Lab #6 Physics with Python I: Plotting .

A. Complete this:

YOUR NAME ______________________________ SLOT ________

PLEASE MARK THE CIRCLE NEXT TO YOUR LAB SECTION:

◯ A, Prof Yecko, Tue 2-4PM
◯ B, Prof Debroy, Wed 10-12noon
◯ C, Prof Yecko, Thu 11-1PM
◯ D, Prof Yecko, Fri 12-2PM
◯ S, Prof Yecko, Tue 10-12noon

B. Read and sign Academic Integrity Statement:

I hereby attest that I have not given or received any unauthorized assistance on this assignment.

____
Sign here

C. Grading rubric:

CATEGORY AND VERY BRIEF GRADING COMMENTS...........	PTS AVAILABLE	PTS EARNED
Purpose	2	
Double Slit Plot	4	
N-slit Plot	4	
Single Slit Plots	8	
Question	1	
Conclusion	1	
Total	20	

Ph 291: Lab #6, Physics with Python I: Plotting

Cooper Union

Fall 2019

I. Brief Introduction and Resources

In this lab you will use the Python computer language to make some basic plots – physics-related, of course – and to compute some solutions to wave equations.[1] Along the way, you should learn a few things in Python that will be useful in other courses, including Modern Physics.

[1] This part of the Lab is not ready, it will be Part II in 2020

As with MATLAB, it is possible to learn Python incrementally, beginning with some simple codes that are easy to understand and easy to modify. To learn new commands and capabilities, you will need some references. Obviously, online searches will be very helpful here, but I would also like you to have a document or book to refer to. For this I recommend the online guide of Prof. John Kitchin at CMU; here is where to find the PDF: https://kitchingroup.cheme.cmu.edu/pycse/pycse.pdf .

II. Find yourself a Python platform (we'll use CoLab)

Python has some features in common with MATLAB although it is more "modular" in nature, meaning you will need to include extensions, called *libraries*, if you want to any science or engineering computing.[2] Anaconda and Enthought make two of the most popular Python distributions and each is very good. You are free to install either of these (both are free for academic use, but Enthought requires an academic account) but in this course you will not need to. While a basic Python distribution is enough to do most anything, most people are more inclined to install a complete *platform* that often includes a GUI and an editor, among other features. One of the more popular platforms is the Jupyter notebook which, although it can work with more languages than Python, is often installed as part of Python. You should also know that there are some significant differences between *version 2* (such as 2.7.X) and *version 3* of Python; we will use version 3.

[2] three of the most popular ones are numpy, matplotlib and pandas for working with mathematical formulas, plotting and data, respectively; you will probably also need scipy eventually

For this lab we recommend using Google CoLab, an online Jupyter based Python platform that can be linked to your Google drive (optionally). Let's now do this in the next section.

III. Procedure

1. Go to The Google CoLab website:[3] https://colab.research.google.com/. You are encouraged to watch the friendly 3 minute "Intro to Google

[3] On the intro page you may notice that CoLab is used for Machine Learning (ML) also; we will stick to Python in this lab.

CoLab" video. Now either Sign In (top right) using your Google account or Create a new account, then sign in. Next go to the CoLab File menu (top left) and select “New Python 3 notebbok." You will get a fresh window and notebook ready to enter code. This step should look like Figure 1.

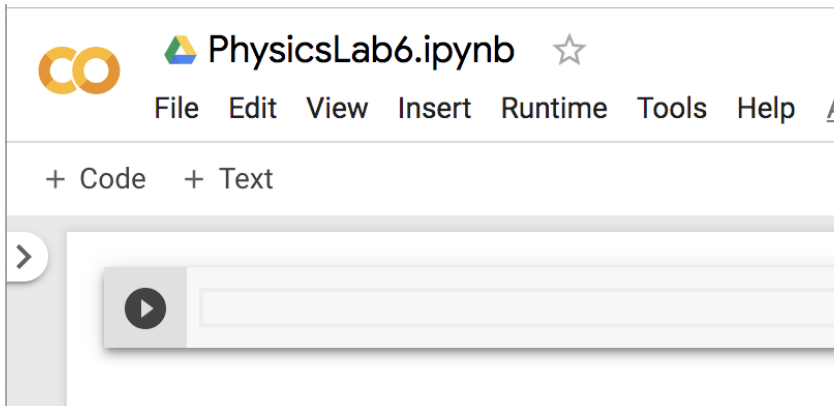

Figure 1: A new python 3 notebook. Below the file menu there are links to add more Code or Text items. The ipynb filename extension indicates a Jupyter notebook; ordinary python code files have extension py. The file is put in my Google Drive (sorry, OneDrive :()

2. First let’s plot something using Python and MatplotLib; the website: https://matplotlib.org/ may be useful. Enter the following code (based on the Example for Simple Plot on the above website):

```
import matplotlib
import matplotlib.pyplot as plt
import numpy as np

# Data for Youngs (lengths in nanometers)
d = 1300.0
lamb = 650.0

# Data for plotting
theta = np.arange(-np.pi/2.0, np.pi/2.0, 0.001)
delta = (2.0 * np.pi / lamb) * d * np.sin(theta)
bigI = (np.cos(delta/2.0))**2

dovlamsintheta = (d / lamb) * np.sin(theta)
fig, ax = plt.subplots()
ax.plot(dovlamsintheta, bigI)

ax.set(xlabel='position (d/lambda)*sin(theta)', ylabel='Intensity (I)',
       title='Youngs Double Slit Intensity')
ax.grid()

fig.savefig("youngs_ds.png")
plt.show()
```

In the above, the numpy command *arange* is used to create an array (here a vector) of values. If you like, you can enter some arange commands directly in a Python code box to see what it does. An alternative to arange is *linspace*. Here is an example linspace command: x = np.linspace(-2,2,100) What is the practical difference between the two?

