



This document is intended to give students at the Bachelor and Master level an overview of courses that could be relevant, if the student would like to know more about, or dive deeper into, the research direction of CogniGron.

CogniGron aims at making the necessary breakthroughs in the field of novel architectures for cognitive computing: there is a need for a new type of computing that can classify, prioritize, combine, and analyse large amounts of data, as well as generate new suggestions, using only a small portion of the energy required by the current technology.

CogniGron aims to make these necessary advances in the field by focusing on a holistic approach of efforts in materials science, physics, mathematics, computer science, artificial intelligence, and combinations thereof.

As a very new field of research, its future will strongly depend on the quality of training we can offer the new generation of students. To this end, CogniGron will develop a curriculum to train a new generation of researchers and equip them with the necessary knowledge to thrive in multidisciplinary teams of the mentioned disciplines.

The current curricula of Materials Science, Physics, Chemistry Mathematics, Computer Science and Artificial Intelligence already provide relevant courses. Below, a summary of the courses can be found. Note, that some courses assume prior knowledge or basic understanding (explicitly mentioned in their Ocasys pages), which require additional prior preparation by interested students from a different discipline than that for which the course was originally designed for.

Material science/ Physics/ Chemistry

Bachelor courses:

- **Physical Properties of Materials I**
 - *A very basic introduction into semiconductors and transistors.*
 - [Ocasys](#)
- **Device Physics**
 - *A basic introduction into (modern) electronic devices. The emphasis will be on understanding the principles and how these devices are being used in current day electronic circuits and systems.*
 - [Ocasys](#)
- **Nanophysics and Nanotechnology**
 - *An introduction to nanophysics and historical remarks, followed by a discussion of phenomena which can be explained with classical physics concepts.*
 - *Assumes prior knowledge acquired from Quantum mechanics and Solid state physics offered in the degree programmes of Physics and Applied Physics.*
 - [Ocasys](#)
- **Principles of Measurement Systems**
 - *A thorough understanding and factual knowledge of the basic principles behind measurement systems.*
 - [Ocasys](#)



- **Electronics and Signal Processing**
 - *All about modern electronic circuits*
 - [Ocasys](#)

Master courses:

- **Mesoscopic physics**
 - *This course deals with a number of electronic transport phenomena that occur in mesoscopic systems consisting of semiconductors, metals, superconductors, molecular systems or a combination of these.*
 - *The course assumes prior knowledge on basic solid state physics./*
 - [Ocasys](#)
- **Memristive Devices**
 - *An introduction to the behaviour and functionality of memristive devices.*
 - *Prior knowledge of Physical Properties of Materials I is assumed.*
 - [Ocasys](#)
- **Neuromorphic Circuit Design**
 - *An introduction to the design of sub-threshold circuits for the physical emulation of neural computation.*
 - [Ocasys](#)
- **Characterisation of Materials**
 - *Presents a broad view of the different experimental characterization techniques and the principles on which they are based*
 - [Ocasys](#)
- **Structure at Macro, Meso and Nano Scale**
 - *Uncovering the relationship between structure over a range of length scales and associated properties in particular electromagnetic properties. However, the main focus is on structure.*
 - [Ocasys](#)

Mathematics

Bachelor courses:

- **Linear Systems**
 - *The course deals with solutions of linear systems (existence and uniqueness, the superposition principle, the matrix exponential) as well as basic concepts and methods in mathematical systems theory.*
 - *The course assumes prior knowledge in linear algebra (as offered in the courses Linear Algebra 1 and 2).*
 - [Ocasys](#)
- **Dynamical Systems**
 - *An introduction to dynamical systems theory.*
 - *Prior knowledge from the courses, Calculus 1, Calculus 2, Linear Algebra 1, Linear Algebra 2, and Linear Systems is required.*
 - *The course prepares for courses in Systems and Control and advanced courses in Dynamical Systems Theory.*
 - [Ocasys](#)



- **Project Chaos Theory**
 - An overview of Chaos Theory which forms a subfield of Dynamical Systems Theory.
 - Prior knowledge of Calculus 1, Calculus 2, Linear Algebra 1, Linear Systems and Dynamical Systems is assumed
 - [Ocasys](#)
- **Mathematical Modelling**
 - Provides a more systematic and fundamental treatment of classes of mathematical models as frequently arising in Applied Mathematics.
 - Basic knowledge of calculus, linear algebra, and differential equations is assumed.
 - [Ocasys](#)
- **Control Engineering (for BME)**
 - An introduction to the analysis and design of linear feedback control systems using state-space and classic control methods.
 - Assumes prior knowledge of "Linear Algebra (for IEM or BME)" and of "Signals and Systems".
 - [Ocasys](#)

