

## Lab Sheet:

### Week 1 - Introduction to Control Systems and Python

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#### Learning Objectives:

1. Set up the Python environment for control system laboratory works.
  2. Basic Python programming
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#### Task 1:

##### Setting up the Python Environment for Control System Laboratory Works

#### What is Python?

Python is a general-purpose programming language that is used for a wide variety of tasks, including data science, machine learning, and web development. It is a popular language because it is easy to learn, powerful, and versatile.

#### What is a Jupyter Notebook?

Jupyter Notebook is a web-based interactive environment that allows you to run Python code, write text, and create visualizations. It is a great tool for prototyping, exploring data, and sharing your work with others.

#### Step 1: Download and install Miniconda

1. Go to the Miniconda website: <https://docs.conda.io/en/latest/miniconda.html> and download the installer for your operating system.

*Latest - Conda 23.5.2 Python 3.11.3 released July 13, 2023*

Platform	Name	SHA256 hash
Windows	<a href="#">Miniconda3 Windows 64-bit</a>	<a href="#">00e8370542836862d4c790aa8966f1d7344a8add4b766004febcb23f40e2914</a>
	<a href="#">Miniconda3 Windows 32-bit</a>	<a href="#">4fb64e6c9c28b88beab16994bfba4829110ea3145baa60bda5344174ab65d462</a>
macOS	<a href="#">Miniconda3 macOS Intel x86 64-bit bash</a>	<a href="#">1622e7a0fa60a7d3d892c2d8153b54cd6ffe3e6b979d931320ba56bd52581d4b</a>
	<a href="#">Miniconda3 macOS Intel x86 64-bit pkg</a>	<a href="#">2236a243b6cbe6f16ec324ecc9e631102494c031d41791b44612bbb6a7a1a6b4</a>
	<a href="#">Miniconda3 macOS Apple M1 64-bit bash</a>	<a href="#">c8f436dbde130f171d39dd7b4fca669c223f130ba7789b83959adc1611a35644</a>
	<a href="#">Miniconda3 macOS Apple M1 64-bit pkg</a>	<a href="#">837371f3b6e8ae2b65bdfc8370e6be812b564ff9f40bcd4eb0b22f84bf9b4fe5</a>
Linux	<a href="#">Miniconda3 Linux 64-bit</a>	<a href="#">634d76df5e489c44ade4085552b97bebc786d49245ed1a830022b0b406de5817</a>
	<a href="#">Miniconda3 Linux-aarch64 64-bit</a>	<a href="#">3962738cfac270ae4ff30da0e382aecf6b3305a12064b196457747b157749a7a</a>
	<a href="#">Miniconda3 Linux-ppc64le 64-bit</a>	<a href="#">92237cb2a443dd15005ec004f2f744b14de02cd5513a00983c2f191eb43d1b29</a>
	<a href="#">Miniconda3 Linux-s390x 64-bit</a>	<a href="#">221a4cd7f0a9275c3263efa07fa37385746de884f4306bb5d1fe5733ca770550</a>

2. Run the installer and follow the on-screen instructions.
  - a. Windows: <https://youtu.be/r7XPcSNmWu4>
  - b. Linux : <https://youtu.be/SJBLJTgdj-g>
  - c. Mac OS : <https://youtu.be/4qS7qw9v884>

#### Step 2: Create a new Python environment

1. Open a terminal window.
2. Type the following command to create a new Python environment named control:

```
Unset  
conda create -n control
```

3. Activate the new environment:

```
Unset  
conda activate control
```

### Step 3: Install the python control and jupyterlab packages

1. In the activated environment, type the following command to install the python-control packages:

```
Unset  
conda install -c conda-forge control slycot
```

2. In the activated environment, type the following command to install the jupyter notebook packages:

```
Unset  
pip install jupyterlab
```

### Step 4: Start JupyterLab

1. Type the following command to start JupyterLab:

```
Unset  
jupyter-lab
```

2. This will open a web browser window with a JupyterLab.

That's it! You have now successfully installed miniconda and set up a Python environment for control systems, including Jupyter Notebook.

