PHYS304 HW2

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1. EXERCISE 2.13A: RECURSION

In this problem, we are asked to write a Python function, using recursion, that calculates the Catalan numbers C_n, and use it to calculate and print C_{100}. The definition given in the problem can be written in the form:

$$C_n = \begin{cases} 1 & \text{if } n = 0, \\ \frac{4n-2}{n+1} C_{n-1} & \text{if } n > 0 \end{cases} \tag{1}$$

Using the conditional Catalan equation above, I write the program using recursion for the function to call and repeat itself with the condition given with if and else function, and then calculate the term. For the C_{100}, the number calculated is 8.965199470901317e+56.

2. EXERCISE 3.3: DENSITY PLOTS OF EXPERIMENTAL DATA,

We are asked to write a program that reads the data contained in the file stm.txt, which contains a grid of values of the height of the surface from scanning tunneling microscope (STM) measurements of the (111) surface of silicon. I generate a density plot of the values using gray scale running from black to white which I think best illustrate the structure of the silicon surface, as shown in the image (1) below.

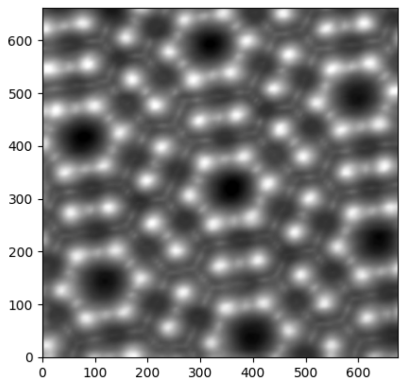

FIG. 1: The density plot of the grid values of the surface of silicon from stm.txt

3. EXERCISE 3.2: CURVE PLOTTING

In this problem, we are asked to make various kinds of adapted plotting. I use the function linspace from numpy to return evenly spaced numbers over a specified interval. This is similar to arange function but instead of step it uses sample number. Linspace is a better option here since we know the exact values for the start and end points of the interval.

a) We are asked to make a plot of the deltoid curve, which is defined by the equations:

$$x = 2cos\theta + cos2\theta,\ y = 2sin\theta - sin2\theta \tag{2}$$

where $0 \leq \theta < 2\pi$. I generate the plot from x and y for each from the equations above, then plot y as a function of x, taken 1,000 values of θ between 0 and 2π, resulted in the image (2) below.

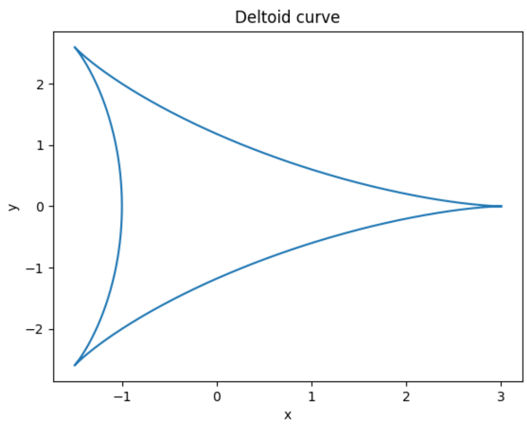

FIG. 2: The deltoid curve plotted with 1,000 values of θ between 0 and 2π

b) Taking the same approach, we are asked to make a plot of the Galilean spiral using a polar plot $r = f(\theta)$, calculating r for a range of values of θ, then converting r and θ to Cartesian coordinates using the standard equations $x = rcos\theta$, $y = rsin\theta$. Using this method, I generate the Galilean spiral plot taken 1,000 values of θ in $r = \theta^2$ for $0 \leq \theta \leq 10\pi$, as shown in the image (3) below.

c) Using the same method above, I make a polar plot of Fey's function taken 10,000 values instead of 1,000 of θ for the more accurate plot, for the equation:

$$r = e^{cos\theta} - 2cos4\theta + sin^5\frac{\theta}{12} \tag{3}$$

in the range of $0 \leq \theta \leq 24\pi$, as shown in the image (4) below.

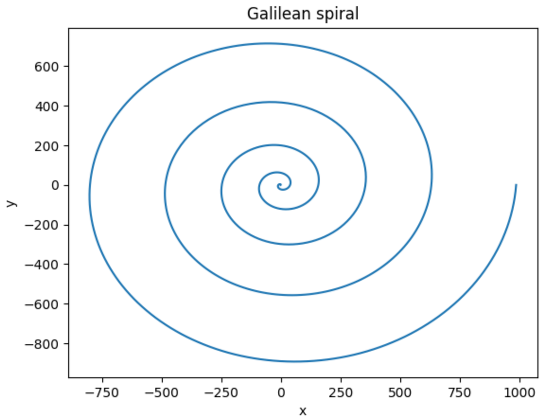

FIG. 3: The Galilean spiral plotted with 1,000 values of θ between 0 and 10π

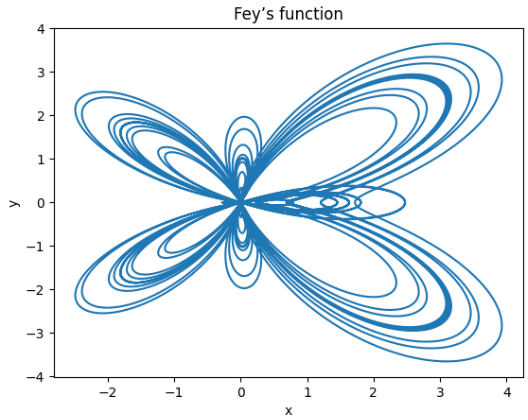

FIG. 4: The Fey's funtion plotted with 10,000 values of θ between 0 and 24π

4. FEEDBACK

I spent about 6-8 hours on this homework including meeting with classmates and attending office hours. Speaking from the perspective that I was doing HW2 and HW3 at the same time, HW2 developed necessary fundamental skills for computational graphics and visualization which is very helpful for HW3 and for further learning materials in the course as well. I think the problems are covered well in the classes and appropriate for the time of the course. I enjoyed doing this homework.

PHYS304 HW2

2.13 a) → According to factorial(n):

def fact(n) if $n == 1$
return 1

call it self

else return n fac(n-1)

for $n! = \begin{cases} 1 & \text{if } n = 1 \\ n \times (n-1)! & \text{if } n > 1 \end{cases}$

→ $C_n = \begin{cases} 1 & \text{if } n = 0 \\ \frac{4n-2}{n+1} C_{n-1} & \text{if } n > 0 \end{cases}$

def C(n) if $n = 0$
return 1

else return $\frac{4n-2}{n+1} C_{n-1}$

$C_{100} = ?$

3.3) → loadtxt from stm.txt
plt. imshow (data)

3.2) a) Deltoid

$x = 2\cos\theta + \cos 2\theta$, $y = 2\sin\theta - \sin\theta$

$0 \leq \theta < 2\pi$

→ linspace or ~~arange~~? ~~step~~

↳ return in sample numbers evenly spaced

→ for θ → linspace $(0, 2\pi)$

→ plt.plot (x, y)

→ axis

→ label

b) Galilean

→ polar $r = \theta^2$, $0 \leq \theta \leq 10\pi$

for $x = r\cos\theta$, $y = r\sin\theta$

θ = linspace $(0, 10\pi)$

→ plt.plot

c) Fey's

→ $r = e^{\cos\theta} - 2\cos 4\theta + \sin^5 \frac{\theta}{12}$

$0 \leq \theta \leq 24\pi$

for $x = r\cos\theta$, $y = r\sin\theta$

θ = linspace $(0, 24\pi)$

→ plt.plot