45.5 + 44 + 5 − 1 = 93.5

$\boxed{93.5/117}$

PHYS 304 HW2 Xiyue Shen

Xiyue Shen

February 2024

Required (graded) Exercises
All Python scripts are located in the same folder. Check the script for specific lines.

1. **Exercise 2.2: Altitude of a satellite**

   (a) For a satellite with mass m orbiting around the Earth with mass M, the motion can be described as a circular motion. The centripetal force is,

   $$F_c = \frac{mv^2}{r} \tag{1}$$

   where v is the tangential velocity, and r is the radius. We can write r as $R+h$, where R is the earth's radius, and h is the satellite altitude. The source of the centripetal force comes from the gravity of the earth. As Newton described, the gravitational force is,

   $$F_g = G\frac{Mm}{r^2} \tag{2}$$

   where the r is the same distance in equation 1.G is the gravitational constant, $6.674 \times 10^{-11} m^3 kg^{-1} s^{-2}$.
   Let $F_g = F_c$, then we have,

   $$\begin{aligned} G\frac{Mm}{r^2} &= \frac{mv^2}{r} \\ v &= \sqrt{\frac{GM}{r}} \end{aligned} \tag{3}$$

   We have $v = \frac{2\pi r}{T}$ as defined. Then, we can substitute the velocity term in equation 3 so that we can derive a relation in between period and altitude.

Please use RevTex template found on moodle −1

$$
\begin{aligned}
\frac{2\pi r}{T} &= \sqrt{\frac{GM}{r}} \\
r &= (\frac{GMT^2}{4\pi^2})^{1/3} \\
h + R &= (\frac{GMT^2}{4\pi^2})^{1/3} \\
h &= (\frac{GMT^2}{4\pi^2})^{1/3} - R \qquad (4)
\end{aligned}
$$

what values for M and R did you use?

From the second line, r was substituted by $h + R$. Equation 4 is what's given in part a.

(b) Figure 1 shows my script. Here, I import all the necessary packages. Then, I assign several constants. "height" is the equation part a gives. Through "rcParams", we import LaTex font for plotting.

```
#Exercise 2.2 part b
import matplotlib.pyplot as plt
import numpy as np
plt.rcParams['text.usetex'] = True
plt.rcParams['text.latex.preamble'] = r'\usepackage{bm}'
plt.rcParams['pgf.texsystem'] = 'pdflatex'  # or 'latex'

T=input("what period T you would like to?")
T=float(T)
G=6.67e-11
M=5.97e24
R=6.371e6
pi=np.pi
height=(G*M*T**2/(4*pi**2))**(1/3)-R
print("the altitude of the satellite is", height)
```

Figure 1: Programming for calculating the height given a period

(c) For one day (86400 seconds), the altitude is 35855910.176174976 meters; for 90 minutes (5400 seconds), the altitude is 279321.6253728606 meters; for 45 minutes (2700 seconds), the altitude is −2181559.8978108233 meters, as indicated by figure 2.

Pt. (c) asks you to make a conclusion based on this result

(d) For a sidereal day, as the code indicates, I calculated the heights for Ta = 24 hours and Tb = 23.93 hours. Then, I subtracted the heights ha and hb to get the difference. The discrepancy is 82147.84627933055 meters, as shown by figure 3

Pt. (d) asks you to describe why there is a difference btwn a solar day and a sidereal day

2. **Exercise 2.5: Quantum potential step**

Firstly, I input several parameters used as constants, such as electron mass m, Planck constant h, and the joules and electron-volt converting constant j.

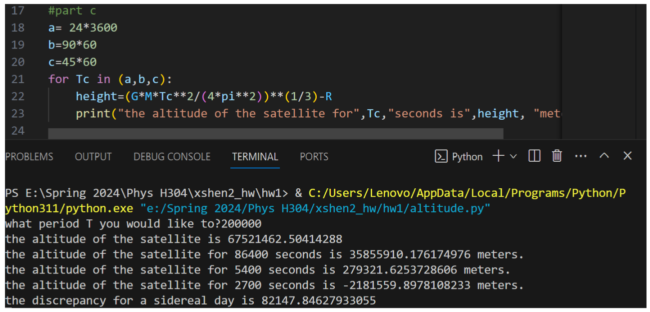


Figure 2: Attached is my code and result after running.

