Bernstein Center for Computational Neuroscience
Technische Universität Berlin Humboldt-
Universität zu Berlin
Charité Universitätsmedizin Berlin

International Master Program Computational Neuroscience

Course Catalogue

04.03.2022

Models of Neural Systems

Module title:	Credits:	Responsible person:
Models of Neural Systems	12	Obermayer, Klaus
	Office:	**Contact person:**
	MAR 5-6	Velenosi, Lisa Alexandria
Website:	**Display language:**	**E-mail address:**
https://www.bccn-berlin.de/courses-and-modules.html	Englisch	graduateprograms@bccn-berlin.de

Learning Outcomes

After this module, students will know:
- the basic concepts of computational neuroscience, their theoretical foundation, and the most common models used
- the relevant basic neurobiological knowledge and the relevant theoretical approaches as well as the findings resulting form these approaches so far
- strengths and limitations of the different models
- how to appropriately choose the theoretical methods for modeling neural systems
- how to apply these methods while taking into account the neurobiological findings
- how to critically evaluate results obtained.
- how to adapt models to new problems as well as to develop new models of neural systems.

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

Module Components

Course Name	Type	Number	Cycle	SWS
Models of Neural Systems – Theoretical Lecture	VL		WS	2
Models of Neural Systems – Tutorial	UE		WS	2
Models of Neural Systems – Computer Lab	UE		WS	2
Models of Neural Systems – Experimental Lecture	VL		WS	2

Workload and Credit Points

Models of Neural Systems – Theoretical Lecture (Vorlesung)	Multiplier	Hours	Total
Attendance	15.0	2.0h	30.0h
Lecture rehearsals/ individual studies	15.0	2.0h	30.0h
			60.0h

Models of Neural Systems – Tutorial (Übung)	Multiplier	Hours	Total
Attendance	15.0	2.0h	30.0h
Homework assignments	15.0	6.0h	90.0h
			120.0h

Models of Neural Systems – Computer Lab (Übung)	Multiplier	Hours	Total
Homework assignments	15.0	6.0h	90.0h
Attendance	15.0	2.0h	30.0h
			120.0h

Models of Neural Systems – Experimental Lecture (Vorlesung)	Multiplier	Hours	Total
Lecture rehearsals/ individual studies	15.0	2.0h	30.0h
Attendance	15.0	2.0h	30.0h
			60.0h

The Workload of the module sums up to 360.0 Hours. Therefore the module contains 12 Credits.

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.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

- 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

Mandatory requirements for the module test application:

1.) *[CNS] Successful participation in the MNS tutorial*
2.) *[CNS] Successful participation in the MNS programming lab*

Module completion

Grading:	Type of exam:	Language:	Duration/Extent:
graded	Oral exam	English	35 Min.

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Wintersemester

Maximum Number of Participants

The maximum capacity of students is 20

Registration Procedures

Please send an email to the teaching coordinator at graduateprograms@bccn-berlin.de

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

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
available	*unavailable*

Recommended literature:

01. Dayan, Abbott, Theoretical Neuroscience, MIT Press, 2001. (recommended)
02. Izhikevich, Dynamical Systems in Neuroscience, MIT Press, 2007. (recommended)
03. Johnston, Wu, Foundations of Cellular Neurophysiology, MIT Press,1995. (recommended)
04. Hertz, Krogh, Palmer, Introduction to the Theory of Neural Computation, Addison-Wesley, 1991. (additional)
05. Hille, Ion Channels of Excitable Membranes, Sinauer, 2001. (additional)
06. Koch, Biophysics of Computation, Oxford University Press, 1999. (additional)
07. Koch, Segev, Methods in Neuronal Modelling, MIT Press, 1998. (additional)

Assigned Degree Programs

This moduleversion is used in the following modulelists:

Miscellaneous

Responsible for this module are:

Prof. Dr. Richard Kempter, HU Berlin (r.kempter@biologie.hu-berlin.de)
Prof. Dr. Benjamin Lindner, HU Berlin (benjamin.lindner@physik.hu-berlin.de)

Models of Higher Brain Functions

Module title:	Credits:	Responsible person:
Models of Higher Brain Functions	12	Sprekeler, Henning
	Office:	**Contact person:**
	MAR 5-3	Sprekeler, Henning
Website:	**Display language:**	**E-mail address:**
https://www.bccn-berlin.de/courses-and-modules.html#ui-id-11	Englisch	graduateprograms@bccn-berlin.de

Learning Outcomes

Having completed this module, participants will know:
- the basic concepts and most important topics in the Cognitive Neurosciences
- the state-of-the-art models in these domains and their theoretical foundations.

They will understand:
- strengths and limitations of the different modeling approaches (e.g. bottom-up versus top-down)
- the rationale behind models and their implementation
- performance criteria and critical statistical tests.

They will be able to:
- modify models of cognitive processes
- apply existing models to novel experimental paradigms, situations or data.

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:
Computational models of
- visual processing
- attention
- multisensory integration
- decision making
- behavioral learning (conditioning, reward learning)
- motor control

Programming Tutorial:
- hands-on experience of the models covered in the lecture, by means of computer simulations in Python.

Module Components

Course Name	Type	Number	Cycle	SWS
Analytical Tutorial	TUT		SS	2
Cognitive Neuroscience	VL		WS	2
Programming Tutorial	TUT		SS	2
Theoretical Lecture	VL		SS	2

Workload and Credit Points

Analytical Tutorial (Tutorium)	Multiplier	Hours	Total
Vor-/Nachbereitung	15.0	6.0h	90.0h
Präsenzzeit	15.0	2.0h	30.0h
			120.0h

Cognitive Neuroscience (Vorlesung)	Multiplier	Hours	Total
Präsenzzeit	15.0	2.0h	30.0h
Vor-/Nachbereitung	15.0	2.0h	30.0h
			60.0h

Programming Tutorial (Tutorium)	Multiplier	Hours	Total
Vor-/Nachbereitung	15.0	6.0h	90.0h
Präsenzzeit	15.0	2.0h	30.0h
			120.0h

Theoretical Lecture (Vorlesung)	Multiplier	Hours	Total
Vor-/Nachbereitung	15.0	2.0h	30.0h
Präsenzzeit	15.0	2.0h	30.0h
			60.0h

The Workload of the module sums up to 360.0 Hours. Therefore the module contains 12 Credits.

