International Master Program
Computational Neuroscience

Course Catalogue
Module Description

1. Qualification Aims
Participants should learn basic concepts, their theoretical foundation, and the most common models used in computational neuroscience. The module also provides the relevant basic neurobiological knowledge and the relevant theoretical approaches as well as the findings resulting from these approaches so far. After completing the module, participants should understand strengths and limitations of the different models. Participating students will learn to appropriately choose the theoretical methods for modeling neural systems. They will learn how to apply these methods while taking into account the neurobiological findings, and they should be able to critically evaluate results obtained. Participants should also be able to adapt models to new problems as well as to develop new models of neural systems.

The course is principally designed to impart

technical knowledge 40%, methodological competence 40%, system design 10%, soft skills and social competence 10%

2. Content
This module provides basic knowledge about the constituents of neural systems and their modeling, which includes basic neurobiological concepts and models concerning information processing within neurons and neural circuitry. Specific topics addressed are:
- Electrical properties of neurons (Nernst equation, Goldman equation, Goldman-Hodgkin-Katz current equation, membrane equation)
- Hodgkin-Huxley model (voltage-dependent conductances, gating variables, transient and persistent conductances, action-potential generation)
- Channel models (state diagram, stochastic dynamics)
- Synapse models (chemical and electrical synapses)
- Single-compartment neuron models (integrate-and-fire, conductance-based)
- Models of dendrites and axons (cable theory, Rall model, multi-compartment models, action-potential propagation)
- Models of synaptic plasticity and learning (release probability, short-term depression and facilitation, long-term plasticity, Hebbian rule, timing-based plasticity rules, supervised/unsupervised and reinforcement learning)
- Network models (feedforward and recurrent, excitatory-inhibitory, firing-rate and stochastic, associative memory)
- Phase-space analysis of neuron and network models (linear stability analysis, phase portraits, bifurcation theory)
### 3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory (C) / Elective (E) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models of Neural Systems – Theoretical Lecture</td>
<td>lecture</td>
<td>Kempter / Lindner</td>
<td>2</td>
<td>2</td>
<td>C</td>
<td>WS</td>
</tr>
<tr>
<td>Models of Neural Systems – Tutorial</td>
<td>tutorial</td>
<td>Kempter / Lindner</td>
<td>2</td>
<td>4</td>
<td>C</td>
<td>WS</td>
</tr>
<tr>
<td>Models of Neural Systems – Computer Lab</td>
<td>tutorial</td>
<td>Kempter</td>
<td>2</td>
<td>4</td>
<td>C</td>
<td>WS</td>
</tr>
<tr>
<td>Models of Neural Systems – Experimental Lecture</td>
<td>lecture</td>
<td>Kempter</td>
<td>2</td>
<td>2</td>
<td>C</td>
<td>WS</td>
</tr>
</tbody>
</table>

### 4. Description of Teaching and Learning Methods

The lecture part consists of teaching in front of the class. Participants are expected to rehearse topics after class, using their class notes as well as recommended book chapters, in preparation for the exercises and tutorials. Homework assignments are given on a regular basis, and must be usually solved within one or two weeks. These assignments cover analytical & mathematical exercises as well as numerical simulations & programming exercises. Working in small groups of two to three students is encouraged. Homework assignments and their solutions are discussed during the tutorial. In addition, selected topics presented during the lecture are rehearsed by the tutor as needed. Tutorials also cover brief mathematics primer, and recommendations are provided for students for the module “individual studies”, if deficits in their mathematical knowledge become obvious.

### 5. Prerequisites

Mathematical knowledge: Analysis, linear algebra, probability calculus and statistics, on a level comparable to mathematics courses for engineers (worth 24 credit points).

Basic programming skills.

Good command of the English language.

### 6. Target Groups / Course Levels

This module is compulsory for students of the Master program Computational Neuroscience, compulsory elective or elective for the specialization Computational Neuroscience and Artificial Intelligence (generally for advanced Diploma students or master students).

### 7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical lecture</td>
<td>30</td>
</tr>
<tr>
<td>Tutorial</td>
<td>30</td>
</tr>
<tr>
<td>Programming Lab</td>
<td>30</td>
</tr>
<tr>
<td>Experimental Lecture</td>
<td>30</td>
</tr>
<tr>
<td>Lecture rehearsals / individual studies</td>
<td>60</td>
</tr>
<tr>
<td>Homework assignments</td>
<td>180</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
</tr>
</tbody>
</table>
8. Module Examination and Grading Procedures

Oral exam; certificates of successful participation in the tutorial and the programming lab is a prerequisite for the oral exam.
The oral exam has to be taken latest by the end of the semester following the one of obtaining the tutorial certificates.

The examination procedure is regulated by the General Examination Regulation of the Technical University (Ordnung zur Regelung des allgemeinen Prüfungsverfahrens in Bachelor- und Masterstudiengängen) and by the Examination Regulation of the Master Program Computational Neuroscience.

9. Duration of Module
The module can be completed within one semester.

10. Number of Participants
Lecture: no limitation
Tutorial: in case of shortage in human resources there can be a limitation.

11. Enrollment Procedures
Enrollment to the module is handled in the first class of each module component (cf. 3). Students must be present in person.

Students of the Master program in Computational Neuroscience have to register for the final oral exam at least three working days prior to the examination date. Registration has to be done with the examination office (Prüfungsamt) of TU Berlin.

12. Recommended Reading, Lecture Notes
Lecture notes available in paper form? yes X no
If yes, where can they be purchased?
Lecture notes in paper form are sometimes made available during class.
Lecture notes available in electronic form? yes no X
Solutions of the assignments are provided to the students in electronic form

Recommended Reading:


Advanced / additional readings:


One or two specific book chapters are assigned / recommended to every topic of the lecture. This list of recommendations is explained during the first class of every module component.

13. Language of Instruction
The language of instruction is English. Oral examinations can be taken either in English or in German.

14. Other Information
<table>
<thead>
<tr>
<th>Title of Module: Acquisition and Analysis of Neural Data</th>
<th>Credit Points: 12 ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person responsible for the module: Prof. Dr. Michael Brecht</td>
<td>Contact: Bernstein Center for Computational Neuroscience, HU Berlin phone: (030) 2093 6770 email: <a href="mailto:michael.brecht@bccn-berlin.de">michael.brecht@bccn-berlin.de</a></td>
</tr>
</tbody>
</table>

## Module Description

### 1. Qualification Aims
Students will gain knowledge about the most important methods for experimental acquisition of neural data and the respective analytical methods. Students will learn about the different fields of application, the advantages and disadvantages of the different methods and will become familiar with the respective raw data. They will be enabled to choose the most appropriate analysis method and apply them to experimental data.

The course is **principally** designed to impart technical knowledge 40%, methodological competence 40%, system design 10%, soft skills and social competence 10%

### 2. Content
The module intends to provide knowledge about experimental acquisition of neural data and their analysis. This comprises two major parts:

1) Acquisition of neural data
   The lecture and tutorial aim at providing a broad overview of the most common techniques for acquiring neural data and the theoretical underpinnings of these techniques.
   Both lecture and tutorial will be divided in a first part dealing with large scale signals (fMRI, EEG, MEG etc) and a second part concerned with cellular signals. In the tutorial emphasis is placed on hands on experience with neural data acquisition techniques.

2) Analysis of neural data
   This lecture gives an broad overview over analysis techniques for neural data. Specifically it will deal with: firing rates, spike statistics, spike statistics and the neural code, neural encoding, neural decoding, discrimination and population decoding, information theory, statistical analysis of electroencephalogram (EEG) data, e.g., investigation of event-related potentials (ERPs) and event-related desynchronization (ERD), spatial filters, classification, adaptive classifiers.
   In the tutorial emphasis is placed on hands on experience with neural data analysis.
3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory(C) / Elective (E) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition and Analysis of Neural Data –Lecture</td>
<td>lecture</td>
<td>Haynes</td>
<td>2 (WS) + 2 (SS)</td>
<td>4</td>
<td>C</td>
<td>WS and SS</td>
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<td></td>
<td></td>
<td>Brecht</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kempter Blankertz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acquisition and Analysis of Neural Data - Laboratory</td>
<td>practical</td>
<td>Haynes</td>
<td>3</td>
<td>3</td>
<td>C</td>
<td>WS</td>
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<td></td>
<td>Brecht</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acquisition and Analysis of Neural Data - Tutorial</td>
<td>tutorial</td>
<td>Kempter Blankertz</td>
<td>2</td>
<td>5</td>
<td>C</td>
<td>SS</td>
</tr>
</tbody>
</table>

4. Description of Teaching and Learning Methods

Lecture: Theoretical and experimental basic knowledge is presented to the class by a lecturer.

