Pandas 1

You are given a CSV file named `projectile_data.csv` containing experimental data of projectile motion. The file contains the following columns:

- `time`: Time in seconds.
- `x_position`: Horizontal position in meters.
- `y_position`: Vertical position in meters.

Your tasks are:

1. **Read** the CSV file into a Pandas DataFrame.
2. **Calculate** the velocity components (`v_x`, `v_y`) at each time step using finite differences.
3. **Add** the velocity components as new columns to the DataFrame.
4. **Calculate** the magnitude of the velocity (`v`) and add it as another column.
5. **Find** the maximum height reached by the projectile.
6. **Find** the time when the projectile hits the ground (i.e., when `y_position` becomes zero after launch).
7. **Plot** the trajectory of the projectile (`y_position` vs. `x_position`) using Pandas plotting.

Provide the code to perform these tasks.

Pandas 2:

A certain radioactive isotope decays over time following an exponential decay law. You are tasked to:

1. **Generate** synthetic data for the number of undecayed nuclei (`N`) over time (`t`) using the decay formula: $N(t)=N0 \cdot e^{-\lambda t}$ where N0 is the initial number of nuclei and λ is the decay constant.
2. **Create** a Pandas DataFrame to store `time` and `N`.
3. **Add** columns to the DataFrame for the activity (`A`) at each time point, calculated as: $A(t)=\lambda N(t)A(t)$
4. **Use** Pandas to compute the half-life of the isotope from the data.
5. **Plot** `N` vs. `time` and `A` vs. `time` on the same graph with appropriate labels.

Provide the code to perform these tasks, assuming $N_0=1000$ nuclei, $\lambda=0.1\ s^{-1}$, and time from 0 to 50 seconds with intervals of 0.5 seconds.

Pandas 3:

You have experimental data of a blackbody radiation spectrum saved in a file named `spectrum_data.csv` with the following columns:

- `wavelength`: Wavelength in nanometers (nm).
- `intensity`: Measured intensity at each wavelength.

Your tasks are:

1. **Read** the data into a Pandas DataFrame.
2. **Use** Pandas to find the wavelength corresponding to the maximum intensity (peak wavelength).
3. **Use** Wien's displacement law to calculate the temperature of the blackbody: $\lambda_{max} T = b$ where $b = 2.897 \times 10^6$ nm·K.
4. **Add** a column to the DataFrame for the theoretical blackbody intensity using Planck's law (you can use a simplified version).
5. **Plot** both the experimental and theoretical intensity curves on the same graph.

Provide the code to perform these tasks.

Pandas 4

You have a dataset `thermo_data.csv` containing measurements of pressure (`P`), volume (`V`), and temperature (`T`) for an ideal gas experiment. The columns are:

- `pressure`: Pressure in Pascals (Pa).
- `volume`: Volume in cubic meters (m^3).
- `temperature`: Temperature in Kelvin (K).

Your tasks are:

1. **Read** the dataset into a Pandas DataFrame.
2. **Verify** the Ideal Gas Law $PV=nRT$ calculating the number of moles `n` for each measurement. Assume $R = 8.314$ J/(mol·K).
3. **Add** a new column `n` to the DataFrame.
4. **Calculate** the mean and standard deviation of `n`.
5. **Determine** whether the number of moles remains constant throughout the experiment.
6. **Plot** `PV` vs. `T` and perform a linear regression using Pandas to check the relationship.

Provide the code to perform these tasks.

Pandas 5

A dataset `oscillation_data.csv` contains time series data of a damped harmonic oscillator with columns:

- `time`: Time in seconds.
- `displacement`: Displacement from equilibrium position in meters.

Your tasks are:

1. **Read** the data into a Pandas DataFrame.
2. **Use** Pandas to calculate the velocity and acceleration at each time point.
3. **Perform** a Fast Fourier Transform (FFT) on the displacement data using Pandas and NumPy to find the dominant frequency.
4. **Plot** the power spectrum of the oscillation.
5. **Estimate** the damping coefficient assuming the displacement follows: $x(t)=Ae^{-\gamma t}\cos(\omega t+\phi)$ where γ is the damping coefficient.

Provide the code to perform these tasks.