### Additional resources:

- Miniconda documentation: <https://docs.conda.io/en/latest/>
- python-control documentation: <https://python-control.readthedocs.io/en/latest/>
- matplotlib documentation: <https://matplotlib.org/>
- Jupyter Notebook documentation: <https://jupyter.org/>

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### Task 2:

#### Basic Jupyter Notebook

Here are some basic Jupyter Notebook concepts that you should know:

- Cells: Cells are the basic building blocks of a Jupyter Notebook. You can write code, text, or visualizations in a cell.

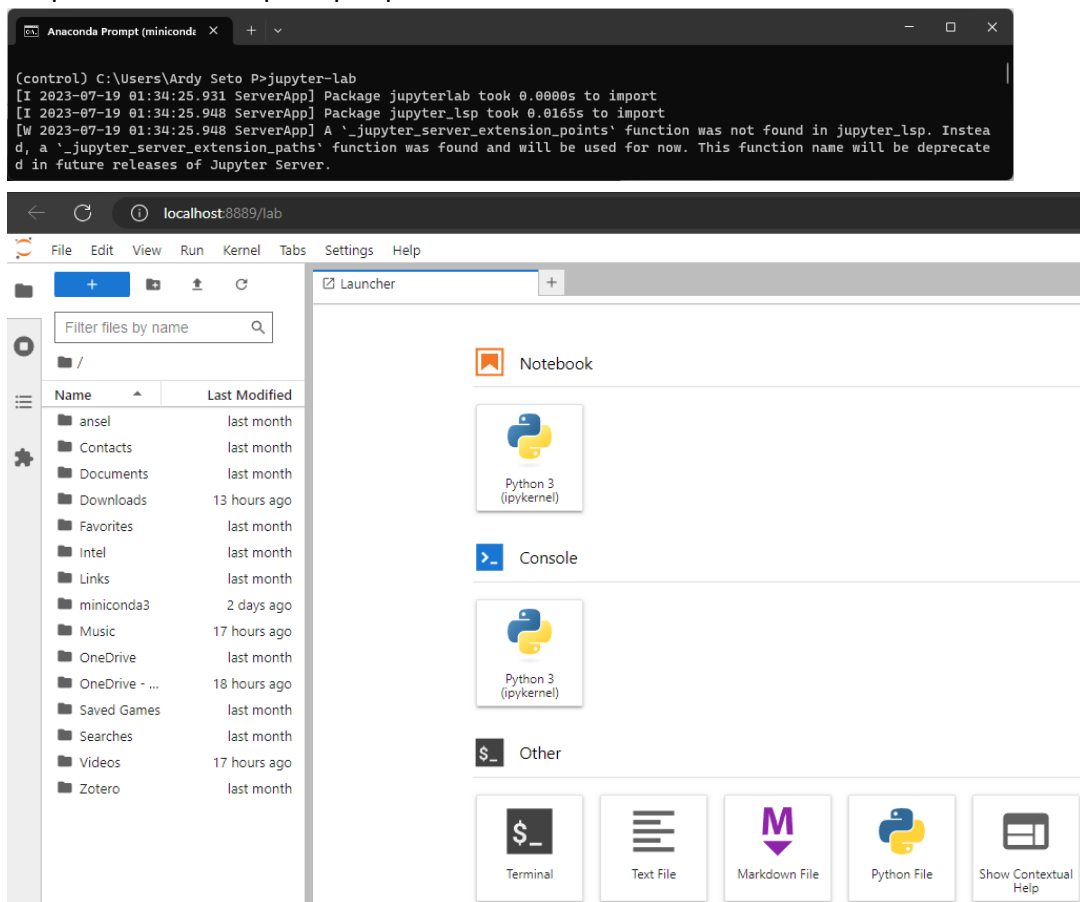
- **Markdown:** Markdown is a lightweight markup language that is used to format text in Jupyter Notebooks.
- **Code cells:** Code cells are used to run Python code. You can run a code cell by clicking on it and pressing Shift+Enter.
- **Output:** The output of a code cell is displayed below the cell.
- **Visualizations:** You can create visualizations in Jupyter Notebooks using the matplotlib library.

