Neuroprothetik Exercise 3
Mathematical Basics 2

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1 Implementations in Matlab or Python

Implement the following methods as functions in Python or Matlab:

- Forward (Explicit) Euler
- Heun Method
- Exponential Euler

2 Solve Functions

Solve the differential equation $\frac{dV}{dt} = 1 - V - t$ where $V(t = -4.5) = V_0 = -4$ with the solvers implemented above. Vary the stepsize (1s, 0.5s, 0.1s, 0.012) and plot the results and answer the following questions.

- Interpret the impact of changing the stepsize.
- Why not just use a very small stepsize.

3 The Leaky Integrate and Fire Neuron

Implement a model of the leaky integrate and fire neuron with the following parameters

$$V_{n+1} = \begin{cases} V_n + \frac{\Delta t}{C_m}(-g_{leak}(V_n - V_{rest}) + I_{input}(t_n)) & V_n < V_{thr} \\ V_{spike} & V_n = V_{thr} \\ V_{rest} & V_n = V_{spike} \end{cases}$$

- $C_m = 1\,\mu\text{F}$
- $g_{leak} = 100\,\mu\text{S}$

- $V_{rest} = -60\,\mathrm{mV}$
- $V_{thr} = -20\,\mathrm{mV}$
- $V_{spike} = 20\,\mathrm{mV}$

And simulate the cell for 50 ms ($\Delta t = 25\,\mu$s should be sufficient) with the following current inputs:

- constant $10\,\mu A$
- constant $20\,\mu A$
- rectified 50Hz sinus with $10\,\mu A$ amplitude
- rectified 50Hz sinus with $30\,\mu A$ amplitude

Plot the results and interpret what you see.