Zachodniopomorski Uniwersytet Technologiczny w Szczecinie

Faculty of Electrical Engineering

FACULTY OF ELECTRICAL ENGINEERING

COURSES OFFER
ACADEMIC YEAR 2015/2016

http://www.we.zut.edu.pl/erasmus/

FACULTY OF ELECTRICAL ENGINEERING				
Course code (if applicable)	**Course title**	**Person responsible for the course**	**Semester** (winter/ summer)	**ECTS points**
WEL_1	**Active Infrared Thermography**	Barbara Szymanik	winter/ summer	2
WEL_2	**Advanced Biosignal Processing and Analysis**	Krzysztof Penkala	winter/ summer	4
WEL_3	**Advanced methods of image reconstruction in medical diagnostic systems**	Wojciech Chlewicki	winter/ summer	4
WEL_4	**Advanced Methods of Speech Processing and Transmission**	Jerzy Sawicki	winter/ summer	4
WEL_5	**Application Specific Integrated Circuits (ASICs)**	Krzysztof Penkala	winter	4
WEL_6	**Artificial Intelligence In Automation and Robotics**	Krzysztof Jaroszewski	summer	2
WEL_7	**ASIC&DSP in Biomedical Applications**	Witold Mickiewicz, Krzysztof Penkala	winter/ summer	4
WEL_8	**Basics of Power Electronics**	Marcin Hołub	winter/ summer	4
WEL_9	**Biomedical Engineering**	Krzysztof Penkala	winter/ summer	3
WEL_10	**Biomedical Imaging –equipment, image processing and analysis**	Krzysztof Penkala, Wojciech Chlewicki	winter/ summer	3
WEL_11	**Biomedical Signal Processing and Analysis**	Krzysztof Penkala Joanna Górecka	winter/ summer	3
WEL_12	**Biomedical Technology Equipment**	Krzysztof Penkala Joanna Górecka	summer	4
WEL_13	**Computer Animation**	Przemysław Mazurek	winter/ summer	4
WEL_14	**Computer Graphics and Visualisation**	Krzysztof Okarma	winter/ summer	4
WEL_15	**Computer Networks**	Piotr Lech	summer	4
WEL_16	**Computer Vision and Image Processing**	Krzysztof Okarma	winter/ summer	6
WEL_17	**Control of Electric Drives**	Marcin Hołub	winter/ summer	4
WEL_18	**Control of Mobile Robots**	Adam Łukomski	winter/ summer	2
WEL_19	**Digital Technique**	Krzysztof Penkala	winter	4
WEL_20	**Electromagnetic Methods of Non-destructive Testing**	Tomasz Chady	winter	6
WEL_21	**EM fields effects in living organisms**	Michał Zeńczak	winter/ summer	4
WEL_22	**Elements of Psychoacoustics and Electroacoustics**	Witold Mickiewicz	winter/ summer	4
WEL_23	**Evolution of cellular networks, 2G, 3G, LTE, LTE-A**	Jakub Borkowski	winter	3

WEL_24	**Fundamentals of Engineering Electromagnetics**	Stanisław Gratkowski	winter/ summer	3
WEL_25	**Grundlagen der Elektrotechnik**	Konstanty Gawrylczyk	winter	6
WEL_26	**High Voltage Engineering**	Szymon Banaszak	winter	4
WEL_27	**Introduction to Electric Circuits 1**	Tomasz Chady	summer	4
WEL_28	**Introduction to Electric Circuits 2**	Tomasz Chady	winter	6
WEL_29	**Introduction to Electroacoustics**	Witold Mickiewicz	summer	4
WEL_30	**Introduction to Multisensor Data Fusion**	Grzegorz Psuj	winter/ summer	2
WEL_31	**Medical Imaging Systems**	Krzysztof Penkala	winter/ summer	3
WEL_32	**Medical Informatics**	Krzysztof Penkala	winter/ summer	3
WEL_33	**Modelling of EM Fields in Human Body**	Stanisław Gratkowski	winter/ summer	4
WEL_34	**Modern Electrical Machines**	Ryszard Pałka	winter/ summer	6
WEL_35	**Movie Special Effects**	Przemysław Mazurek	winter/ summer	4
WEL_36	**Network Systems Administration**	Piotr Lech	winter	4
WEL_37	**Nonlinear Control**	Adam Łukomski	winter/ summer	3
WEL_38	**Optimization Theory**	Marcin Ziółkowski	winter/ summer	4
WEL_39	**Power Electric Engineering**	Michał Balcerak	winter/ summer	4
WEL_40	**Power Electronics for Renewable Energy Sources**	Marcin Hołub	winter/ summer	3
WEL_41	**Programmable Logic Devices**	Witold Mickiewicz	winter	4
WEL_42	**Radiographic Nondestructive Testing**	Marcin Ziółkowski	winter/ summer	1
WEL_43	**Sound Engineering**	Witold Mickiewicz	winter	4
WEL_44	**Sound System Design**	Witold Mickiewicz	winter/ summer	4
WEL_45	**Telemedicine, IT&T in Health Care**	Krzysztof Penkala	winter/ summer	3
WEL_46	**Terahertz Technique**	Przemysław Łopato	winter/ summer	2
WEL_47	**Ultrasonic Nondestructive Testing**	Marcin Ziółkowski	winter/ summer	1
WEL_48	**Visual Programming in LabVIEW**	Paweł Dworak	winter	3
WEL_49	**B.Sc. Thesis**	Depends on the subject of the thesis	winter/ summer	15
WEL_50	**M.Sc. Thesis**	Depends on the subject of the thesis	winter/ summer	20

Basics of Electrical Engineering

Course code (if applicable)	Course title	Person responsible for the course	Semester (winter/ summer)	ECTS points
WEL_26	High Voltage Engineering	Szymon Banaszak	summer	4
WEL_24	Fundamentals of Engineering Electromagnetics	Stanisław Gratkowski	summer	3
WEL_27	Introduction to Electric Circuits 1	Tomasz Chady	summer	4
WEL_17	Control of Electric Drives	Marcin Hołub	summer	4

WEL_8	Basics of Power Electronics	Marcin Hołub	summer	4
WEL_34	Modern Electrical Machines	Ryszard Pałka	summer	6

Introduction to ICT

Course code (if applicable)	Course title	Person responsible for the course	Semester (winter/ summer)	ECTS points
WEL_41	Programmable Logic Devices	Witold Mickiewicz	winter	4
WEL_19	Digital Technique	Krzysztof Penkala	winter	4
WEL_48	Visual Programming in LabVIEW	Paweł Dworak	winter	3
WEL_16	Computer Vision and Image Processing	Krzysztof Okarma	winter	6
WEL_15	Computer networks	Piotr Lech	winter	4
WEL_36	Network Systems Administration	Piotr Lech	winter	4

