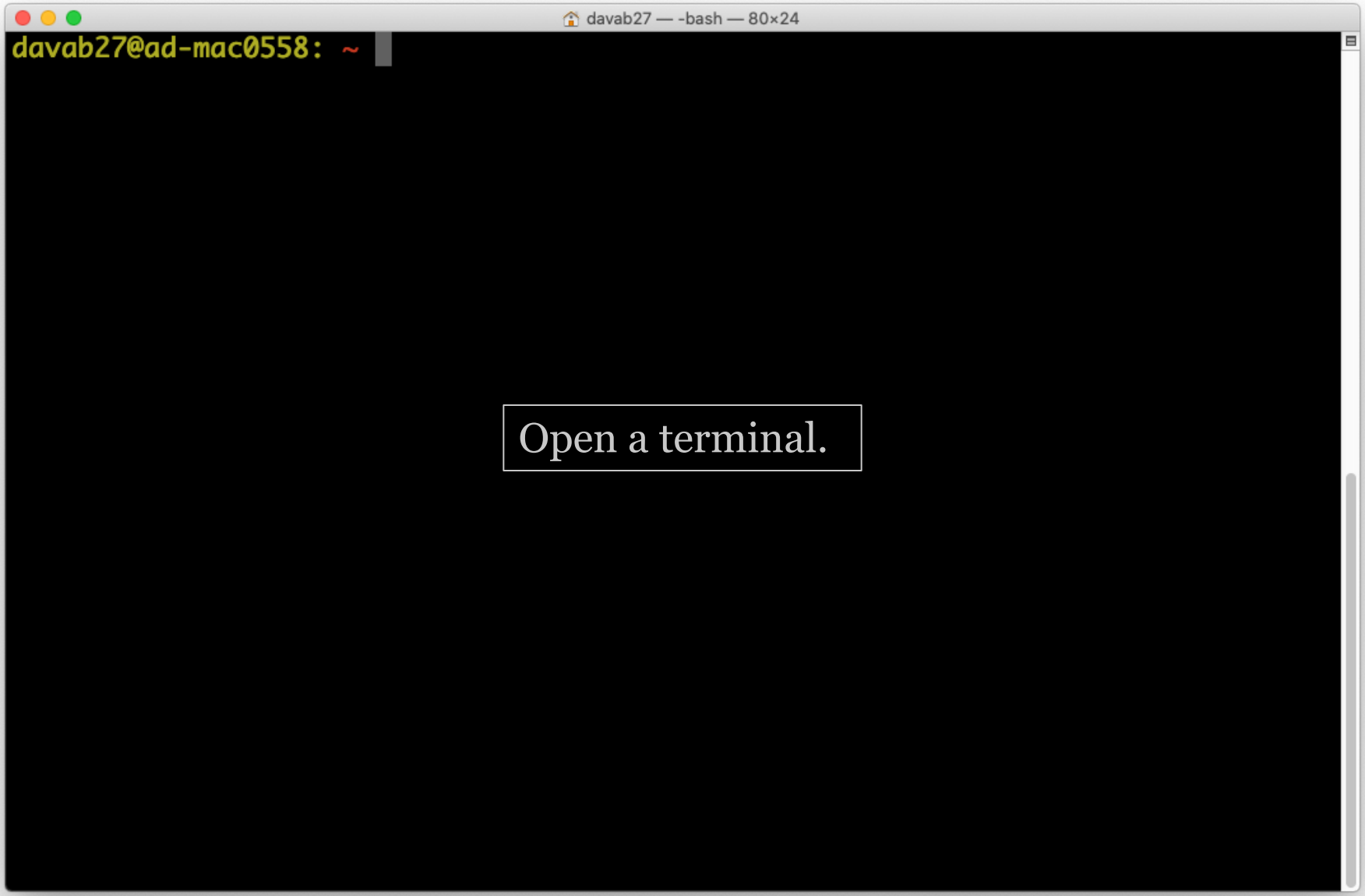
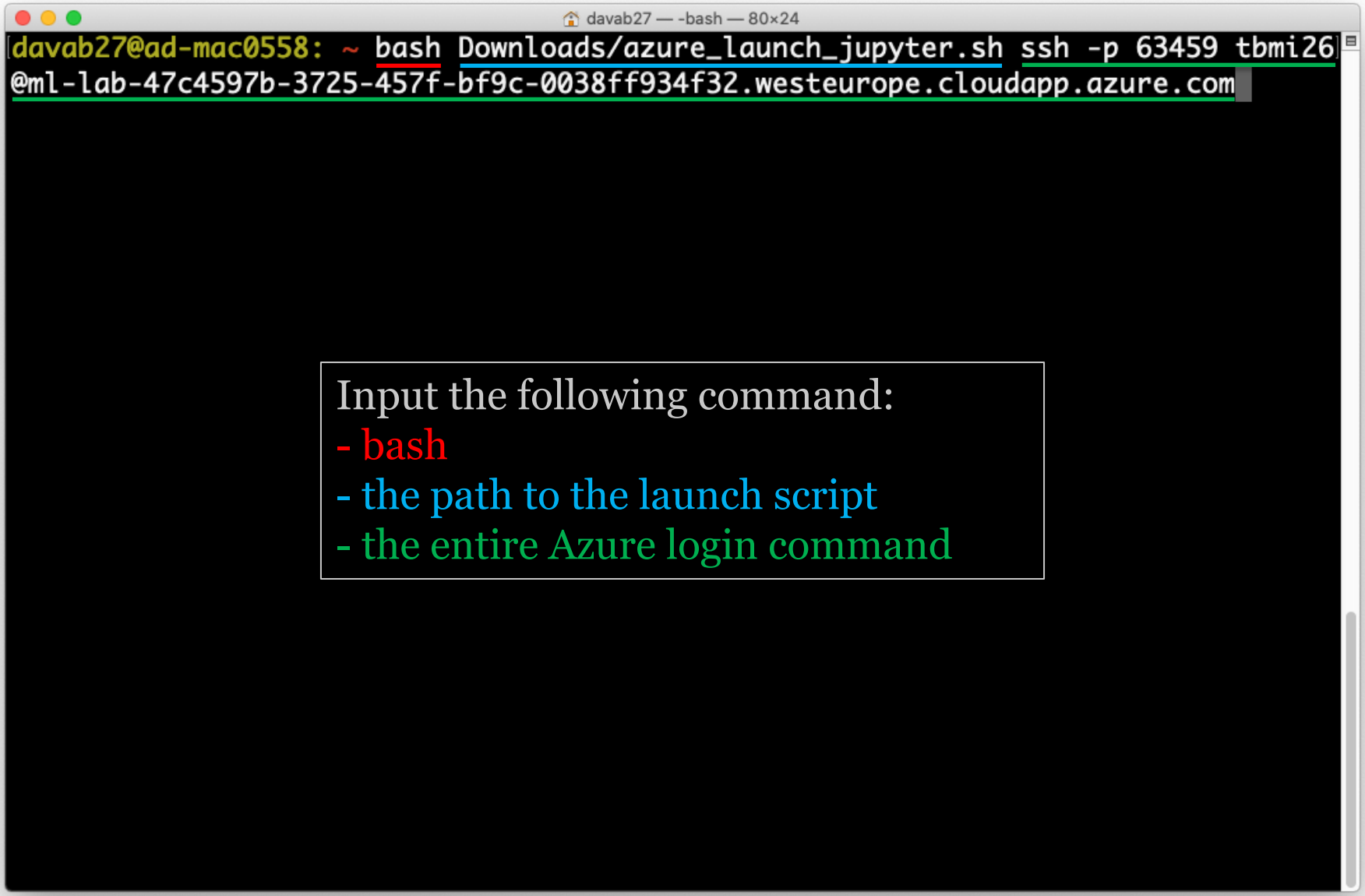
