Set 1

- Basic Numpy Functions
- Plotting with Matplotlib

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1. Basic Array Operations

- Create a NumPy array with values from 1 to 10.
- Calculate the mean, median, and standard deviation of the array.
- Reshape the array into a 2x5 matrix.
- Extract the elements from the second row of the matrix.
- Replace all even numbers in the matrix with zeros.

2. Projectile Motion A ball is launched with an initial velocity of 20 m/s at an angle of 45 degrees above the horizontal. Assume no air resistance. Calculate the horizontal and vertical components of velocity. Calculate the time of flight. Determine the maximum height reached by the ball. Plot the trajectory of the ball using Matplotlib.

3. Simple Harmonic Motion A mass-spring system has a mass of 0.5 kg and a spring constant of 100 N/m. The mass is displaced 0.2 meters from equilibrium and released from rest.

- Calculate the angular frequency of the oscillation.
- Find the displacement equation as a function of time.
- Plot the displacement vs. time graph using Matplotlib.

4. Consider a series circuit consisting of a resistor and an inductor connected in series to a sinusoidal AC voltage source. The resistor has a resistance of 50 ohms, and the inductor has an inductance of 0.1 H. The AC voltage source has a frequency of 50 Hz and an amplitude of 100 V. Calculate and plot the phase difference between the voltage across the resistor and the current flowing through the circuit as a function of frequency.

5. Consider a series RLC circuit with a resistor (R=100Ω), an inductor (L=0.1H), and a capacitor(C=0.001F) connected to an AC voltage source (Vrms=50V) at a frequency of

f=50Hz. Calculate the impedance of the circuit at this frequency and plot the phase angle of the impedance as a function of frequency from 1 to 100 Hz.

6. A hot body at an initial temperature $T_0 = 100℃$ is placed in a room with an ambient temperature $T_{room} = 25℃$. The body cools down through three different methods: conduction, convection, and radiation. The cooling rates (k) for each method are as follows:

- Conduction: $k_{cond}=0.1\ min^{-1}$

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- ➔ Convection: $k_{conv}=0.2\ min^{-1}$
- ➔ Radiation: $k_{rad}=0.15\ min^{-1}$

Calculate and plot the temperature of the body as a function of time over a span of 60 minutes for each cooling method.

$$T(t)=T_{room}+(T_0-T_{room})\cdot e^{-kt}$$

7. Consider a particle with a quantum wavefunction described by the following Gaussian function in one dimension:

$$\psi(x)=A\cdot e^{\frac{-(x-\mu)^2}{2\sigma^2}}$$

Where:

- ➔ A is the normalization constant.
- ➔ μ is the mean or central position of the wavefunction.
- ➔ σ is the standard deviation that determines the width of the wavefunction.

Given

A=1,

μ=0, and

σ=0.5, calculate and visualize the probability density

$|\psi(x)|^2$ over a range of x values from -5 to 5 using Python's NumPy and Matplotlib libraries.