## 1. Starting the Jupyter Notebook Server

Unset

jupyter-lab

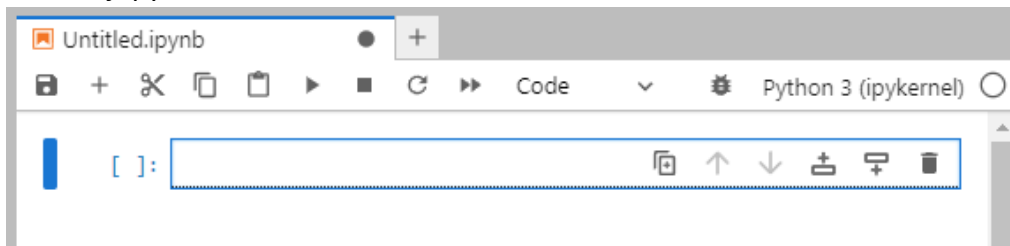
Keep the command prompt open



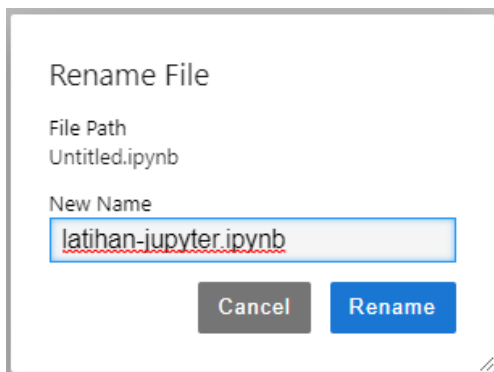
## 2. Creating a Notebook with click on the Python 3 logo (ipykernel)



### View of jupyter notebook worksheet



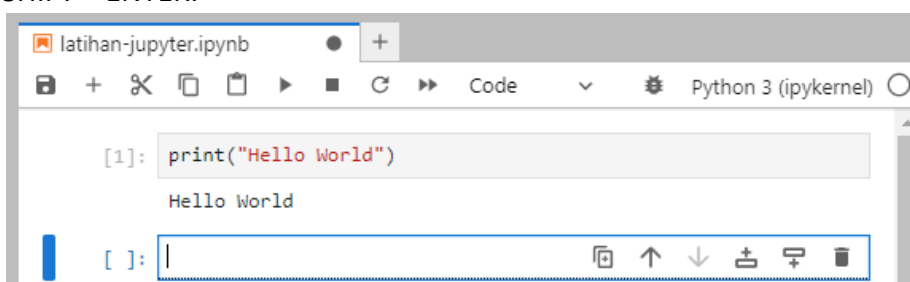
3. Rename notebook because default name Untitled that isn't a very descriptive name



4. Running Cells

A Notebook's cell defaults to using code whenever you first create one, and that cell uses the kernel that you chose when you started your Notebook. In this case, you started yours with Python 3 as your kernel, so that means you can write Python code in your code cells. Since your initial Notebook has only one empty cell in it, the Notebook can't really do anything. Thus, to verify that everything is working as it should, you can add some Python code to the cell and try running its contents.

Running a cell means that you will execute the cell's contents. To execute a cell, you can just select the cell and click the Run button that is in the row of buttons along the top. It's towards the middle. If you prefer using your keyboard, you can just press SHIFT + ENTER.



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### Task 3:

#### Basic Python Programming Language

Here are some basic Python concepts that you should know:

- Variables: Variables are used to store data in Python. You can declare a variable by using the `var_name = value` syntax.

- Data types: Python has a variety of data types, including integers, floats, strings, lists, and dictionaries.
- Operators: Operators are used to perform mathematical operations on data. Some common operators include +, -, \*, /, and %.
- Control flow: Control flow statements allow you to control the order in which your code executes. Some common control flow statements include if, else, for, and while.

## 1. Variable

```
Python
# Variables
my_variable = 10
print(my_variable)
```

## 2. Data types

```
Python
# Data types
integer = 10
float = 10.0
string = "Hello, world!"
list = [1, 2, 3]
dictionary = {"key1": "value1", "key2": "value2"}

print(integer, type(integer))
print(float, type(float))
print(string, type(string))
print(list, type(list))
print(dictionary, type(dictionary))
```

## 3. Operators

```
Python
# Operators
print(10 + 20)
print(10 - 20)
print(10 * 20)
print(10 / 20)
print(10 % 20)
```

## 4. Control flow

```
Python
# Control flow
if 10 > 20:
    print("10 is greater than 20")
else:
    print("10 is not greater than 20")

for i in range(10):
    print(i)

while i < 10:
```

```
print(i)
i += 1
```

## 5. Function

Python

```
# Function
def greet(name):
    print(f"Hello, {name}!")

greet("Alice")
```

Python

```
def multiply_numbers(num1, num2=1):
    return num1 * num2

result = multiply_numbers(5)
print(result)
```

Additional Resource:

- <https://www.pythontutorial.net/python-basics/>
- <https://www.programiz.com/python-programming>
- [https://www.tutorialspoint.com/python/python\\_basic\\_syntax.htm](https://www.tutorialspoint.com/python/python_basic_syntax.htm)

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### Task 4:

Importing the python control and matplotlib modules

In this exercise, you will learn how to import the python-control and matplotlib modules into your Python code.

1. Open a Jupyter Notebook file.
2. Import the python control module and matplotlib:

Python

```
import control
import matplotlib
```

3. Verify that the modules have been imported correctly by printing the following code:

Python

```
print(control.__version__)
print(matplotlib.__version__)
```

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### Task 5:

Plotting with Matplotlib in JupyterLab

*Labsheet for Control System Laboratory Works*  
*Electronics Engineering - Vocational Faculty UNY*

Matplotlib is a widely used plotting library in Python that provides a comprehensive set of tools for creating various types of plots and visualizations. In this tutorial, we will explore the basics of plotting with Matplotlib in JupyterLab.

#### Step 1: Importing the Matplotlib Library

1. Open a JupyterLab notebook or create a new one.
2. Import the necessary Matplotlib library by running the following code in a code cell:

```
Python
import matplotlib.pyplot as plt
```

#### Step 2: Creating Basic Plots

1. Matplotlib provides multiple types of plots, such as line plots, scatter plots, bar plots, histograms, and more. Let's start with a line plot.
2. Create two lists representing the x and y coordinates of the points:

```
Python
x = [1, 2, 3, 4, 5]
y = [2, 4, 6, 8, 10]
```

3. Plot the line graph using the plot() and show() function:

```
Python
plt.plot(x, y)
plt.show()
```

4. You will see a new window pop up displaying the line plot.

#### Step 3: Customizing the Plot

1. You can customize various aspects of the plot, such as the title, labels, axes limits, and more. Let's add some customizations to the line plot:

```
Python
plt.plot(x, y)
plt.title('Line Plot')
plt.xlabel('X-axis')
plt.ylabel('Y-axis')
plt.xlim(0, 6)
plt.ylim(0, 12)
plt.grid(True)
plt.show()
```

2. Run the code cell to display the customized line plot.

#### Step 4: Creating Other Types of Plots

1. Matplotlib supports a wide range of plot types. Let's create a scatter plot and a bar plot as examples.
2. For the scatter plot, define two lists representing the x and y coordinates of the points and Create the scatter plot using the scatter() function:

```
Python
x = [1, 2, 3, 4, 5]
y = [2, 4, 6, 8, 10]

plt.scatter(x, y)
plt.title('Scatter Plot')
plt.xlabel('X-axis')
plt.ylabel('Y-axis')
plt.grid(True)
plt.show()
```

3. For the bar plot, define a list of categories and their corresponding values and create the bar plot using the `bar()` function:

```
Python
categories = ['A', 'B', 'C', 'D', 'E']
values = [20, 35, 30, 15, 25]

plt.bar(categories, values)
plt.title('Bar Plot')
plt.xlabel('Categories')
plt.ylabel('Values')
plt.grid(True)
plt.show()
```

#### Step 5: Saving the Plot to an Image File

1. You can save the plot as an image file directly from JupyterLab. For example, to save the bar plot as a PNG image, add the following code:

```
Python
plt.bar(categories, values)
plt.title('Bar Plot')
plt.xlabel('Categories')
plt.ylabel('Values')
plt.grid(True)
plt.savefig('bar_plot.png')
```