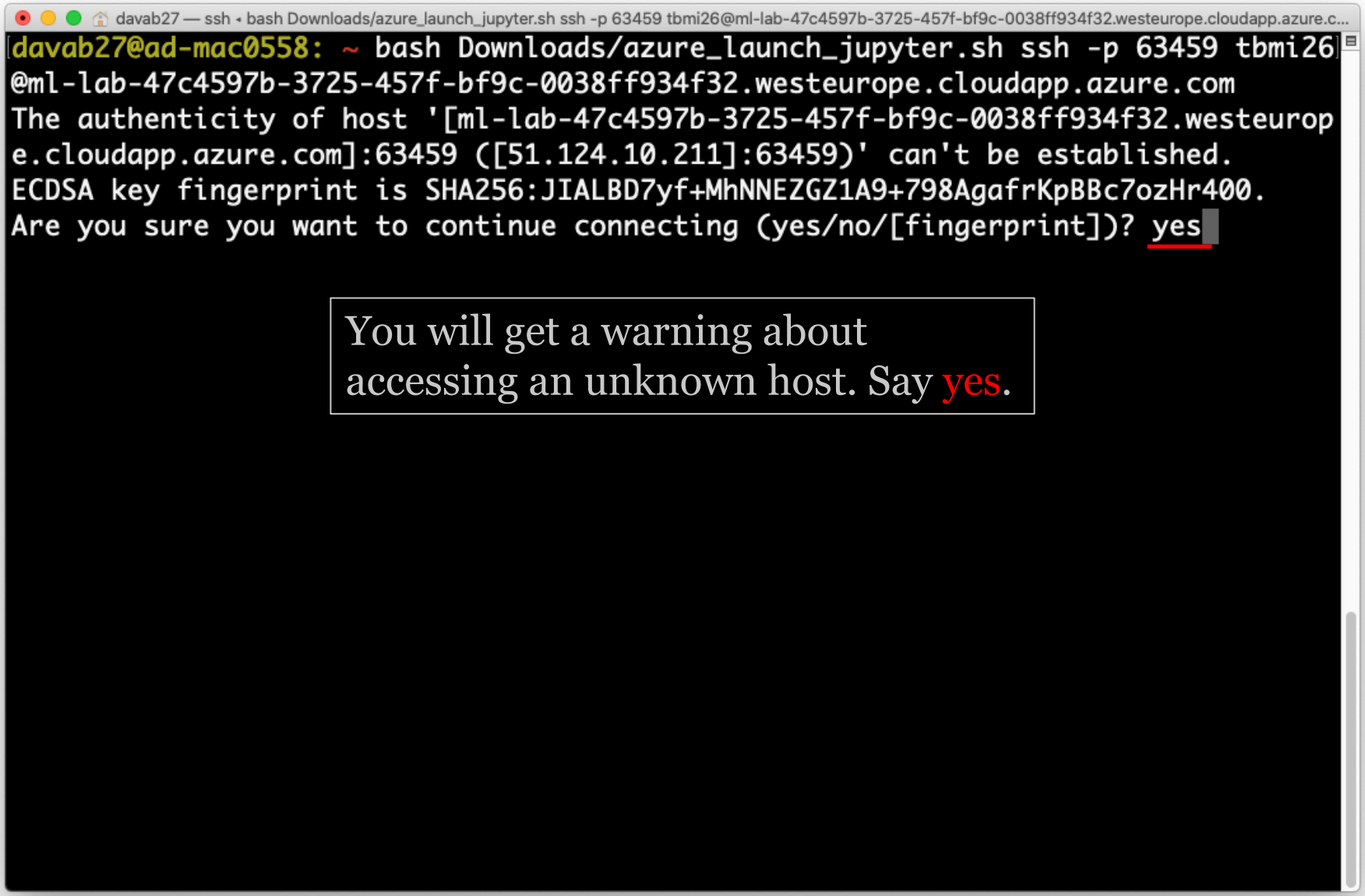
