

Lab 00: Jupyter Notebooks

Reference Reading: N/A

Goals:

- 1) Introduce the Linux operating system.
- 2) Gain more experience programming in Python.
- 3) Begin to use Jupyter Notebooks
 - a) Code Cells in Python
 - b) Markdown (Text) cells
 - i) Entering plain text
 - ii) Entering equations in LaTeX format
 - iii) Adding figures
 - iv) Building tables
- 4) Understand the importance of documenting measurements and the use of measurement files to accomplish this.

Expectations:

These are expectations for your efforts at documenting your work on the lab activities in this class.

1. All sections of code should be clearly commented. These comments need to indicate the purpose of the section of code as well as the methods used.
2. All data tables need to be clearly labeled. Labels must include units and descriptive names. Appropriate precision should be used for all displayed data.
3. Where it makes sense, you are expected to make plots of your data. For frequency-response measurements, these are typically a Bode plot and a phase-difference plot.
4. On Bode plots, you should clearly identify the -3 dB point as well as measure the roll off of your data. (We will work on how to do this as part of the lab.)
5. If it is possible to compare your measurements with an expectation or a prediction, you are expected to do so.
6. Write your own measurement files that can be used as input for computer control of the oscilloscope and function generator. (We will work on this in a later lab.)

0.1 Introduction

The purpose of this lab is to introduce you to Jupyter Notebooks (JN) and the Linux operating system on the classroom computers. You are going to be using JNs for every lab activity. This will be the equivalent of an electronic lab notebook. All of your activities associated with a lab will be recorded in the JN for that lab. Any calculations required to prepare for a measurement will be completed in the JN. Any preliminary graphs of data will be done in the JN. All pre-lab questions will be answered in the JN.

The laboratory computers will have JN along with all other software for the semester installed on them. These computers are running Ubuntu Linux version 22.04 (released in April of 2022). This is a free operating system that you can download and install in almost any computer. It provides you with a windowing environment not unlike Windows and Mac OS X. There are some big differences, for one, it will not run the latest PC games. However, it is a great way to revitalize an old computer that will not handle the latest Windows or Mac operating systems. You can use this OS to get a number of good, useful years out of an older computer.

While the laboratory computers are setup with all of the software you will need this semester, you do not have to use them. JN can be installed on any operating system. If you want, you can install it on a Windows or Mac machine. As it is web based, any notebooks you develop in class will most likely work on any computer with JN installed. There may be conflicts with specific Python packages, but these can be identified and cleared up. Later this semester, we will use the computers to control data acquisition through the USB ports. There is more preliminary work required to make this possible, so it may be better to use the classroom computers.

0.2 Equipment and Parts

In this lab we will utilize the following equipment. This equipment is located at your lab station.

- 1 One laptop with Ubuntu 22.04 installed

0.3 Procedure.

0.3.1 The Linux Operating System

The computer that we will be using in lab are older model PC's that have Ubuntu 22.04 installed as the operating system. This is a public domain Linux system. The username for your computer is given on the label on the computer. It will be "enr2447-x", where x is one of a-e. The password for each of the machines is "spring2024". You should plan on using your own cloud storage or a thumb drive to store your work. You will note when you log in, that you are in a windows-like environment. You can point and click on apps to run them. There is a launch icon (the icon of 3x3 squares) down in the bottom left of the screen that will show you all of the apps installed. Feel free to explore and see what is available.

0.3.1.1 The Terminal Window

We will use a terminal window to move around in the file system and to launch any control some programs, like Jupyter Notebooks. You can open a new terminal window using the icon on the Favorites bar located on the left side of the screen. Left clicking the icon once will bring up one new window. Clicking twice will bring up two. Table 1 shows a few common linux commands. You should run them and get comfortable with moving around in the file structure. All of the commands are case sensitive.

Command	Result
ls	provides a content list of the current folder
ls -a	list all files even hidden ones
ls -al	list all files with information on each one
cd <i>directory</i>	move into directory
mv <i>filename new.filename</i>	Change the name of a file to <i>new.filename</i>
mv <i>filename new.directory/filename</i>	Can also be used to move a file from one directory to another
rm <i>filename</i>	delete a file
clear	clear the screen on the terminal
pwd	returns the current path, where you are in the file structure
man <i>command</i>	return the manual page for <i>command</i>
jupyter notebook	starts an instance of Jupyter Notebook in the current directory

Table 1 Some simple commands to get you started in Linux. All of the commands are case sensitive.

To practice working with this new system, complete the following commands.

- 1 Open a terminal window by clicking on the icon on the left of the screen.
- 2 In the terminal window do the following:
 - a) Use the “cd” command to move into the Documents folder.
 - b) Use “ls” to get a list of the files and folders in Documents. What do you see?
 - c) Use the command “mkdir *stuff*” to create a folder called stuff in the Documents folder.
 - d) Move into your “stuff” folder.
- 3 Using the app launch icon, start the text editor app.
 - a) Create a new file (name it what you want to) and put the following in it.
 - b) Today’s date on the first line.
 - c) Your name on the second.
 - d) Your major on the third.
 - e) Save this file in the stuff folder.
- 4 Move back to the terminal window...Run “ls”, what do you see?
- 5 In the Text Editor
 - a) Create another file in the stuff folder using the text editor.
 - b) Name this file “secretstuff.txt”.
 - c) Put what you want for your birthday in this file and save it.
- 6 Move back to the terminal window
 - a) Run “ls” in the stuff folder. What do you see?
 - b) Run “ls -a”, what do you see now.
 - c) Run “cd ~”. This will take you back to your home folder. The ~ is a shortcut for the path to your home folder.

You will want to use some method of backing up your work. The computer at your station is yours to use for the entire semester, however, should there be a problem you want to make sure that you lose as little work as possible. I would suggest either using a thumb drive or your UCA Google Drive as a backup. You will be able to drag and drop files in to either backup.

0.3.1.2 Jupyter Notebooks

We will use Jupyter Notebooks as the platform for our data acquisition automation. A JN is a web-based interactive platform for working with code, data analysis, and reporting. The notebooks that we will be running will be able to evaluate and run Python code interactively. You can set these notebooks up to use other platforms for computation and analysis such as: MATLAB, Octave, Wolfram (Mathematica), and many others. We will use a notebook (*Rigol_lab.ipynb*) later that uses Python code to control the function generator and oscilloscope. As you can see these notebooks are very versatile.

To start the notebook: in a terminal window, run the command *jupyter notebook* (the commands are case sensitive). You will see Firefox open and take you to a JN page showing all of the files in the folder you are in when you start the program. Note files and folders are active links. Click on a file to open it or a folder to enter it. JN files have names that end in “.ipynb”. We will walk through a notebook in class.

0.3.1.3 Geany IDE

You also have access to the Geany IDE app on the classroom computers (you can install this on most any OS). Using the launch window select the magic lamp icon to launch. You can use this app to create code in python by itself. I will personally go back and forth between the two depending on what I am doing. Geany will provide you with color coded text that is very helpful when developing code. You can run programs inside Geany for debugging as well. You should use what you are most comfortable with.

3.3.2 Sections in the Notebook

You can use a notebook to document your measurements and your preparations. This includes using a notebook to complete calculations used to prepare a lab and to analyze data as well as written documentation. This is accomplished using two types of cells in the notebook, Code cells and Markdown cells.

0.3.2.1 Code Cells

These cells will contain Python code. When you run these cells, they interpret the python code entered to complete calculations, make graphs, control the acquisition of data, and other commands. The flow of the code is from the first cell to the last. You can use the results of previous cells in subsequent ones.

0.3.2.1 Markdown Cells

These cells will contain text discussing or describing measurements or preparations. You can use a format called markdown in these cells. This allows you to use LaTeX formatting for equations. There are also different ways to include **bold** and *italic* fonts. You can create tables and include graphics as well. This is what you will use to describe and discuss each lab activity.

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3.3.3 Notebook Practice

Download “Lab 00 notebook” from Blackboard.