2. Run the code cell, and the bar plot will be saved as a PNG file in the current directory.

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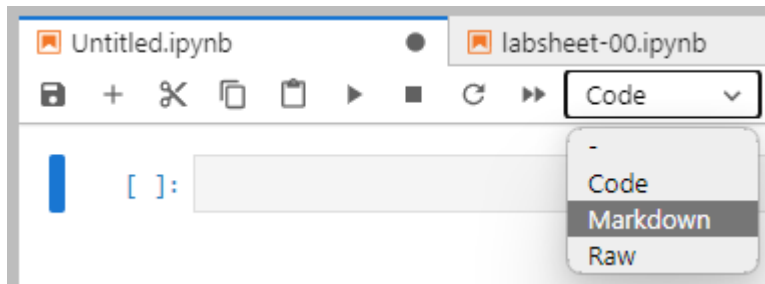
### Task 6:

#### More about Jupyterlab

1. Markdown on Jupyterlab

Markdown is a lightweight markup language that allows you to format text and incorporate elements like headings, lists, images, links, and more in a simple and readable manner. Jupyter Notebook supports Markdown cells, enabling you to create richly formatted documentation, reports, and presentations within your notebooks. In this tutorial, we will explore the basic syntax and features of Markdown in Jupyter Notebook.





Unset

Markdown supports tables:

```
| Column 1 | Column 2 |  
| ----- | ----- |  
| Row 1, Column 1 | Row 1, Column 2 |  
| Row 2, Column 1 | Row 2, Column 2 |
```

You can display code blocks with syntax highlighting:

```
```Python  
def multiply_numbers(num1, num2=1):  
    return num1 * num2  
  
result = multiply_numbers(5)  
print(result) # Output: 5  
```
```

You can include mathematical equations using LaTeX syntax:

```
$$  
m_n = k_p e_n + \frac{k_e T}{T_{\text{reset}}} \sum_{i=0}^n e_i + k_d \frac{e_n - e_{n-1}}{\Delta t} + m_R  
$$
```

You can use basic formatting options like *italic*, **bold**, and ``code`` highlighting.

Markdown supports both ordered and unordered lists:

- Unordered List Item 1
- Unordered List Item 2
- Unordered List Item 3
  
- 1. Ordered List Item 1
- 2. Ordered List Item 2
- 3. Ordered List Item 3

You can add links to websites or local files:

- [Google Website](https://google.com)
- [labsheet-00.ipynb](labsheet-00.ipynb)

Embedding images is also possible:

```
![Google Logo](google.png)
```

Additional Resource:

- <https://www.datacamp.com/tutorial/markdown-in-jupyter-notebook>

- <https://saturncloud.io/blog/jupyter-markdown-cheat-sheet-a-quick-guide-for-data-scientists/>

## 2. Ipywidgets

JupyterLab provides an interactive environment where you can create dynamic and interactive user interfaces using widgets. Widgets allow users to interact with code and visualize data in real-time. In this tutorial, we will explore the basics of using widgets in JupyterLab.

Before we start, ensure that you have the necessary packages installed. Open a terminal and run the following command to install the required packages:

```
Unset  
pip install ipywidgets
```

Here's an example code that demonstrates the usage of a few commonly used ipywidgets:

```
Python  
import ipywidgets as widgets  
from IPython.display import display  
  
# Create a text input widget  
text_input = widgets.Text(value='Hello', description='Enter text:')  
  
# Create a button widget  
button = widgets.Button(description='Click me!')  
  
# Create a dropdown menu widget  
dropdown = widgets.Dropdown(options=['Option 1', 'Option 2', 'Option 3'],  
description='Select an option:')  
  
# Create a slider widget  
slider = widgets.IntSlider(value=50, min=0, max=100, step=1,  
description='Slider:')  
  
# Create an output widget  
output = widgets.Output()  
  
# Event handler for the button click  
def on_button_click(button):  
    with output:  
        print(f"Text: {text_input.value}")  
        print(f"Selected option: {dropdown.value}")  
        print(f"Slider value: {slider.value}")  
  
# Assign the event handler to the button's on_click event  
button.on_click(on_button_click)  
  
# Display the widgets  
display(text_input)  
display(button)  
display(dropdown)
```

```
display(slider)  
display(output)
```