Tutorial: self-contained solving of programming exercises regarding problems of data analysis.

Practical: lab work, supervised conduction of an experiment and analysis of data

5. Prerequisites

Obligatory: sound knowledge in mathematics (Analysis, Linear Algebra, and Probability Theory / Statistics) and basic programming knowledge.

6. Target Groups / Course Levels

This module is compulsory for students of the Master program Computational Neuroscience, compulsory elective or elective for the specialization Computational Neuroscience, Artificial Intelligence, and Signal Processing (generally for advanced Diploma students or master students).

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition and Analysis of Neural Data – Lecture</td>
<td>60</td>
</tr>
<tr>
<td>Acquisition and Analysis of Neural Data - Laboratory</td>
<td>45</td>
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<tr>
<td>Acquisition and Analysis of Neural Data - Tutorial</td>
<td>30</td>
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<tr>
<td>Lecture rehearsals / individual studies</td>
<td>60</td>
</tr>
<tr>
<td>Homework assignments</td>
<td>165</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
</tr>
</tbody>
</table>

8. Module Examination and Grading Procedures

Oral exam; certificates of successful participation in the practical and in the tutorial are a prerequisite for the oral exam. The oral exam has to be taken latest by the end of the semester following the one of obtaining the tutorial certificates. The examination procedure is regulated by the General Examination Regulation of the Technical University (Ordnung zur Regelung des allgemeinen Prüfungsverfahrens in Bachelor- und Masterstudiengängen) and by the Examination Regulation of the Master Program Computational Neuroscience.

9. Duration of Module

The module can be completed within two semesters.
10. Number of Participants
Lecture: no limitation
Tutorial: in case of shortage in human resources there can be a limitation.

11. Enrollment Procedures
Enrollment to the module is handled in the first class of each module component (cf. 3). Students must be present in person.
Students of the Master program in Computational Neuroscience have to register for the final oral exam at least three working days prior to the examination date. Registration has to be done with the examination office (Prüfungsamt) of TU Berlin.

12. Recommended Reading, Lecture Notes
Lecture notes available in paper form? yes ☑ no ☒
Lecture notes in paper form are sometimes made available during class.
Lecture notes available in electronic form? yes ☑ no ☒
Lecture notes are provided to the students through the teaching coordinator

Recommended Reading:
M.F. Bear, Neuroscience: Exploring the Brain, Williams & Wilkins, 1996

Advanced / additional reading:

13. Language of Instruction
The language of instruction is English. Oral examinations can be taken either in English or in German

14. Other Information
Title of Module: Machine Intelligence
Credit Points: 12 ECTS

Person responsible for the module: Prof. Dr. Klaus Obermayer
Contact: MAR 5-6, room MAR 5042, TU Berlin, phone: (030) 314-73442, email: sekr@cs.tu-berlin.de

Module Description

1. Qualification Aims
Participants should learn basic concepts, their theoretical foundation, and the most common algorithms used in machine learning and artificial intelligence. After completing the module, participants should understand strengths and limitations of the different paradigms, should be able to correctly and successfully apply methods and algorithms to real world problems, should be aware of performance criteria, and should be able to critically evaluate results obtained with those methods. Participants should also be able to modify algorithms to new tasks at hand as well as to develop new algorithms according to the paradigms presented in this course.

The course is principally designed to convey: technical knowledge 40%, methodological competence 40%, system design 10%, soft skills and social competence 10%

2. Content
Part 2: Learning theory and support vector machines. Elements of statistical learning theory, learning by structural risk minimization, the C Support Vector Machine, kernels and non-linear decision boundaries, SMO optimization, the P-SVM.
Part 3: Probabilistic methods. Reasoning under uncertainty and Bayesian inference; graphical models, graphs vs. distributions, and belief propagation; generative models; Bayesian inference and neural networks; non-parametric density estimation; parametric density estimation and maximum likelihood methods.
Part 5: Stochastic optimization. Simulated annealing, mean-field techniques.

3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory(C) / Elective (E) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Intelligence I</td>
<td>lecture</td>
<td>Obermayer / Lochmann</td>
<td>2</td>
<td>2 ECTS</td>
<td>C</td>
<td>WS</td>
</tr>
<tr>
<td>Machine Intelligence I</td>
<td>tutorial</td>
<td>Obermayer / Lochmann</td>
<td>2</td>
<td>4 ECTS</td>
<td>C</td>
<td>WS</td>
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<tr>
<td>Machine Intelligence II</td>
<td>lecture</td>
<td>Obermayer</td>
<td>2</td>
<td>2 ECTS</td>
<td>C</td>
<td>SS</td>
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<tr>
<td>Machine Intelligence II</td>
<td>tutorial</td>
<td>Obermayer</td>
<td>2</td>
<td>4 ECTS</td>
<td>C</td>
<td>SS</td>
</tr>
</tbody>
</table>
4. Description of Teaching and Learning Methods
The lecture part consists of teaching in front of the class. Participants are expected to rehearse topics after class, using their class notes as well as recommended book chapters, in preparation for the exercises and tutorials. Homework assignments are given on a regular basis, and must be usually solved within one or two weeks. These assignments cover analytical & mathematical exercises as well as numerical simulations & programming exercises. Working in small groups of two to three students is encouraged. Homework assignments and their solutions are discussed during the tutorial. In addition, selected topics presented during the lecture are rehearsed by the tutor as needed. The first tutorials cover a brief mathematics primer, and recommendations are provided for students for the module “individual studies”, if deficits in their mathematical knowledge become obvious.

5. Prerequisites
Mathematical knowledge: Analysis, linear algebra, probability calculus and statistics, on a level comparable to mathematics courses for engineers (worth 24 credit points).
Basic programming skills.
Good command of the English language.

6. Target Groups / Course Levels
This module is compulsory for students enrolled in the Master program Computational Neuroscience. Module components are compulsory elective or elective for students of other Master and Diploma programs of Berlin's universities, who wish to specialize in Machine Learning and Artificial Intelligence, and who fulfill the above mentioned prerequisites.

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture (WS &amp; SS)</td>
<td>60</td>
</tr>
<tr>
<td>Tutorial (WS &amp; SS)</td>
<td>60</td>
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<tr>
<td>Lecture rehearsals / individual studies</td>
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</tr>
<tr>
<td>Homework assignments</td>
<td>180</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
</tr>
</tbody>
</table>

8. Module Examination and Grading Procedures
At least 60% of all homework assignments have to be completed and an oral examination of up to one hour length has to be taken. The final grade is determined by the grade obtained in the oral examination.

The oral exam has to be taken latest by the end of the semester which follows the semester in which the tutorial certificates were obtained. The examination procedure is regulated by the General Examination Regulation of the Technical University (Ordnung zur Regelung des allgemeinen Prüfungsverfahrens in Bachelor- und Masterstudiengängen) and by the Examination Regulation of the Master Program Computational Neuroscience.

9. Duration of Module
This module can be completed within two semesters.

10. Number of Participants
No limitation.
11. Enrollment Procedures
Enrollment to the module is handled in the first class of each module component (cf. 3). Students must be present in person. The module components Machine Intelligence I (lecture with exercises) and Machine Intelligence II (lecture with exercises) can be taken in any order, i.e. students may also start the module in the summer term.

Students of the Master program in Computational Neuroscience have to register for the final oral exam at least three working days prior to the examination date. Registration has to be done with the examination office (Prüfungsamt) of TU Berlin. For students from other programs, other regulations may apply. Please consult the examination regulations (Prüfungsordnung) of your program.

12. Recommended Reading, Lecture Notes
Lecture notes available in paper form? yes no x
Lecture notes available in electronic form? yes x no

Lecture notes are available via the ISIS teaching platform of TU Berlin. Notes are password protected. Access procedures are explained to the students during the first class of each module component.

Supplementary material (copies of slides, proofs, background information) is also available via ISIS, but can also be downloaded at the course web-page http://www.ni.cs.tu-berlin.de/lehre/mi.html.

Recommended Readings:

Advanced / additional readings:
Jordan (Editor), Learning in Graphical Models, MIT Press, 1999.

One or two specific book chapters are assigned / recommended to every topic of the lecture. This list of recommendations is explained during the first class of every module component and is available via TU Berlin's ISIS platform.

13. Language of Instruction
The language of instruction is English. Oral examinations can be taken either in English or in German.