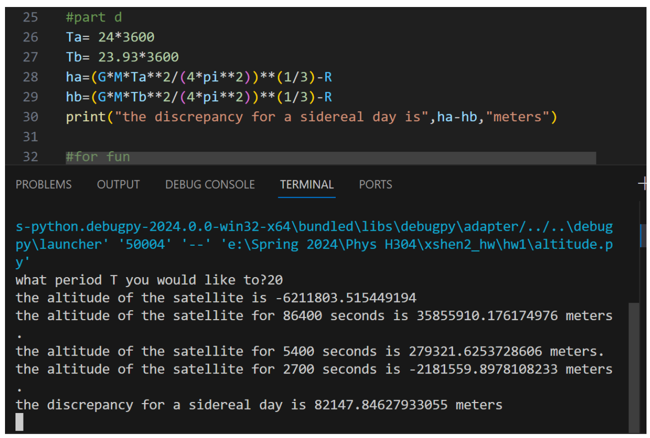


Figure 3: Height difference of a sidereal day.

what values did you use?

Define transmission and reflection

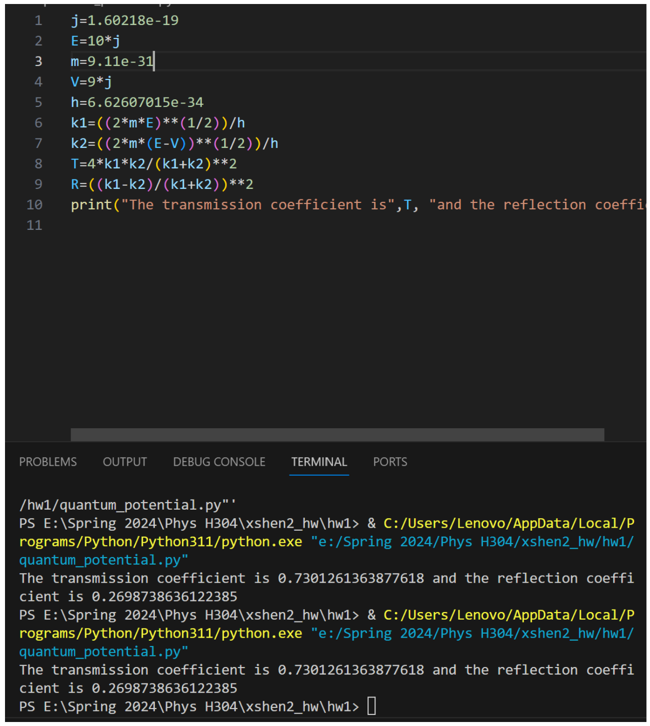
Then, I assign values to energy E and potential V. k_1 and k_2 are equations given for wavevectors. T and R are the probability for transmission and reflection.

After all equations and constants are set, I print out the probabilities. For transmission probability, I get 0.730; for reflection probability, I get 0.270 as shown in figure 4.

3. **Exercise 3.3: STM density plot**

Coding structure: Firstly, I import all packages that I need, such as "numpy", "matplotlib", and some LaTex rendering. After downloading the data and saving it in the same folder as my python script, I use "loadtxt" to read and get the data. Then, I use inshow to plot the data. I got three different plots with gray, rainbow, and Viridis color bars. To make the color contrast more obvious, I set vmin and vmax values, which employ the extremes in the data to make the color distribution.