### 3. Exporting Jupyter Notebook (ipynb) to PDF

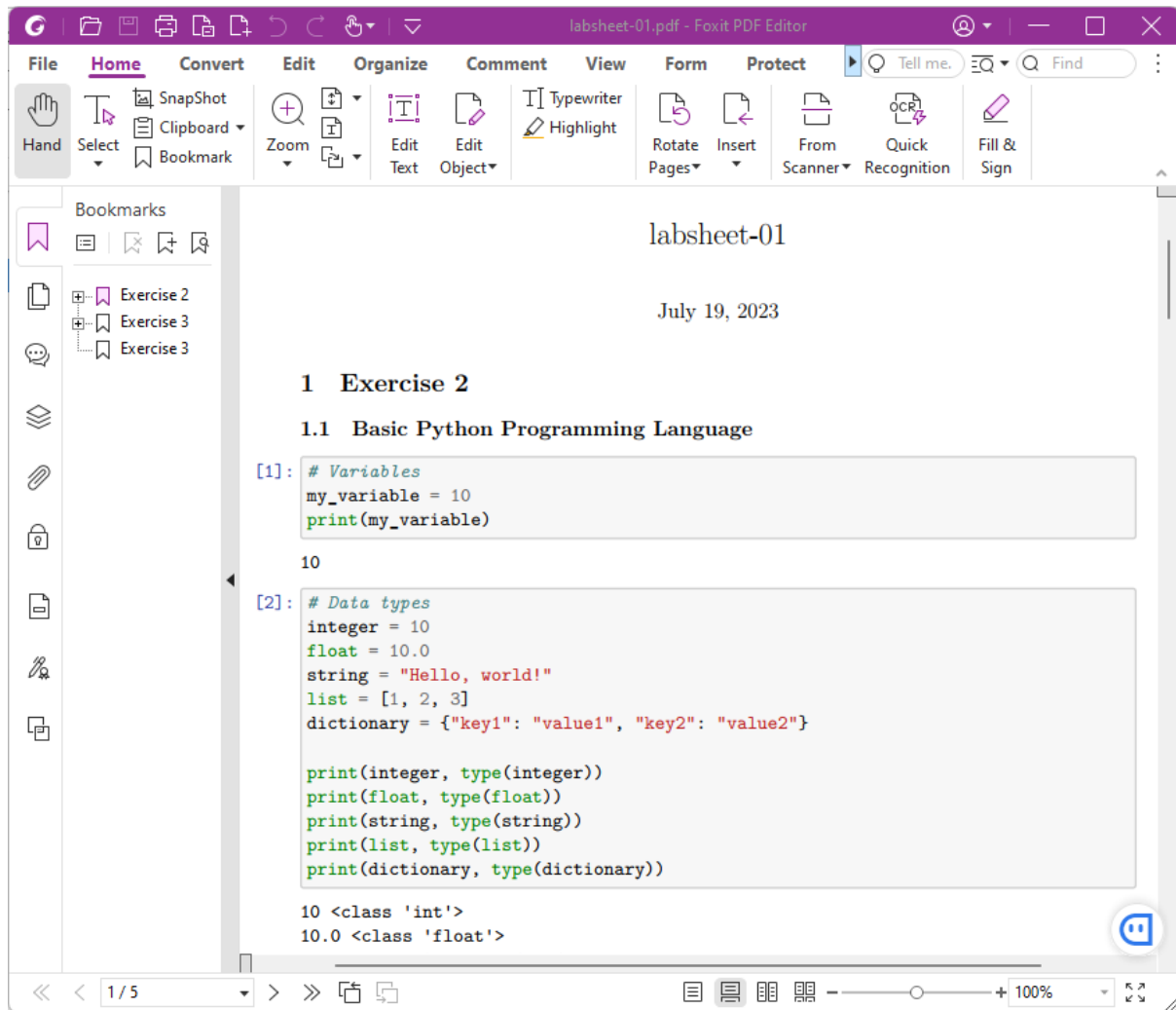
Jupyter Notebook provides a simple and convenient way to export your notebooks to PDF format. In this tutorial, we will walk through the steps to export a Jupyter Notebook as a PDF document.

