

Lab 6: Advanced Plotting and SciPy

Name: _____

University Number: _____

Exercise 1: Wave Function for a 2D Infinite Square Well

AIM:

The normalized wave functions for a particle in a 2D infinite square well located in the region $0 \leq x \leq L$, $0 \leq y \leq L$ are

$$\psi_{m,n}(x, y) = \frac{2}{L} \sin\left(\frac{m\pi x}{L}\right) \sin\left(\frac{n\pi y}{L}\right)$$

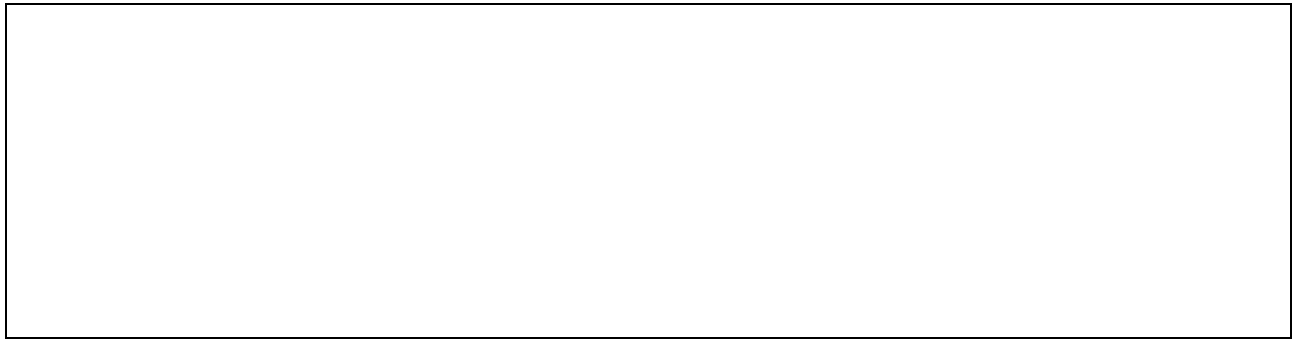
where (x, y) is the position of the particle, $m = 1, 2, 3, \dots$ and $n = 1, 2, 3, \dots$ are the quantum numbers of the state. Write a Python program that uses the `matplotlib` module to make the 3D surface plot and the 3D wireframe plot of the wave function $\psi_{4,3}(x, y)$ over the region $0 \leq x \leq L$, $0 \leq y \leq L$ side-by-side inside the same figure.

ALGORITHM:

PROGRAM:



OUTPUT:



Exercise 2: Mass, Center of Mass, and Moment of Inertia of a Lamina**AIM:**

For a lamina occupying a region D in the x - y plane with mass density $\sigma(x, y)$, the mass M , the center of mass $(x_{\text{cm}}, y_{\text{cm}})$, as well as the moment of inertia about the x -axis I_x and about the y -axis I_y are given by the double integrals

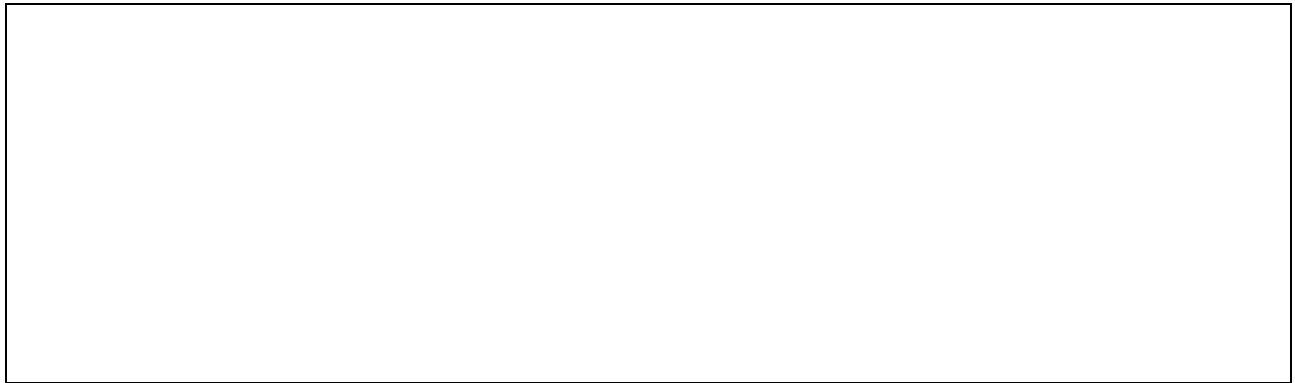
$$M = \iint_D \sigma(x, y) dA,$$
$$x_{\text{cm}} = \frac{1}{M} \iint_D x \sigma(x, y) dA, \quad y_{\text{cm}} = \frac{1}{M} \iint_D y \sigma(x, y) dA,$$
$$I_x = \iint_D y^2 \sigma(x, y) dA, \quad I_y = \iint_D x^2 \sigma(x, y) dA.$$

Write a Python program that uses the `scipy.integrate` function `dblquad` to compute M , x_{cm} , y_{cm} , I_x , and I_y for a lamina occupying the region $0 \leq x \leq 2$, $0 \leq y \leq xe^{-x}$ with mass density $\sigma(x, y) = x^2 y^2$ and then outputs the results. Assume all the quantities are expressed in SI units.

ALGORITHM:**PROGRAM:**



OUTPUT:



Exercise 3: Series *LRC* Circuit

AIM:

A series *LRC* circuit is composed of an inductor of inductance L , a resistor of resistance R , and a capacitor of capacitance C connected in series with an alternating emf $\xi(t)$. It can be shown that the charge q on the capacitor obeys the differential equation:

$$L \frac{d^2 q}{dt^2} + R \frac{dq}{dt} + \frac{q}{C} = \xi(t)$$

where the current in the circuit $I(t) = q'(t)$. Write a Python program to solve this equation subject to the initial conditions $q(0) = 0$ C, $I(0) = 6$ A from time $t = 0$ to 5s for the case $L = 0.5$ H, $R = 20$ Ω , $C = 0.001$ F, and $\xi(t) = 100 \sin 60t$ V by using the `scipy.integrate.odeint` method. Your program should also use the `matplotlib` module to plot the numerical solutions of $q(t)$ and $I(t)$ versus t as separate plots sharing the same horizontal axis.

ALGORITHM:

PROGRAM:

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OUTPUT:

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Exercise 4: Legendre Polynomial

AIM:

Below is a table listing the data set drawn from the Legendre polynomial of degree 4, $P_4(x)$, with some noise added.

x	-1.0	-0.8	-0.6	-0.4	-0.2	0
y	0.91695	-0.19706	-0.29293	-0.04645	0.24494	0.44410
x	0.2	0.4	0.6	0.8	1.0	
y	0.31141	-0.04369	-0.42651	-0.39541	1.14994	

Write a Python program that uses the `scipy.optimize` function `curve_fit` to fit the data set to a degree-4 polynomial of x with the initial guesses of all fitting parameters set to 1, prints out the fitting parameters, as well as plots the data set, fitting result, and the polynomial $P_4(x)$ on the same graph using the `matplotlib` module and the `scipy.special` function `eval_legendre`.

ALGORITHM:

PROGRAM:

OUTPUT: