Neuroprothetik Exercise 2
Mathematical Basics 1

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1. Plot slope fields and isocline

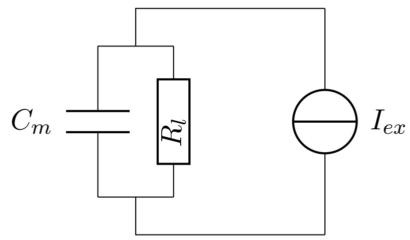
Plot the slope fields for $t \in [-5, 5]s$ and $V \in [-5, 5]V$ as well as the isocline for (-2, -1, 0, 1, 2) V/s for the following differential equations.

$$\frac{dV}{dt} = 1 - V - t \tag{1}$$

$$\frac{dV}{dt} = sin(t) - \frac{1}{1.5}V \tag{2}$$

2. Differential equations of a simple cell model

Derive the differential equation for the following equivalent circuit of a leaky integrate and fire neuron.



$$I_{ex} = I_{max} sin(t)$$

2.1. Plot the slope field

Plot the slope field for:

- $R_l = 1\,\Omega$; C=1 F; I_{max}=0 A

- $R_l = 1\,\Omega$; C=1 F; I_{max}=1 A

Add another constant term D=2 A to the differential equation and plot:

- $R_l = 1\,\Omega$; C=1 F; I_{max}=0 A
- $R_l = 1\,\Omega$; C=1 F; I_{max}=1 A

A. Coding Recipes

A.1. Matlab

Function handles:

```
ode_rhs = @(V, t) sin(t) - V / 1.50; % Define the DGL right hand side
```

Plot a slopefields:

```
v = linspace(-5, 5, 30) %voltage Interval
t = linspace(-5, 5, 30) %time Interval
[t_grid, v_grid] = meshgrid (t, v) % create a mesh

lng = sqrt(ode_rhs(v_grid, t_grid).^2 + 1); %Length of the vector
dt = 1 ./ lng; %Get the horizontal component
dv = ode_rhs(v_grid, t_grid) ./ lng; %Get the vertical component

quiver(t, v, dt, dv); % Plot the vectors
```

A.2. Python

Lambda functions:

```
ode_rhs = lambda V, t: np.sin(t) - V / 1.50 # Define the DGL right hand side
```

Plot a slopefields:

```
import numpy as np
import matplotlib.pyplot as plt

v = np.linspace(-5, 5, 30) #voltage Interval
t = np.linspace(-5, 5, 30) #time Interval
t_grid, v_grid = np.meshgrid (t, v) # create a mesh

lng = np.sqrt(ode_rhs(v_grid, t_grid)**2 + 1) #Length of the vector
dt = 1 / lng; #Get the horizontal component
dv = ode_rhs(v_grid, t_grid) / lng; #Get the vertical component

plt.quiver(t, v, dt, dv); #Plot the vectors
plt.show()
```