ECE 451

Automated Microwave Measurements Laboratory

Experiment 01 - Introduction to Python programming and Jupyter Lab

1 Introduction

This lab is dedicated to familiarize you with Jupyter lab interface. We will use this interface to write Python scripts as the lab materials progress into measurement and data processing techniques.

Your Jupyter lab workspace looks like the figure below, dark theme is also available in **Settings** > **JupyterLab Theme**.

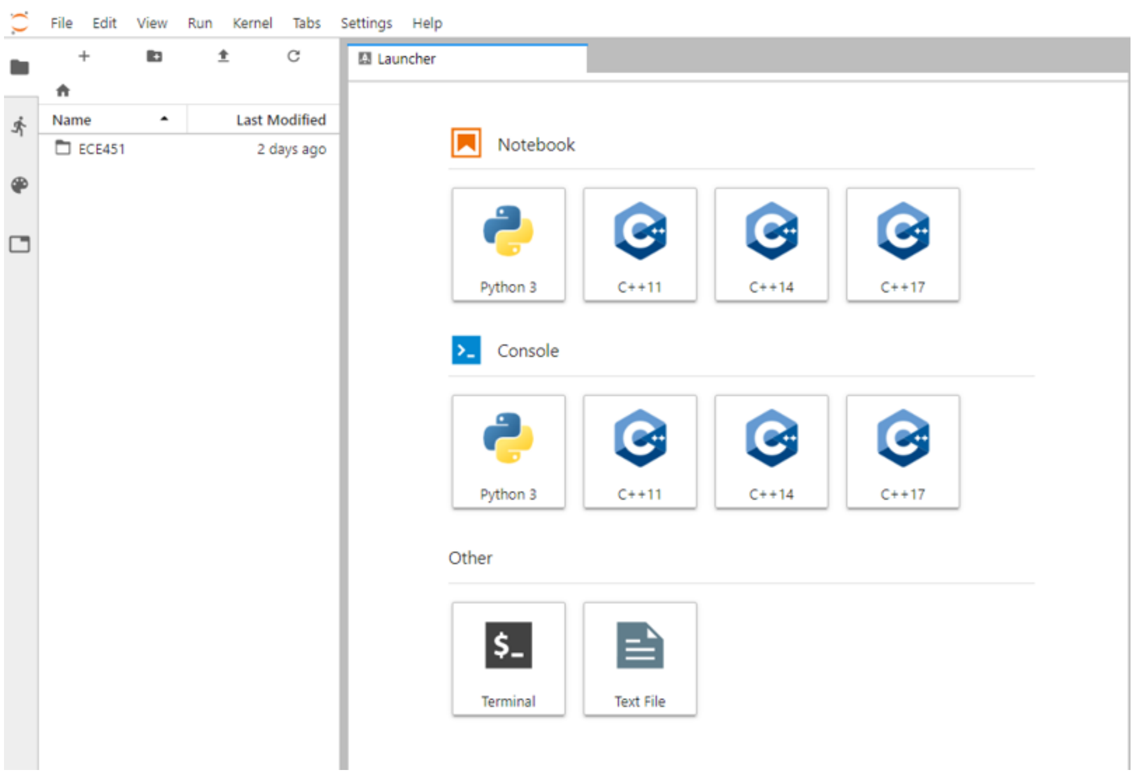


Figure 1: Jupyterlab interface

This video presents a quick introduction to Jupyterlab UI. This video shows a much longer presentation, in which you will learn about all Jupyterlab features that could help with Python programming, especially for Data Science.

2 Pre-lab

1. Your Jupyterlab account should be already created for you. The username is your netID and the default password is your netID appended by "123" (without quotes). Please verify that your account is active by logging into your account using ssh. After you successfully ssh into your account, you will be asked to immediately change the default password to your own choice one. This is a tutorial showing how to use ssh to log into your account.

The server IP address is `192.17.223.38`. If your netID is `tnnguye3`, the command would be

```
ssh tnnguye3@192.17.223.38
```

and the first time log-in password would be `tnnguye3123`

2. After verifying your account and changing password, open a browser and go to http://192.17.223.38:8000, log in with your account and read through the first jupyter notebook, named *01-intro-jupyter.ipynb*

3. If this is your first experience with Python, watch all Python tutorials linked in the notebook.

3 Equipment

- Jupyterlab

4 Procedure

1. Follow the instruction in *01-intro-jupyter.ipynb* and run through the notebook, complete exercises therein, if any.

2. Create a new jupyter notebook and name it "lab01_exercise.ipynb". Write python programs that do the following

   (a) Set up and solve the following system, verify the solved solution is correct (by performing the forward calculations)

$$\begin{bmatrix} 0.05+j0.51 & 0.57-j0.25 \\ 0.41-j0.88 & 0.05+j0.13 \end{bmatrix} x = \begin{bmatrix} -0.42+j1.78 \\ 1.18-j2.77 \end{bmatrix}$$

$$\begin{bmatrix} 0.98-j0.69 & 0.72-j0.47 \\ 0.59+j0.80 & 0.31+j0.53 \end{bmatrix} x = \begin{bmatrix} 2.22-j1.6 \\ 1.46+j1.87 \end{bmatrix}$$

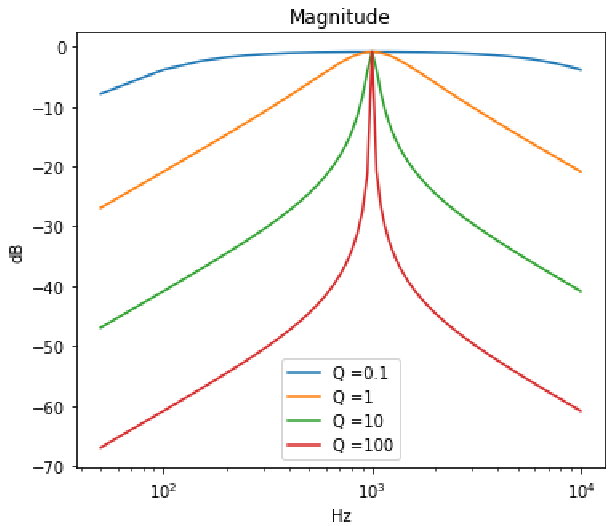
$$\begin{bmatrix} -0.45-j0.85 & 0.80+j0.77 \\ -0.10+j0.76 & 0.15-j0.17 \end{bmatrix} x = \begin{bmatrix} -2.15-j3.32 \\ -0.45+j2.45 \end{bmatrix}$$

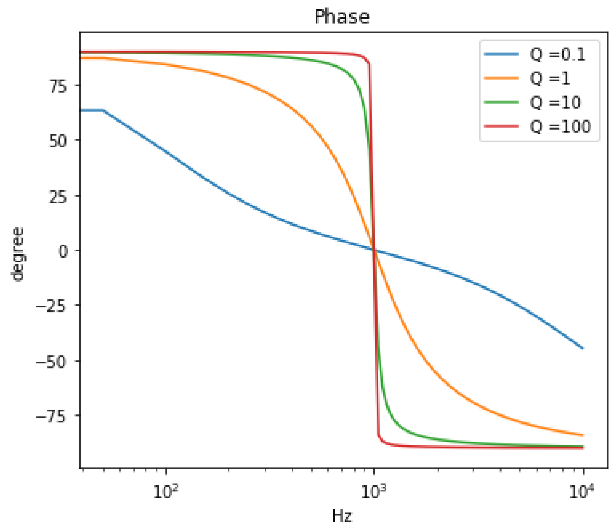
   If solving directly as is, the result will be complex-value. What if x is known to be purely real? How would you set up the linear system to enforce the realness of x?

   (b) A typical band-pass frequency response is

$$H(s) = \frac{H_0 \frac{\omega_0}{Q} s}{s^2 + \frac{\omega_0}{Q} s + \omega_0^2}$$

   where $H_0 = 0.9$ is the peak gain (Q peaking) at resonant frequency $\omega_0 = 2\pi f_0$, $f_0 = 1$kHz, Q is the Q-factor. Plot the transfer for different values of $Q = 0.1, 1, 10$ and 100 for frequency from 0Hz to 10kHz. You should obtain a plot similar below for your report





Also plot H on Smith Chart. Comment on what you observe on Smith Chart compared to the magnitude - phase plot?

3. In the Smith Chart section (the last cell), we want to plot S_{21} with a dash, green line, how would we modify the code to achieve it?

4. A signal is given by $y = 1.5 + \sin(400\pi t) + 2.4 \sin(1,200\pi t)$. Plot this signal in time and find its spectrum. Verify the magnitude in frequency domain is correct.

5 Conclusion

Take screenshots of input/output cells in the jupyter notebook for your report (show both code and result for each question)