# Computational Techniques for Physicists ELECTIVE PACKAGE

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Computational Techniques for Physicists		
Offered by	Department of Applied Physics and Science Education	
Language	English	
Primarily interesting for	All the Applied Physics and Science Education students	
Prerequisites	-	
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## **Content and composition**

Today's physics cannot advance without computers. Computers are essential for controlling experiments and to analyze the (very often) massive amounts of data. They are also essential tools for the advancement and testing of theoretical ideas, "in silico" experiments live entirely in the computer and can do things that are often not possible in real experiments. This coherent package is composed of three courses that complement each other.

The first course focuses on the use of computers and programming for experiments in physics. Here you will learn basics aspects of computer I/O and programming language, how to control an experiment with a self-written program, and you will get an understanding of computer architecture and of the requirements that you have to consider in order to rapidly respond to events and streams of data coming from an experiment. In addition, you learn about desired quantities to measure, and algorithms for computing them efficiently.

The second course focuses on the use of computers to simulate physical reality. Computers allow to numerically approximate differential equations as well as to model the behavior of stochastic systems. In the course a self-consistent introduction to numerical techniques will be provided and the methods will be illustrated on the basis of real physical systems. An essential computational physics course for anybody interested in simulating or in understanding how simulations of physical systems on a computer really work.

The third course introduces machine learning concepts relevant for physicists. When systems are studied for which experimental data is available, machine learning techniques allow the researcher to generalize from the example data, and to make predictions without the need for traditional modeling. The course focuses on basic machine learning concepts and algorithms that are introduced via hands-on computational experiences with smallscale data sets.

Course code	Course name	Level classification
3EDX0	Control and Data Processing in Physics Experiments	-
3FMX0	Physical modelling and simulating	-
3EBX0	Machine Learning in Science	-



#### Control and Data Processing in Physics Experiments (2EDX0)

Every physicist will, in his or her career, encounter experimental physics. Nowadays, nearly 100% of our experiments is coupled to one or more computers in one way or another. In this course we want you to experience modern ways of controlling simple physics experiments and of gathering the data from these experiments and processing it. These simple experiments will be placed in the context of realistic experiments, including extremely complex experiments like LOFAR and LHC-detectors.

### Physical modeling and simulating (3FMX0)

Modeling physics often supplements experiments, and has sometimes even a life of its own: the physical system just lives in the computer. It is crucial to come to grips with this important aspect of physics: being able to simulate and model a physical system. The computer simulation of physics is more than numerical methods, although mastering the basics of these methods comes in handy. Examples of physics-based simulation are particle-based methods where the properties of solids, liquids or gases are computed by following millions of particles in a computer program. The course offers insight and provides hands-on experience in modern methods of simulation. It provides you with the key ingredients of computer simulation, something that you will undoubtedly need in your future career.

#### Machine Learning in Science (3EBX0)

In recent years machine learning is increasingly used in physics research. Applications include interpreting (large) data sets, fast (real-time) prediction, and system optimisation. In all these examples, computers are used to generalize based on a limited number of examples. The course offers insights into algorithms used to generalize and predict based on example data. These algorithms range from regression analysis to deep learning. The course is relevant not only to physics students, but to any engineering student eager to obtain an intuitive understanding of key machine learning concepts.