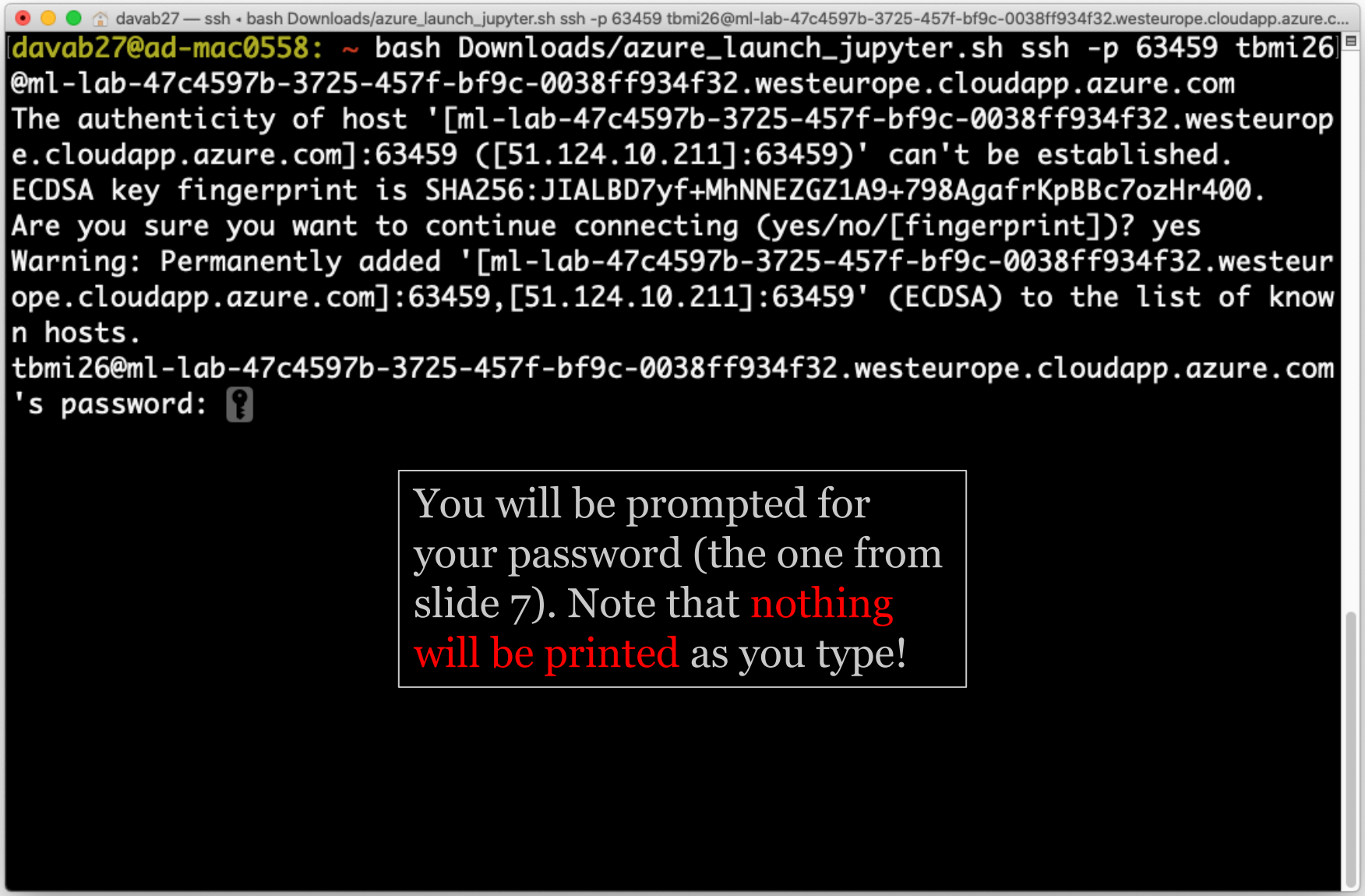
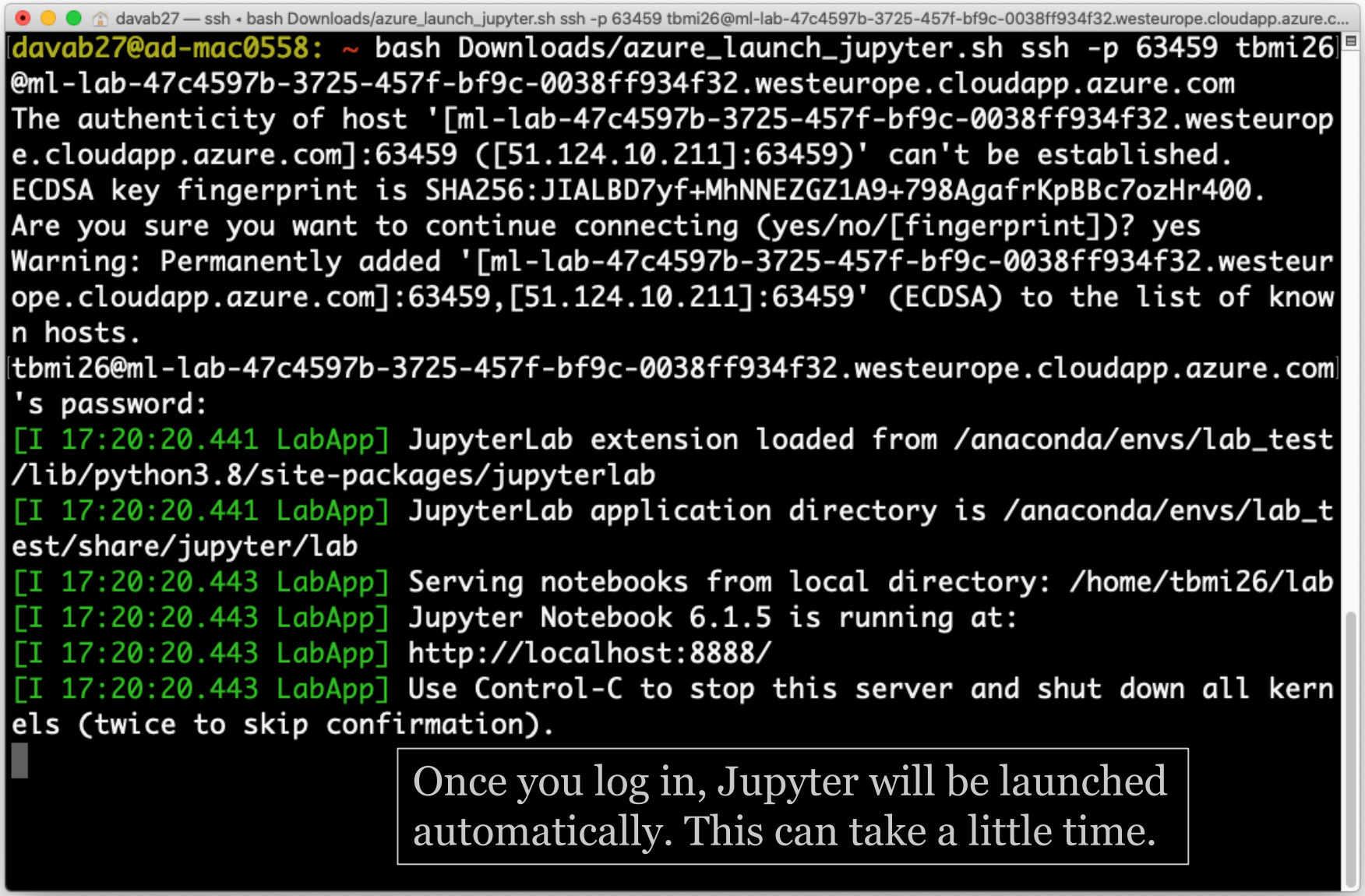