BIO

Course code (if applicable)	Course title	Person responsible for the course	Semester (winter/ summer)	ECTS points
WEL_5	Application Specific Integrated Circuits (ASICs)	Krzysztof Penkala	winter	4
WEL_9	Biomedical Engineering	Krzysztof Penkala	winter	3
WEL_11	Biomedical Signal Processing and Analysis	Krzysztof Penkala Joanna Górecka	winter	3
WEL_12	Biomedical Technology Equipment	Krzysztof Penkala Joanna Górecka	winter	4
WEL_19	Digital Technique	Krzysztof Penkala	winter	4
WEL_31	Medical Imaging Systems	Krzysztof Penkala	winter	3

Course title	**ACTIVE INFRARED THERMOGRAPHY**		
Teaching method	Lectures with simple experiments, project – computer simulations, experiments		
Person responsible for the course	Barbara Szymanik	**E-mail address to the person responsible for the course**	szymanik@zut.edu.pl
Course code (if applicable)	WEL_1	**ECTS points**	2
Type of course	Obligatory	**Level of course**	master
Semester	Winter or summer	**Language of instruction**	English

Hours per week	1L/1Project, other organization is possible)	**Hours per semester**	15L/15Project
Objectives of the course	This course is intended to present the basics of active infrared thermography. Simple examples of applications are also provided.		
Entry requirements	Mathematics, physics		
Course contents	Introduction to thermal emission: blackbody, Plank's law, Wien displacement law, Stefan-Boltzmann law, reflection, emission, transmission, emissivity. Introduction to heat transfer: Fourier law of conduction, conduction heat transfer, radiation heat transfer, convection heat transfer. Infrared sensors. Active thermography: pulsed thermography, stepped heating, lock-in thermography. Energy sources: microwave heating, halogen lamps heating, induction heating. Computer aided analysis of electromagnetic and thermal fields: finite element method. Methodology of experiments.		
Assessment methods	Lectures – oral exam; project – continuous assessment		
Learning outcomes	After the course student will be able to: - list and explain the basic laws connected with infrared radiation theory and heat transfer theory, - compare and critique the different methods of active thermography, - assess the possibility of usage the chosen active thermography method in real life problem, - design the models for computer aided analysis of thermal field, - perform the basic experiments using the active thermography method.		
Recommended readings	1. M Vollmer and K. P. Möllmann. *Infrared themal imaging. Fundamenals, research and applications*. Wiley-VCH Verlag GmbH & Co., 2010 2. W. Minkina. *Infrared thermography: errors and uncertainties*. John Wiley and Sons, 2009 3. X. Maladegue. *Theory and practice of infrared technology for nondestructive testing*. JohnWiley and Sons, 2001		
Additional information			

Course title	**APPLICATION SPECIFIC INTERGRATED CIRCUITS (ASICs)**		
Teaching method	lectures, labs		
Person responsible for the course	Krzysztof Penkala	**E-mail address to the person responsible for the course**	Krzysztof.Penkala@zut.edu.pl
Course code (if applicable)	WEL_5	**ECTS points**	4
Type of course	compulsory	**Level of course**	bachelor
Semester	winter	**Language of instruction**	English
Hours per week	1 L / 2 Lab	**Hours per semester**	15 L / 30 Lab
Objectives of the course	To provide knowledge on programmable logic devices (CPLD, FPGA) and to develop skills in analysis, testing and designing digital circuits and systems in PLD technology, using product data sheets, application notes as well as CAE systems		

Entry requirements	Mathematics, Informatics, Fundamentals of semiconductor electronics, Digital technique
Course contents	Lectures: ASICs, PLDs – classification, development of architecture and technology. Review and comparison of CPLDs and FPGAs of some manufacturers. ISP and ICR programming and testing, Boundary Scan Test, JTAG standard. Cost-of-Ownership analysis for ISP modules. A systematic approach to digital system design, functional decomposition. Review of CAE systems, introduction to VHDL. Examples of ASICs, particularly used in telecommunications, computer, audio-video and biomedical equipment. Labs: Designing and testing sample digital circuits and systems, implementation in CPLDs and FPGAs (Xilinx) with support of CAE systems
Assessment methods	Written exam, accomplishment of practical lab tasks
Learning outcomes	The student has knowledge on programmable logic devices (CPLD, FPGA), on their architectures, technologies and applications. He has skills in the field of analysis, testing and designing digital circuits and systems in CPLD & FPGA structures as well as programming the modules, using product data sheets, application notes as well as dedicated software tools (CAE systems)
Recommended readings	1. Nelson V. P., Nagle H. T., Carroll B. D., Irwin I. D.: "Digital Logic Circuit Analysis and Design". Prentice Hall, New Jersey, 1995 2. Perry D. L.: "VHDL". McGrawHill, 1997 3. Oldfield J. V., Dorf R. C.: "FPGAs. Reconfigurable Logic for Rapid Prototyping and Implementation of Digital Systems". John Wiley&Sons, Inc., N.Y., 1995 4. Sunggu Lee: "Design of computers and other complex digital devices". Prentice Hall, 2000 5. Xilinx data sheets and programmer literature at www.xilinx.com
Additional information	

Course title	**ARTIFICIAL INTELLIGENCE IN AUTOMATION AND ROBOTICS**		
Teaching method	Lecture, laboratory		
Person responsible for the course	Krzysztof Jaroszewski	**E-mail address to the person responsible for the course**	kjaroszewski@zut.edu.pl
Course code (if applicable)	WEL_6	**ECTS points**	2
Type of course		**Level of course**	bachelor
Semester	summer	**Language of instruction**	English
Hours per week	1 L / 1 Lab	**Hours per semester**	15 L / 15 Lab
Objectives of the course	Basic knowledge about artificial intelligence with special focus on genetic algorithms, neural networks and fuzzy logic. Student achieve competence of using mentioned methods in task of optimization, modeling, control, recognition and classification – Matlab environment.		
Entry requirements	Mathematics		

Course contents	Perceptron – decisive boundary. Multilayer neural network – backpropagation learning algorithm. Recursive neural networks. Selection, crossing and mutation – steps and genetic operators. Membership functions, rules editing, fuzzyfication and defuzzyfication, concluding in expert and fuzzy systems.
Assessment methods	Grade Project work
Learning outcomes	Ability to define basic subjects connected with artificial intelligence. Skills in implementing and using proper method of artificial intelligence.
Recommended readings	1. Artificial Intelligence: A Modern Approach, Stuart Russell, Peter Norvig, ISBN 0136042597 2. Artificial Intelligence, Patrick Henry Winston, ISBN: 0201533774 3. Artificial Intelligence: A New Synthesis, Nils J. Nilsson, ISBN: 1558604677
Additional information	Max 12 persons.