Figure 5d is a $3D$ plot, which shows the height distribution more obviously.



```
j=1.60218e-19
E=10*j
m=9.11e-31
V=9*j
h=6.62607015e-34
k1=((2*m*E)**(1/2))/h
k2=((2*m*(E-V))**(1/2))/h
T=4*k1*k2/(k1+k2)**2
R=((k1-k2)/(k1+k2))**2
print("The transmission coefficient is",T, "and the reflection coeffi
```

```
PROBLEMS   OUTPUT   DEBUG CONSOLE   TERMINAL   PORTS

/hw1/quantum_potential.py"'
PS E:\Spring 2024\Phys H304\xshen2_hw\hw1> & C:/Users/Lenovo/AppData/Local/P
rograms/Python/Python311/python.exe "e:/Spring 2024/Phys H304/xshen2_hw/hw1/
quantum_potential.py"
The transmission coefficient is 0.7301261363877618 and the reflection coeffi
cient is 0.2698738636122385
PS E:\Spring 2024\Phys H304\xshen2_hw\hw1> & C:/Users/Lenovo/AppData/Local/P
rograms/Python/Python311/python.exe "e:/Spring 2024/Phys H304/xshen2_hw/hw1/
quantum_potential.py"
The transmission coefficient is 0.7301261363877618 and the reflection coeffi
cient is 0.2698738636122385
PS E:\Spring 2024\Phys H304\xshen2_hw\hw1>
```

Figure 4: Quantum potential probability code

4. **Exercise 3.2: Curve plotting**

   I assigned θ with evenly distributed values using "linspace". Then, set x and y as functions of θ given in the problem.

   (a) We have $x = 2\cos(\theta) + \cos(2\theta)$ and $y = 2\sin(\theta)\sin(2\theta)$

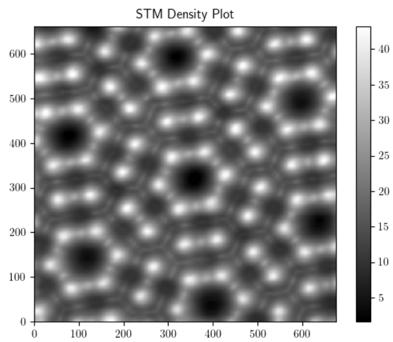
   (b) We have $r = \theta^2$; then, $x = \theta^2\cos(\theta)$ and $y = \theta^2\sin(\theta)$. In the coding, I used ϕ instead of θ to avoid confusion with part a.

   (c) We have $r = e^{cos\theta} - 2\cos(4\theta) + \sin^5(\frac{\theta}{12})$; then, $x = [e^{cos\theta} - 2\cos(4\theta) + \sin^5(\frac{\theta}{12})]\cos(\theta)$ and $y = [e^{cos\theta} - 2\cos(4\theta) + \sin^5(\frac{\theta}{12})]\sin(\theta)$. I used α instead of θ to avoid confusion with part a in the coding.

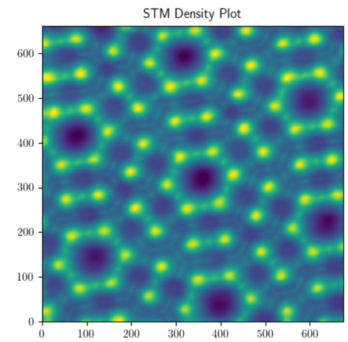
Survey Questions

I spent roughly 3 hours on this week's homework, but I spent another 3 hours figuring out how to apply LaTex rendering and adding the path to the terminal. I learned to make plots, define equations, arrange, linspace, etc. I think the problem set is about the right length. ✓ +5