davab27 — -bash — 80×24
davab27@ad-mac0558: ~
Open a terminal.


davab27 — -bash — 80×24
davab27@ad-mac0558: ~ bash Downloads/azure_launch_jupyter.sh ssh -p 63459 tbmi26
@ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com
Input the following command:
- bash
- the path to the launch script
- the entire Azure login command


davab27 — ssh ◂ bash Downloads/azure_launch_jupyter.sh ssh -p 63459 tbmi26@ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.c...
davab27@ad-mac0558: ~ bash Downloads/azure_launch_jupyter.sh ssh -p 63459 tbmi26@ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com
The authenticity of host '[ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com]:63459 ([51.124.10.211]:63459)' can't be established.
ECDSA key fingerprint is SHA256:JIALBD7yf+MhNNEZGZ1A9+798AgafrKpBBc7ozHr400.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
You will get a warning about accessing an unknown host. Say yes.

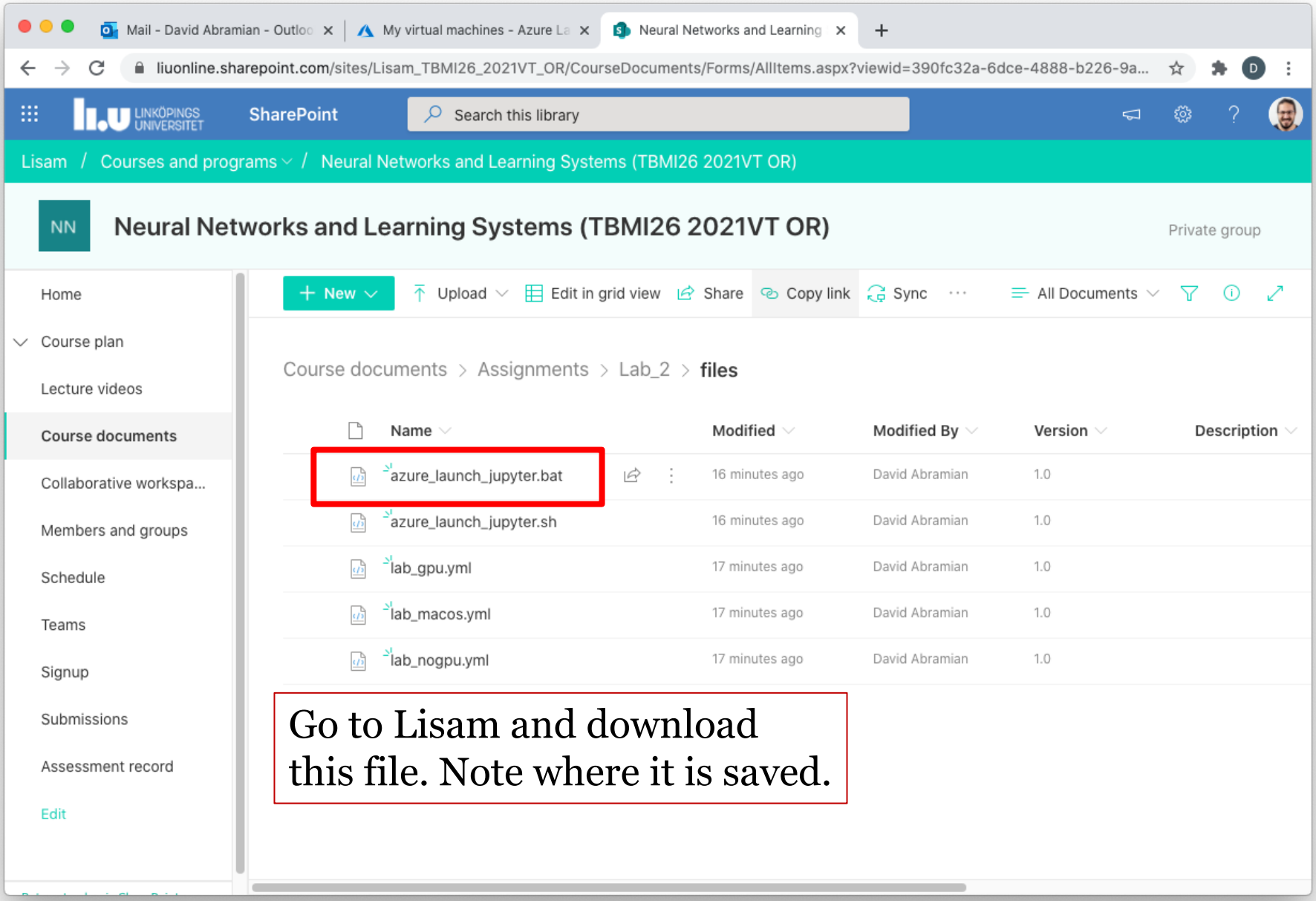



You will be prompted for your password (the one from slide 7). Note that nothing will be printed as you type!




Once you log in, Jupyter will be launched automatically. This can take a little time.

