T-860-IMAG **MEDICAL IMAGING AND MODELLING** **6 ECTS**

Year of study: 4th year (1st year MSc).
Semester: Fall.
Level of course: 5. Second cycle, intermediate.
Type of course: Core for MSc Biomedical Engineering.
Prerequisites: BSc degree in biomedical engineering. That means adequate coverage of mathematics, physics including modern physics and physiology. Students should also have knowledge in electrical theory, electronics, automatic control theory, computers and signal processing.
Schedule: Runs for 12 weeks – 6 teaching hours a week.
Supervisor: Þórður Helgason.
Lecturer: Þórður Helgason.

Learning outcome: At the end of the course the student should
• have a thorough understanding of the tomography image reconstruction methods.
• know the functional principle of computer tomography devices.
• know the functional principle of magnetic resonance imaging devices.
• have a thorough understanding of the functional principle of positron emitting tomography devices (PET), running cost and clinical advantage.
• have a thorough understanding of the functional principle of ultrasound imaging, running cost and clinical advantage.
• know to a thorrough dept the technique of own choose and corresponding devices in the frame of PET or ultrasound imaging.
• have exercised the assembly of a CT device.
• be able to choose components and assemble a simple computer tomographic device.
• have exercised the use of image reconstruction algorithms.
• be able to estimate the quality of slice images and see ways to improve them.
• have exercise in estimating technical properties of tomographic images.
• know the basics of ultrasound current source imaging, be able to estimate what technology is necessary for its realisation and its diagnostic and monitoring possibilities.
• know the procedures of taking imaging data and convert into 3D model.
• know how material properties of bone can be extracted from a calibrated CT image.

Content: The main theme in imaging is tomography as realised in computer tomography (CT), magnetic resonance imaging (MR), positron emitting tomography (PET) and ultrasound imaging. Emphasis is on sensors, methods and algorithms for image reconstruction, and the architecture of the devices.Students choose two projects they deliver towards the end of the semester. One project is in the field of imaging and the other in modelling. The former will be delivered by a report, lecture slides and a 30 minutes lecture. The latter is a modelling project and deliverables are ??? The goal is that the student acquires a thorough understanding of his own theme and a good understanding of the themes of his fellow students. In the imaging the assignment can be in the frame of positron emitting tomography (PET) or in ultrasound imaging technology. Every student takes one aspect of the imaging chain and in summary the reports should give a good understanding of PET and ultrasound imaging. The later assignment is in the frame of modelling. Its purpose is to train FEA methods and to demonstrate how going from CT/MRI scans to a 3D model to a finite element model can be achieved. Ultrasound current source density imaging is an emerging technology, technology in development. This is an attempt to investigate the future.

All course descriptions may be subject to change. Revised information on the course schedule, reading material, teaching and learning activities, and assessment methods will be introduced in the learning management system Canvas at the beginning of the semester.

The fundamental physics of the method are covered, main properties and the need for technological developments. Then the possibilities in diagnostic and therapy monitoring will be discussed. Loadstar of the coverage is how physiology, physics, mathematics and electronic are applied to define the system and used for its design.

Reading material: The book from John Enderle and Joseph Bronzino: *Introduction to Biomedical Engineering,* latest edition, serves as basic literature. Students and teacher will gather new articles representing the forefront of each technique in order to capture the state of the art in each field. This is especially important in fast evolving areas medical imaging. Students are encouraged to make a thorough literature search for their chosen projects and list them in their references. Other literature: 1) John Enderle, Joseph Bronzino, ed, *Introduction to Biomedical Engineering*, Third Edition, Academic Press, 2012. 2) John G. Webster, ed. *Medical Instrumentation, Application and Design*, John Wiley and Sons, 2010.
Teaching and learning activities: Lectures, problem-oriented classes, projects, and visits.
Assessment methods:
1. Exercise of the week. To acquire right to take the final exam at least 80% of the exercises of the week have to be finished with a minimum average grade of 6,0. That is four out of five.
2. Assignments – 30%. Two assignments are done in the semester. The former assignment is about one subject common to all students, Ultrasound imaging. Each student works on one aspect of the subject, and delivers his report on that, but all students work on the same subject and can share work and information. The later assignment is in modelling and will be done during that part of the course. The first assignment on a common subject weights 20% and the later individual assignment weights 10% in the final grade.
3. Practical exercise - 20%. One practical exercise will be done during the semester. See exercise description.
4. Oral exam - 50 %. In the end of the semester. The oral exam has to be successful, meaning grade 6,0 or higher, in order to have the above items accounted – 50%.

Language of instruction: English.