14. Other Information
Title of Module: Programming Course and Project

Credit Points: 6 ECTS

Person responsible for the module: Dr. Tiziano Zito

Contact: Bernstein Center for Computational Neuroscience, HU Berlin
e-mail: graduateprograms@bccn-berlin.de

Module Description

1. Qualification Aims
After completion of this course, students are able to:
- write complex computer programs, and to apply basic as well as advanced concepts of a modern programming language, such as imperative and object oriented programming, and the basics of using design patterns
- use tools for successful project management, such as version control tools, bug tracking, etc
- develop a larger program in collaboration with other students – including the necessary specifications, documentation and test

The course is principally designed to impart technical knowledge 20%, methodological competence 30%, system design 25%, soft skills and social competence 25%

2. Content
- using the UNIX operating system: basic commands, editor, navigation
- using a repository (subversion) for version control during code development
- introduction to the programming language python
- objects and object attributes in python
- object oriented programming in python
- integrated development environments
- test driven code development
- extreme programming
- refactoring
- project management
- design patterns

3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecture / Tutorial</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory(C) / Elective (E) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
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<tbody>
<tr>
<td>Programming Course and Project – Lecture</td>
<td>lecture</td>
<td>Zito</td>
<td>2</td>
<td>2</td>
<td>C</td>
<td>WS</td>
</tr>
<tr>
<td>Programming Course and Project – Tutorial</td>
<td>tutorial</td>
<td>Zito</td>
<td>2</td>
<td>2</td>
<td>C</td>
<td>SS</td>
</tr>
<tr>
<td>Programming Course and Project – Project</td>
<td>project</td>
<td>Zito</td>
<td>-</td>
<td>2</td>
<td>C</td>
<td>SS</td>
</tr>
</tbody>
</table>
4. Description of Teaching and Learning Methods

**Lecture:** background knowledge and the principal concepts of the employed programming language are presented to the class by a lecturer. In order to integrate any specialist knowledge that some of the students in the interdisciplinary Computational Neuroscience Program may have, some topics may also introduced by individual students in seminar-style talks.

**Tutorial:** groups of up to 20 participants are taught the relevant practical details to complete programming exercises on the computer. They solve small programming tasks, partially in class, partially as homework.

**Project:** Large programming projects are solved in collaboration with other students (in groups of ca. 4-6), including students taking different roles within those projects, using project management tools and learning to effectively lead such projects. The different projects are individually supervised by the tutor.

5. Prerequisites

None

6. Target Groups / Course Levels

This module is compulsory for students enrolled in the Master program Computational Neuroscience.

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture (WS)</td>
<td>20</td>
</tr>
<tr>
<td>Tutorial (WS)</td>
<td>20</td>
</tr>
<tr>
<td>Lecture rehearsals / individual studies</td>
<td>20</td>
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<tr>
<td>Homework assignments</td>
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<tr>
<td>Project (SS)</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
</tr>
</tbody>
</table>

8. Module Examination and Grading Procedures

To pass the module, both of the following requirements (Prüfungsäquivalente Studienleistung) have to be fulfilled:
- at least 50% of all assignments have to be completed satisfactorily (passed)
- the project has to be completed and presented satisfactorily (passed)

The module is ungraded. If both components are passed, the module is passed.

The examination procedure is regulated by the General Examination Regulation of the Technical University (Ordnung zur Regelung des allgemeinen Prüfungsverfahrens in Bachelor- und Masterstudiengängen) and by the Examination Regulation of the Master Program Computational Neuroscience.

9. Duration of Module

This module can be completed within two semesters.

10. Number of Participants

Lecture: no limitation

Tutorial and project: in case of shortage in human resources there can be a limitation.

11. Enrollment Procedures

Enrollment to the module is handled in the first class of each module component (cf. 3). Students must be present in person. The module components Programming Course (lecture with exercises) and Project (lecture with exercises) have to be taken successively. Students of the Master program in Computational Neuroscience have to register with the examination office (Prüfungsamt) of TU Berlin before the first study achievement (homework assignment). For students from other programs, other regulations may apply. Please consult the examination regulations (Prüfungsordnung) of your program.
12. Recommended Reading, Lecture Notes

| Lecture notes available in paper form? | yes | no | x |
| Lecture notes available in electronic form? | yes | x | no |

Lecture notes (copies of slides) and supplementary materials (background information, example programs) are available via the course web-page.

**Recommended Readings:**

Lutz, Programming Python, O'Reilly, 2006.
Lutz and Ascher, Learning Python (Help for Programmers), O'Reilly, 2008.
Martelli, Ravenscroft and Ascher, Python Cookbook, O'Reilly, 2005.

and multiple online resources found on the courses web-page

http://www.bccn-berlin.de/Graduate+Programs/Courses+and+Modules/Programming_Course_and_Project

One or two specific book chapters are assigned / recommended to every topic of the lecture. This list of recommendations is explained during the first class of every module component and is available via the web page.

13. Language of Instruction

The language of instruction is English

14. Other Information
Title of Module: Individual Studies
Credit Points: 6 ECTS

Person responsible for the module: Prof. Dr. Klaus Obermayer
Contact: MAR 5-6, room MAR 5042, TU Berlin,
phone: (030) 314-73442, email: sekr@cs.tu-berlin.de

Module Description

1. Qualification Aims
Students shall acquire essential knowledge and skills, which are necessary to successfully attend the courses of the first year of study but which have not been covered during the studies leading to their first university degree.

The module is principally designed to impart:
technical knowledge 30%, methodological competence 30%, system design 20%, soft skills and social competence 20%

2. Content
Students choose the topics in consultation with their mentor. Depending on the subject of their first degree as well as on their individual background, students may for example choose to consolidate their mathematical knowledge in a specific area, acquire elementary computer skills, or study specific subjects in neurobiology. A two-week preparatory course in mathematics and/or a one-week preparatory course in neurobiology offered at the Bernstein Center can be recognized for this module.

3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory(C) / Elective (E) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Studies</td>
<td></td>
<td></td>
<td>6</td>
<td>CE</td>
<td>WS or SS</td>
<td></td>
</tr>
</tbody>
</table>

4. Description of Teaching and Learning Methods
Students can attend courses, but - alternatively - they may also receive a specific assignment by their mentor, e.g. reading recommended book chapters or solving specific homework assignments.

5. Prerequisites
The subject(s) of the individual studies must be approved by the mentor.

6. Target Groups / Course Levels
This module is compulsory for students enrolled in the Master program Computational Neuroscience.

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Studies</td>
<td>180</td>
</tr>
</tbody>
</table>
### 8. Module Examination and Grading Procedures

Examination type and grading procedures are determined by the mentor of the student, depending on the chosen teaching and learning methods. The module is evaluated as “passed” or “not passed”. The grade “not passed” is assigned in case of an inadequate achievement which does not fulfill the standards for approval. Students will obtain a course certificate from the mentor which contains the number of ECTS credit points and the grade “passed” or “not passed”.

### 9. Duration of Module

The module can be completed within one semester.

### 10. Number of Participants

Participation is restricted to students of the Master Program in Computational Neuroscience.

### 11. Enrollment Procedures

Students must register for this Module at the Examination Office (Prüfungsamt) of the TU Berlin. After having achieved the courses, they must exhibit the respective Course Certificates to the Examination Office.

### 12. Recommended Reading, Lecture Notes

| Lecture notes available in paper form? | yes ☑️ | no X |
| Lecture notes available in electronic form? | yes ☑️ | no X |

**Recommended Reading**: readings will be provided by the mentor of the lecturer responsible for the courses taken.

### 13. Language of Instruction

As a general rule, the language of instruction is English, however, students can also take courses in German.

### 14. Other Information
### Module Description

#### 1. Qualification Aims

Participants should learn the basic concepts and most important topics in the Cognitive Neurosciences. In addition, they should know the state-of-the-art models in these domains and their theoretical foundations. After completing the module, participants should understand strengths and limitations of the different modeling approaches (e.g. bottom-up versus top-down), should be able to understand the rationale behind models and their implementation, and should be aware of performance criteria and critical statistical tests. Participants should also be able to modify models of cognitive processes as well as to apply existing models to novel experimental paradigms, situations or data.

The course is **principally** designed to convey:

- technical knowledge 40%,
- methodological competence 40%,
- system design 10%,
- soft skills and social competence 10%.