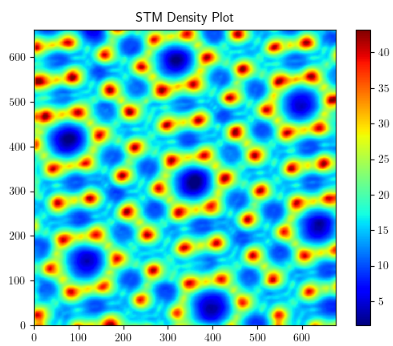
Required (ungraded) work



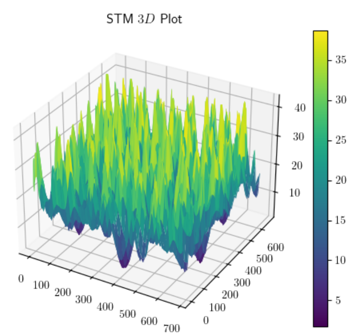
(a) STM plot in gray colorbar



(b) STM plot in Viridis colorbar



(c) STM plot in Rainbow colorbar



(d) 3D STM Plot

Figure 5: STM Density Plot

- I have downloaded the repository
- I followed along with class notes and understood every code
- I tried some examples.

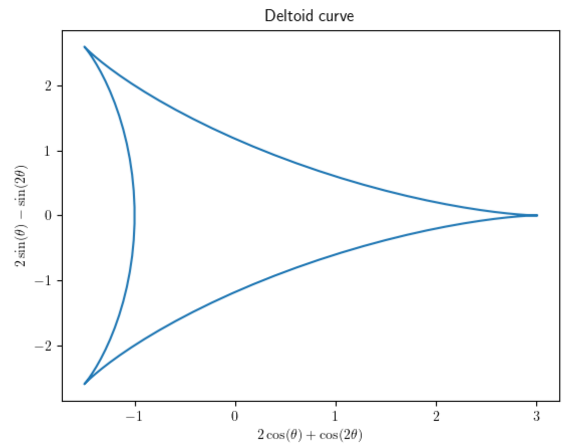


Figure 6: Deltoid curve

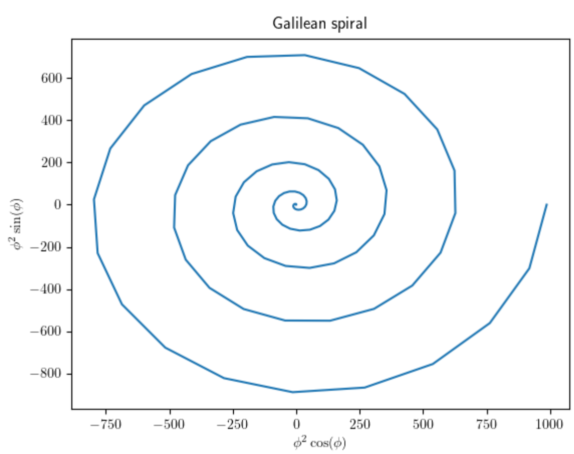


Figure 7: Galilean spiral

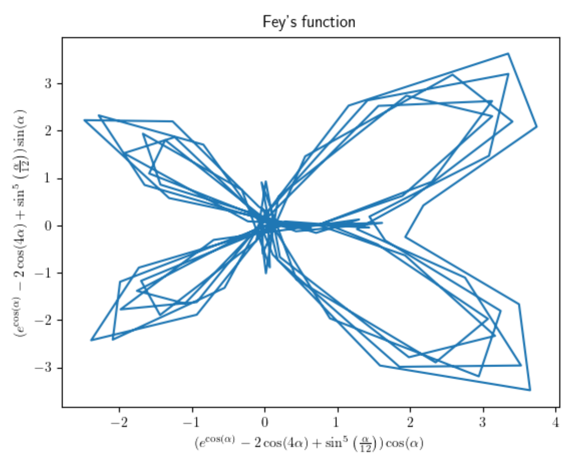


Figure 8: Fey's function

Ex. 2.2 45.5/56

Computational Physics/Astrophysics, Winter 2024:

Grading Rubrics [1]

Haverford College, Prof. Daniel Grin

For coding assignments, roughly 56 points will be available per problem. Partial credit available on all non-1 items.