Course title	**BASICS OF POWER ELECTRONICS**		
Teaching method	lecture / project / laboratory		
Person responsible for the course	Marcin Hołub	**E-mail address to the person responsible for the course**	mholub@zut.edu.pl
Course code (if applicable)	WEL_8	**ECTS points**	4
Type of course	Obligatory or optional	**Level of course**	bachelor
Semester	winter / summer	**Language of instruction**	English
Hours per week	1L/2Lab/2Project	**Hours per semester**	15 L 30 Project 30 Lab.
Objectives of the course	Student will be able to: - distinguish basic types of power semiconductors. - calculate basic losses and cooling requirements. - distinguish basic rectifier topologies and their main properties, - draw basic waveforms for different types of loads. - distinguish basic types of AC/AC converters. - give basic properties and characteristics for main types of switched mode power supplies. - perform basic calculations for main circuit components and adjust component type and kind. - use CAD software for basic simulations and basic types of projects. - perform basic project for a small scale power converter. - analyze basic structures of power converters.		
Entry requirements	Electronics, basics of electrical engineering		

Course contents	Power electronics: past and present, perspectives, connections with other technical branches Semiconductor power devices: thyristors (SCR, GTO, IGCT), power transistors (BJT, MOSFET, IGBT). Power modules. ontrol of semiconductor power devices, power transistor driving stages Static and dynamic losses of power semiconductors. Thermal characteristics, cooling methods. Over-voltage, over-current and short-circuit protection systems Rectifiers – one phase, three phase. Characteristics under resistive, RL and RLE load. Controlled rectifiers – thyristor rectifiers with the 4T and 6T topology. Characteristics under resistive, RL and RLE load. Hard switching DC/DC choppers, single and three-phase. Boost and buck/boost converters, smps systems topologies, basics of magnetics and design of chokes and HF transformers. Transistor inverters – single and three-phase topology. Methods of voltage and current shaping (PWM,SVM, harmonics elimination). Special converters (PFC, E-class). Electric drive converter systems, power electronics for photovoltaic and wind energy conversion.
Assessment methods	Written tests Project work assessment Laboratory reports
Learning outcomes	Ability to distinguish properties of power semiconductors. Ability to define and measure basic waveforms and characteristics of AC/DC, AC/AC, DC/DC and DC/AC converters. Ability to analyze and choose converter topology. Basic knowledge on converter construction. Basic knowledge on converter simulation.
Recommended readings	1. K. Billings, T. Morey "Switching power supply design", ISBN 978-0-07-148272-1McGrawHill 2009 2. K. Billings "Switchmode power supply handbook", ISBN 0-07-006719-8McGrawHill 1999 3. M. H. Rashid, "Power Electronics Handbook", Elsevier 2007, ISBN-13: 978-0-12-088479-7
Additional information	

Course title	**BIOMEDICAL ENGINEERING**		
Teaching method	lectures, labs (also in hospitals)		
Person responsible for the course	Krzysztof Penkala	**E-mail address to the person responsible for the course**	Krzysztof.Penkala@zut.edu.pl
Course code (if applicable)	WEL_9	**ECTS points**	3
Type of course	compulsory	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	2L/2Lab	**Hours per semester**	30L/30Lab
Objectives of the course	To provide up to date knowledge on Biomedical Engineering as an inter-disciplinary field and to develop practical skills useful in this area		
Entry requirements	Mathematics, Physics, Informatics, Electronics		

Course contents	Lectures: Biomedical Engineering as an inter-disciplinary field: definitions, links with other biomedical sciences. Biosystems, biomaterials, biomechanics – overview. Biomeasurements, biomedical instrumentation, biosignal acquisition, processing and analysis. Equipment: ECG, EEG, EMG, ENG, ERG/VEP etc. Medical imaging systems: physical principles of image formation, equipment: TG, DR, DSA, CT, MRI, USG, Nuclear Medicine (SPECT, PET) etc. Medical informatics and telematics, IT in e-Health. Electronic patient record. Computer aided medical diagnosis. Systems and standards: HIS, PACS and HL 7, DICOM 3, problems of systems integration and interoperability. Assessment of emerging biomedical technologies Labs: Biosignals and biomeasurements: biosignal acquisition, processing and analysis using specialized equipment and software tools: MATLAB, IDL, LabView. Demonstration of medical equipment in hospitals, e.g. imaging systems
Assessment methods	Written exam, accomplishment of lab tasks
Learning outcomes	The student has knowledge on Biomedical Engineering as an inter-disciplinary field, on main problems of BME as well as on research methodology and standards used in this area. He has practical skills useful in the field of biomedical technologies regarding their development and assessment
Recommended readings	1. Bronzino J. D. (ed.): "Biomedical Engineering Handbook". CRC Press, IEEE Press, 1995 2. Bemmel, van J. H., Musen M. A.: "Handbook of Medical Informatics". Bohn Stafleu Van Loghum, Springer, 1997 3. Christensen D. A.: "Ultrasonographic Bioinstrumentation". J. Wiley & Sons, N.Y., 1988 4. Huang H. K.: "PACS in Biomedical Imaging". VCH Publ. Inc., N.Y., 1996
Additional information	

Course title	**BIOMEDICAL SIGNAL PROCESSING AND ANALYSIS**		
Teaching method	lectures, labs (also in hospitals)		
Person responsible for the course	Krzysztof Penkala Joanna Górecka	**E-mail address to the person responsible for the course**	Krzysztof.Penkala@zut.edu.pl
Course code (if applicable)	WEL_11	**ECTS points**	3
Type of course	compulsory	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	2L/1Lab	**Hours per semester**	30L/15Lab
Objectives of the course	To provide up to date knowledge on methods and techniques used in acquisition, processing and analysis of biosignals and to develop practical skills useful in this field		
Entry requirements	Mathematics, Physics, Informatics, Electronics, Signal theory, Signal processing, Biomedical Engineering		

Course contents	**Lectures:** Biosignals: definitions, classification. Bio-measurements: (bio)sensors, electrodes, transducers, amplifiers. Methods and techniques of biosignal acquisition, processing and analysis. Electrophysiology systems: ECG, EEG, EMG, ENG, ERG/VEP etc. Biosignal analysis in time and frequency domain: spectral analysis, FFT, STFT, time-frequency analysis, Wavelet Transformation. Methods of statistical biosignal analysis. MATLAB, IDL, LabView environments in biosignal processing and analysis, dedicated toolboxes. Examples of advanced ECG, EEG, ERG/VEP processing and analysis **Labs:** Biosignals and bio-measurements: biosignal acquisition, processing and analysis using specialized equipment (sensors, transducers, amplifiers etc.) and software tools: MATLAB, IDL, LabView. Bioelectrical signals mapping: TBM, mfERG and mfVEP systems. MATLAB, IDL and LabView systems in biosignals processing. Demonstration of diagnostic equipment (mainly electrophysiological) in hospitals
Assessment methods	Lectures: grade, accomplishment of lab tasks
Learning outcomes	The student has knowledge on methods and techniques used in acquisition, processing and analysis of biomedical signals as well as on research methodology used in this field. He has practical skills useful in this area regarding bio-measurements (instrumentation, specialized software tools)
Recommended readings	1. Bronzino J. D. (ed.): "Biomedical Engineering Handbook". CRC Press, IEEE Press, 1995 2. Shortliffe E. H., Perreault L. E.: "Medical informatics. Computer applications in Health Care". Addison-Wesley Publ. Comp., Readng, Mass., 1990 3. Oppenheim, A.V. and Schafer W.: "Discrete-time signal processing". Prentice Hall, 1999 4. Qian S., Chen D.: "Joint time-frequency analysis. Methods and applications". Prentice-Hall, 1996 5. Vetterli M., Kovacevic J.: "Wavelets and subband coding". Prentice Hall, 1996 6. IT-EDUCTRA. FUNDESCO, Commission of the EC, 1998
Additional information	