Before we start, ensure that you have the required packages installed. First download pandoc here: <https://pandoc.org/installing.html> and install on your machine. Second, open a terminal or command prompt and run the following command:

```
Unset  
pip install nbconvert
```

Open a terminal or command prompt and navigate to the directory where your Jupyter Notebook (.ipynb file) is located. Run the following command to convert the notebook to PDF:

```
Unset  
jupyter nbconvert --to pdf notebook.ipynb
```



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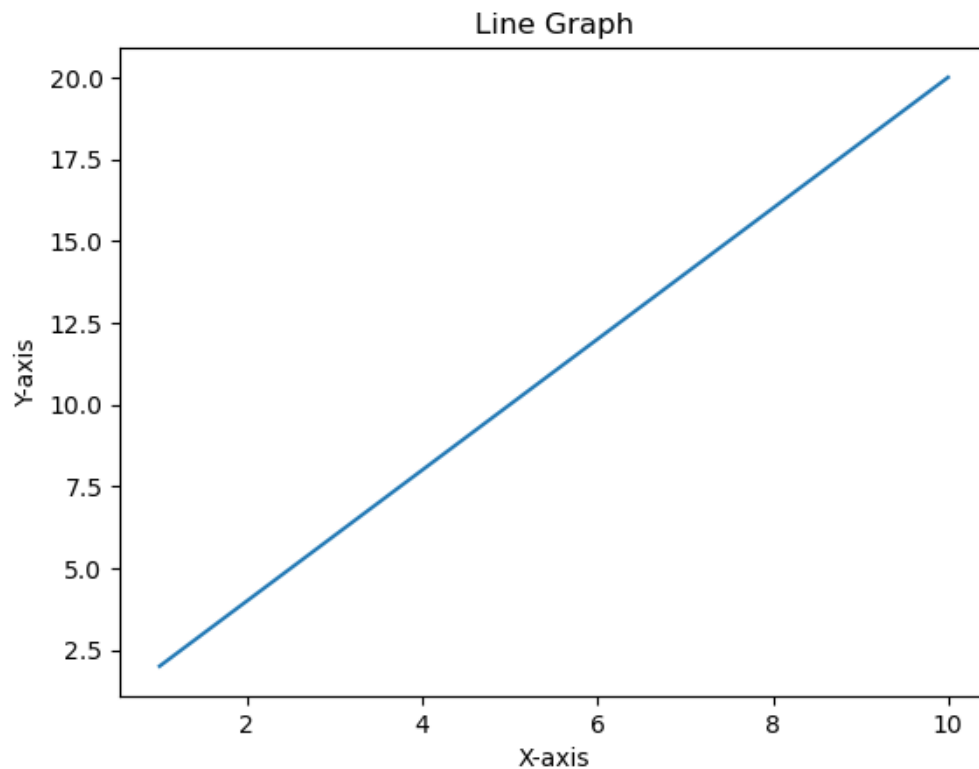
#### Assignment:

1. Write a Python program that calculates the sum of all numbers from 1 to a given number (inclusive). The program should take a number as input from the user and print the sum.  

```
Enter a number: 100
The sum of numbers from 1 to 100 is: 5050
```
2. Write a Python program that checks if a given number is prime. The program should take a number as input from the user and print "Prime" or "Not Prime" accordingly.  