#### 2. Content

- **Cognitive Neuroscience Lecture:**
  - Auditory and visual system,
  - natural image statistics and sensory processing,
  - motor system,
  - psychology and neuroscience of attention,
  - memory systems,
  - executive control,
  - decision making,
  - science of free will and consciousness.
- **Theoretical Lecture & Analytic Tutorial:**
  - Data modeling and essential statistics,
  - psychometric methods,
  - signal detection theory,
  - models of visual processing,
  - models of visual attention,
  - models of executive function.
- **Programming Tutorial:**
  - Signal processing,
  - sensory and cognitive modeling using Python.
## 3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory (C) / Elective (E) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Neuroscience</td>
<td>lecture</td>
<td>Haynes</td>
<td>2</td>
<td>2 ECTS</td>
<td>C</td>
<td>SS</td>
</tr>
<tr>
<td>Theoretical Lecture</td>
<td>lecture</td>
<td>Sprekeler</td>
<td>2</td>
<td>2 ECTS</td>
<td>C</td>
<td>SS</td>
</tr>
<tr>
<td>Analytical Tutorial</td>
<td>tutorial</td>
<td>Sprekeler</td>
<td>2</td>
<td>4 ECTS</td>
<td>C</td>
<td>SS</td>
</tr>
<tr>
<td>Programming Tutorial</td>
<td>tutorial</td>
<td>Sprekeler</td>
<td>2</td>
<td>4 ECTS</td>
<td>C</td>
<td>SS</td>
</tr>
</tbody>
</table>

## 4. Description of Teaching and Learning Methods

The lecture part consists of teaching in front of the class. Participants are expected to rehearse topics before class using the recommended literature. In preparation for the exercises and tutorials they use, in addition, their class notes. Homework assignments are given on a regular basis, and must be usually solved within one week. These assignments cover analytical & mathematical exercises (Analytical Tutorial) as well as numerical simulations & programming exercises (Programming Tutorial). Working in small groups of two to three students is encouraged. Homework assignments and their solutions are discussed during the tutorial. In addition, selected topics presented during the lecture are rehearsed by the tutor as needed.

## 5. Prerequisites

Mathematical knowledge: Some acquaintance with analysis, linear algebra, probability calculus and statistics is desirable; in addition, basic knowledge about neurobiology and cognitive psychology is a prerequisite. Basic programming skills, preferably some knowledge of Python. Good command of the English language.

## 6. Target Groups / Course Levels

This module is compulsory for students enrolled in the Master program Computational Neuroscience.

For students not enrolled in the Master of Computational Neuroscience following combinations of module components can be taken:

1. Cognitive Neuroscience Lecture (2 ECTS)
2. Theoretical lecture + Analytical Tutorial + Programming Tutorial (10 ECTS)
3. Theoretical lecture + Analytical Tutorial + Cognitive Neuroscience Lecture (8 ECTS)

(The combination of Theoretical lecture + Analytical Tutorial is a module of its own, called “Theoretical Cognitive Neuroscience” (6 ECTS). Students interested in this combination should consult the module description of TCN.)

Module components are compulsory elective or elective for students of other Master and Diploma programs of Berlin's universities, who wish to specialize in the Cognitive Neurosciences, and who fulfill the above mentioned prerequisites.

## 7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures (SS)</td>
<td>60</td>
</tr>
<tr>
<td>Tutorials (SS)</td>
<td>60</td>
</tr>
<tr>
<td>Lecture rehearsals / individual studies</td>
<td>60</td>
</tr>
<tr>
<td>Homework assignments</td>
<td>180</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
</tr>
<tr>
<td>8. Module Examination and Grading Procedures</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>About the contents of the Theoretical Lecture and Cognitive Neuroscience Lecture an oral examination of up to 30 minutes (total duration) has to be taken.</td>
<td></td>
</tr>
<tr>
<td>Analytical Tutorial: to obtain the course certificate (Schein) students have to hand in solved exercises, and have to gain at least 50% of the total number of points of the homework assignments.</td>
<td></td>
</tr>
<tr>
<td>Programming Tutorial: to obtain the course certificate (Schein) students have to complete a sufficient number of the programming assignments.</td>
<td></td>
</tr>
<tr>
<td>Important Note: for the complete module as well combinations involving the Analytic Tutorial and/or the Programming Tutorial the respective course certificates are a prerequisite for the admission to the oral examination. The final grade is determined by the oral examination, only, however.</td>
<td></td>
</tr>
<tr>
<td>The oral exam has to be taken at the latest by the end of the semester which follows the semester in which the tutorial certificates were obtained. The examination procedure is regulated by the General Examination Regulation of the Technical University (Ordnung zur Regelung des allgemeinen Prüfungsverfahrens in Bachelor- und Masterstudiengängen) and by the Examination Regulation of the Master Program Computational Neuroscience.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9. Duration of Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>This module can be completed in one semester.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10. Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>No limitation for the lectures and the analytical tutorial. For the programming tutorial there may be restrictions depending on the number of computers and instructors available.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11. Enrollment Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students must enroll per e-mail (to: <a href="mailto:graduateprograms@bccn-berlin.de">graduateprograms@bccn-berlin.de</a>) before the fourth (4th) lecture took place. Registration must include the following information: name, email, study program and university, matriculation number, module components to be taken.</td>
</tr>
<tr>
<td>Students of the Master program in Computational Neuroscience have to register for the final oral exam at least three working days prior to the examination date. Registration has to be done with the examination office (Prüfungsamt) of TU Berlin. For students from other programs, other regulations may apply. Please consult the examination regulations (Prüfungsordnung) of your program.</td>
</tr>
</tbody>
</table>
### 12. Recommended Reading, Lecture Notes

<table>
<thead>
<tr>
<th>Lecture notes available in paper form?</th>
<th>yes</th>
<th>no</th>
<th>x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture notes available in electronic form?</td>
<td>yes</td>
<td>x</td>
<td>no</td>
</tr>
</tbody>
</table>

Lecture notes and background information are available on the course page in Moodle [http://moodle.hu-berlin.de](http://moodle.hu-berlin.de) (search for MHBF). Notes are password protected, please ask the coordination office for the password. Access procedures are explained to the students during the first class of each module component.

#### Recommended Readings:


#### Advanced / additional readings:


### 13. Language of Instruction

The language of instruction is English. Oral examinations can be taken either in English or in German.

### 14. Other Information
### Module Description

#### 1. Qualification Aims

Students are trained in skills necessary for successfully doing independent research. Supervised by a hosting research group, students learn how to properly address a scientific problem and how to present research results in a rigorous scientific way. The abilities trained in this module include: literature survey, formulation of scientific hypotheses, project planning and design of experiments / computational studies, adequate documentation (lab book), critical evaluation and interpretation of results, report writing and oral presentation, and training of social competence in collaboration with the hosting research unit.

The course is principally designed to convey: technical knowledge 10%, methodological competence 50%, system design 15%, soft skills and social competence 15%.

#### 2. Content

The curriculum comprises three lab rotations which can consist of experimental, computational, and theoretical work. At least one project should have an experimental focus, at least one project a theoretical focus. Each project shall be completed in a different working group of the center. The research topic is usually chosen from the current research projects of the program’s teaching faculty. Topics must be in line with those covered by the Master Program in Computational Neuroscience.

#### 3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory(C) / Elective (E) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab Rotation</td>
<td>project</td>
<td>teaching faculty</td>
<td>-</td>
<td>9 ECTS</td>
<td>CE</td>
<td>WS / SS</td>
</tr>
</tbody>
</table>

#### 4. Description of Teaching and Learning Methods

Students have to conduct a (guided) literature survey within the area the research problem has been chosen from, and have to read and understand one or two selected original publications. Students have to formulate a short (max. 2 page) project proposal, which is then to be discussed with members of the supervising research group. Students will then address the research problem independently in a rigorous scientific manner. Progress is monitored through regular meetings with members of the supervising research group.

At the end of the course, students have to compile a written report in the format of a short research paper (max. 8 pages) and have to present their findings to the hosting research group either through a poster or an oral presentation. It is recommended to take the course as a block of seven consecutive weeks.

It is possible to prepare a poster instead of one of three lab rotation reports, according to the prior agreement with the lab rotation supervisor. Students are welcome to present their posters at the annual lab rotations symposium for BCCN master students.
5. Prerequisites
Project-specific knowledge covered in the modules Models of Neural Systems, Models of Higher Brain Functions, Analysis of Neural Data, or Machine Intelligence. Please consult the hosting research group for further details. Depending on the concrete research problem, mathematical knowledge in analysis, linear algebra, and/or probability calculus and statistics, on a level comparable to mathematics courses for engineers, as well as basic programming skills may be required.
Good command of the English language.

6. Target Groups / Course Levels
Compulsory-elective for Students of the Master Program in Computational Neuroscience.

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature survey and project proposal</td>
<td>60</td>
</tr>
<tr>
<td>Project work</td>
<td>150</td>
</tr>
<tr>
<td>Compilation of the written report</td>
<td>40</td>
</tr>
<tr>
<td>Presentation, including preparations</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>270</strong></td>
</tr>
</tbody>
</table>

8. Module Examination and Grading Procedures
The student's performance is assessed according to the following criteria: understanding of the topic and the research problem, quality of the project proposal, scientific rigor during project work, independence and creativity during project work, quality of the documentation, quality of the written report (or poster, see §4), and quality of the final presentation. The course is graded either "passed", if achievements were at least fair, otherwise "not passed".

