Numerical Methods - Final Assignment (30 Marks)

Instructions:

I.   All the answers has to be put in a report including (a.) Equations/derivations if any (b.) results (c.) plots as well as (d.) code.
II. The choice of approach taken or the method used has to be explicitly mentioned. Justification for the choice made has to explicitly mentioned.
III. In case of issues with the results or bugs in the code, you need to clearly state it and suggest a solution, so I can judge your thinking process.
IV. The required data are linked in each question as well as in the following [document](#).
V.   Deadline for submission of assignment is 14th of December 2022. Viva will be on 15th or 16th December 2022 over online mode.

Assignment problem set 1 (10 marks)

1. Fit the following data and obtain the slope. Comment on the value of slope. Mention the method used to fit the slope. **(3 marks).**
2. Consider the Cauchy's distribution $P(x) = 1/(\pi(1 + x^2))$ within the limits (-10,10). Obtain the integral of P(x) in single application of Simpson's ⅜ rule and compare with Gauss Quadrature methods. Numerically obtain the F(x), the cumulative distribution function using best numerical integral method. Justify the choice **(4 marks)**.
3. Consider $U(r) = (1/r^{12}) - (1/r^6)$. Compute the minimum of the function using the parabolic interpolation method (slide 15 in the notes). Compare with the value obtained analytically **(3 marks)**.

Assignment problem set 2 (10 marks)

4. Consider a simple pendulum consisting of a ball of mass m hung by a (massless) thread of length L, on earth. Let θ be the angular displacement.

   a. Write down the equation of motion (without assuming small angle approximation) and solve using RK4 ODE solver. Solve the **simple** pendulum problem using RK4 ODE solver **(3 marks)**.

   b. For a fixed L=1, for small initial θ_i (<20^0) approximation, compare with analytical solution (i.) θ vs. time (ii.) period of oscillation T **(2 marks)**.

   c. Compare the phase space trajectory (θ vs dθ/dt) for θ_i = 10, 20, 50, 90 **(2 marks)**.

   d. Compare the phase space trajectory for the simple pendulum on sun, moon and mars with earth (for fixed θ_i = 20) **(2 marks)**.

   e. Write the equation of motion for double pendulum problems and discuss implementation **(1 mark)** or Visualize the motion of single pendulum and show the animation **(1 mark).**

Assignment problem set 3 (10 marks)

5. Read the following [text](#) in matlab and convert all to lowercase **(2 marks)** (string manipulation related queries can be discussed with me or TA). Answer the following
   a. Count the number of letters and words **(1 Marks)**
   b. Obtain the normalised distribution of alphabets **(4 marks)**
   c. The first 5 most frequently found english letter are (e, a, r, i, o). For each of this letter which another letter follows more frequently (eg., In the following words - english, engine, energy, enigma, enter, empire - **'e'** is followed by **'n'** 6 times, **'r'** twice, **'m'** once. So **n** is the most frequently followed letter for **e**) **(3 marks)**