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 additionally use their class notes. Homework assignments are given on a regular basis, and must usually be 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.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

- mathematical knowledge: Some acquaintance with analysis, linear algebra, probability calculus and statistics
- basic knowledge about neurobiology and cognitive psychology
- basic programming skills, preferably some knowledge of Python
- good command of the English language

Mandatory requirements for the module test application:

1.) *Analytical Tutorial: gain at least 60% of the points in the homework assignments*
2.) *Programming Tutorial: complete 60% of the programming assignments*

Module completion

Grading:	Type of exam:	Language:	Duration/Extent:
graded	Oral exam	English	30 Min.

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

2 Semester

This module may be commenced in the following semesters:

Winter- und Sommersemester

Maximum Number of Participants

The maximum capacity of students is 30

Registration Procedures

Students must enroll per e-mail (to: graduateprograms(at)bccn-berlin.de) 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.
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.

Note that the total number of participants in the three variants of this module (MHBF, MHBF: Theory and Simulation, MHBF: Introduction) is limited to 30 participants. Preference is given to students in the MSc Computational Neuroscience, for whom the module is mandatory.

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
available

Recommended literature:

01. "Cognitive Neuroscience - The Biology of the Mind", Gazzaniga, Ivry, Mangun
02. "The Student's Guide to Cognitive Neuroscience", Ward
03. "Essentials of Cognitive Neuroscience", Postle

Assigned Degree Programs

This moduleversion is used in the following modulelists:

Computer Engineering (Master of Science)
StuPO 2015
Modullisten der Semester: SoSe 2021 WS 2021/22 SoSe 2022
Computer Science (Informatik) (Master of Science)
StuPO 2015
Modullisten der Semester: SoSe 2021 WS 2021/22 SoSe 2022
Elektrotechnik (Master of Science)
StuPO 2015
Modullisten der Semester: SoSe 2021 WS 2021/22 SoSe 2022
Informatik (Master of Science)
MSc Informatik PO 2013
Modullisten der Semester: SoSe 2021

Miscellaneous

No information

Acquisition and Analysis of Neural Data

Module title:	Credits:	Responsible person:
Acquisition and Analysis of Neural Data	12	Obermayer, Klaus
	Office:	**Contact person:**
	MAR 5-6	Velenosi, Lisa Alexandria
Website:	**Display language:**	**E-mail address:**
https://www.bccn-berlin.de/courses-and-modules.html	Englisch	graduateprograms@bccn-berlin.de

Learning Outcomes

In this module, students will gain knowledge about:
- the most important methods for experimental acquisition of neural data
- the respective analytical methods
- the different fields of application
- the advantages and disadvantages of the different methods
- how to handle the respective raw data.

They will be enabled to:
- choose the most appropriate analysis method
- apply them to experimental data.

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.

Module Components

Course Name	Type	Number	Cycle	SWS
Acquisition and Analysis of Neural Data - Laboratory	PR		WS/SS	3
Acquisition and Analysis of Neural Data - Lecture	VL		WS/SS	2
Acquisition and Analysis of Neural Data - Tutorial	UE		SS	2

Workload and Credit Points

Acquisition and Analysis of Neural Data - Laboratory (Praktikum)	Multiplier	Hours	Total
Präsenzzeit	15.0	3.0h	45.0h
Vor-/Nachbereitung	15.0	3.0h	45.0h
			90.0h

Acquisition and Analysis of Neural Data - Lecture (Vorlesung)	Multiplier	Hours	Total
Präsenzzeit	30.0	2.0h	60.0h
Vor-/Nachbereitung	30.0	2.0h	60.0h
			120.0h

Acquisition and Analysis of Neural Data - Tutorial (Übung)	Multiplier	Hours	Total
Präsenzzeit	15.0	2.0h	30.0h
Vor-/Nachbereitung	15.0	8.0h	120.0h
			150.0h

The Workload of the module sums up to 360.0 Hours. Therefore the module contains 12 Credits.

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

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

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

Mandatory requirements for the module test application:

1.) *[CNS] Certificate of successful participation in the tutorial AAND*
2.) *[CNS] Certificate of successful participation in the practical AAND*

Module completion

Grading:	Type of exam:	Language:	Duration/Extent:
graded	Oral exam	English	40 Min.

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

2 Semester

This module may be commenced in the following semesters:

Winter- und Sommersemester

Maximum Number of Participants

The maximum capacity of students is 20

Registration Procedures

Enrollment to the module: write an email to graduateprograms@bccn-berlin.de.
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.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	available

Recommended literature:

01. Kandel et al., Principles of Neural Science, McGraw-Hill Medical, 2000. (recommended)
02. M.F. Bear, Neuroscience: Exploring the Brain, Williams & Wilkins, 1996 (recommended)
03. Johnston and Wu, Foundations of Cellular Neurophysiology, MIT Press, 1994 (recommended)
04. Sakman and Neher, Single-Channel Recording, Springer, 2007 (recommended)
05. Jezzard et al., Functional MRI : An Introduction to Methods, Oxford University Press), 2003. (recommended)
06. Guido Dornhege, José del R. Millán, Thilo Hinterberger, Dennis McFarland, and Klaus-Robert Müller, editors. Toward Brain-Computer Interfacing. MIT Press, Cambridge, MA, 2007. (recommended)
07. Dayan, Abbott, Theoretical Neuroscience, MIT Press, 2001. (recommended)
08. Koch, Segev, Methods in Neuronal Modelling, MIT Press, 1998. (recommended)
09. Benjamin Blankertz, Ryota Tomioka, Steven Lemm, Motoaki Kawanabe, and Klaus- Robert Müller. Optimizing spatial filters for robust EEG single-trial analysis. IEEE Signal Proc Magazine, 25(1):41-56, 2008. (additional)
10. Lucas C. Parra, Clay D. Spence, Adam D. Gerson, and Paul Sajda. Recipes for the linear analysis of EEG. NeuroImage, 28(2):326-341, 2005. (additional)
11. Jonathan R. Wolpaw, Niels Birbaumer, Dennis J. McFarland, Gert Pfurtscheller, and Theresa M. Vaughan. Brain-computer interfaces for communication and control. Clin. Neurophysiol., 113:767-791, 2002. (additional)
12. Gert Pfurtscheller and F. H. Lopes da Silva. Event-related EEG/MEG synchronization and desynchronization: basic principles. Clin Neurophysiol, 110(11):1842-1857, Nov 1999. (additional)
13. Key AP, Dove GO, Maguire MJ. Linking brainwaves to the brain: an ERP primer. Dev Neuropsychol. 2005;27(2):183-215. (additional)

Assigned Degree Programs

This moduleversion is used in the following modulelists:

Miscellaneous

Responsible for this module are:
Prof. Dr. Richard Kempter, HU Berlin (r.kempter@biologie.hu-berlin.de)
Prof. Dr. Michael Brecht, HU Berlin (Michael.Brecht@bccn-berlin.de)
Prof. Dr. John-Dylan Haynes, Charité Universitätsmedizin Berlin (johndylan.haynes@gmail.com)
Prof. Dr. Benjamin Blankertz, TU Berlin (benjamin.blankertz@tu-berlin.de)

Machine Intelligence

Module title: Machine Intelligence	**Credits:** 12	**Responsible person:** Obermayer, Klaus
	Office: MAR 5-6	**Contact person:** Groiß, Camilla
Website: https://www.bccn-berlin.de/courses-and-modules.html	**Display language:** Englisch	**E-mail address:** sekr@ni.tu-berlin.de

Learning Outcomes

In this module, participants will gain knowledge about:
- basic concepts, their theoretical foundation and the most common algorithms used in machine learning and artificial intelligence
- strengths and limitations of the different paradigms

They will be enabled to:
- apply methods and algorithms to real world problems
- be aware of performance criteria
- critically evaluate results obtained with those methods
- modify algorithms to new tasks at hand
- develop new algorithms according to the paradigms presented in this course.

Content

Part 1: Artificial neural networks. Connectionist neurons, the multilayer perceptron, radial basis function networks, learning by empirical risk minimization, gradient-based optimization, overfitting and underfitting, regularization techniques, deep networks, applications to classification and regression problems.

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 4: Reinforcement learning (MDP, value iteration, policy iteration, Q-learning).

Part 5: Projections methods. Principal Component Analysis and Kernel-PCA; independent component analysis and blind source separation techniques (Infomax, Fast-ICA, ESD).

Part 6: Stochastic optimization. Simulated annealing, mean-field techniques.

Part 7: Clustering and embedding. K-means clustering, pairwise clustering methods, self-organizing maps for central and pairwise data.

Module Components

Course Name	Type	Number	Cycle	SWS
Machine Intelligence I	VL	0434 L 866	WS	2
Machine Intelligence II	VL	0434 L 867	SS	2
Machine Intelligence I	UE	0434 L 866	WS	2
Machine Intelligence II	UE	0434 L 867	SS	2

Workload and Credit Points

Machine Intelligence I (Vorlesung)	Multiplier	Hours	Total
Vor-/Nachbereitung	15.0	2.0h	30.0h
Präsenzzeit	15.0	2.0h	30.0h
			60.0h

Machine Intelligence II (Vorlesung)	Multiplier	Hours	Total
Präsenzzeit	15.0	2.0h	30.0h
Vor-/Nachbereitung	15.0	2.0h	30.0h
			60.0h

Machine Intelligence I (Übung)	Multiplier	Hours	Total
Vor-/Nachbereitung	15.0	6.0h	90.0h
Präsenzzeit	15.0	2.0h	30.0h
			120.0h

Machine Intelligence II (Übung)	Multiplier	Hours	Total
Präsenzzeit	15.0	2.0h	30.0h
Vor-/Nachbereitung	15.0	6.0h	90.0h
			120.0h

The Workload of the module sums up to 360.0 Hours. Therefore the module contains 12 Credits.

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 Computational Neuroscience master students for the module “Individual Studies”, if deficits in their mathematical knowledge become obvious.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

- 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.

Mandatory requirements for the module test application:

1.) *[NI] Machine Intelligence I - Hausaufgabe*
2.) *[NI] Machine Intelligence II - Hausaufgabe*

Module completion

Grading:	Type of exam:	Language:	Duration/Extent:
graded	Oral exam	English	30 Min.

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

2 Semester

This module may be commenced in the following semesters:

Winter- und Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration 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. To be allowed to do the oral exam, students must achieve (seperately) at least 60% of the points awarded for homework in each of the two lectures.

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.

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
available

Recommended literature:

01. Bishop, Pattern Recognition and Machine Learning, Springer-Verlag, 2006. (recommended)
02. Duda, Hart, Stock, Pattern Classification, Wiley, 2000. (recommended)
03. Haykin, Neural Networks, Prentice Hall, 1998. (recommended)
04. Kohonen, Self-Organizing Maps, Springer-Verlag, 1997. (recommended)
05. Schölkopf, Smola, Learning with Kernels, MIT Press, 2002. (recommended)
06. Russel, Norvig, Artificial Intelligence, Prentice Hall, 2003, Chapters 13 and 14. (recommended)
07. Cichocki, Amari, Adaptive Blind Signal and Image Processing, Wiley, 2002. (additional)
08. Cowell, Dawid, Lauritzen, Spiegelhalter, Probabilistic Networks and Expert Systems, Springer Verlag, 1999. (additional)
09. Hyvärinen, Karhunen, Oja, Independent Component Analysis, Wiley, 2001. (additional)
10. Jordan (Editor), Learning in Graphical Models, MIT Press, 1999. (additional)
11. Kay, Fundamentals of Statistical Signal Processing - Vol. I: Estimation Theory, Prentice Hall, 1993. (additional)
12. Ripley, Pattern Recognition and Neural Networks, Cambridge University Press, 1996. (additional)
13. Vapnik, Statistical Learning Theory, Wiley, 1998. (additional)

One or two specific book chapters are assigned / recomended 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

Assigned Degree Programs

This moduleversion is used in the following modulelists:

Miscellaneous

The module is exclusively reserved for students of the program "Computational Neuroscience (MSc)."

Students of other programs should take the modules "Machine Intelligence 1" and "Machine Intelligence 2".

Programming Course and Project

Module title:	Credits:	Responsible person:
Programming Course and Project	6	Sprekeler, Henning
	Office:	**Contact person:**
	MAR 5-3	Velenosi, Lisa Alexandria
Website:	**Display language:**	**E-mail address:**
https://www.bccn-berlin.de/courses-and-modules.html#ui-id-13	Englisch	graduateprograms@bccn-berlin.de

Learning Outcomes

At the end of the module, students will be able to:
- write complex computer programs
- follow common software design principles
- apply basic as well as advanced concepts of a modern programming language
- use tools for successful project management (version control tools, testing, etc.)
- develop a larger program, including the necessary specifications, documentation and test

The course puts strong emphasis on the use of online resources and self-guided learning in order to teach the students how to acquire skills in a modern programming language using manuals and available resources.

Content

The main objective of the course is to teach students how to plan and complete a complex software project. The specific topic is subject to change and is announced at the beginning of the semester.

Depending on the level of background, the first tutorials can feature introductory topics such as:
- using the UNIX operating system: basic commands, editor, navigation
- introduction to the programming language python and common libraries
- objects and object attributes in python
- object oriented programming in python

The main focus of the course is on software carpentry techniques/tools such as:
- version control during code development using git
- integrated development environments
- test driven code development
- code documentation
- refactoring
- debugging
- profiling & optimization

Module Components

Course Name	Type	Number	Cycle	SWS
Programming Course and Project	PJ		SS	4

Workload and Credit Points

Programming Course and Project (Projekt)	Multiplier	Hours	Total
Unsupervised work	15.0	8.0h	120.0h
Attendance & supervised work	15.0	4.0h	60.0h
			180.0h

The Workload of the module sums up to 180.0 Hours. Therefore the module contains 6 Credits.

Description of Teaching and Learning Methods

The weekly tutorial contains a teaching component, supervised discussions among the students and time for supervised work on the project. The teaching component will be larger in the beginning of the semester in order to introduce core concepts. In the first few weeks, students will receive necessary background information about
- the employed programming language, depending on the level of experience of the students,
- software carpentry techniques & tools,
- the topic of the software project.

This involves lectures/computer demonstrations by the lecturer as well as smaller assignments, which are solved partially in class, partially as homework and serve as building blocks for a first prototype or a simpler version of the final project (depending on the topic).

Building on the introductory tutorials, students will plan and execute their own larger software projects. Depending on the complexity of their proposed projects, working in small groups is encouraged. The different projects are supervised by the tutor. Part of the work on the projects is done during the tutorials, during which students can get assistance from the tutor, but a substantial part of of the work is done outside of class.

Throughout the course, strong emphasis is put on discussions among students. Both reading other students' code and giving feedback as well as receiving feedback from others are essential to improve their coding style.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

Basic programming skills in Python, or basic experience in another programming language and a willingness to quickly learn Python.

Mandatory requirements for the module test application:

No information

Module completion

Grading:	Type of exam:	Language:
ungraded	Portfolio examination 100 points in total	English

Grading scale:
At least 50 points in total needed to pass.

Test description:
No information

Test elements	Categorie	Points	Duration/Extent
(Deliverable assessment) Final software implementation	written	50	Software submission
(Deliverable assessment) Software implementation of prototype	written	40	Software submission
(Deliverable assessment) Presentation of the project	oral	10	~15 min (presentation + questions)

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Sommersemester

Maximum Number of Participants

The maximum capacity of students is 20

Registration Procedures

Enrollment to the module is handled by the teaching coordinator of the MSc program Computational Neuroscience and finalized in the first class of the semester.
Students of the Master program in Computational Neuroscience have to register with the examination office (Prüfungsamt) of TU Berlin before the first test element.
For students from other programs, other regulations may apply. Please consult the examination regulations (Prüfungsordnung) of your program.

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
unavailable

Recommended literature:

Lutz and Ascher, Learning Python (Help for Programmers), O’Reilly, 2008.
Martelli, Ravenscroft and Ascher, Python Cookbook, O’Reilly, 2005.
Multiple online resources provided on the course's web page
Pilgrim, Dive into Python, Springer-Verlag, 2004.

Assigned Degree Programs

This moduleversion is used in the following modulelists:

Miscellaneous

No information

Ethical Issues and Implications for Society

Module title:	Credits:	Responsible person:
Ethical Issues and Implications for Society	3	Obermayer, Klaus
	Office:	**Contact person:**
	MAR 5-6	Velenosi, Lisa Alexandria
Website:	**Display language:**	**E-mail address:**
No information	Englisch	sekr@ni.tu-berlin.de

Learning Outcomes

After completing the course, students will know:
- how to reflect on the ethical and societal consequences of modern neuroscience.
- the principles of good scientific conduct and of data protection
- how 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
- how to integrate the ethical aspects into their own ongoing and future research.