9. Duration of Module
The module can be completed within one semester.

10. Number of Participants
Participation is restricted to students of the Master Program in Computational Neuroscience, who need this module as their compulsory elective. Otherwise, the number of participants is not limited.

11. Enrollment Procedures
Students first select a research group as their host for the lab rotation. If the responsible faculty member agrees, students have to register with the examination office before the project proposal is due.

12. Recommended Reading, Lecture Notes
Lecture notes available in paper form? yes no x
Lecture notes available in electronic form? yes no x

Recommended Reading: Recommended readings and study material depends on the topic of the lab rotation and will be handed out to the student at the beginning of the course.

13. Language of Instruction
The language of instruction is English.

14. Other Information
1. Qualification Aims

In this module participants should learn to reflect on the ethical and societal consequences of modern neuroscience. After completing the course the student should understand the principles of good scientific conduct and of data protection. Furthermore, the student should be able to critically discuss the ethics of animal experimentation, ethical implications and limits of clinical and biomedical research (e.g. stem cell research) and the ethics of mental privacy. Of particular importance is that the student should be able to integrate the ethical aspects into their own ongoing and future research.

The course is principally designed to impart technical knowledge 10%, methodological competence 30%, system design 30%, soft skills and social competence 30%.

2. Content

- Introduction
- Hand-out of topics for group work
- Philosophical theories of ethics
- Ethics and neuroscience
- Mental privacy
- Ethical aspects of animal experiments
- Ethical aspects of stem cell research
- Ethical aspects of clinical neuroscience and patient research
- Good scientific practice
- Data protection and computer security
- Discussion of group topics

3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory(C) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethical Issues and Implications for Society</td>
<td>integrated course</td>
<td>Haynes and invited speakers</td>
<td>Block (30 hours)</td>
<td>3</td>
<td>C</td>
<td>WS or SS</td>
</tr>
</tbody>
</table>
4. Description of Teaching and Learning Methods
Subjects are required to prepare for the course using the reading material provided. The course itself consists of a combination of lectures and group discussions. At the end of each section the lecturer will engage the students in a critical discussion of each topic. At the beginning of the course students will also be assigned to discussion groups where each group takes over one typical “ethical dilemma” faced everyday in neuroscientific research and in clinical practice. Over the week the students will learn to view their chosen topic from different angles and critically present their view on the topic in a group discussion in the last course section. The individual sections will be covered by experts in each field (stem cell research, animal experiments) and the data protection lecture will be provided by a computer security/data protection specialist.

5. Prerequisites
Basic knowledge of neuroscientific research, good command of the English language

6. Target Groups / Course Levels
Compulsory for Students of the Master Program in Computational Neuroscience.

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>30</td>
</tr>
<tr>
<td>Work on papers an their presentation</td>
<td>30</td>
</tr>
<tr>
<td>Individual study</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>90</td>
</tr>
</tbody>
</table>

8. Module Examination and Grading Procedures
Students must participate in group discussions and give a presentation before the other students and the lecturers. The student’s performance is assessed according to the following criteria: participation in the group discussion, understanding of the topics, critical thinking, quality of the final presentation. The course is graded either “passed”, if achievements were at least fair, otherwise “not passed”.

9. Duration of Module
The module can be completed within one semester.

10. Number of Participants
In case of shortage in human resources there can be a limitation.

11. Enrollment Procedures
Enrollment to the module is handled in the first class. Students must be present in person.
Students of the Master program Computational Neuroscience must register for this module at the Examination Office of the TU Berlin.
12. **Recommended Reading, Lecture Notes**

<table>
<thead>
<tr>
<th>Lecture notes available in paper form?</th>
<th>yes</th>
<th>no x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture notes available in electronic form?</td>
<td>yes</td>
<td>no x</td>
</tr>
</tbody>
</table>

Reading materials are provided before and during the lecture

**Recommended Reading:**


13. **Language of Instruction**

Language of instruction is English

14. **Other Information**
Title of Module: Courses on Advanced Topics

Credit Points: 10 ECTS

Person responsible for the module: Prof. Dr. Klaus Obermayer

Contact: MAR 5-6, room MAR 5042, TU Berlin, phone: (030) 314-73442, email: sekr@cs.tu-berlin.de

Module Description

1. Qualification Aims
These courses shall complement the expertise in the topics selected for the lab rotations and shall provide the students the background knowledge in the subject area of the Master thesis.

The course is principally designed to impart technical knowledge 30%, methodological competence 30%, system design 20%, soft skills and social competence 20%

2. Content
Students can choose from all courses offered within the "Hauptstudium"- or Master programs of all Berlin universities. Subjects will typically be chosen from the areas brain sciences, mathematics, psychology and cognitive science, computer science and engineering.

3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory(C) / Elective (E) Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Courses on Advanced Topics</td>
<td>CE</td>
<td></td>
<td>10</td>
<td>CE</td>
<td>WS or SS</td>
<td></td>
</tr>
</tbody>
</table>

4. Description of Teaching and Learning Methods
Teaching and learning methods are established by the lecturers of the respective courses.

5. Prerequisites
The selection of courses as module components must be approved by Examination Board.

6. Target Groups / Course Levels
Compulsory-elective for Students of the Master Program in Computational Neuroscience.

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Courses on Advanced Topics</td>
<td>300</td>
</tr>
</tbody>
</table>
### 8. Module Examination and Grading Procedures
- Examination type and grading procedures for each module component are determined by the lecturer who is responsible for the corresponding course.
- At least 6 ECTS must be earned through graded courses. Up to 4 ECTS can consist of ungraded achievements.
- In order to pass the module, every module component must be passed individually.
- The final grade is then given by the numerical average of the grades of the graded components, weighted by the corresponding proportion of ECTS credit points earned.

### 9. Duration of Module
The module can be completed within one semester.

### 10. Number of Participants
Participation is restricted to students of the Master Program in Computational Neuroscience.

### 11. Enrollment Procedures
After having achieved the courses (module components), students must fulfill the "Form for the registration of Courses on Advanced Topics" and exhibit it along with the respective Course Certificates to the Examination Office.

### 12. Recommended Reading, Lecture Notes
<table>
<thead>
<tr>
<th>Lecture notes available in paper form?</th>
<th>yes ☒</th>
<th>no x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture notes available in electronic form?</td>
<td>yes ☒</td>
<td>no x</td>
</tr>
</tbody>
</table>

Lecture notes (if available) and recommended readings will be provided by the lecturers responsible for the module components.

### 13. Language of Instruction
As a general rule, the language of instruction is English, however, students can also take courses in German.

### 14. Other Information
A comprehensive list of classes which are currently offered can be found at:
http://www.bccn-berlin.de/Graduate+Programs/Web_Links/
# Title of Module:
**Neural Noise and Neural Signals - Spontaneous Activity and Information Transmission in Models of Single Nerve Cells**

<table>
<thead>
<tr>
<th>Credit Points:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 ECTS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Person responsible for the module:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Dr. Benjamin Lindner</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contact:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bernstein Center for Computational Neuroscience</td>
</tr>
<tr>
<td>Philippstr. 13, House 2</td>
</tr>
<tr>
<td>10115 Berlin</td>
</tr>
<tr>
<td>phone: 0049 (0) 30 2093 6336</td>
</tr>
<tr>
<td>email: benjamin.lindner at physik.hu-berlin.de</td>
</tr>
</tbody>
</table>

## Module Description

1. **Qualification Aims**
   Aspects of randomness in neural activity and information processing can be successfully analyzed in terms by stochastic models. This course gives an introduction to the models and measures of neural noise (or 'variability' as it is more often called) and should enable the student to follow the current literature on the subject on his/her own. To this end, some key concepts from nonlinear dynamics, stochastic processes, and information theory are outlined. Then a number of basic problems (see below) is addressed; here, the main emphasis is given to analytically tractable models, but simulation techniques are explained as well. As an outlook some more involved problems (ISI statistics under correlated ('colored') noise, with subthreshold oscillations, or with adaptation, stimulus-induced correlations) are sketched at the end of the course.

