EE 291- Project 1

Shooting Method – Ordinary Differential Equations

NV Energy Estimate Request:

NV Energy is looking to hang power lines using a new line. Due to the Newtonian mechanics associated with the behavior of 1-D lines, there is a sag that will be associated with hanging lines between posts. NV Energy is looking to hang new single core lines. There is a maximum allowable drop of the lines of 3 m. NV Energy is planning on spacing the wire posts 100 m apart. They need an estimate to wires will sag.

Relevant Differential Equation and Information:

The shapes of the lines from post to post are well described by the following second order non-linear equation. The posts will all be 25 m high. The 25 m describes the boundary value problem described by the following equation.

$$\frac{d^2y}{dx^2} = \frac{w}{T}\sqrt{1+\left(\frac{dy}{dx}\right)^2}$$

$y \equiv$ The vertical height of the line in meters. [m]

x ≡ The horizontal position of the line in meters [m]

w ≡ The linear weight density of the line in $\left[\frac{\mathrm{N}}{\mathrm{m}}\right]$

T ≡ The horizontal tension in terms of [N]

Material Data:

- NV Energy Selected Single Core Wire
  - Max Safe Tension Force: 10,000 N
  - Linear Weight: 4 N/m

Category 1: Submitted as a PDF

NV Energy wants the following Questions Answered. The review will be scored based on the number of requests effectively answered.

1. Demonstrate how the 2nd Order ODE is converted to a system of 1st Order ODEs.
2. NV Energy desires the problem to be solved utilizing Shooting Method for BVPs. Describe the process of shooting method as well as how new guesses will be generated, see the Shooting Method Implementation Section for methods.
3. A ODE approximation method must be selected from one of the following for second order ODEs: Euler's Explicit Method, Euler's Modified Method, scipy.solve_ivp, RK4. For options 1,2,4, demonstrate one full step. For option 3, discuss how scipy.solve_ivp solves the problem compared to the others.
4. Shooting Method Requires 1 to 2 initial value guesses. Use your intuition related to hanging wires to determine to reasonable initial guesses.

Category 1	Programming Preparation Scoring
1	Two of Four Questions Effectively Answered
2	Two of Four Questions Effectively Answered
3	Three of Four Questions Effectively Answered
4	All Four Questions Effectively Answered

Category 2: Submitted as a Python File

Category 2 will be scored based on the ODE Solver Implementation

Category 2	Programming Preparation Scoring
1	Euler's Explicit Method Implemented
2	Euler's Explicit Modified Method Implemented
3	scipy.solve_ivp Implemented
4	RK4 Implemented

Category 3: Submitted as same Python File

Category 3 will be scored based on the Shooting Method Implementation

Category 3	Programming Preparation Scoring
1	-Not Available-
2	Shooting Method performed by USER Guess and Check
3	Shooting Method Performed Automatically Via Bisection Method
4	Shooting Method Protected Against Non Convergence

Category 4: Submitted as same Python File and printing out the answers to these questions to the user.

Category 4 will be scored based on answering the following questions

Category 4	Programming Preparation Scoring
1	How much will the wire drop when the posts are 100 m apart?
2	What is the maximum distances post can be such that the wire wont drop more than 3 m.
3	How much more wire is needed to hang the wire between the maximum distance and the 100 m.
4	Will the maximum distance change based on changed in the heights of one post to the next. So will the posts need to be closer or further apart if the posts are on a hill.

Reminders:

- A minimum score of 1 is required for every category. Be sure to do what you must to complete each category.
- Achieving Higher Scores are results of either completing more work, implementing more difficult methods, or answering more challenging questions.