

Biomedical Acoustics (E022030)

Course size (nominal values; actual values may depend on programme)

Credits 6.0 Study time 180 h Contact hrs 67.5 h

Course offerings and teaching methods in academic year 2018-2019

A (semester 2)	English	demonstration	5.0 h
		self-reliant study	17.5 h
		activities	
		lecture	30.0 h
		seminar	5.0 h

Lecturers in academic year 2018-2019

Botteldooren, Dick	TW05	lecturer-in-charge
Verhulst, Sarah	TW05	co-lecturer

Offered in the following programmes in 2018-2019

	crdts	offering
Master of Science in Biomedical Engineering	6	A
International Master of Science in Biomedical Engineering	6	A
Master of Science in Biomedical Engineering	6	A
Master of Science in Engineering Physics	6	A

Teaching languages

English

Keywords

Acoustics, sound, diagnostic ultrasound, therapeutic ultrasound, human auditory system

Position of the course

Enhance physical insight in a number of advanced acoustical phenomena, particularly in the context of classical and innovative biomedical applications where acoustics play a crucial role.

Develop skills required to analyse and design acoustical systems focusing on biomedical applications:

- diagnostic ultrasound imaging (commonly known as echography): widely used in clinical practice for a huge range of imaging applications such as foetal imaging, cardiovascular screening, etc...
- therapeutic ultrasound: using the beneficial biological effects of ultrasound for medical treatment, with a wide range of applications going from cancer treatment to physiotherapy, and resolving kidney stones
- the human hearing system: hearing protection devices, hearing aids, advanced hearing diagnostic equipment

The topics treated are chosen to cover all basic problems that an engineer can face during this process.

Contents

1. Physical basis:

- Generic description of acoustic waves: Conservation laws and acoustic waves
- Sound in fluidum: Linear acoustics, macro-acoustics and shock waves, moving fluidum, influence of viscosity and heat conduction, moving fluidum, cavitation and bubbles
- Sound in solids and soft tissue: Dispersive media, anisotropic media
- Coupled media: Surface impedance, fluid loading and radiation efficiency, surface waves, porous materials

2. Application oriented:
 - Diagnostic ultrasound: image acquisition techniques scattering of ultrasound waves in biological media
 - Therapeutic ultrasound: hyperthermia and high-intensity focused ultrasound (cancer treatment), lithotripsy (mechanically resolving kidney stones), drug delivery bubbles
 - Human auditory system: outer and middle ear acoustics, inner ear dynamics, otoacoustic emission, neural sound processing

Initial competences

Basis wave physics

Final competences

- 1 Students understand the acoustical phenomena that underly biomedical applications. In particular en thorough understanding in acoustic waves, eigenmodes, diffraction, scattering, interference, dispersion and distortion.
- 2 Students can formulate wave equations and boundary conditions for a wide variety of acoustical phenomena including equivalent impedances and can solve these equations analytically for simple situations. They can identify and use the best available numerical techniques to solve wave equations including dispersion, non) linearity and anisotropy.
- 3 Students have a thorough understanding in diagnostic use of ultrasound: scattering in tissue and generation of ultrasonic beams for medical imaging.
- 4 Students have a thorough understanding in therapeutic use of ultrasound: physical processes leading to heating and medication delivery.
- 5 Students have a thorough understanding of the human auditory system and the physical processes of medical applications in this area.
- 6 Students have obtained the skills to innovate and further develop biomedical applications of sound.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Demonstration, lecture, seminar, self-reliant study activities

Extra information on the teaching methods

During lectures various theoretical concepts will be introduced with a strong focus on applications, mainly biomedical in nature.
 Computer simulations are used to demonstrate how the applications can be optimized.
 Exercises are prepared at home and discussed in the group.
 A demonstration of operational medical equipment is foreseen.

Learning materials and price

Slides, (e-)book chapters, publications

References

See course material

Course content-related study coaching

Evaluation methods

end-of-term evaluation and continuous assessment

Examination methods in case of periodic evaluation during the first examination period

Written examination, open book examination, oral examination

Examination methods in case of periodic evaluation during the second examination period

Written examination, open book examination, oral examination

Examination methods in case of permanent evaluation

Assignment

Possibilities of retake in case of permanent evaluation

examination during the second examination period is possible in modified form

Extra information on the examination methods

During examination period: oral open-book exam, written exercise
 During semester: graded project reports, contribution to tasks.

Calculation of the examination mark

Activities during the semester count for 25%