PH 434 Autumn 2025 – Programming Lab.

Practical Class 11 (Dated: 31. 10. 2025)

Question 1

The spread of the viral infection in a body with an initial infection is approximated with balance equations on the number of healthy cells (H), infected cells (I), and virus count (V), which are governed by:

$$\begin{aligned}\frac{dH}{dt} &= r_1 - r_2 H - r_3 HV \\ \frac{dV}{dt} &= -r_3 HV - r_4 V + r_5 I, \\ \frac{dI}{dt} &= r_3 HV - r_6 I\end{aligned}$$

where, $r_1 = 10^5$ is the growth rate of healthy cells, $r_2 = 0.1$ is the death rate, $r_3 = 2 * 10^{-7}$ is the rate of conversion of healthy cells into infected cells, $r_4 = 5$ is the death rate of virus, $r_5 = 100$ is the production of virus by infected cells, and $r_6 = 0.5$ is the death rate of infected cells. All rates are per month.

Plot the healthy cell, infected cell, and the virus count over the course of 15 months, if the initial counts are: $H(0) = 10^6$, $V(0) = 100$, and $I(0) = 0$.

Create a dictionary: dict = {'time':[],'healthy cells':[], 'virus count':[], 'infected cells':[] }, and store the output of the differential equation in the dictionary.

Save it as both a pickle and numpy file. Load the pickle file that you have saved and, using matplotlib, plot the change of I, H and V with time.

Question 2

Consider the series $f(x, n)$, defined as

$$f(x, n) = 1 + \frac{1}{x} + \frac{1}{x^2} + \frac{1}{x^3} + \cdots + \frac{1}{x^n}.$$

Define a function that saves the different terms $1/x^k$ for $k \in [0, n]$ and the sum $f(x, n)$ in a list.

Using the above defined function, write a python script to create a csv file called **series.csv** that saves the table below (in csv format), for $x = [2, 10]$ and $n = 10$.

x	0	1	2	3	...	n	sum
2	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	...	$\frac{1}{2^n}$	2
$\vdots$							$\vdots$
10	1	$\frac{1}{10}$	$\frac{1}{10^2}$	$\frac{1}{10^3}$	...	$\frac{1}{10^n}$	$f(10, n)$

Note that the last column $f(x, n)$ should be the actual sum. The first row and column serve as the indices/labels, if the csv file is opened in a spreadsheet (MS Excel, Google sheets etc.). Try opening the csv file in Excel.

Question 3

Import the csv file **series.csv** and print all the elements as a panda dataframe.

Using pandas set the column **x** as the index columns and print the list of elements for the powers $0, 1$ and 2 for **x=5**.

Question 4

Using pandas, read the **ipl_data.csv** file.

Do the following:

i) Create and print the smaller panda dataframe that contains the values corresponding to season, host city and winners (please check the exact key).

ii) Count the number of wins and losses for Kolkata Knight Riders in 2010, when they have hosted the match in Kolkata.

iii) Write a **function** that will take the season/year as an argument and make a plot, that shows the winning margin in each game in terms of either the runs or wickets. Note only one of the two can be non-zero for a particular game.

You can make two separate plots or just a single one.

Challenge

Using pandas, read the **Nifty50_Data.csv** data file, which contains the daily Nifty 50 index value from 2015 to 2025.

Do the following:

i) Present the data in the form of a panda dataframe.

ii) Plot the daily price, daily high and daily low value of the index, where the x-axis presents the days since the start of the data. I mean day 0 is the date 1.04.2015.

iii) Write a code that calculates the monthly rate of change of the Nifty index (use the daily price). Find which month and year represents the best price increase of the Nifty 50 index.

iv) Using discrete Fourier transform, check whether there is any dominant cyclic behaviour in the price of Nifty 50 index.