# Logging in with Windows 10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lab_nogpu.yml
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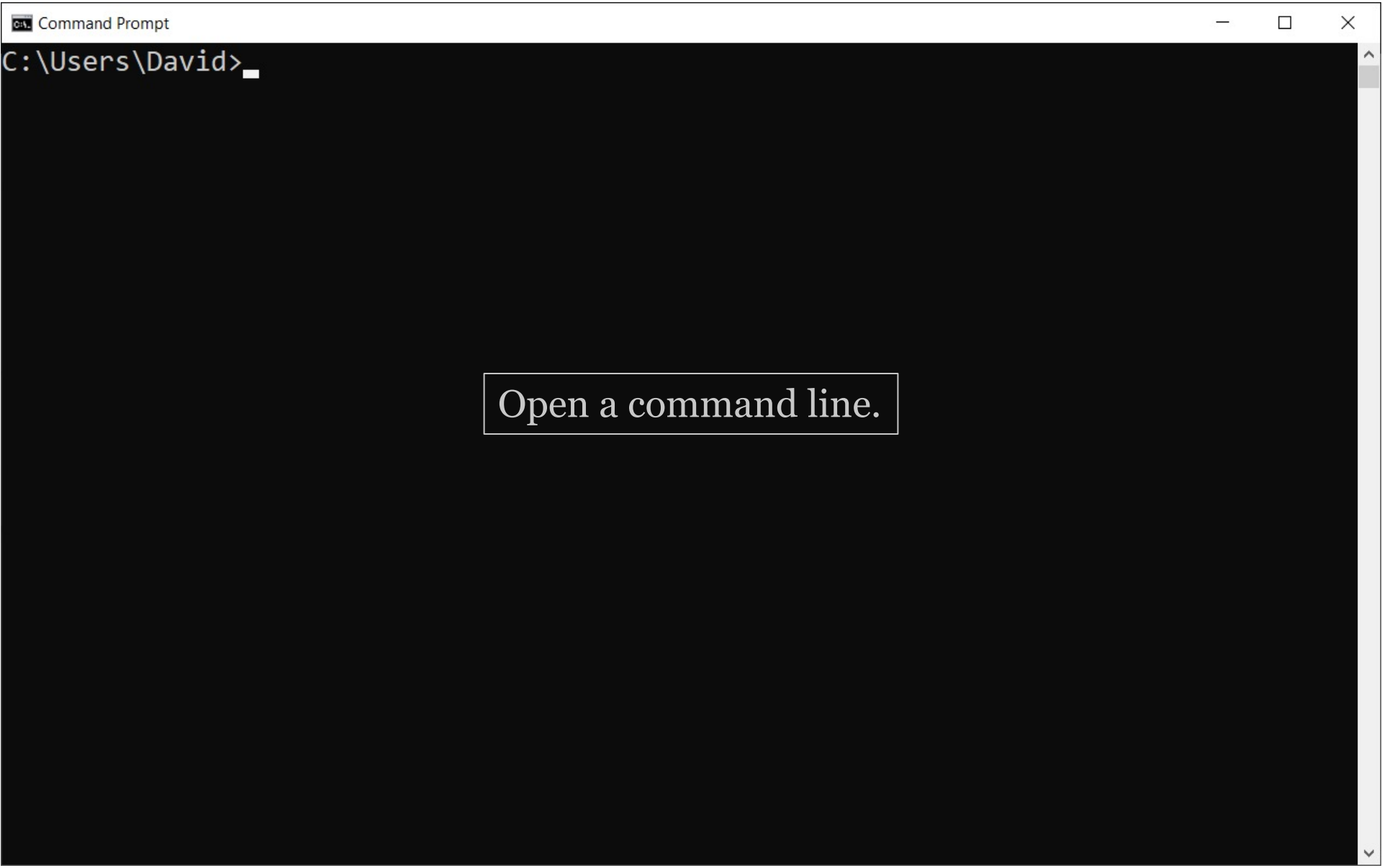
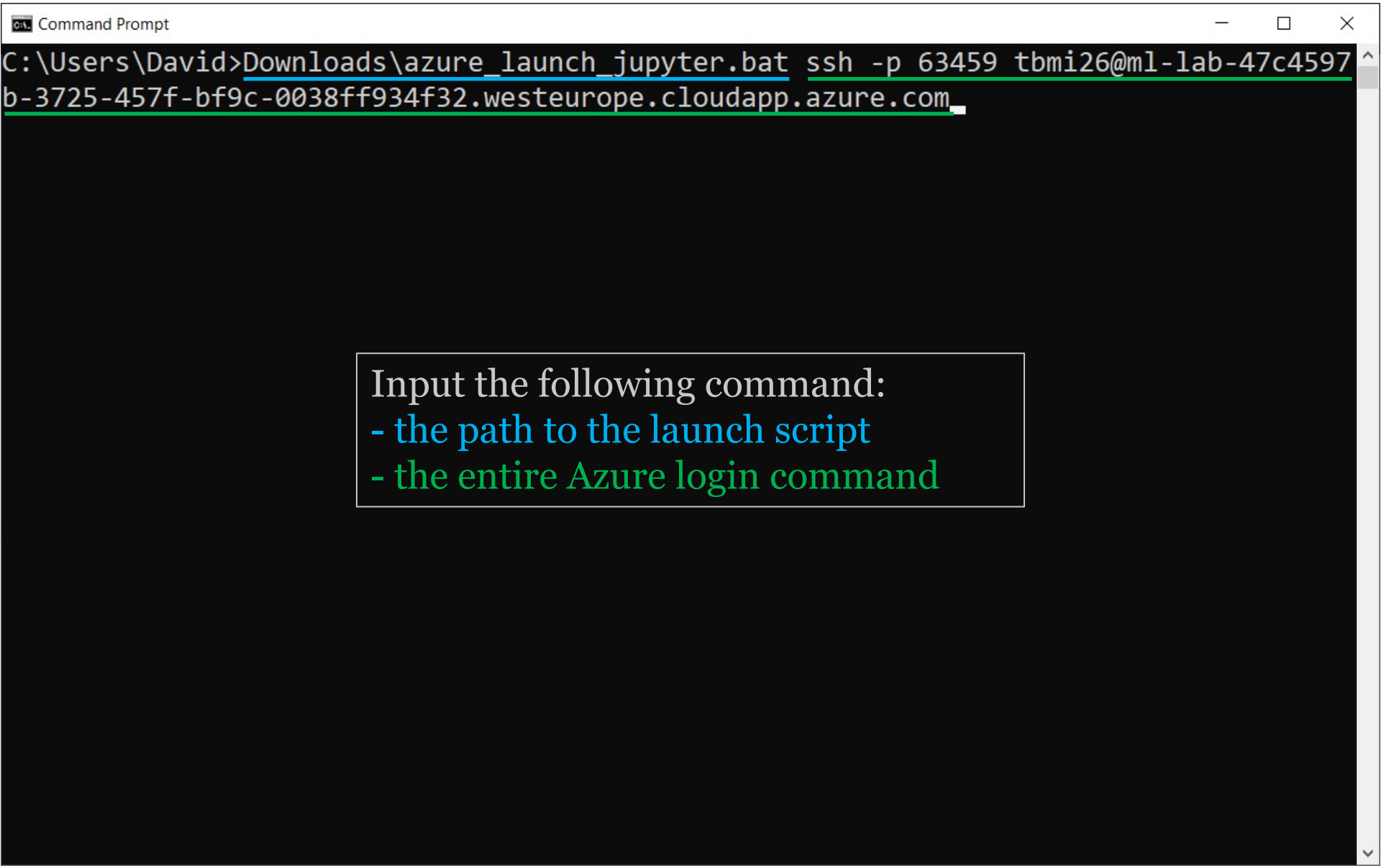
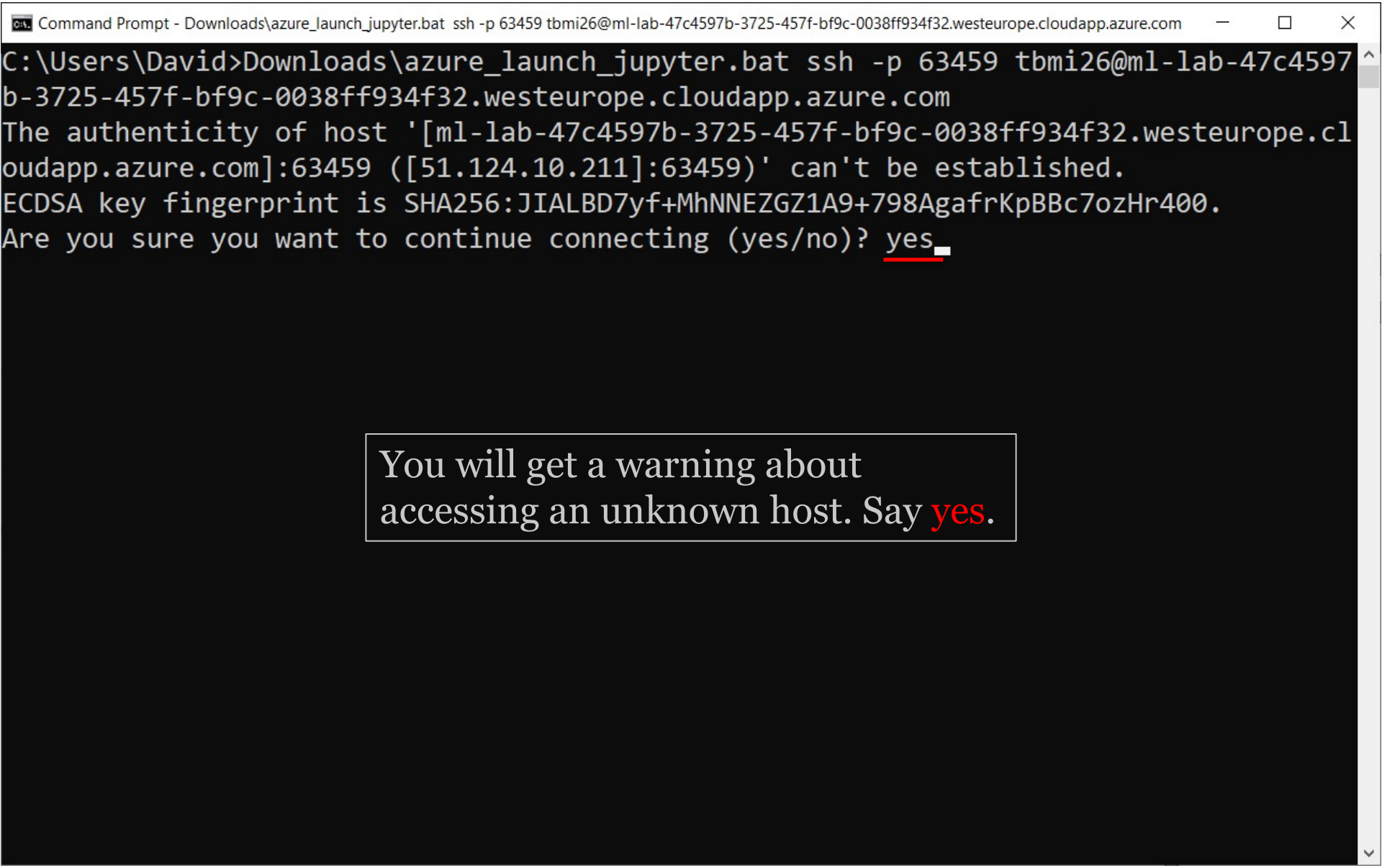
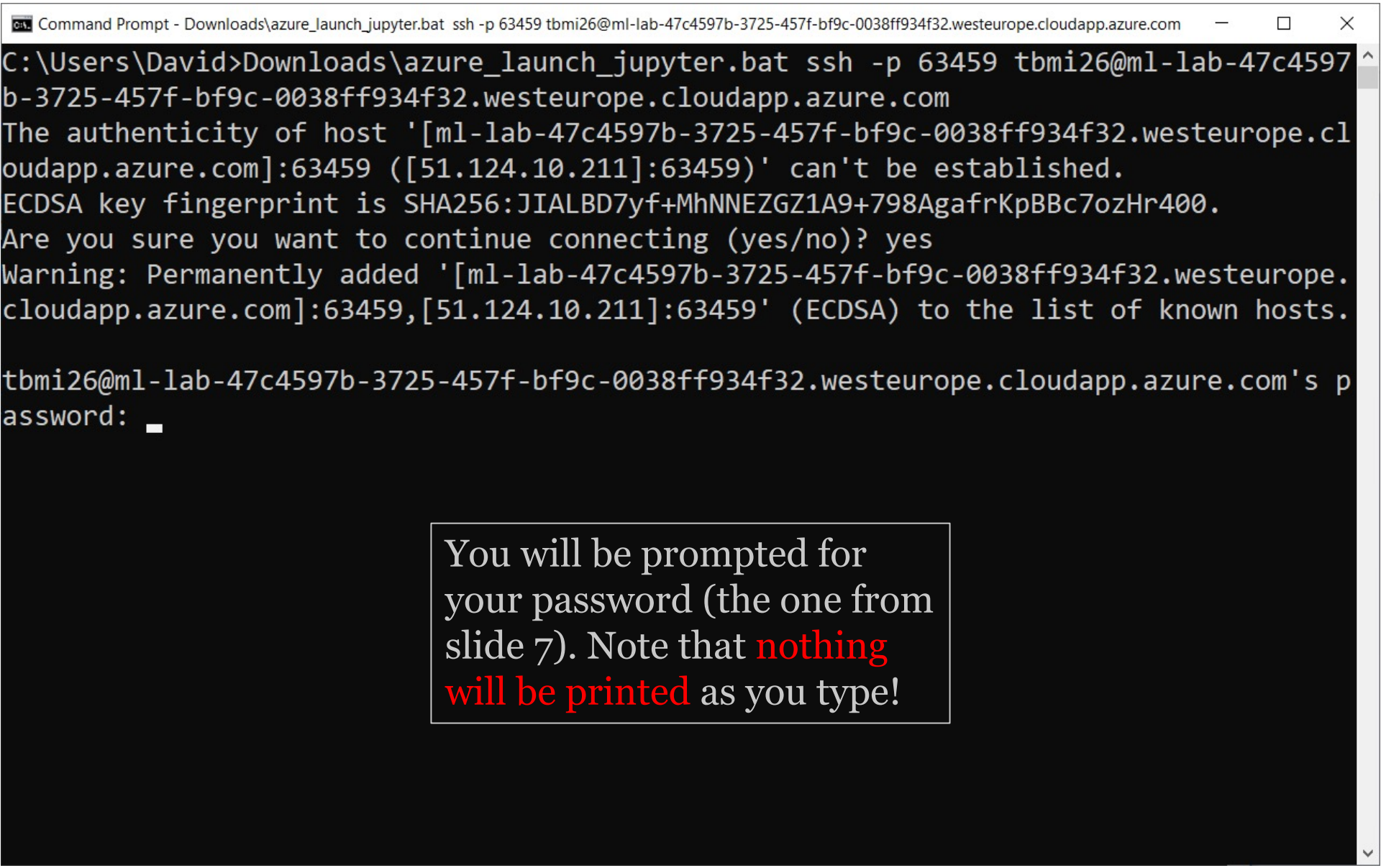
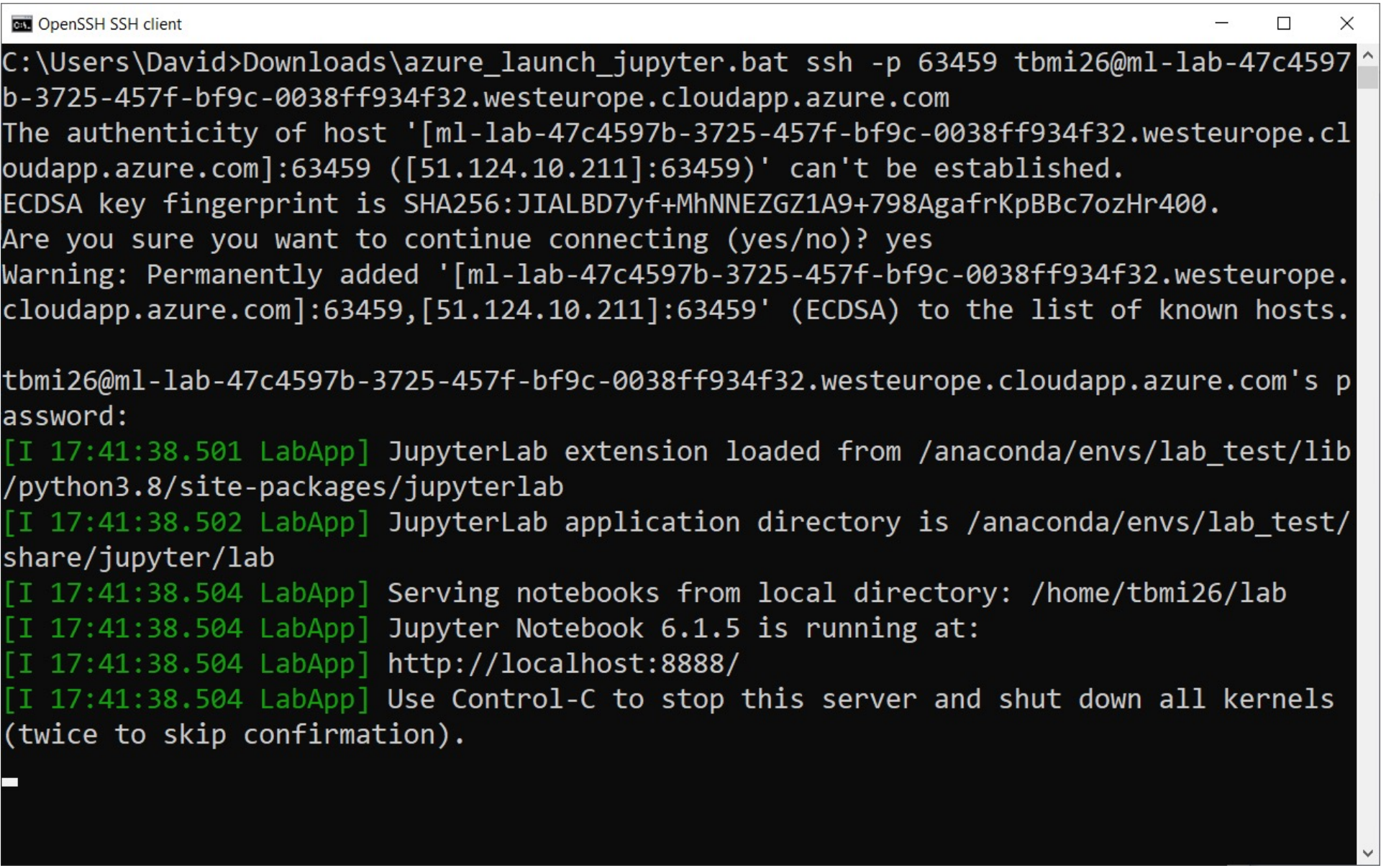

Command Prompt
C:\Users\David>
Open a command line.


Command Prompt
C:\Users\David>Downloads\azure_launch_jupyter.bat ssh -p 63459 tbmi26@ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com
Input the following command:
- the path to the launch script
- the entire Azure login command

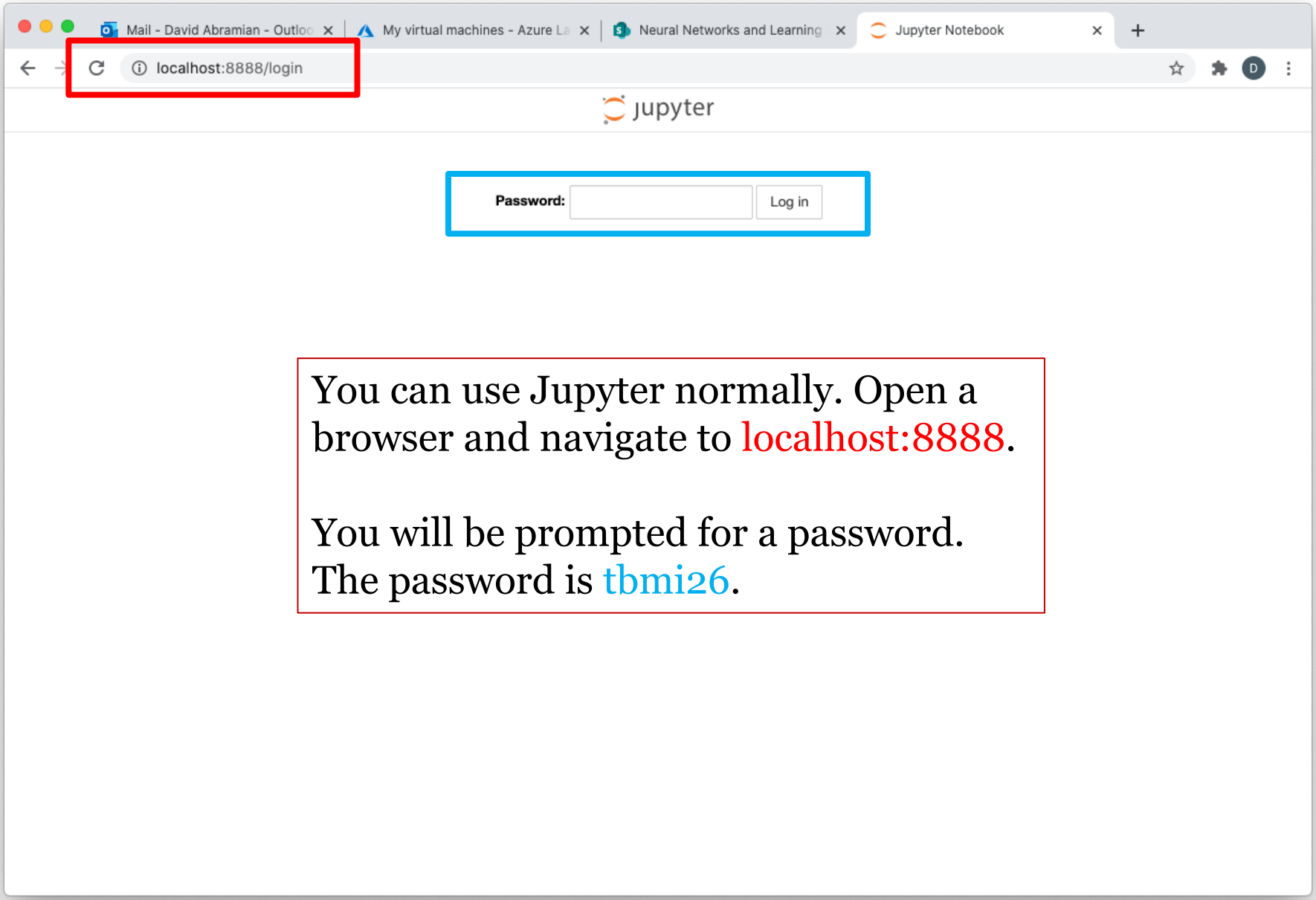

Command Prompt - Downloads\azure_launch_jupyter.bat ssh -p 63459 tbmi26@ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com
C:\Users\David>Downloads\azure_launch_jupyter.bat ssh -p 63459 tbmi26@ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com
The authenticity of host '[ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com]:63459 ([51.124.10.211]:63459)' can't be established.
ECDSA key fingerprint is SHA256:JIALBD7yf+MhNNEZGZ1A9+798AgafrKpBBc7ozHr400.
Are you sure you want to continue connecting (yes/no)? yes
You will get a warning about accessing an unknown host. Say yes.


Command Prompt - Downloads\azure_launch_jupyter.bat ssh -p 63459 tbmi26@ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com
C:\Users\David>Downloads\azure_launch_jupyter.bat ssh -p 63459 tbmi26@ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com
The authenticity of host '[ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com]:63459 ([51.124.10.211]:63459)' can't be established.
ECDSA key fingerprint is SHA256:JIALBD7yf+MhNNEZGZ1A9+798AgafrKpBBc7ozHr400.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '[ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com]:63459,[51.124.10.211]:63459' (ECDSA) to the list of known hosts.
tbmi26@ml-lab-47c4597b-3725-457f-bf9c-0038ff934f32.westeurope.cloudapp.azure.com's password:
You will be prompted for your password (the one from slide 7). Note that nothing will be printed as you type!