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

Module Components

Course Name	Type	Number	Cycle	SWS
Ethical Issues and Implications of Society	IV		WS	3

Workload and Credit Points

Ethical Issues and Implications of Society (Integrierte Veranstaltung)	Multiplier	Hours	Total
Vor-/Nachbereitung	15.0	3.0h	45.0h
Präsenzzeit	15.0	3.0h	45.0h
			90.0h

The Workload of the module sums up to 90.0 Hours. Therefore the module contains 3 Credits.

Description of Teaching and Learning Methods

The IV takes place as a 1 week block at the beginning of the lecture-free period.
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.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

Wünschenswerte Voraussetzungen für die Teilnahme zu den Lehrveranstaltungen:
- Basic knowledge of neuroscientific research
- good command of the English language

Mandatory requirements for the module test application:

No information

Module completion

Grading:	Type of exam:	Language:
ungraded	Portfolio examination 100 points in total	English

Grading scale:

At least 50 points in total needed to pass.

Test description:

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.

To pass the Module 60 Pts are required.

Test elements	Categorie	Points	Duration/Extent
(Deliverable assessment) Successful participation in group work & presentation	oral	50	30 min
(Deliverable assessment) Essay on one of the block weeks lecture	written	50	3 h

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Wintersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration Procedures

Students should contact Robert Martin (graduateprograms@bccn-berlin.de) to register.
Students of the Master program Computational Neuroscience must register for this module at the Examination Office of the TU Berlin.
sekr@ni.tu-berlin.de

Recommended reading, Lecture notes

Lecture notes:
unavailable

Electronical lecture notes :
unavailable

Recommended literature:

01. Farah (2005). Neuroethics: the practical and the philosophical. Trends Cogn Sci 9, 34-40.
02. Martinson et al. (2005). Scientists behaving badly. Nature 435, 737-738
03. R Gillon (1994). Medical ethics: four principles plus attention to scope. BMJ 1994;309-184 (16 July)
04. J. Vollmann et al. (2003). Competence of mentally ill patients: a comparative empirical study. Psychological Medicine, 33, 1463–1471.
05. Iles and Bird (2006). Neuroethics: a modern context for ethics in neuroscience. Trends Neurosci. 29(9): 511–517.
06. Tovino (2007). Functional Neuroimaging and the Law: Trends and Directions for Future Scholarship. The American Journal of Bioethics, 7:9, 44 – 56
07. Wolpe (2005). Emerging Neurotechnologies for Lie-Detection: Promises and Perils. The American Journal of Bioethics, 5(2): 39–49.
08. Mayer-Schoenberger (2007). Useful Void: The Art of Forgetting in the Age of Ubiquitous Computing. KSG Working Paper No. RWP07-022

Assigned Degree Programs

This moduleversion is used in the following modulelists:

Miscellaneous

Responsible for this module is:
Prof. Dr. John-Dylan Haynes, Charité Universitätsmedizin Berlin (johndylan.haynes@gmail.com)

Master Thesis

Module title:	Credits:	Responsible person:
Master Thesis	20	Obermayer, Klaus
	Office:	**Contact person:**
	MAR 5-6	Martin, Robert
Website:	**Display language:**	**E-mail address:**
http://www.bccn-berlin.de/Graduate+Programs/0_Teaching/Courses+and+Modules/#mt	Englisch	graduateprograms@bccn-berlin.de

Learning Outcomes

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.

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.

Module Components

Workload and Credit Points

Course-independent workload	Multiplier	Hours	Total
Master Thesis defence	1.0	30.0h	30.0h
Master Thesis	1.0	570.0h	570.0h
			600.0h

The Workload of the module sums up to 600.0 Hours. Therefore the module contains 20 Credits.

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.

Requirements for participation and examination

Desirable prerequisites for participation in the courses:

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”.

Mandatory requirements for the module test application:

1.) Module *Acquisition and Analysis of Neural Data (#40785)* passed
2.) Module *Ethical Issues and Implications for Society (#40788)* passed
3.) Module *Machine Intelligence (#40786)* passed
4.) Module *Models of Neural Systems (#40042)* passed
5.) Module *Models of Higher Brain Functions (#40078)* passed

Module completion

Grading:	Type of exam:	Language:	Duration/Extent:
graded	Thesis	English	No information

Test description:
No information

Duration of the Module

The following number of semesters is estimated for taking and completing the module:

1 Semester

This module may be commenced in the following semesters:

Winter- und Sommersemester

Maximum Number of Participants

This module is not limited to a number of students.

Registration 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.

Recommended reading, Lecture notes

Lecture notes:	Electronical lecture notes :
unavailable	*unavailable*

Assigned Degree Programs

This moduleversion is used in the following modulelists:

Miscellaneous

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).

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.

Module description

Individual Studies

Module title:	**Credits:**	**Responsible person:**
Individual Studies	6	Obermayer, Klaus
	Office:	**Contact person:**
	MAR 5-6	Velenosi, Lisa
Website:	**Display language:**	**E-Mail address:**
No information	English or German	graduateprograms@bccn-berlin.de

Learning Outcomes

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%

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.

Module Components

Course Name	Type	Number	Cycle	SWS
Individual Studies	diverse		WS/ SS	

Workload and Credit Points

Analytical Tutorial (Tutorium)	*Multiplier*	*Hours*	*Total*
Attendance/Lecture rehearsals/Individual studies	15.0	12.0	180.0h
			180.0h

One ECTS/Credit Point equals 30h of workload.

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.

Requirements for participation and examination

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

Module completion

Type of exam:	**Grading:**
Portfolio exam	ungraded

Duration of the Module

This module can be completed in 1 semester.

Maximum Number of Participants

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

Registration 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.

Recommended Reading, Lecture notes

Lecture notes:	**Electronic lecture notes:**
Not available	*Not available*

Recommended literature:
Readings will be provided the mentor of by the lecturer responsible for the courses taken.

Assigned Degree Programs

No information

Miscellaneous

No information

Module description

Lab Rotation

Module title:	Credits:	Responsible person:
Lab Rotation	9	Obermayer, Klaus
	Office:	**Contact person:**
	MAR 5-6	Velenosi, Lisa
Website:	**Display language:**	**E-Mail address:**
no information	English or German	graduateprograms@bccn-berlin.de

Learning Outcomes

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%

Content

Students choose the topics in consultation with their mentor. 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.

Module Components

Course Name	Type	Number	Cycle	SWS
Individual Studies	PJ		WS/ SS	-

Workload and Credit Points

Analytical Tutorial (Tutorium)	*Multiplier*	*Hours*	*Total*
Literature survey and project proposal	1.0	60.0	60.0h
Project work	8.0	18.75	150.0
Compilation of the written report	1.0	40.0	40.0
Presentation, inclusing preparations	1.0	20.0	20.0
			270.0h

One ECTS/Credit Point equals 30h of workload.

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.

Requirements for participation and examination

- 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.

Module completion

Type of exam:	Grading:
Written report/ poster + presentation	unbenotet

Duration of the Module
Das Modul kann in 1 Semester(n) abgeschlossen werden.

Maximum 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.

Registration 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.

Recommended Reading, Lecture notes
Lecture notes:
Not available

Electronic lecture notes:
Not available

Recommended literature:
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.

Assigned Degree Programs
No information

Miscellaneous
No information

Module description

Courses on Advanced Topics

Module title:	**Credits:**	**Responsible person:**
Courses on Advanced Topics	10	Obermayer, Klaus
	Office:	**Contact person:**
	MAR 5-6	Velenosi, Lisa
Website:	**Display language:**	**E-Mail address:**
No information	English	graduateprograms@bccn-berlin.de

Learning Outcomes

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%

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.

Module Components

Course Name	Type	Number	Cycle	SWS
Courses on Advanced Topics	diverse		WS/ SS	

Workload and Credit Points

Courses on Advanced Topics	*Multiplier*	*Hours*	*Total*
Attendance/Lecture rehearsals/Individual studies	15.0	20.0	300.0h
			300.0h

One ECTS/Credit Point equals 30h of workload.

Description of Teaching and Learning Methods

Teaching and learning methods are established by the lecturers of the respective courses.

Requirements for participation and examination

The selection of courses as module components must be approved by the student’s mentor and examination board.

Module completion

Type of exam:	**Grading:**
Portfolio exam	Graded

At least 6 ECTS must be earned through graded courses. Up to 4 ECTS can consist of ungraded achievements. The final grade is then given by the rounded numerical average of the grades of the graded components, weighted by the corresponding proportion of ECTS credit points earned. The final grade is rounded so that the first decimal is 0, 3 or 7. If the first decimal of the weighted average is 1 or 2, it is rounded to 0. If the first decimal is between 4 and 6, it is rounded to 3. Finally, if the decimal is 8 or 9, it is rounded to 7. The ECTS weighting is chosen so as to maximize the students’ final grade.

Duration of the Module

This module can be completed in 1 semester.

Maximum Number of Participants

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

Registration Procedures

Before beginning the course, students must receive permission from their mentor and submit a signed course registration document to the Examination Office for approval. 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.

Recommended Reading, Lecture notes

Lecture notes:
Not available

Electronic lecture notes:
Not available

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

Assigned Degree Programs

No information

Miscellaneous

A comprehensive list of classes which are currently offered can be found at: https://www.bccn-berlin.de/web-links.html

Other modules
(possible as elective courses within the modules “Individual studies” or “Courses on Advanced Topics”)

Module description

Mathematics Prep-Course for Computational Neuroscience

Module title:	Credits:	Responsible person:
Mathematics Prep-Course for Computational Neuroscience	4	Stannat, Wilhelm
	Office:	Contact person:
Website:	MAR 5-6	Velenosi, Lisa
http://www.bccn-berlin.de/Graduate+Programs/0_Teaching/Courses+and+Modules/#math-prep- course	Display Language: English	E-Mail address: graduateprograms@bccn-berlin.de

Learning Outcomes

Having completed this course, students will have:

- 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.
- 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%

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

Module Components

Course Name	Type	Number	Cycle	SWS
Mathematics Prep-Course for Computational Neuroscience (Theoretical Lecture)	VL		WS	2
Mathematics Prep-Course for Computational Neuroscience (Tutorial)	UE		WS	2

Workload and Credit Points

Mathematics Prep-Course for Computational Neuroscience (Theoretical Lecture)	*Multiplier*	*Hours*	*Total*
Attendance	15.0	2.0	30.0h
Lecture rehearsals/ individual studies	15.0	2.0	30.0h
			60.0h

Mathematics Prep-Course for Computational Neuroscience (Tutorial)	*Multiplier*	*Hours*	*Total*
Attendance	15.0	2.0	30.0h
Lecture rehearsals/ individual studies	15.0	2.0	30.0h
			60.0h

One ECTS/Credit Point equals 30h of workload.

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. 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.

Requirements for participation and examination

Desirable prerequisites for participation:

- 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.

Mandatory requirements for the module exam authorization:
none

Module completion

Type of exam:
written exam

Grading:
ungraded

Duration of the Module

This module can be completed in 1 semester.

Maximum Number of Participants

No maximum capacity

Registration Procedures

Enrollment per Email to graduateprograms@bccn-berlin.de.

Recommended Reading, Lecture notes

Lecture notes:
Lecture notes are available.

Note concerning the lecture notes:
Lecture notes in paper form are sometimes made available during class.

Electronic lecture notes:
Electronic lecture notes are available.

Note concerning the electronic lecture notes:
Solutions of the assignments are provided to the students in electronic form.

Recommended literature:

01. Sinz, Macke & Liesge, Essential mathematics for Neuroscience, Lecture Notes, Tübingen, 2012 (recommended)
02. Strang, Linear Algebra and its applications, Brooks Cole Pub Co, 2005 (recommended)
03. Dayan, Abbott, Theoretical Neuroscience, Computational and Mathematical Modeling of Neural Systems. MIT Press 2001/2005 (additional)
04. Gabbiani, Cox, Mathematics for Neuroscientists, Academic Press 2010 (additional)

Assigned Degree Programs

Students of other courses can take this module without a capacity test.

Miscellaneous

No information

Module description

Neurobiology Preparatory Course

Module title:	**Credits:**	**Responsible person:**
Neurobiology Preparatory Course	2	Larkum, Matthew
	Office:	**Contact person:**
	MAR 5-6	Velenosi, Lisa
Website:	**Display language:**	**E-Mail address:**
http://www.bccn-berlin.de/Graduate+Programs/0_Teaching/Courses+and+Modules/#neuro-prep- course	English	graduateprograms@bccn-berlin.de

Learning Outcomes

This course is intended as bridge for students enrolled in Computational Neuroscience. The aim is to provide the basics in neurophysiology.

Having completed this module, students will know:

- the current state of brain research
- the fundamental biological background necessary for the design and implementation of models.
- 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.
- the basic state-of-the-art research approaches in various disciplines of neuroscience including behavioral neuroscience, electrophysiology and imaging techniques.
- 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%

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.

Module Components

Course Name	Type	Number	Cycle	SWS
Neurobiology Preparatory Course	VL		WS	2

Arbeitsaufwand und Leistungspunkte

Neurobiology Preparatory Course	*Multiplier*	*Hours*	*Total*
Attendance	15.0	2.0	30.0h
Lecture rehearsals/individual studies	15.0	2.0	30.0h
			60.0h

One ECTS/Credit Point equals 30h of workload.

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.

Requirements for participation and examination

Desirable prerequisites for participation:

- Good command of the English language

Mandatory requirements for the module exam authorization:

none

Module completion

Type of exam:	**Grading:**
written exam	ungraded

Duration of the Module
This module can be completed in 1 semester.

Maximum Number of Participants
This module is limited to 15 participants.

Registration Procedures
Enrollment per e-mail to graduateprograms@bccn-berlin.de.

Recommended Reading, Lecture notes
Lecture notes:
not available

Electronic lecture notes:
Electronic lecture notes are available.

Recommended literature:
01. M.F. Bear et al., Neuroscience: Exploring the Brain, Williams & Wilkins, 2012 (recommended)
02. Kandel et al., Principles of Neural Science, McGraw-Hill Medical, 2000 (additional)

Assigned Degree Programs
No information

Miscellaneous
No information

Module description

Neural Noise and Neural Signals - Spontaneous Activity and Information Transmission in Models of Single Nerve Cells

Module title:
Neural Noise and Neural Signals - Spontaneous Activity and Information Transmission in Models of Single Nerve Cells

Website:
http://www.bccn-berlin.de/Graduate+Programs/0_Teaching/Courses+and+Modules/#noisig

Credits:
6

Office:
MAR 5-6

Display language:
English

Responsible person:
Lindner, Benjamin

Contact person:
Velenosi, Lisa

E-Mail address:
graduateprograms@bccn-berlin.de

Learning Outcomes

After completing this module, students will know:
- basic models and measures of neural noise (or variability as it is more often called)
- how to follow the current literature on the subject on his/her own
- some key concepts from nonlinear dynamics, stochastic processes, and information theory
- a number of basic problems; here, the main emphasis is given to analytically tractable models, but simulation techniques are explained as well
- some more involved problems (ISI statistics under correlated (colored) noise, with subthreshold oscillations, or with adapt ation, stimulus-induced correlations)

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

Module Components

Course Name	Type	Number	Cycle	SWS
Neural Noise and Neural Signals	VL		SS	2
Neural Noise and Neural Signals	UE		SS	1

Arbeitsaufwand und Leistungspunkte

Neural Noise and Neural Signals (Vorlesung)	*Multiplier*	*Hours*	*Total*
Attendance	15.0	2.0	30.0h
Lecture rehearsals/ individual studies	15.0	2.0	30.0h
			60.0h

Neural Noise and Neural Signals (Übung)	*Multiplier*	*Hours*	*Total*
Attendance	15.0	2.0	30.0h
Lecture rehearsals/ individual studies	15.0	2.0	30.0h
			60.0h

One ECTS/Credit Point equals 30 h of workload.

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.

Requirements for participation and examination

Desirable prerequisites for participation:
- 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

Mandatory requirements for the module exam authorization:
1.) Certificate of successful participation in the tutorial NNNS

Module completion

Type of exam:
oral exam

Grading:
graded

Duration of the Module

This module can be completed in 1 semester.

Maximum Number of Participants

No maximum capacity

Registration Procedures

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

Recommended Reading, Lecture notes

Lecture notes:
Lecture notes are available.

Electronic lecture notes:
not available

Note concerning the lecture notes:
Lecture notes in paper form are sometimes made available during class.

Recommended literature:
01. Gabbiani & Cox Mathematics for Neuroscientists Elsevier 2010 (recommended)
02. Gerstner & Kistler Spiking Neuron Models Cambridge University Press 2002 (recommended)
03. Cox & Isham Point Processes Chapman & Hall 1980 (recommended)
04. Borst & Theunissen Information theory and neural coding Nature Neuroscience Review 1999 (additional)

Assigned Degree Programs

Students of other courses can take this module without a capacity test.