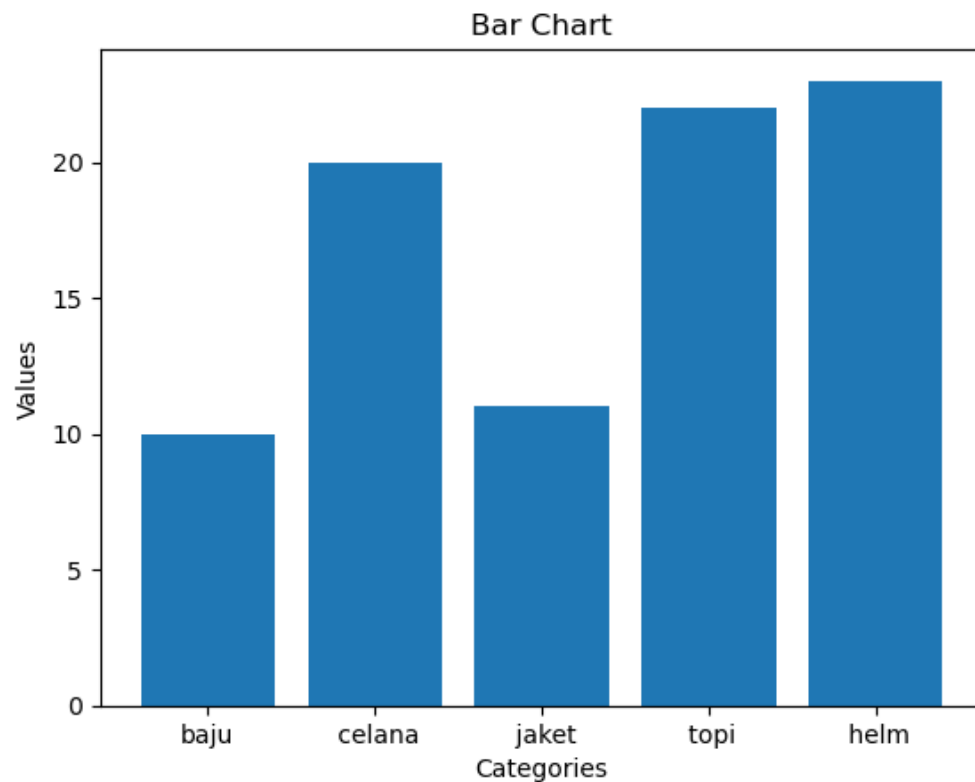
```
Enter a number: 99
99 is not a prime number.
```
3. Write a Python program that plots a line graph of a given list of x and y coordinates. The program should take the x and y coordinates as input from the user and display the line graph using Matplotlib.

```
Enter the x-coordinates (comma-separated): 1,2,3,4,5,6,7,8,9,10
Enter the y-coordinates (comma-separated): 2,4,6,8,10,12,14,16,18,20
```

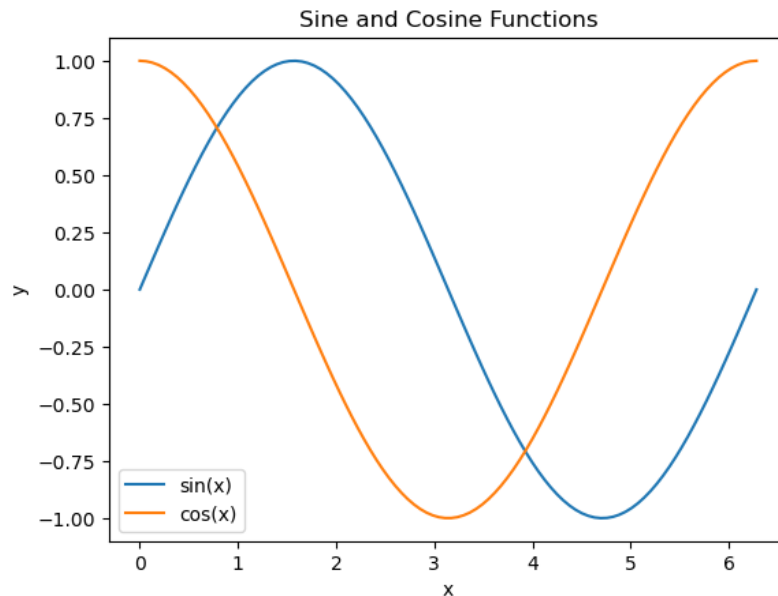


4. Write a Python program that plots a bar chart of a given list of categories and their corresponding values. The program should take the categories and values as input from the user and display the bar chart using Matplotlib.

```
Enter the categories (comma-separated): baju, celana, jaket, topi, helm
Enter the values (comma-separated): 10, 20, 11, 22, 23
```



5. Write a Python program that plots the sine and cosine functions on the same figure using Matplotlib. The program should generate x values from 0 to  $2\pi$  and calculate the corresponding y values for the sine and cosine functions. After plotting the functions, the program should display the figure with appropriate labels, title, and a legend.



6. Write a Python program in Jupyter Notebook that creates an interactive plot of the cosine function using Matplotlib. The program should include a slider widget that allows the user to adjust the frequency and amplitude of the cosine function dynamically. As the user adjusts the slider, the plot should update in real-time to reflect the changes.