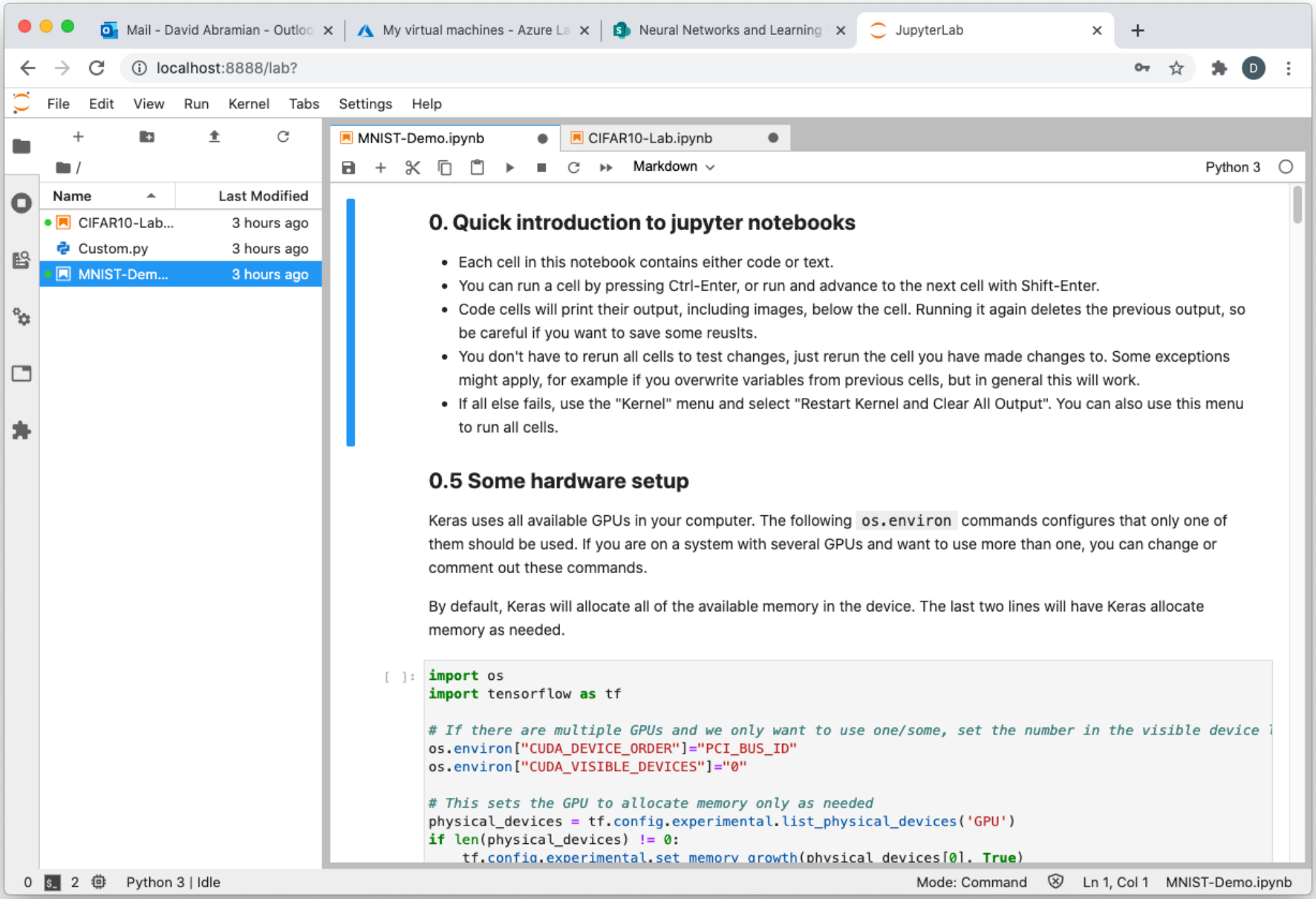

Once you log in, Jupyter will be launched automatically. This can take a little time.

# Running the lab




You can use Jupyter normally. Open a browser and navigate to localhost:8888.

You will be prompted for a password. The password is tbmi26.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JupyterLab
localhost:8888/lab?
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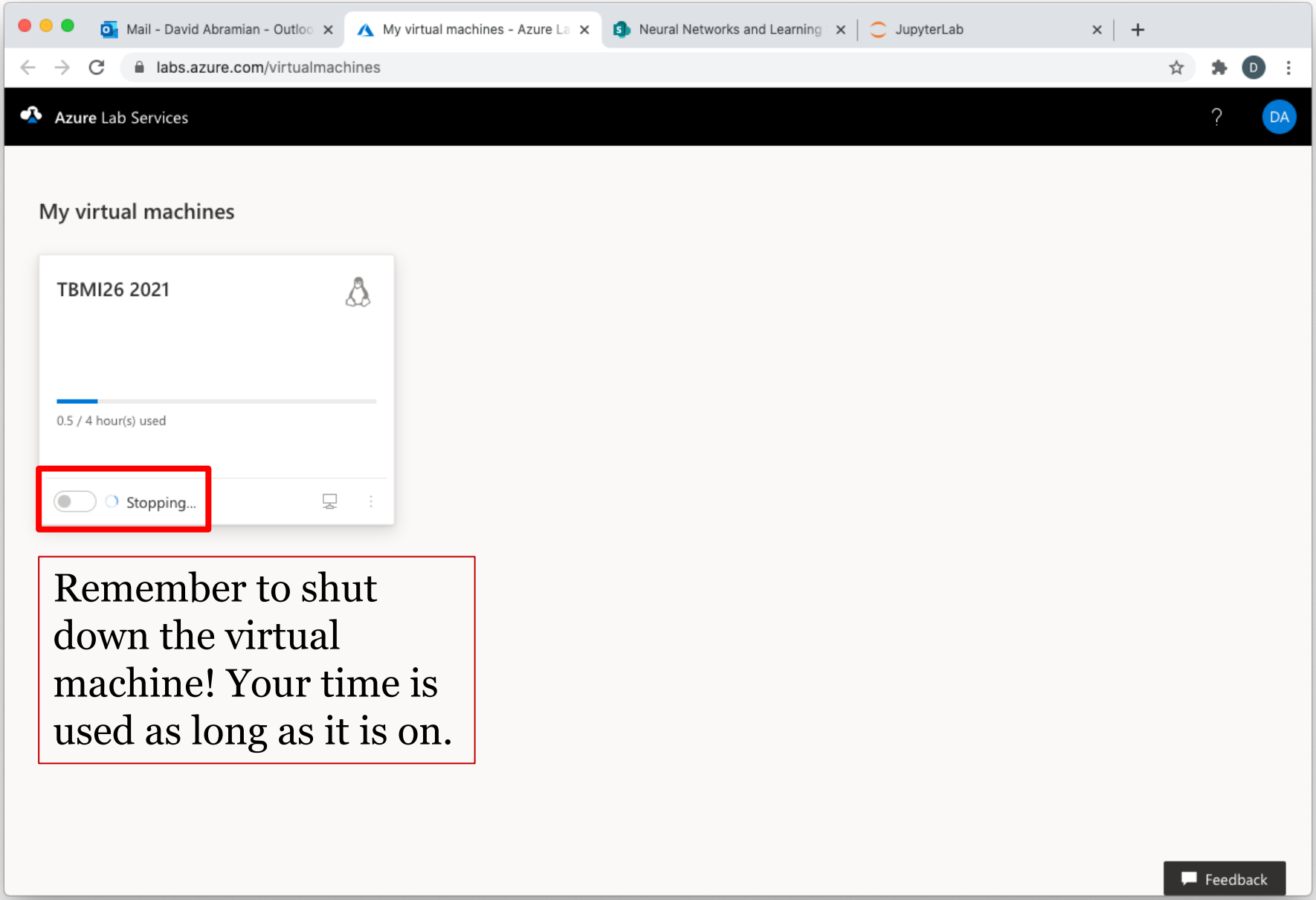
/
Name
Last Modified
CIFAR10-Lab...
3 hours ago
Custom.py
3 hours ago
MNIST-Dem...
3 hours ago
MNIST-Demo.ipynb
CIFAR10-Lab.ipynb
Markdown
Python 3
0. Quick introduction to jupyter notebooks
Each cell in this notebook contains either code or text.
You can run a cell by pressing Ctrl-Enter, or run and advance to the next cell with Shift-Enter.
Code cells will print their output, including images, below the cell. Running it again deletes the previous output, so be careful if you want to save some reuslts.
You don't have to rerun all cells to test changes, just rerun the cell you have made changes to. Some exceptions might apply, for example if you overwrite variables from previous cells, but in general this will work.
If all else fails, use the "Kernel" menu and select "Restart Kernel and Clear All Output". You can also use this menu to run all cells.
0.5 Some hardware setup
Keras uses all available GPUs in your computer. The following os.environ commands configures that only one of them should be used. If you are on a system with several GPUs and want to use more than one, you can change or comment out these commands.
By default, Keras will allocate all of the available memory in the device. The last two lines will have Keras allocate memory as needed.
[ ]:
import os
import tensorflow as tf
# If there are multiple GPUs and we only want to use one/some, set the number in the visible device l
os.environ["CUDA_DEVICE_ORDER"]="PCI_BUS_ID"
os.environ["CUDA_VISIBLE_DEVICES"]="0"
# This sets the GPU to allocate memory only as needed
physical_devices = tf.config.experimental.list_physical_devices('GPU')
if len(physical_devices) != 0:
tf.config.experimental.set_memory_growth(physical_devices[0], True)
0 2 Python 3 | Idle
Mode: Command
Ln 1, Col 1
MNIST-Demo.ipynb

# When you are done




Remember to shut down the virtual machine! Your time is used as long as it is on.