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 $0 \le x \le L$, $0 \le y \le L$ 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, $m = 1, 2, 3, \ldots$ and $n = 1, 2, 3, \ldots$ 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 $0 \le x \le L$, $0 \le y \le L$ side-by-side inside the same figure.

ALGORITHM:

PROGRAM:

OUTPUT:

Exercise 2: Mass, Center of Mass, and Moment of Inertia of a Laminar

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_{cm}, y_{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

$$M = \iint_D \sigma(x, y)\, dA,$$

$$x_{\mathrm{cm}} = \frac{1}{M}\iint_D x\,\sigma(x, y)\, dA, \qquad y_{\mathrm{cm}} = \frac{1}{M}\iint_D y\,\sigma(x, y)\, dA,$$

$$I_x = \iint_D y^2\,\sigma(x, y)\, dA, \qquad I_y = \iint_D x^2\,\sigma(x, y)\, dA.$$

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 $0 \le x \le 2$, $0 \le y \le xe^{-x}$ with mass density $\sigma(x, y) = x^2y^2$ 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:

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

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, $R = 20\ \Omega$, $C = 0.001$ 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:

OUTPUT:

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: