Exercise 11

Exercise 11 details

- PINN/Digital Twin assignment without PID control – the **Falling Body with Air Resistance (Terminal Velocity)** model.

- This system models an object (like a skydiver or a dropped sphere) accelerating due to gravity while being opposed by a non-linear drag force.

- **Physics and Governing Equation -** The system's dynamics are governed by Newton's Second Law applied to the vertical axis, where the drag force is proportional to the **square of the velocity** (v2). This square term makes the system non-linear.

- **Governing Equation (First-Order ODE):**

- $m\frac{dv}{dt} = mg \; - \gamma v^2$(Where m is mass, g is gravitational acceleration, and γ is the drag coefficient).

Key Features

- Non-Linearity: The v2 term makes the equation non-linear, which is more challenging than a simple linear drop but easily handled by a PINN.

- Terminal Velocity: The solution naturally approaches a constant terminal velocity ($v_t = \left(\frac{mg}{\gamma}\right)^{0.5}$) when acceleration (dv/dt) becomes zero.

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Assignment Focus (DT Goal)

- DT Goal: The PINN acts as the digital twin, predicting the velocity $v(t)$ and position $y(t)$ over time.
- PINN Inputs/Outputs: Input is only time (t); Outputs are Velocity (v) and Position (y).
- Initial Conditions ($v(0)=0$, $y(0)=0$) and a few sparse data points near the start.
- The Physics Loss forces the PINN to predict the correct long-term behavior (reaching terminal velocity) even if the training data doesn't fully cover the entire terminal velocity phase.
- Simple State: The system's state is fully defined by velocity (v), and position (y) can be found by integrating velocity ($dy/dt=v$).
- Mass (m) 80 kg (Represents a typical object/person)
- Gravitational Accel. (g) 9.81 m/s2 (Standard)
- Drag Coefficient (γ) 0.31 kg/m (Yields a terminal velocity of ≈50.3 m/s)