Assignment-3

PHY617/473-Computational Physics

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Explain the algorithm you are using for each question. Use for loop and function to make your code efficient.

Question 1. Write a python program that computes the sum of all the elements of a matric C, where C = AB. Here A and B are two matrices of size $N \times N$. The value of N should be taken as input from the keyboard and take N = 100. The elements of the matrices are defined as:

$$A[i,j] = i \star j/100$$

$$B[i,j] = (i+1) \star (j+1)/100.$$

Do the matrix multiplications using (a) the for loop and (b) using numpy.dot functions. [**4+4 marks**]

Round up your answer up to three decimal places using numpy.round(x,3) function of python for both cases. Which method [(a) or (b)] is taking less time and why?[**2 marks**]

Question 2. **Compute velocity and acceleration from 1D position data**
Suppose we have recorded GPS coordinates $x_0, ..., x_n$ at times $t_0, ..., t_n$ while running or driving along a straight road. We want to compute the velocity v_i and acceleration a_i from these position coordinates. Using finite difference approximations, one can establish the formulas

$$v_i \approx \frac{x_{i+1} - x_{i-1}}{t_{i+1} - t_{i-1}},$$

$$a_i \approx 2(t_{i+1} - t_{i-1})^{-1} \left(\frac{x_{i+1} - x_i}{t_{i+1} - t_i} - \frac{x_i - x_{i-1}}{t_i - t_{i-1}} \right),$$

for $i = 1, ..., n-1$ (v_i and a_i correspond to the velocity and acceleration at point x_i at time t_i, respectively)

a) Write a Python function kinematics(i, x, t) for computing v_i and a_i, given the arrays x and t of position and time coordinates ($x_0, ..., x_n$ and t_0, ..., t_n).[**5 marks**]

b) Write a Python function test_kinematics() for testing the implementation in the case of constant velocity V. Take the dataset for position and time from the given datafile *GPS_data.txt* using numpy loadtxt(). Call the kinematics function for the legal i values and calculate v_i and a_i.[**5 marks**]

Question 3. a. Write a function count_pairs(dna, pair) that returns the number of occurrences of a pair of characters(pair) in a DNA string (dna). For example, calling the function with dna as 'ACTGCTATCCATT' and pair as 'AT' will return 2. [**5 marks**]

b. Count how many times a certain string appears in another string. For example, the function returns 3 when called with the DNA string 'ATCTTATCGAATC' and the substring 'ATC'. [**5 marks**]

Hint: For each match of the first character of the substring in the mainstring,check if the next n characters in the main string matches the substring, where n is the length of the substring. Use slices like $s[3:9]$ to pick out a substring of s.

Question 4. Look at the datafile *planet_data.txt* which has information about orbital period, semi major axis, radius and mass of a planet which is orbiting a star.

(a)Read them using numpy loadtxt and verify Kepler's third law ($T^2 \propto a^3$). [**6 marks**]

(b)Also plot mass and radius of the planet using python plot function.[**4 marks**]