Miscellaneous

No information

Module description

Stochastic Partial Differential Equations

Module title:	**Credits:**	**Responsible person:**
Stochastic Partial Differential Equations	10	Stannat, Wilhelm
	Office:	**Contact person:**
	MAR 5-6	Velenosi, Lisa
Website:	**Display language:**	**E-Mail address:**
http://www.bccn-berlin.de/Graduate+Programs/0_Teaching/Courses+and+Modules/#stoch_pde	English	graduateprograms@bccn-berlin.de

Learning Outcomes

Having completed this module, students will know:
- 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
- basic techniques to analyze global properties of neural systems both qualitatively and quantitatively
- basic simulation techniques for stochastic neural systems and how to evaluate simulation output
- how 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%

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

Module Components

Course Name	Type	Number	Cycle	SWS
Stochastic Partial Differential Equations (Theoretical Lecture)	VL		SS	4
Stochastic Partial Differential Equations (Tutorial)	UE		SS	2

Workload and Credit Points

Stochastic Partial Differential Equations (Theoretical Lecture)	*Multiplier*	*Hours*	*Total*
Attendance	15.0	4.0	60.0h
Lecture rehearsals/ individual studies	15.0	8.0	120.0h
			180.0h

Stochastic Partial Differential Equations (Tutorial)	*Multiplier*	*Hours*	*Total*
Attendance	15.0	2.0	30.0h
Lecture rehearsals/ individual studies	15.0	6.0	90.0h
			120.0h

One ECTS/Credit Point equals 30 h of workload.

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.

Requirements for participation and examination

Desirable prerequisites for participation:

- 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

Mandatory requirements for the module exam authorization:
1.) Certificate of successful participation in the tutorial SPDE

Module completion

Type of exam:
oral exam

Grading:
graded

Duration of the Module

This module can be completed in 1 semester.

Maximum Number of Participants

No maximum capacity

Registration Procedures

Students must enroll per e-mail (to: graduateprograms@bccn-berlin.de) 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. 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.

Recommended Reading, Lecture notes

Lecture notes:
Lecture notes are available.

Electronic lecture notes:
not available

Note concerning the lecture notes:
Lecture notes in paper form are sometimes made available during class.

Recommended literature:
01. Da Prato, Zabczyk, Stochastic Evolution Equations in Infinite Dimensions, Cambridge University Press, 2008
02. Prevot, Roeckner, A Concise Course on Stochastic Partial Differential Equations, Springer 2007
03. Lang, Lord, Stochastic Methods in Neuroscience, Oxford University Press 2009
04. Ermentrout, Terman, Foundations of Mathematical Neuroscience, Springer 2010

Assigned Degree Programs

Students of other courses can take this module without a capacity test.

Miscellaneous

No information

Module description

Stochastic Processes in Neuroscience

Module title:	Credits:	Responsible person:
Stochastic Processes in Neuroscience	10	Stannat, Wilhelm
	Office:	**Contact person:**
	MAR 5-6	Velenosi, Lisa
Website:	**Display language:**	**E-Mail address:**
http://www.bccn-berlin.de/Graduate+Programs/0_Teaching/Courses+and+Modules/#stoch_neuroscience	English	graduateprograms@bccn-berlin.de

Learning Outcomes

Having completed this module, students will know:
- basic concepts, their theoretical foundation, and the most common models of stochastic processes used in computational neuroscience to model noisy neural systems
- basic techniques to analyze the stochastic behavior of singles neurons and neural systems both qualitatively and quantitatively
- basic simulation techniques for stochastic neural systems and how to evaluate simulation output
- how 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%

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

Module Components

Course Name	Type	Number	Cycle	SWS
Stochastic Processes in Neuroscience (Theoretical Lecture)	VL		WS	4
Stochastic Processes in Neuroscience (Tutorial)	UE		WS	2

Workload and Credit Points

Stochastic Processes in Neuroscience (Theoretical Lecture)	*Multiplier*	*Hours*	*Total*
Attendance	15.0	4.0	60.0h
Lecture rehearsals/ individual studies	15.0	8.0	120.0h
			180.0h

Stochastic Processes in Neuroscience (Tutorial)	*Multiplier*	*Hours*	*Total*
Attendance	15.0	2.0	30.0h
Lecture rehearsals/ individual studies	15.0	6.0	90.0h
			120.0h

One ECTS/Credit Point equals 30h of workload.

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.

Requirements for participation and examination

Desirable prerequisites for participation:

- 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

Mandatory requirements for the module exam authorization:
1.) Certificate of successful participation in the tutorial SPN

Module completion

Type of exam:
oral exam

Grading:
graded

Duration of the Module

This module can be completed in 1 semester.

Maximum Number of Participants

No maximum capacity

Registration Procedures

Students must enroll per e-mail (to: graduateprograms@bccn-berlin.de) 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. 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.

Recommended Reading, Lecture notes

Lecture notes:
Lecture notes are available.

Note concerning the lecture notes:
Lecture notes in paper form are sometimes made available during class.

Electronic lecture notes:
Electronic lecture notes are available.

Note concerning the electronic lecture notes:
Solutions of the assignments are provided to the students in electronic form.

Recommended literature:
01. Ermentrout, Terman, Foundations of Mathematical Neuroscience, Springer 2010 (recommended)
02. Klenke, Probability Theory – a comprehensive course, Springer 2008 (recommended)
03. Oksendal, Stochastic Differential Equations, Springer 2010 (recommended)
04. Lang, Lord, Stochastic Methods in Neuroscience, Oxford University Press 2009 (additional)

Assigned Degree Programs

Students of other courses can take this module without a capacity test.

Miscellaneous

No information