Master Courses:

- **Caput Dynamical Systems and Chaos**
 - Provide a solid background Caput Dynamical Systems and Chaos and studying a topic in contemporary research on dynamical systems and their applications.
 - Assumes prior knowledge acquired from an introductory course to dynamical systems theory like the compulsory course Dynamical Systems.
 - [Ocasys](#)
- **Complexity and Networks**
 - Presents different aspects of the theme Complexity and Networks from both the pure and applied mathematics points of view.
 - The course assumes prior knowledge in, Real and complex analysis, Probability theory, Linear algebra (vector spaces, invariant subspaces, quotient spaces, eigenvalues, eigenvectors), Fourier series, Dynamical systems (equilibria, linear stability), Systems theory (state and controllability) and Programming skills.
 - [Ocasys](#)

Computer Science

Master courses:

- **Advanced Parallel Programming**
 - *Introduction to the fundamentals of programming massively parallel heterogeneous accelerators and in particular to advanced techniques towards system design and programming of emerging computing systems, e.g., GPUs and FPGAs.*
 - *Prior knowledge of C, Java, and Computer Architecture is assumed.*
 - [Ocasys](#)
- **Neural Networks and Computational Intelligence**
 - *An introduction to neural networks and related concepts in machine learning.*
 - *Assumes prior knowledge in the sense that basic programming skills in one of the major programming languages and/or tools like Matlab or Mathematica have been acquired.*



- [Ocasys](#)
- **Modelling and Simulation**
 - *Introduction to some of the most important techniques used in the simulation of systems, which could come from physics, chemistry, biology, sociology or other fields.*
 - *Assumes prior knowledge in the sense that students should have some basic experience with programming.*
 - [Ocasys](#)
- **Systems engineering**
 - *Addresses the need for all industrial engineering professionals to understand the interdisciplinary and cross-functional nature of Systems Engineering (SysEng), and the benefits of following a sound SysEng process.*
 - *Assumes prior knowledge acquired from all the previous courses in the master program.*
 - [Ocasys](#)

Artificial Intelligence

Bachelor courses:

- **Introduction to Machine Learning**
 - *An introduction to the concepts of machine learning, including unsupervised and supervised learning.*
 - [Ocasys](#)
- **Neural Networks**
 - *An introduction to a choice of neural network specimen which together illustrate the powers of NN models as an integrative link between AI, machine learning, computational neuroscience, theoretical physics and – since a few years increasing in importance – microchip technologies and material science.*
 - *For this course a basic knowledge of Calculus, Linear Algebra and Multivariable Calculus is required.*
 - [Ocasys](#)

Master courses:

- **Machine Learning**
 - *Introduces fundamental concepts and a choice of standard model formalisms (decision trees, linear classifiers and regressors, K-means clustering, self-organizing feature maps, sampling / energy based distribution modeling, hidden Markov models and graphical models, feedforward and recurrent neural networks).*
 - [Ocasys](#)
- **Deep Learning**
 - *Will study different deep learning algorithms, starting from training feed-forward neural networks with multiple layers, going through convolutional neural networks and recurrent neural networks and ending with generative models.*
 - *Prior knowledge about Linear Algebra and Calculus is assumed.*
 - *Limited enrollment.*
 - [Ocasys](#)
- **Neural Networks and Computational Intelligence**
 - *An introduction to neural networks and related concepts in machine learning. The course unit assumes prior knowledge in the sense that basic programming skills in*



one of the major programming languages and/or tools like Matlab or Mathematica have been acquired.

- *Having attended courses like Introduction to Intelligent Systems or Introduction to Artificial Intelligence is beneficial but not required.*
- Limited enrollment.
- [Ocasys](#)

- **Computational Cognitive Neuroscience**
 - *Computational models in cognitive neuroscience.*
 - [Ocasys](#)

- **Robotics for IEM**
 - *Introduction to the principles of robotics.*
 - *Assumes prior knowledge acquired from control engineering, mechatronics, signal processing, digital and hybrid control.*
 - [Ocasys](#)