

# Organisation of exercises

NX 465

Computational Neuroscience:  
Neuronal Dynamics



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## ■ Exercises

- Pen and paper exercises
- Python exercises

## ■ Mini-project

- In groups of 2
- Handed out around week 7
- 2 topics to choose from
- Coding + written report (30% of final grade)
- Mandatory!

# Pen and paper exercises

- On the content of the lecture
- Partly covered together during class
- Released weekly
- Answers released later in the week
- Exam material!

## Exercise 1: Inhibitory rebound

Consider the following two-dimensional Fitzhugh-Nagumo model:

$$\begin{cases} \frac{du}{dt} = u(1-u^2) - w + I \equiv F(u, w) \\ \frac{dw}{dt} = \epsilon(u - 0.5w + 1) \equiv \epsilon G(u, w), \end{cases} \quad (1)$$

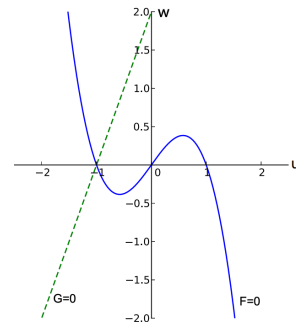
where  $\epsilon \ll 1$ .

1.1 Suppose that an inhibitory current step is applied,

$$I(t) = \begin{cases} -I_0 & t \leq 0 \\ 0 & t > 0 \end{cases}$$

How does the fixed point move?

1.2 What happens after the driving current is removed? Sketch the form of the trajectories for increasing values of  $I_0$ . What happens for large  $I_0$ ?



## Exercise 2: Phase Plane Analysis

In this exercise, we use the phase plane to study the dynamics of a two dimensional, nonlinear neuron model. The system is described by:

$$\begin{cases} \frac{du}{dt} = F(u, w) \\ \frac{dw}{dt} = G(u, w) \end{cases} \quad (2)$$

where  $F(u, w) = f(u) - w + I(t)$  and  $G(u, w) = \epsilon(g(u) - w)$  with  $\epsilon = 0.1$ .  $I(t)$  is an external current.

- Complementary to the written exercises
- Using pre-implemented functions
- Easy network simulations with Brian2
- We can help with the installation of the neuronal dynamics package

## Neuronal Dynamics: Python Exercises

This documentation is automatically generated documentation from the corresponding code repository hosted at [Github](#). The repository contains python exercises accompanying the book [Neuronal Dynamics](#) by Wulfram Gerstner, Werner M. Kistler, Richard Naud and Liam Paninski.

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- Course overview
- Course material:
  - Video lectures
  - Slides
  - Exercises
  - Solutions
  - Announcements

### ▼ Week 1

**LECTURE 1.** Introduction: brain vs. computer and a first simple neuron model

- First introduction and overview of the course
- Coding by spikes (action potentials)
- Model of a passive membrane
- Leaky integrate-and-fire model
- Nonlinear integrate-and-fire model
- Quality of integrate-and-fire models: comparison with experiments



Slides Lecture 1 - Integrate-and-Fire neurons



Question Set 1



Python Exercise: LIF



Suggested Reading

- Q&A and discussion forum
- Ask questions and answer other students
- Moderated by TAs



Ed Discussion NX-465

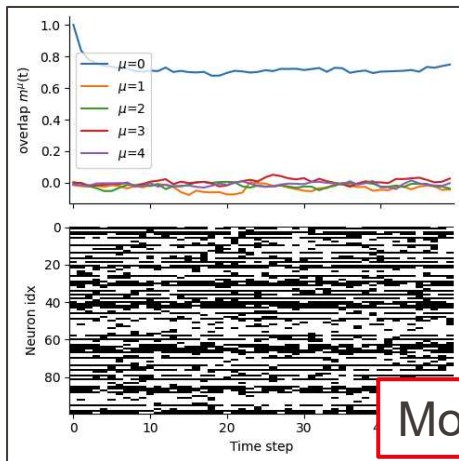
Link on Moodle!

Use the Ed forum for questions and discussions. Updates will be posted here

- In pairs!
- Choose from two projects:

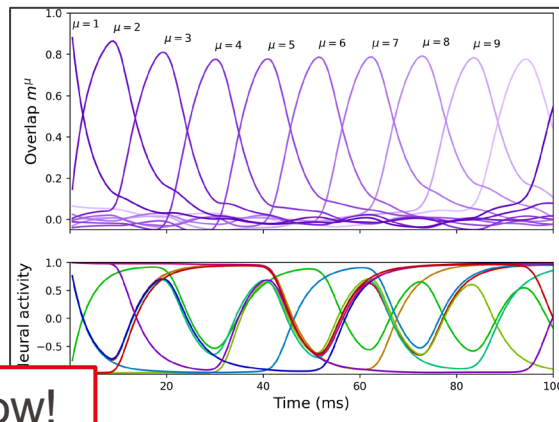
## Bioplausible Hopfield model

Model of memory storage and recall with biological constraints



## Dynamic Hopfield model

Model of information propagation through cyclical dynamics



More details will follow!