

Care and Cure elective package

Care and Cure	
Offered by	Department of Electrical Engineering
Language	English
Primarily interesting for	All students, but most relevant for students with background in EE, TN, BMT, MWT (with additional requirements)
Prerequisites	Prior knowledge of Circuits (5ECA0) or equivalent, Electromagnetics I (5EPA0) or equivalent, Electronic circuits I/II (5ECB0/5ECC0) or equivalent, and DSP fundamentals (signals II) (5ESC0) or equivalent is needed (or at least strongly recommended). This is especially relevant for non-EE students (contact the responsible teacher when in doubt).
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Content and composition

Healthcare systems are in crisis, worldwide. In the USA alone, preventable medical errors cause around 100,000 mortalities each year, twice as much as traffic accidents. Simultaneously, medical costs are skyrocketing, fuelled in part by demographic trends. Accordingly, there is an urgent need to improve quality of care while limiting costs. Throughout the world there is growing consensus that the paradigm shift towards patient-centered care will fit this bill. Patient-centered care has been embraced by the USA as its core health-care model for the future, and is at the heart of the business strategies of major industrial health-care players. It aims to put the patient rather than the doctor in direct control of his/her health. Underpinning this shift are novel medical technologies to support the patient in managing his/her health, and helping him/her to stay away from the hospital. In the transition from high-care to lower-care departments and from the ward to the home, patients become more ambulatory, and professional medical support is shrinking, both quantitatively and qualitatively. For medical technology to support this trend, this technology should hence operate reliably in more ambulatory settings, and provide a more continuous and autonomous indication of patient condition, preferably in a wireless fashion. Similar requirements apply to medical technology in a preventive setting, with an added emphasis on low cost. These requirements figure prominently in the Care and Cure program.

The theme Care and Cure is concerned with the medical side of electrical engineering; with the goal of making hospital intake less necessary. By means of this, the quality of care can improve, the patient can exercise more control over his own health and costs become lower. The elective package covers the fundamentals of medical systems in the domain of electrical engineering.

Course code	Course name	Level classification	Last year course is offered	Last year exam is offered
5XPC0	Neurophysiology and neurostimulation	2, advanced	2024-2025*	2025-2026
5XCBO	Electronic and photonic components	3, deepening	2024-2025*	2025-2026
5XSD0	Medical ultrasound	3, deepening	2024-2025*	2025-2026

*Course will continue in Bachelor College 2.0 in a similar form. Exams can be taken up to and including academic year 2025-2026.

Course descriptions

Neurophysiology and neurostimulation (5XPC0)

Information processing in the brain is governed by bioelectrical and biochemical processes in and among neurons. These processes can be simulated using electrical networks that model the capacitive properties and dynamic conductive behavior of excitable cell membranes. In this course, such models are used to explain and simulate action potentials (neural spikes), postsynaptic potentials and information conduction across neuronal cell membranes. Next, the scope of the course is extended towards the collective bioelectrical behavior of populations of neurons and the currents they cause in the extracellular space. These currents are the sources of the surface field potentials that can be measured as Electroencephalographic (EEG), Event Related (ERP) and/or Sensory Evoked Potentials (SEP) at the skin using electrodes.

The second part of the course focuses on neurostimulation modalities from an electromagnetic point of view. After a brief recap, Maxwell's equations will be tailored for low-frequency (static/stationary and quasi-static) applications. The electromagnetic power balance will be considered, as well as interaction of electromagnetic fields with human tissue. Regulations for this will also be covered. Next, with the acquired knowledge, various neurostimulation modalities and applications will be covered, such as deep brain stimulation (DBS), transcranial magnetic stimulation (TMS), vagus nerve stimulation (VNS), and transcranial electric current stimulation (tDCS, tACS). For all of these, the working principles, equipment, efforts in field modeling and, stimulation protocols will be detailed.

Electronic and photonic components (5XCB0)

In this course an introduction will be given into electronic and photonic components which are used in several applications. Key electronic components in medical applications will be discussed in detail, including:

- Refresh relevant basic knowledge
- Hands-on: introduction software for simulation of circuits and simple assignments to get familiar with the basics
- Advanced fundamentals of CMOS devices: physics, sub-threshold behavior, noise, max gm/Id
- Amplifier basics (e.g. gain, BW, noise, power)
- Hands-on: experiments with device behavior and basic amplifier simulations
- Low-power principles for modern electronic circuit design
- Amplifier support circuits (e.g. CM feedback, biasing)
- Hands-on: amplifier optimization (e.g. stability, CM feedback, biasing, ...)
- Advanced amplifier techniques (e.g. chopping, positive feedback, DSL)
- Hands-on: implementation of advanced amplifier techniques
- Hands-on: Evaluation of total system: optical part + designed amplifier

Next to this, the course will give an introduction into photonics, including geometrical optics, imaging systems and various photonic techniques in the field of health. This includes applications in optical coherence tomography and microscopy imaging techniques. A hands-on lab assignment is included in which the students will design an optical sensor with an electronic amplifier.

Medical Ultrasound (5XSD0)

The basic principles of ultrasound sonography (also known in Dutch as 'echografie') are discussed. This includes generation and propagation of ultrasound pressure waves, Doppler effect, and electro-mechanical conversion. Furthermore, basic image formation topics, such as beamforming, scan-conversion, and filtering will be discussed. Medical applications will be investigated in hands-on assignments and a short sonography practical training will be given. The field of medical ultrasound is experiencing a revolutionary period, and new advanced solutions are emerging for quantitative functional imaging. The latest developments, such as ultrafast imaging by plane/diverging waves, elastography, contrast-enhanced ultrasound, and photo-acoustics, will also be presented and discussed.