4 1. Does the program complete without crashing in a reasonable time frame? (+4 points)

2 2. Does the program use the exact program files given (if given), and produce an answer in the specified format? (+2 points)

3 3. Does the code follow the problem specifications (i.e numerical method; output requested etc.) (+3 points)

5 4. Is the algorithm appropriate for the problem? If a specific algorithm was requested in the prompt, was it used? (+5 points)

4 5. If relevant, were proper parameters/choices made for a numerically converged answer? (+4 points)

4 6. Is the output answer correct? (+4 points).

2 7. Is the code readable? (+3 points)

. 5.1. Are variables named reasonably?

. 5.2. Are the user-functions and imports used?

[1] Inspired by rubric of D. Narayanan, U. Florida, and C. Cooksey, U. Hawaii

. 5.3. Are units explained (if necessary)? Please comment units next to your variables -1

. 5.4. Are algorithms found on the internet/book/etc. properly attributed?

| 8. Is the code well documented? (+3 points)

. 6.1. Is the code author named? please comment your name at the top of your code -1

. 6.2. Are the functions described and ambiguous variables defined?

. 6.3. Is the code functionality (i.e. can I run it easily enough?) documented? need comments describing how your code works -1

9. Write-up (up to 28 points)

0 . Is the problem-solving approach clearly indicated through a flow-chart, pseudo-code, or other appropriate schematic? (+5 points) please include psuedocode with your write-up -5

use RevTex → . Is a clear, legible LaTeX type-set write up handed in?

2 . Are key figures and numbers from the problem given? (+ 3 points) define all variables -1

4 . Do figures and or tables have captions/legends/units clearly indicated. (+ 4 points)

3 . Do figures have a sufficient number of points to infer the claimed/desired trends? (+ 3 points)

0.5 . Is a brief explanation of physical context given? (+2 points) make sure you answer all parts of the questions -1.5

1 . If relevant, are helpful analytic scalings or known solutions given? (+1 point)

3 . Is the algorithm used explicitly stated and justified? (+3 points)

2 . When relevant, are numerical errors/convergence justified/shown/explained? (+2 points)

2 . Are 3-4 key equations listed (preferably the ones solved in the programming assignment) and algorithms named? (+2 points)

1 . Are collaborators clearly acknowledged? (+1 point)

2 . Are any outside references appropriately cited? (+2 point)

EX. 2.5 44/56

Computational Physics/Astrophysics, Winter 2024:

Grading Rubrics [1]

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5 4. Is the algorithm appropriate for the problem? If a specific algorithm was requested in the prompt, was it used? (+5 points)

4 5. If relevant, were proper parameters/choices made for a numerically converged answer? (+4 points)

4 6. Is the output answer correct? (+4 points).

2 7. Is the code readable? (+3 points)

. 5.1. Are variables named reasonably?

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. 6.2. Are the functions described and ambiguous variables defined?

. 6.3. Is the code functionality (i.e. can I run it easily enough?) documented? Need comments describing how your code works -1

9. Write-up (up to 28 points)

- 0 . Is the problem-solving approach clearly indicated through a flow-chart, pseudo-code, or other appropriate schematic? (+5 points) Please include psuedocode with your write-up -5
- use ReVTeX → . Is a clear, legible LaTeX type-set write up handed in?
- 2 . Are key figures and numbers from the problem given? (+ 3 points) Numerically define all of your variables -1
- . Do figures and or tables have captions/legends/units clearly indicated. (+ 4 points)
- . Do figures have a sufficient number of points to infer the claimed/desired trends? (+ 3 points)
- 1 . Is a brief explanation of physical context given? (+2 points) Explain the problem e.g. define T & R -1
- . If relevant, are helpful analytic scalings or known solutions given? (+1 point)
- . Is the algorithm used explicitly stated and justified? (+3 points)
- . When relevant, are numerical errors/convergence justified/shown/explained? (+2 points)

include all equation -s from the problem -2

0 . Are 3-4 key equations listed (preferably the ones solved in the programming assignment) and algorithms named? (+2 points)

1 . Are collaborators clearly acknowledged? (+1 point)

2 . Are any outside references appropriately cited? (+2 point)