Plot for Youngs Double Slit Interference: Remake the above plot using linspace in place of arange. In your caption or in the figure, include the linspace command that you used. Be sure to make your figure and caption complete (see the Lab 6 Report section below). In the same plot, change the slit separation to exactly 1.0 micrometer and change the line color of the intensity pattern to red (after all, we are using red light). Remember that this intensity pattern is found only when we assume that the slits have infinitessimally small width! We will “fix" this below in 4, accounting for finite width.

3. As we derived in class, the intensity pattern observed on a distant screen (Figure 1) due to the interference of N sources, also known as the N-slit or grating pattern, is given by:

$$I = I_0 \left[\frac{sin(N\delta/2)}{sin(\delta/2)} \right]^2 \tag{1}$$

where $\delta = (2\pi/\lambda)d\sin\theta$ and you can find the meanings of other quantities in your notes or in the posted lecture notes.

Plot for N-Slit Interference: Make a plot based on Eqn.(1) for red light and $N = 4$. On the same plot show $N = 16$ using a blue line and $N = 256$ with a black line. *Find a way to plot these 3 curves such that they all have the same maximum Intensity value,* otherwise your plot will look strange. I don’t care if you use linspace or arange. Again, be sure to make your figure and caption complete (see the Lab 6 Report section below).

4. Finally, let’s look at the single slit interference pattern. Go look up the formula in either your notes, the lecture notes on Moodle or even the Lab 5 guide. You must make two separate plots for this pattern:

Plots (2) for Single Slit Diffraction: First make a plot showing the pattern formed by a slit of width 1.5 micrometers illuminated with very blue (350 nm wavelength) and very red (700 nm wavelength) light. Obviously, make the curve for the red light red, and that for blue, blue. Again, be sure your plot itself and the caption are complete. For your 2nd plot in this section, you will show the pattern formed by a Youngs Double Slit but with slits of **finite width**. We will not derive this result (but think about it): ***the resulting intensity pattern is simply the product of the YDS function (cosine squared) and the single slit pattern***.

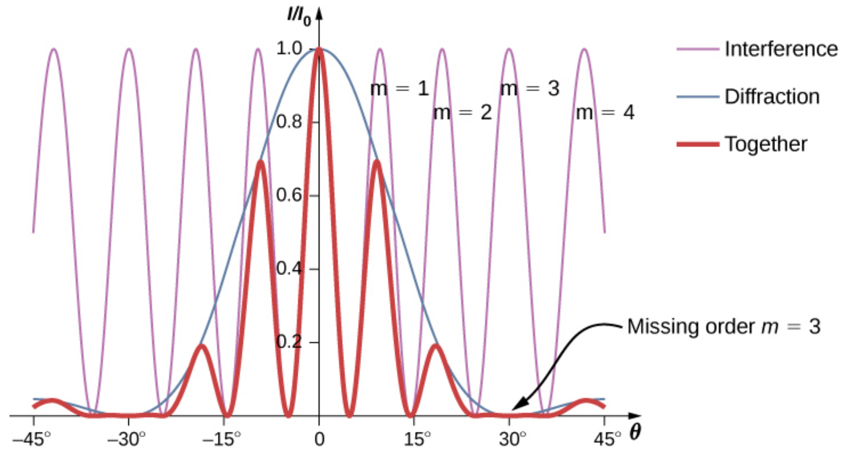

Figure 2: An example of Youngs Double Slit interference for a finite slit width. Try to reproduce this case. Hint: the slit width is twice the wavelength and the slit separation is a few times the slit width.

IV. Advanced Stuff: a Preview This part is not ready, so you can skip it. If surious, go to the website: http://physics.oregonstate.edu/ landaur/Books/Problems/

Here you will find useful codes for physics problems. Most of the matplotlib and vpython codes will run in CoLab. We will use some bits of these codes in Modern Physics.

V. The Lab 6 Report Write a short report, including the following:

1. Purpose (2 points)
2. Results (16 points) : Show your plots for the double slit (4 points for 1 plot), the N slit (4 points for 1 plot) and the single slit (8 points for 2 plots) sections. To get full credit, the plots must be correct, adequately labeled and captioned (use a +Text box in the notebook if you like) so that someone not in our class can understand and apply the plot.
3. Conclusion (1 point)
4. Question (1 point) Why is the $m = 3$ order missing in Figure 2?

This is an atypical report since this is an atypical lab.

Enjoy your break!