Course title	**BIOMEDICAL TECHNOLOGY EQUIPMENT**		
Teaching method	lectures, labs (also in hospitals)		
Person responsible for the course	Krzysztof Penkala Joanna Górecka	**E-mail address to the person responsible for the course**	Krzysztof.Penkala@zut.edu.pl
Course code (if applicable)	WEL_12	**ECTS points**	4
Type of course	compulsory	**Level of course**	bachelor
Semester	Winter/summer	**Language of instruction**	English
Hours per week	2L/2Lab	**Hours per semester**	30L/30Lab
Objectives of the course	To provide basic knowledge on Biomedical technology: instrumentation, equipment, software, specialized systems, and to develop practical skills useful in this area of engineering		
Entry requirements	Mathematics, Physics, Informatics, Electronics		

Course contents	Lectures: Biomedical Engineering as an inter-disciplinary science. Biomeasurements, biomedical instrumentation, biosignals (1-D, 2-D) acquisition, processing and analysis. Equipment: ECG, EEG, EMG, ERG/VEP etc. Medical imaging systems: TG, DR, DSA, CT, MRI, USG, Nuclear Medicine etc. Medical telematics, IT in e-Health. Computer aided medical diagnosis. Hospital Information Systems (HIS), PACS, overview of standards: HL 7, DICOM 3, systems integration and interoperability. Assessment of biomedical devices and technologies Labs: Biosignals and biomeasurements. Biosignal acquisition, processing and analysis using specialized transducers, amplifiers, equipment and software tools: MATLAB, IDL, LabView. Demonstration of medical equipment in hospitals (e.g. imaging systems)
Assessment methods	Lectures: grade, accomplishment of lab tasks
Lerning outcomes	The student has basic knowledge on Biomedical technology (instrumentation, equipment, software, specialized systems and standards used in this field). He has practical skills useful in the area of Biomedical technologies regarding their development, implementation, exploitation and assessment
Recommended readings	1. Bronzino J. D. (ed.): "Biomedical Engineering Handbook". CRC Press, IEEE Press, 1995 2. Bemmel, van J. H., Musen M. A.: "Handbook of Medical Informatics". Bohn Stafleu Van Loghum, Springer, 1997 3. Christensen D. A.: "Ultrasonographic Bioinstrumentation". J. Wiley & Sons, N.Y., 1988 4. Huang H. K.: "PACS in Biomedical Imaging". VCH Publ. Inc., N.Y., 1996
Additional information	

Course title	**COMPUTER ANIMATION**		
Teaching method	Lecture / laboratory / project		
Person responsible for the course	Przemyslaw Mazurek	**E-mail address to the person responsible for the course**	przemyslaw.mazurek@zut.edu.pl
Course code (if applicable)	WEL_13	**ECTS points**	4
Type of course	obligatory / optional (depending on chosen speciality)	**Level of course**	bachelor
Semester	winter or summer	**Language of instruction**	English
Hours per week	2L/2Project	**Hours per semester**	30 L / 30 Project
Objectives of the course	This course is intended to present fundamental techniques in computer animation		
Entry requirements	Fundamentals of computer engineering, computer visualization		
Course contents	3D modeling techniques. Computer animation techniques: key frames, morphing, bones including skinning. Particle systems. Rendering techniques. Lighting. Texturing including UV maps. 3D model generation using dedicated tools. Motion capture techniques.		

Assessment methods	Written exam (test), project work / continuous assessment (laboratory)
Learning outcomes	Knowledge about 3D modeling and computer animation applied techniques.
Recommended readings	• Blender tutorials • 3DS max tutorials • Vue tutorials
Additional information	Blender / 3DS MAX selectable Selected topics in Vue 6

Course title	**COMPUTER GRAPHICS AND VISUALISATION**		
Teaching method	Lecture / laboratory / project		
Person responsible for the course	Krzysztof Okarma	**E-mail address to the person responsible for the course**	okarma@zut.edu.pl
Course code (if applicable)	WEL_14	**ECTS points**	4
Type of course	optional	**Level of course**	bachelor
Semester	winter or summer	**Language of instruction**	English
Hours per week	2Lecture / 2Project	**Hours per semester**	30 Lecture / 30 Project
Objectives of the course	This course is intended to present fundamental algorithms in computer graphics as well as some advanced techniques used in image synthesis		
Entry requirements	Fundamentals of computer engineering, mathematics (a short introduction to 3-D geometry is provided)		
Course contents	Digital image – classes, representations and conversion methods. Characteristics and parameters of computer images. Raster and vector graphics. Methods of line drawing in raster computer graphics. Bresenham's algorithm. Polygon triangulation methods. Techniques of area's filling in raster images. Geometric operations on raster images in two-dimensional and 3-D spaces. Visualisation of 3-D figures. Field of view. Virtual camera model used in computer graphics. Algorithms for surfaces' visibility detection. Depth buffer. Texturing methods. Modelling of smooth shapes and surfaces. Applications of fractals in computer graphics. Data structures used in computer graphics. Methods of colours' representing (colour spaces). Graphic file formats. OpenGL standards – specification and properties. 3-D images synthesis methods. Light modelling and shading methods. Ray-tracing and radiosity methods in computer visualisation.		
Assessment methods	Written exam (test) / project work		
Learning outcomes	Knowledge of fundamentals of computer graphics. Ability to utilize some computer graphics algorithms and/or applications for computer visualisation purposes.		

Recommended readings	1. Foley J.D. et al: An Introduction to Computer Graphics. Addison-Wesley, 2000. 2. Pavlidis T.: Algorithms for Graphics and Image Processing, Computer Science Press, Rockville, 1982. 3. Yun Q. Shi, Huifang Sun: Image and Video Compression for Multimedia Engineering - Fundamentals, Algorithms and Standards. CRC Press 2000. 4. Ling Guan, Sun-Yuan Kung, Larsen J.: Multimedia Image and Video Processing. CRC Press 2001.
Additional information	

Course title	**COMPUTER NETWORKS**		
Teaching method	Lecture / laboratory		
Person responsible for the course	Piotr Lech	**E-mail address to the person responsible for the course**	Piotr.lech@zut.edu.pl
Course code (if applicable)	WEL_15	**ECTS points**	4
Type of course	obligatory	**Level of course**	bachelor
Semester	Winter/summer	**Language of instruction**	English
Hours per week	1 L / 2 Lab.	**Hours per semester**	15 L / 30 Laboratory
Objectives of the course	This course introduces the fundamental problems of computer networking, from sending bits over wires to running distributed applications. Topics include error detection and correction, multiple-access, bandwidth allocation, routing, internetworking, reliability, quality of service, naming, content delivery, and security.		
Entry requirements	Prerequisites and additional requirements not specified		
Course contents	Introduction,to Network Models, Protocols and Layering, Physical and Link layers, Retransmissions, Multiple access, Switching , Network layer, Internet working, Routing, Internet protocol suite , Transport layer, Reliability , Congestion Control, DNS, Web/HTTP, Content Distribution, Quality of Service and Real-time Apps Network Security , Client-server and peer-to-peer architectures.		
Assessment methods	Written exam (test), continuous assessment (laboratory)		
Learning outcomes	Knowledge of basic configuration of computer networks and IP networks .Addressing in computer networks. Understanding of layered models in networking.Understanding of protocols' operation.		

Recommended readings	1. Carla Schroder Linux Networking Cookbook O'Reilly Media 2007 ISBN: 978-0-596-10248-7 2. Ciprian Adrian Rusen, 7 Tutorials Network Your Computers & Devices Step by Step Microsoft Press 2010 ISBN: 978-0-7356-5216-3 3. Selected RFC documents.
Additional information	

Course title	**COMPUTER VISION AND IMAGE PROCESSING**		
Teaching method	Lecture + project		
Person responsible for the course	Krzysztof Okarma	**E-mail address to the person responsible for the course**	okarma@zut.edu.pl
Course code (if applicable)	WEL_16	**ECTS points**	6
Type of course	optional	**Level of course**	bachelor
Semester	winter or summer	**Language of instruction**	English
Hours per week	2 Lecture / 2 project	**Hours per semester**	30 Lecture / 30 project
Objectives of the course	This course is intended to present a unified approach to image processing techniques with introduction to image analysis and basics of computer visualisation		
Entry requirements	Basic knowledge of Matlab or Mathcad environments, basic knowledge about programming and signal processing		
Course contents	Digital image – classes, representations and conversion methods. Colour models. Arithmetic and logic operations on digital images. Geometric operations, matrix notation. Digital image acquisition. Local processing and filtration using convolution filters. Methods for reduction of the number of colours. Deformations, bilinear projection and morphing. Frequency-based image processing methods. Histogram and histogram-based operations. Binarization. Morphological operations. Image segmentation. Indexing techniques in image processing. Measuring methods using image analysis. Lossy and lossless image compression standards. Image and video quality assessment methods. Nonlinear filtration of colour images. Photogrammetry and 3D Vision. Applications of machine vision in automation and robotics.		
Assessment methods	Written exam (test) / project work		
Learning outcomes	Knowledge of basic image processing and analysis algorithms. Ability to implement some image processing and basic image analysis algorithms in chosen environment (e.g. Matlab).		

Recommended readings	1. Foley J.D. et al: An Introduction to Computer Graphics. Addison-Wesley, 2000 . 2. Pavlidis T.: Algorithms for Graphics and Image Processing, Computer Science Press, Rockville, 1982. 3. Nelson M.: The Data Compression Book. IDG Books Worldwide, Inc. 2000. 4. Pratt W.K.: Digital Image Processing (2 nd Edition.). Wiley Interscience, New York 1991. 5. Ritter G.X., Wilson J.N.: Handbook of Computer Vision - Algorithms in Image Algebra. CRC Press 1996. 6. Russ J.C.: The Image Processing Handbook. CRC Press 1999.
Additional information	

Course title	**CONTROL OF ELECTRIC DRIVES**		
Teaching method	lecture / laboratory		
Person responsible for the course	Marcin Hołub	**E-mail address to the person responsible for the course**	mholub@zut.edu.pl
Course code (if applicable)	WEL_17	**ECTS points**	4
Type of course	Obligatory	**Level of course**	master
Semester	winter / summer	**Language of instruction**	English
Hours per week	1L/2Lab	**Hours per semester**	15 L /30 Lab.
Objectives of the course	Student will recognize and distinguish basic properties and parameters of DC motors, will be able to construct basic motor models. Will understand cascaded control systems, PI controller operation and basics of controller tuning. Will have an overview of basic properties of PM excited and series and parallel connected DC machines. Students will recognize basic properties, characteristics and types of induction machines (IM and DFIG) as well as types of controllers and control types for induction machines. Students will get familiar with basics of frequency converter operation and parametrization. Students will distinguish scalar and vector control. Students will recognize basic properties of permanent magnet excited machines (PMSM and BLDC) and will be able to draw basic waveforms for BLDC and PM type machines operation. Students will be able to set up a basic control type (torque, speed) and frequency converter operation.		
Entry requirements	Basics of electrical engineering, electric machines, basics of automatic control, power electronics		
Course contents	Overview of basic types of DC machines: auxiallary excited, series and parallel connected. Mechanical characteristics. DC machines: parameters, models. Automatic control rules, controller types, basic definitions. Cascaded control: controller tuning using module and symmetry criterion. Induction machines: construction (IM and DFIG), properties, control types. Basic scalar control: types, voltage control, frequency control. Vector control: axis transformation, voltage based control, Blaschke equations, current based methods. Characteristics and basic properties of different constructions. Control system examples in Matlab and using Simovert drives. PM excited machines: types, basic properties. BLDC control systems, vector control strategies for PMSM motors. Drive systems for automobile applications.		

Assessment methods	Written exam Laboratory reports and written tests
Learning outcomes	Ability to calculate and analyze properties of torque, speed and position controller settings in case of DC – based, Ac – based and PM – based drive systems. Ability to define and analyze parameters of machines and construct a proper machine model. Practical abilities on controller setting influence on drive properties, drive system parametrization, inverter settings.
Recommended readings	1. M. H. Rashid Power Electronics Handbook, Elsevier 2007, ISBN-13: 978-0-12-088479-7 2. Bimal Bose, Power electronics and motor drives, Elsevier 2006, ISBN-13 978-0-12-088405-6 3. Miroslav Chomat: "Electric Machines and Drives", ISBN 978-953-307-548-8, February 2011, Intech 4. Christian Kral and Anton Haumer: "Object Oriented Modeling of Rotating Electrical Machines", Advances in Computer Science and Engineering, ISBN 978-953-307-173-2, publishing date: March 2011, Intech
Additional information	

Course title	**CONTROL OF MOBILE ROBOTS**		
Teaching method	Laboratory course involving simulation of control algorithms for mobile robots, path planning and experimental verification on wheeled mobile robots.		
Person responsible for the course	Adam Łukomski	**E-mail address to the person responsible for the course**	lukomski@zut.edu.pl
Course code (if applicable)	WEL_18	**ECTS points**	2
Type of course	optional	**Level of course**	bachelor
Semester	winter/summer	**Language of instruction**	English
Hours per week	2Lab	**Hours per semester**	30Lab
Objectives of the course	The Student will learn to control various types of mobile robots.		
Entry requirements	Linear control, Dynamic systems, Mathematics		
Course contents	This course covers basic modelling of mobile robots, kinematics and dynamics, nonlinear control design, path planning and trajectory following.		
Assessment methods	Continuous assessment during laboratory course Final project: mobile robot following a path		
Learning outcomes	Ability to create a kinematic and dynamic model of the mobile robot. Ability to create, analyse and implement a model-based control system.		