2. **Content**
   This module provides basic knowledge about aspects of random neural activity. Methods from different fields are needed requiring the introduction of a few key concepts from nonlinear dynamics (bifurcations, fixed points, manifolds, limit cycle), stochastic processes (Langevin and Fokker-Planck equations, Master equation, linear response theory), information theory (mutual information and its lower and upper bounds), point processes (Poisson process; renewal vs nonrenewal point process)

   Specific problems that are then addressed include:
   - neural noise sources and how they enter different neuron models (e.g. conductance vs current noise)
   - the diffusion approximation of synaptic input or channel fluctuations by a Gaussian noise
   - measures of spike train and interval variability and their interrelation
   - Poisson spike train: entropy & information content
   - one-dimensional stochastic integrate-and-fire (IF) neurons: spontaneous activity, response to weak stimuli & information transfer
   - different forms of stochastic resonance in single neurons and neuronal populations
   - multidimensional IF models: subthreshold resonances, synaptic filtering & spike-frequency adaptation
   - effect of nonrenewal behavior of the spontaneous activity on the information transfer
   - outlook: stimulus-driven correlations; networks of stochastic neurons

27
3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory(Elective)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neural noise and neural signals</td>
<td>lecture</td>
<td>Lindner</td>
<td>2</td>
<td>2</td>
<td>E</td>
<td>SS</td>
</tr>
<tr>
<td>Neural noise and neural signals</td>
<td>tutorial</td>
<td>Schwalger</td>
<td>1</td>
<td>4</td>
<td>E</td>
<td>SS</td>
</tr>
</tbody>
</table>

4. Description of Teaching and Learning Methods

The lecture part consists of teaching in front of the class. Participants are expected to rehearse topics after class, using their class notes as well as recommended book chapters, in preparation for the exercises and tutorials. Homework assignments are given biweekly, and must be usually solved within one or two weeks. These assignments cover mainly analytical & mathematical exercises. Working in small groups of two to three students is encouraged. Homework assignments and their solutions are discussed during the tutorial.

5. Prerequisites

Mathematical knowledge: Analysis, linear algebra, probability calculus and statistics, on a level comparable to mathematics courses for engineers (worth 24 credit points). Good command of the English language.

6. Target Groups / Course Levels

This module is elective for students of the Master program Computational Neuroscience (generally for advanced Diploma students or master students) and for PhD students of the research training group “Sensory Computation in Neural Systems”.

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical lecture</td>
<td>30</td>
</tr>
<tr>
<td>Tutorial</td>
<td>15</td>
</tr>
<tr>
<td>Lecture rehearsals / individual studies</td>
<td>30</td>
</tr>
<tr>
<td>Homework assignments</td>
<td>45</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
</tr>
</tbody>
</table>
### 8. Module Examination and Grading Procedures

Oral exam; certificates of successful participation in the tutorial is a prerequisite for the oral exam. The oral exam has to be taken latest by the end of the semester following the one of obtaining the tutorial certificates.

### 9. Duration of Module

The module can be completed within one semester.

### 10. Number of Participants

Lecture: no limitation  
Tutorial: in case of shortage in human resources there can be a limitation.

### 11. Enrollment Procedures

Enrollment to the module is handled in the first class of each module component (cf. 3). Students must be present in person.

### 12. Recommended Reading, Lecture Notes

<table>
<thead>
<tr>
<th>Lecture notes available in paper form?</th>
<th>yes</th>
<th>no x</th>
</tr>
</thead>
<tbody>
<tr>
<td>If yes, where can they be purchased?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes in paper form are sometimes made available during class.</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Lecture notes available in electronic form?</td>
<td>yes</td>
<td>no x</td>
</tr>
<tr>
<td>Solutions of the assignments are provided to the students in electronic form:</td>
<td>no</td>
<td></td>
</tr>
</tbody>
</table>

**Recommended Reading:**

- Gabbiani & Cox *Mathematics for Neuroscientists* Elsevier 2010
- Gerstner & Kistler *Spiking Neuron Models* Cambridge University Press 2002
- Cox & Isham *Point Processes* Chapman & Hall 1980

**Advanced / additional readings:**


### 13. Language of Instruction

The language of instruction is English. Oral examinations can be taken either in English or in German.

### 14. Other Information
Title of Module:
Stochastic Processes in Neuroscience

Credit Points:
10 ECTS

Person responsible for the module:
Prof. Dr. Wilhelm Stannat

Contact:
Fakultät II, Institut für Mathematik, TU Berlin
Straße des 17. Juni 136, 10623 Berlin
phone: 
email: stannat at math.tu-berlin.de

Module Description

1. Qualification Aims
Participants should learn basic concepts, their theoretical foundation, and the most common models of stochastic processes used in computational neuroscience to model noisy neural systems. Participants will learn basic techniques to analyze the stochastic behavior of single neurons and neural systems both qualitatively and quantitatively. Participants will also learn basic simulation techniques for stochastic neural systems and how to evaluate simulation output. Participants should also be able to adapt models to new problems as well as to develop new models of neural systems.

The course is principally designed to impart

technical knowledge 50%, methodological competence 30%, system design 10%, soft skills and social competence 10%

2. Content
This module provides basic knowledge about the mathematical modelling, analysis and numerical simulation of neural systems under the influence of noise using stochastic processes.

Specific topics addressed are:
- Brownian motion and stochastic calculus
- stochastic models for single neurons (stochastic Hodgkin-Huxley model, stochastic integrate-and-fire models, random oscillators)
- coupled neurons with noise, synchronization
- stochastic stability
- stochastic neural fields, travelling waves

3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory (C) / Elective (E) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stochastic Processes in Neuroscience – Theoretical Lecture</td>
<td>lecture</td>
<td>Stannat</td>
<td>4</td>
<td>6</td>
<td>E</td>
<td>WS</td>
</tr>
<tr>
<td>Stochastic Processes in Neuroscience – Tutorial</td>
<td>tutorial</td>
<td>N.N.</td>
<td>2</td>
<td>4</td>
<td>E</td>
<td>WS</td>
</tr>
</tbody>
</table>

4. Description of Teaching and Learning Methods
The lecture part consists of teaching in front of the class. Participants are expected to rehearse topics after class, using their class notes as well as recommended book chapters, in preparation for the exercises and tutorials. Homework assignments are given on a regular basis, and must be usually solved within one or two weeks. These assignments cover analytical & mathematical exercises as well as numerical simulations & programming exercises. Working in small groups of two to three students is encouraged. Homework assignments and their solutions are discussed during the tutorial. In addition, selected topics presented during the lecture are rehearsed by the tutor as needed.

5. Prerequisites
Mathematical knowledge: Analysis (worth 20 credit points), linear algebra (worth 10 credit points) and probability theory (worth 10 credit points) on a level comparable to courses for mathematicians.
Basic programming skills.
Good command of the English language.

6. Target Groups / Course Levels
This module is elective for students of the Master program Mathematics and Computational Neuroscience (generally for advanced Diploma students or master students).

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical lecture</td>
<td>60</td>
</tr>
<tr>
<td>Tutorial</td>
<td>30</td>
</tr>
<tr>
<td>Lecture rehearsals / homework assignments</td>
<td>150</td>
</tr>
<tr>
<td>Exam revisions</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>300</td>
</tr>
</tbody>
</table>

8. Module Examination and Grading Procedures
Oral exam; certificates of successful participation in the tutorial is a prerequisite for the oral exam. The oral exam has to be taken latest by the end of the semester following the one of obtaining the tutorial certificates.

The examination procedure is regulated by the General Examination Regulation of the Technical University (Ordnung zur Regelung des allgemeinen Prüfungsverfahrens in Bachelor- und Masterstudiengängen) and by the Examination Regulation of the Master Program Computational Neuroscience.

9. Duration of Module
The module can be completed within one semester.

10. Number of Participants
Lecture: no limitation
Tutorial: in case of shortage in human resources there can be a limitation.

11. Enrollment Procedures
Enrollment to the module is handled in the first class of each module component (cf. 3). Students must be present in person.

12. Recommended Reading, Lecture Notes
Lecture notes available in paper form? yes X no
If yes, where can they be purchased?
Lecture notes in paper form are sometimes made available during class.
Lecture notes available in electronic form? yes X no
Solutions of the assignments are provided to the students in electronic form

Recommended Reading:
Ermentrout, Terman, Foundations of Mathematical Neuroscience, Springer 2010
Klenke, Probability Theory – a comprehensive course, Springer 2008
Oksendal, Stochastic Differential Equations, Springer 2010

Advanced / additional readings:
Lang, Lord, Stochastic Methods in Neuroscience, Oxford University Press 2009

One or two specific book chapters are assigned / recommended to every topic of the lecture. This list of recommendations is explained during the first class of every module component

13. Language of Instruction
The language of instruction is English. Oral examinations can be taken either in English or in German

14. Other Information
Title of Module: Stochastic Partial Differential Equations

Credit Points: 10 ECTS

Person responsible for the module: Prof. Dr. Wilhelm Stannat

Contact: Fakultät II, Institut für Mathematik, TU Berlin
Strasse des 17. Juni 136, 10623 Berlin
phone: 
email: stannat at math.tu-berlin.de

Module Description

1. Qualification Aims
Participants should learn basic concepts, their theoretical foundation, and the most common models of stochastic evolution equations on Hilbert spaces with a view towards its applications to the modelling, analysis and numerical approximation of spatially extended neurons and neural systems subject to noise. Participants will learn basic techniques to analyze global properties of neural systems both qualitatively and quantitatively. Participants will also learn basic simulation techniques for stochastic neural systems and how to evaluate simulation output. Participants should also be able to adapt models to new problems as well as to develop new models of neural systems.

The course is principally designed to impart technical knowledge 50%, methodological competence 30%, system design 10%, soft skills and social competence 10%

2. Content
This module provides basic knowledge about the mathematical modelling, analysis and numerical simulation of neural systems under the influence of noise using stochastic processes.

Specific topics addressed are:
- Gaussian measures on Hilbert spaces
- stochastic integration on Hilbert spaces
- semilinear stochastic evolution equations
- stochastic reaction diffusion systems
- continuum limits of neural networks

3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory( C) / Elective (E) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stochastic Partial Differential Equations – Theoretical Lecture</td>
<td>lecture</td>
<td>Stannat</td>
<td>4</td>
<td>6</td>
<td>E</td>
<td>SS</td>
</tr>
<tr>
<td>Stochastic Partial Differential Equations – Tutorial</td>
<td>tutorial</td>
<td>N.N.</td>
<td>2</td>
<td>4</td>
<td>E</td>
<td>SS</td>
</tr>
</tbody>
</table>

4. Description of Teaching and Learning Methods
The lecture part consists of teaching in front of the class. Participants are expected to rehearse topics after class, using their class notes as well as recommended book chapters, in preparation for the exercises and tutorials. Homework assignments are given on a regular basis, and must be usually solved within one or two weeks. These assignments cover analytical & mathematical exercises as well as numerical simulations & programming exercises. Working in small groups of two to three students is encouraged. Homework assignments and their solutions are discussed during the tutorial. In addition, selected topics presented during the lecture are rehearsed by the tutor as needed.

5. Prerequisites
Mathematical knowledge: Analysis (worth 20 credit points), linear algebra (worth 10 credit points) and probability theory (worth 10 credit points) on a level comparable to courses for mathematicians. Basic programming skills. Good command of the English language.

6. Target Groups / Course Levels
This module is elective for students of the Master program Mathematics and Computational Neuroscience (generally for advanced Diploma students or master students).

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical lecture</td>
<td>60</td>
</tr>
<tr>
<td>Tutorial</td>
<td>30</td>
</tr>
<tr>
<td>Lecture rehearsals / homework assignments</td>
<td>150</td>
</tr>
<tr>
<td>Exam revisions</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>300</td>
</tr>
</tbody>
</table>

8. Module Examination and Grading Procedures
Oral exam; certificates of successful participation in the tutorial is a prerequisite for the oral exam. The oral exam has to be taken latest by the end of the semester following the one of obtaining the tutorial certificates.

The examination procedure is regulated by the General Examination Regulation of the Technical University (Ordnung zur Regelung des allgemeinen Prüfungsverfahrens in Bachelor- und Masterstudiengängen) and by the Examination Regulation of the Master Program Computational Neuroscience.

9. Duration of Module
The module can be completed within one semester.

10. Number of Participants
Lecture: no limitation
Tutorial: in case of shortage in human resources there can be a limitation.

11. Enrollment Procedures
Enrollment to the module is handled in the first class of each module component (cf. 3). Students must be present in person.

12. Recommended Reading, Lecture Notes
Lecture notes available in paper form? yes X no
If yes, where can they be purchased?
Lecture notes in paper form are sometimes made available during class.
Lecture notes available in electronic form? yes no X
Solutions of the assignments are provided to the students in electronic form

**Recommended Reading:**

Prevot, Roeckner, A Concise Course on Stochastic Partial Differential Equations, Springer 2007
Lang, Lord, Stochastic Methods in Neuroscience, Oxford University Press 2009
Ermentrout, Terman, Foundations of Mathematical Neuroscience, Springer 2010

**13. Language of Instruction**
The language of instruction is English. Oral examinations can be taken either in English or in German

**14. Other Information**
Title of Module: Mathematics Prep-Course for Computational Neuroscience

Credit Points: 4 ECTS

Person responsible for the module: Prof. Dr. Wilhelm Stannat

Contact: Fakultät II, Institut für Mathematik, TU Berlin
Straße des 17. Juni 136, 10623 Berlin
phone: 
email: stannat at math.tu-berlin.de

Module Description

1. Qualification Aims

Broad mathematical knowledge of functions in one resp. several real variables, in linear algebra, in differential equations, in probability theory and statistics, as needed for Computational Neuroscience. Basic mathematical skills for the analysis and approximation of functions, solutions of differential equations and signals. Basic mathematical skills for solving linear systems and systems of ordinary differential equations. Participants know mathematical foundations for the modeling and analysis of neural data and can apply with guided assistance basic mathematical techniques to problems in Computational Neuroscience.

The course is principally designed to impart technical knowledge 50%, methodological competence 30%, system design 10%, soft skills and social competence 10%.

2. Content

Mathematical foundations of Computational Neuroscience.

Specific topics addressed are:

- Calculus of functions in one real variable
- Linear Algebra: Vectors, Matrices and Systems of linear equations
- Complex numbers and Fourier transform
- Differential equations: linear and nonlinear, stability
- Probability theory and stochastic processes

3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours</th>
<th>Credit Points</th>
<th>Compulsory (C) / Elective (E) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics Prep-Course for Computational Neuroscience – Theoretical Lecture</td>
<td>lecture</td>
<td>Stannat</td>
<td>30</td>
<td>2</td>
<td>E</td>
<td>WS</td>
</tr>
<tr>
<td>Mathematics Prep-Course for Computational Neuroscience – Tutorial</td>
<td>tutorial</td>
<td>N.N.</td>
<td>30</td>
<td>2</td>
<td>E</td>
<td>WS</td>
</tr>
</tbody>
</table>

4. Description of Teaching and Learning Methods

36
The lecture part consists of teaching in front of the class. Participants are expected to rehearse topics after class, using their class notes as well as recommended book chapters, in preparation for the exercises and tutorials. Assignments are given on a daily basis and their solutions are discussed during the tutorial. In addition, selected topics presented during the lecture are rehearsed by the tutor as needed.

5. Prerequisites
Mathematical knowledge: Analysis, linear algebra, probability calculus and statistics, on a level comparable to mathematics courses for engineers (worth 24 credit points). Good command of the English language.

6. Target Groups / Course Levels
This module is elective for students of the Master program Mathematics and Computational Neuroscience (generally for advanced Diploma students or master students).

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical lecture</td>
<td>30</td>
</tr>
<tr>
<td>Tutorial</td>
<td>30</td>
</tr>
<tr>
<td>Lecture rehearsals / homework assignments</td>
<td>30</td>
</tr>
<tr>
<td>Exam revisions</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>

8. Module Examination and Grading Procedures
Written exam; grading system "pass/fail". The examination procedure is regulated by the General Examination Regulation of the Technical University (Ordnung zur Regelung des allgemeinen Prüfungsverfahrens in Bachelor- und Masterstudiengängen) and by the Examination Regulation of the Master Program Computational Neuroscience.

9. Duration of Module
The module can be completed before the start of the winter semester.

10. Number of Participants
Lecture: no limitation
Tutorial: in case of shortage in human resources there can be a limitation.

11. Enrollment Procedures
Enrollment per Email to graduateprograms AT bccn-berlin.de.

12. Recommended Reading, Lecture Notes
<table>
<thead>
<tr>
<th>Lecture notes available in paper form?</th>
<th>yes X no</th>
</tr>
</thead>
<tbody>
<tr>
<td>If yes, where can they be purchased?</td>
<td></td>
</tr>
<tr>
<td>Lecture notes in paper form are sometimes made available during class.</td>
<td></td>
</tr>
<tr>
<td>Lecture notes available in electronic form?</td>
<td>yes X no</td>
</tr>
<tr>
<td>Solutions of the assignments are provided to the students in electronic form</td>
<td></td>
</tr>
</tbody>
</table>

**Recommended Reading:**

2. Strang, Linear Algebra and its applications, Brooks Cole Pub Co, 2005

**Advanced / additional readings:**


One or two specific book chapters are assigned / recommended to every topic of the lecture. This list of recommendations is explained during the first class of every module component

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**13. Language of Instruction**

The language of instruction is English.

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**14. Other Information**
# Title of Module: Neurobiology Preparatory Course

<table>
<thead>
<tr>
<th>Credit Points:</th>
<th>2 ECTS</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Person responsible for the module:</th>
<th>Prof. Matthew Larkum</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Contact:</th>
<th>Neuroscience Research Center, Charité Berlin, Hufelandweg 14, 10115 Berlin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone:</td>
<td>(030) 450 530 117</td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:larkumma@biologie.hu-berlin.de">larkumma@biologie.hu-berlin.de</a></td>
</tr>
</tbody>
</table>

## Module Description

### 1. Qualification Aims

This course is intended as bridge for students enrolled in Computational Neuroscience. The aim is to provide the basics in neurophysiology. The module provides an overview of the current state of brain research and a summary of the fundamental biological background necessary for the design and implementation of models. After completing the module, participants should understand the general architecture of the mammalian brain with its major components and areas including circuitry, the major cell types and their function and the basic physiological principles that govern brain function. Participating students will be given an introduction to state-of-the-art research approaches in various disciplines of neuroscience including behavioral neuroscience, electrophysiology and imaging techniques. The emphasis of the course is on imparting the absolutely necessary basics required for modeling biologically relevant information systems.

The course is *principally* designed to impart:

technical skills 40%, method skills 40%, system skills 10%, social skills 10%

### 2. Content

The course covers basic neuroscience largely following the approach used in the textbook Bears, Connors & Paradiso. The course begins with a basic introduction to cells and neurons, the basic physiology of nerve cells and basic anatomy of the brain including the specific circuitry of major subregions such as the neocortex, hippocampus, limbic system, cerebellum and the basal ganglia. After this introduction, specific biologically based topics of interest to computational neuroscientist are treated including sensory transduction and different modalities, learning and memory, biological constraints on coding in the brain, large-scale approaches to understanding the brain, neuroscience in the laboratory and behavioural neuroscience. Time is given at the mid-point and end of the course for revision and discussions of relevant topics of interest to the students.
3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory(C) / Elective (E) / Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurobiology Preparatory Course</td>
<td>lecture</td>
<td>Larkum</td>
<td>30 hrs en block (2 SWS)</td>
<td>2</td>
<td>E</td>
<td>WS</td>
</tr>
</tbody>
</table>

4. Description of Teaching and Learning Methods

The lecture part consists of teaching in front of the class. Participants are expected to rehearse topics after class, using their class notes as well as recommended book chapters. The course is complemented by discussions and Q&A sessions based on reading materials provided during the lectures.

5. Prerequisites

Good command of the English language.

6. Target Groups / Course Levels

This module is elective for students of the Master and Doctoral program Computational Neuroscience. Master students of the Computational Neuroscience can take this course for the compulsory-elective module “Individual Studies”.

7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>30</td>
</tr>
<tr>
<td>Lecture rehearsals / exam preparation</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
</tr>
</tbody>
</table>
### 8. Module Examination and Grading Procedures

The module examination consists in a written multiple-choice test. It will be assessed as "passed" or "not passed". Ungraded course certificates can be handed to course participants who pass the final exam.

### 9. Duration of Module

Lectures: en block in one week. The module is completed after successful examination.

### 10. Number of Participants

Up to 15 participants.

### 11. Enrollment Procedures

Per Email to: graduateprograms AT bccn-berlin.de

### 12. Recommended Reading, Lecture Notes

<table>
<thead>
<tr>
<th>Lecture notes available in paper form?</th>
<th>yes</th>
<th>no</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>If yes, where can they be purchased?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes available in electronic form?</td>
<td>yes</td>
<td>X</td>
<td>no</td>
</tr>
</tbody>
</table>

**Recommended Reading:**

M.F. Bear et al., Neuroscience: Exploring the Brain, Williams & Wilkins, 2012

**Advanced / additional readings:**


### 13. Language of Instruction

The language of instruction is English.

### 14. Other Information
Title of Module: Master Thesis
Credit Points: 20 ECTS

Person responsible for the module: Examination Board Computational Neuroscience
Contact: Prof. Dr. Lindner, head of the Examination Board, Bernstein Center for Computational Neuroscience Philippstr. 13, House 2 10115 Berlin phone: 0049 (0) 30 2093 6336 email: benjamin.lindner at physik.hu-berlin.de

Module Description

1. Qualification Aims
In the Master thesis, the candidate shall demonstrate that she/he is able to deal with a task in a selected study field independently and according to scientific methods within the stipulated period of time, and to present the results of such work appropriately in compliance with the standards of good scientific practice.

2. Content
The contents of the Master Thesis depend:
a) on the study and research interests of the student
b) on the subject of the Master Thesis.
The candidate has the right to propose a topic for the Master Thesis which may consist of an interdisciplinary research project. The examination board allocates the topics by taking into consideration their homogeneity and the feasibility of the project within the given deadline.
For the Master Thesis, it is recommended to select the subject of one of the Lab Rotations.

3. Module Components

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Course Type</th>
<th>Lecturer</th>
<th>Hours / Week</th>
<th>Credit Points</th>
<th>Compulsory(C) / Elective (E)</th>
<th>Compulsory Elective (CE)</th>
<th>Semester (WS / SS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master Thesis</td>
<td>master thesis</td>
<td></td>
<td></td>
<td>20</td>
<td>C</td>
<td>CE</td>
<td>WS or SS</td>
</tr>
</tbody>
</table>

4. Description of Teaching and Learning Methods
The Master Thesis of the Master Program Computational Neuroscience must be submitted as a written scientific report. Upon decision of the Examination Board, the Master Thesis can also be accomplished as a team-work.

5. Prerequisites
The candidate must have completed the modules "Models of Neural Systems", "Models of Higher Brain Functions", "Acquisition and Analysis of Neural Data", "Machine Intelligence", "Individual Studies" and "Ethical Issues and Implications for Society".

6. Target Groups / Course Levels
The Module is compulsory for students of the Master Program Computational Neuroscience.
7. Work Load Assessment

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature survey and project proposal</td>
<td>90</td>
</tr>
<tr>
<td>Project work</td>
<td>360</td>
</tr>
<tr>
<td>Compilation of the thesis</td>
<td>120</td>
</tr>
<tr>
<td>Presentation, including preparation</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>600</strong></td>
</tr>
</tbody>
</table>

8. Module Examination and Grading Procedures

The finished thesis shall be submitted, in due time, in triplicate to the Examination Office of the Technical University of Berlin, which will put the time of submission on record and forward the thesis for examination and assessment. The candidate shall defend the results of the final thesis in a university-public colloquium. The Master thesis shall be assessed by at least two experts, among them the supervisor. The second expert will be appointed by the Examination Board. Assessments shall be delivered to the Examination Board within two months upon submission of the thesis. If assessments differ from each other and prove to be Nicht Ausreichend (Unsatisfactory) in one case, the Examination Board will seek to reach an agreement between the experts – if necessary, with the aid of another expert. The grade as well as the assessment will in this case be determined by the professors of the Examination Board. If the assessments given by the experts differ from each other, but are at least Ausreichend (Fair) in both cases, the individual grades will be averaged and an overall grade will be determined.

The Master Thesis is assessed accordingly to the same criteria as for the individual modules.

The grading scale is regulated by the General Examination Regulation of the Technical University (Ordnung zur Regelung des allgemeinen Prüfungsverfahrens in Bachelor- und Masterstudiengängen) and by the Examination Regulation of the Master Program Computational Neuroscience (Prüfungsordnung für den internationalen Masterstudiengang Computational Neuroscience an der Humboldt Universität zu Berlin und der Technischen Universität Berlin).

9. Duration of Module

The period for completion of the thesis is four months. At the candidate’s request, upon hearing the supervisor, the Examination Board may, by way of exception, extend this period. The topic of the Master thesis can be returned only once and only within the first six weeks of the period granted for completion of the thesis.

10. Number of Participants

Participation is restricted to students of the Master Program in Computational Neuroscience.

11. Enrollment Procedures

The student applies to the Examination Board for approval of a Master thesis topic. In this context, the student can propose a supervisor and a topic; any examiner can be a supervisor. At the suggestion of the supervisor, upon consultation with the candidate, the Examination Board will allocate the topic and put the date of allocation on record.

12. Recommended Reading, Lecture Notes

- Lecture notes available in paper form? yes [ ] no [x]
- Lecture notes available in electronic form? yes [ ] no [x]

13. Language of Instruction

The Master thesis must be written in English. Exceptional cases will be decided upon by the Examination Board.

14. Other Information