Recommended readings	1. Murray, Li, Sastry, "A Mathematical Introduction to Robotic Manipulation" 2. Slotine, Li, "Applied Nonlinear Control"
Additional information	

Course title	**DIGITAL TECHNIQUE**		
Teaching method	lectures, lab		
Person responsible for the course	Krzysztof Penkala	**E-mail address to the person responsible for the course**	Krzysztof.Penkala@zut.edu.pl
Course code (if applicable)	WEL_19	**ECTS points**	4
Type of course	compulsory	**Level of course**	bachelor
Semester	winter	**Language of instruction**	English
Hours per week	2L / 2Lab	**Hours per semester**	30L / 30 Lab
Objectives of the course	To provide basic knowledge on digital circuit theory and design and to develop skills in analysis, testing and designing digital circuits using product data sheets as well as application notes		
Entry requirements	Mathematics, Informatics, Fundamentals of semiconductor electronics		
Course contents	Lectures: Analogue versus digital technique. Number systems. Binary codes, BCD codes. Basics of binary arithmetic. Automata, logic circuit, digital circuit – basic definitions. Boolean Algebra, fundamental thorems. Switching (Boolean) functions, simplification, minimisation. Realising logic functions with gates, multiplexers and demultiplexers, ROMs, PLA modules. Digital logic circuit realisation techniques & technologies - overview, comparison, development. Time-dependent circuits, multi-vibrators, generators. Flip-flops, logic description. Fundamentals of digital functional blocks - modules (combinatorial and sequential). Digital control system, logic description – algorithms. Basics of microprogramming technique. Introduction to ASICs, PLD modules – classification, development Labs: Switching functions minimisation. Realising logic functions with gates and different modules. Logic gates testing (switching functions, static and dynamic characteristics). Flip-flops, registers and counters testing. Testing time-dependent circuits, multi-vibrators, generators. Testing arithmetic circuits. Testing memories, input circuits and digital displays. Transmission of digital signals		
Assessment methods	Written exam, accomplishment of practical lab tasks		
Learning outcomes	The student has knowledge on digital circuit theory, methods and techniques of digital circuit analysis and synthesis, as well as digital circuit design. He has skills in the field of analysis, testing and designing digital circuits using product data sheets, application notes as well as dedicated software tools		
Recommended readings	1. Beards P. H.: "Analog and Digital Electronics. A First Course, II ed." Prentice Hall, 1991 2. Nelson V. P., Nagle H. T., Carroll B. D., Irwin I. D.: "Digital Logic Circuit Analysis and Design". Prentice Hall, New Jersey, 1995 3. Burger P.: "Digital Design. A Practical Course". John Wiley & Sons, New York, 1998		

Additional information	

Course title	**ELECTROMAGNETIC METHODS OF NON-DESTRUCTIVE TESTING**		
Teaching method	Lecture and experimental laboratory		
Person responsible for the course	Tomasz Chady Ryszard Sikora Przemysław Łopato Grzegorz Psuj	**E-mail address to the person responsible for the course**	tchady@zut.edu.pl rs@zut.edu.pl plopato@zut.edu.pl gpsuj@zut.edu.pl
Course code (if applicable)	WEL_20	**ECTS points**	6
Type of course	Obligatory	**Level of course**	master
Semester	Winter	**Language of instruction**	English
Hours per week	3L / 2Lab	**Hours per semester**	45L. / 30Lab
Objectives of the course	To teach basics of electromagnetic methods of NDT To teach how to apply specific method in practical applications		
Entry requirements	Academic course of mathematics, physics, Introduction to electric circuits 1 and 2		
Course contents	• Non-destructive testing - the introduction, the basic idea, the historical background • Overview of different methods of non-destructive testing • Transducers for measuring magnetic fields • Non-destructive testing using Barkhausen noise • Method of flux leakage • Eddy current method • Evaluation of low conductivity materials using electromagnetic waves of high frequency • Computer and digital radiography • Numerical modeling in NDT • The algorithms of digital signal processing in NDT • Algorithms for identification in NDT • Data fusion algorithms • Computer systems in NDT • Industrial tomography • Overview of commercial non-destructive testing systems • Standards used in NDT • Laboratory experiments for selected topics.		
Assessment methods	Written exam (Lect.) + Continuous assessment (Lab)		

Learning outcomes	Upon successful completion of this course, the student will be able to: • work independently and collaboratively to understand and formulate problems, and solve these problems using the provided tools and methods, • use THz imaging system, eddy current system, MFL system, computer and digital XRay system, • use in a careful, precise manner the numerical simulator in order to analyze the electromagnetic transducers for NDT, • select appropriate NDT method for specific case, • carry out tests using various NDT equipment, • write reports on laboratory experiments.
Recommended readings	1. Blitz. J., Electrical And Magnetic Methods Of Non-Destructive Testing, Springer-Verlag, 1997 2. Hellier C. J., Handbook of Nondestructive Evaluation, McGrown-Hill, 2003 3. Jiles D. C., Introducting to Magnetism and Magnetic Materials, Springer, 1990 4. Mester M. L., McIntire P, Nondestructive Testing Handbook Volume 4 Electromagnetic Testing, ASNT, 1996
Additional information	

Course title	**EVOLUTION OF CELLURAT NETWORKS, 2G, 3G, LTE, LTE-A**		
Teaching method	Instructor led classroom course (L) with laboratory assignments (Lab).		
Person responsible for the course	Dr inż Jakub Borkowski	**E-mail address to the person responsible for the course**	Jakub.borkowski@zut.edu.pl
Course code (if applicable)	WEL_23	**ECTS points**	3
Type of course		**Level of course**	master
Semester	Winter	**Language of instruction**	English
Hours per week	2 (L), 2 (Lab)	**Hours per semester**	30 (L), 30 (W)
Objectives of the course	The main objective of this course is to present cellular network architecture, evolution trends, strategies and in particular to provide a more detailed walkthrough the 2G, 3G,HSPA,HSPA+, LTE, LTE-A architecture and functionality essentials. The course includes presentation of basic cellular concepts with focus on the radio access network part including multiple-access schemes, physical layer evolution, control- and user-plane information processing flow, functionality essentials,, as well as provide a high level view on the practical network performance audit methods.		
Entry requirements	Digital Communication		
Course contents	Lectures: Cellular network architecture and network elements Functionality of network elements and interfaces RAN interfaces – protocol architecture – general overview Differences between cellular network generations Principles of GSM - physical layer, multiple access, functionality Principles of 3G -- physical layer, multiple access, functionality Principles of LTE - physical layer, multiple access, functionality Overview of LTE-A enhancement features		

	Overall Rollout process - Network monitoring and optimization process Laboratory: Cellular network planning – coverage and capacity planning Network monitoring (monitoring of commercial 2G, 3G, and LTE network)
Assessment methods	Written exam Continuous Assessment (Lab)
Learning outcomes	By the end of this course, students will be able to : -List the major components of the cellular network including 2G, 3G, and LTE systems - Discuss the strategy for cellular network evolution - Present 2G/3G/HSPA/LTE network architecture, physical layer - Discuss major functionality aspects of 2G/3G/HSPA/LTE systems - Present major HSPA+ and LTE-A features and their impact on the network architecture
Recommended readings	1. S. Saunders, A. Zavala „ Antennas and Propagation for Wireless Communication Systems", J.Wiley & Sons Ltd 2. H. Holma, A. Toskala, „WCDMA for UMTS, Third Edition", J. Wiley&Sons Ltd 3. H. Holma, A. Toskala, "LTE for UMTS: Evolution to LTE Advanced, 2nd Edition", J. Wiley&Sons Ltd 4. J. Laiho, A. Wacker, T. Novosad, "Radio Network Planning and Optimisation for UMTS, 2nd Edition
Additional information	

Course title	**FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS**		
Teaching method	Lectures with simple experiments, laboratory – computer simulations		
Person responsible for the course	Stanisław Gratkowski (laboratory – Krzysztof Stawicki)	**E-mail address to the person responsible for the course**	Stanislaw.Gratkowski@zut.edu.pl (Krzysztof.Stawicki@zut.edu.pl)
Course code (if applicable)	WEL_24	**ECTS points**	3
Type of course	Obligatory	**Level of course**	bachelor
Semester	Winter or summer	**Language of instruction**	English
Hours per week	2L/2Lab, other organization is possible)	**Hours per semester**	30L/30Lab
Objectives of the course	This course is intended to present a unified approach to electromagnetic fields (advanced undergraduate level)		
Entry requirements	Mathematics (a knowledge of vector calculus is helpful, but not necessary, since a short introduction to vectors is provided); physics		

Course contents	Electromagnetic field concept. Vector analysis. Electrostatics: Coulomb's law, Gauss's law and applications, electric potential, electric dipole, materials in an electric field, energy and forces, boundary conditions, capacitances and capacitors, Poisson's and Laplace's equations, method of images. Steady electric currents. current density, equation of continuity, relaxation time, power dissipation and Joule's law, boundary conditions. Static magnetic fields: vector magnetic potential, the Biot-Savart law and applications, magnetic dipole, magnetic materials, boundary conditions, inductances, magnetic energy, forces and torques. Time-varying electromagnetic fields and Maxwell's equations: Faraday's law, Maxwell's equations, potential functions, time-harmonic fields, Poynting's theorem, applications of electromagnetic fields. Plane wave propagation: plane waves in lossless media, plane waves in lossy media, polarization of wave. Computer aided analysis of electromagnetic fields: finite element method, integral equations.
Assessment methods	Lectures – written and oral exam; laboratory – continuous assessment
Learning outcomes	On successful completion of this course: Students will be familiar with the different vector operators used in Maxwells' equations Students will be able to describe and understand the basic concepts underpinning electricity and magnetism such as potential and field Students will have an understanding of Maxwell's equations Students will be able to select the most appropriate laws/theorems/solution techniques for electromagnetic field analysis
Recommended readings	1. Cheng D. K.: *Fundamentals of Engineering Electromagnetics*. Addison-Wesley Publishing Company, Inc., New York 1993 2. Pollack G. L., Stump D. R.: *Electromagnetism*. Addison Wesley Publishing Company, Inc., New York 2002 3. Stewart J. V.: *Intermediate Electromagnetic Theory*. World Scientific Publishing Co. Pte. Ltd., London 2001 4. Chari M. V. K., Salon S. J.: *Numerical Methods in Electromagnetism*. Academic Press, San Diego 2000
Additional information	

Titel der Vorlesung	**GRUNDLAGEN DER ELEKTROTECHNIK**		
Lehrmethode	Vorlesung pflichtig im Hörsaal, individuelle Entwurf (Projekt)		
Person für den Kurs verantwortlich	Prof. Dr. Ing.-habil. Konstanty Gawrylczyk	**E-mail addresse der verantwortlichen Person**	kmg@zut.edu.pl
Vorlesungscode	WEL_25	**ECTS Punkte**	6
Vorlesungstype	pflichtig	**Niveau der Lehrveranstaltung**	bachelor
Semester	3 (Winter)	**Sprache von Einleitung**	Deutsch
Stunden pro Woche	2+2	**Stunden pro Semester**	30 + 30
Ziele des Kurses	Kenntnis: der Theorie von Gleichströme, Lösung der Netzwerke, Wechselstrom, Resonanz, 3-Phasen Netzwerke, induktive Kopplungen, Transformator, transiente Vorgänge		

Eintrittbestimmungen	Mathematik, Physik
Inhalt des Kurses	Gleichströme, Lösungsmethoden der Netzwerke, sinusförmige Wechselstrom, Methode der komplexen Variablen, Resonanz, 3-Phasen Netzwerke, Leistungsmessung, Gegeninduktivitäten, Transformator mit Ersatzschaltungen, Magnetisierungsschleife und Verluste, transiente Vorgänge
Bewertungsmethoden	schriftliche Prüfung, Bewertung von Projekten
Empfohlene Literatur	1. E. Philippow „Grundlagen der Elektrotechnik", J. Wallot „Schwachstromtechnik"
Zusätzliche Informationen	

Course title	**HIGH VOLTAGE ENGINEERING**		
Teaching method	lecture / laboratory		
Person responsible for the course	Szymon Banaszak	**E-mail address to the person responsible for the course**	szymon.banaszak@zut.edu.pl
Course code (if applicable)	WEL_26	**ECTS points**	4
Type of course	Compulsory	**Level of course**	bachelor
Semester	Winter/summer	**Language of instruction**	English
Hours per week	2L / 2 Lab	**Hours per semester**	30L / 30Lab
Objectives of the course	The aim of the subject is to acquaint students with high voltage technology, especially with phenomena related to high voltages, construction of insulation systems, methods of preventing or generating discharges, lightning and surge protection.		
Entry requirements	It is necessary to have basic information in the field of physics, electrical engineering, material engineering.		
Course contents	The course is based on the following points: - economic issues of high voltage application, - electric fields in various electrodes setups, - practical applications of high voltage, - dielectric strength and discharge development mechanisms in vacuum/gas/liquids/solids, - electric discharges, lightnings and protection against them, - high voltage metrology and testing.		
Assessment methods	- written and oral exam (lecture), - grade (laboratory)		

Learning outcomes	Student gains knowledge on high voltage engineering including economic issues of high voltage application, practical applications of high voltage and high voltage metrology and testing. Student is able to use methods and devices for measurement of high voltages, for proper operation and development of high voltage insulation systems, knows safety precautions in high voltage engineering.
Recommended readings	1. E. Kuffel, W. S. Zaengl, J. Kuffel: High voltage engineering: fundamentals, Newnes (An imprint of Elsevier), 2004 2. M.S. Naidu, V. Kamaraju: High Voltage Engineering, Tata McGraw-Hill, 2009 3. H.M. Ryan: High Voltage Engineering and Testing, 2nd edition, The Institution of Electrical Engineers, 2001
Additional information	

Course title	**INTRODUCTION TO ELECTRIC CIRCUITS 1**		
Teaching method	Lecture, practical exercises and experimental laboratory		
Person responsible for the course	Tomasz Chady Ryszard Sikora Przemysław Łopato Grzegorz Psuj Krzysztof Stawicki	**E-mail address to the person responsible for the course**	tchady@zut.edu.pl rs@zut.edu.pl plopato@zut.edu.pl gpsuj@zut.edu.pl ks@zut.edu.pl
Course code (if applicable)	WEL_27	**ECTS points**	4
Type of course	Obligatory	**Level of course**	bachelor
Semester	Summer	**Language of instruction**	English
Hours per week	2L / 1Practical / 2Lab	**Hours per semester**	30L / 15Practical / 30Lab
Teaching method	Lecture, practical exercises and experimental laboratory		
Objectives of the course	To teach basics of electrical circuit theory To teach how to solve electrical circuits in various conditions		
Entry requirements	Academic course of mathematics and physics		
Course contents	• Introduction and electric circuit variables (Definitions, Units, Types of signals, Circuits and current flow, units, voltage, power and energy) • Circuit elements (linear model, active and passive elements, independent and dependent elements) • Resistive circuits (resistors, Ohm and Kirchhoff's law, basic circuit analysis) • Circuit theorems (superposition, substitution, fitting, Thevenin's and Norton's theorem) • Circuit analysis (nodal analysis, mesh analysis) • Energy storage elements (inductors, capacitors) • Sinusoidal steady-state analysis (classical method, phasor method, circuit law in phasor method) • Ideal and real resonance, frequency characteristics • Laboratory experiments for selected topics.		

Assessment methods	Written exam (Lect.) + Continuous assessment (Practical, Lab)
Learning outcomes	Upon successful completion of this course students will be able to: • perform design and analysis of AC and DC circuits, • select optimal method of circuit analysis for the specific case, • work independently and collaboratively to understand and formulate problems, and solve these problems using the provided tools and methods, • connect correctly an electrical circuit according to a given circuit diagram and use the analogue and digital multimeters as well as an oscilloscope with confidence, • write reports on laboratory experiments.
Recommended readings	1. W.H. Hayt, J.E. Kemmerly: Engineering circuit analysis, McGraw-Hill Book Company, ISBN 0-07-027393-6 2. J.O. Attia: Pspice and Matlab for Electronics, CRC Press 2002, ISBN 0-8493-1263-9
Additional information	

Course title	**INTRODUCTION TO ELECTRIC CIRCUITS 2**		
Teaching method	Lecture and experimental laboratory		
Person responsible for the course	Tomasz Chady Ryszard Sikora Przemysław Łopato Grzegorz Psuj Krzysztof Stawicki	**E-mail address to the person responsible for the course**	tchady@zut.edu.pl rs@zut.edu.pl plopato@zut.edu.pl gpsuj@zut.edu.pl ks@zut.edu.pl
Course code (if applicable)	WEL_28	**ECTS points**	6
Type of course	Obligatory	**Level of course**	bachelor
Semester	Winter	**Language of instruction**	English
Hours per week	3L / 2Lab	**Hours per semester**	45L / 30Lab
Objectives of the course	To teach how to solve electrical circuits in various conditions To teach how to use computer simulators for circuits analysis		
Entry requirements	Academic course of mathematics, physics, Introduction to electric circuits 1		

Course contents	• Three phase circuits (symmetric Y and triangular, unsymmetrical circuits, power, reactive power compensation) • Self and mutual inductance (ideal and with ferromagnetic core transformers) • Transient phenomena (DC and AC circuits) • The Laplace transformation (direct and inverse transformation) • Analysis of complex circuits in the transient state • The amplifiers (the operational and ideal operational amplifier) • Two-port's (passive, active, equations, T and Pi scheme, A, A-1 Y, Z, h, g parameters, relationship between parameters, interconnection of two port networks) • Fourier series (formulas, spectrum, power, compensation reactive power) • Digital transformation (Nyquist's formula, Shannon's formula) • Filters (passive, active and digital) • Computer simulators for circuit analysis (SPICE) • Laboratory experiments for selected topics.
Assessment methods	Written exam (Lect.) + Continuous assessment (Lab)
Learning outcomes	Upon successful completion of this course, the student will be able to: • work independently and collaboratively to understand and formulate problems, and solve these problems using the provided tools and methods, • use in a careful, precise manner the electric circuits simulators in order to analyze the circuits in transient and steady state, • solve circuit in transient state using Laplace transform, • solve circuits using two-ports networks, • analyze and design circuits with operational amplifiers and mutual inductances, • design analog and digital filters, • carry out electrical measurements using laboratory equipment, • write reports on laboratory experiments.
Recommended readings	1. W.H. Hayt, J.E. Kemmerly: Engineering circuit analysis, McGraw-Hill Book Company, ISBN 0-07-027393-6 2. J.O. Attia: Pspice and Matlab for Electronics, CRC Press 2002, ISBN 0-8493-1263-9
Additional information	

Course title	**INTRODUCTION TO ELECTROACOUSTIC**		
Teaching method	lectures, seminar, laboratory		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person responsible for the course**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WEL_29	**ECTS points**	4
Type of course	compulsory	**Level of course**	bachelor
Semester	summer	**Language of instruction**	English
Hours per week	1 L/1 Sem/1 Lab	**Hours per semester**	15L/ 15Sem. 15Lab
Objectives of the course	To provide knowledge on psychoacoustics basics and selected topics on electroacoustics (sound fields, transducers, sound reinforcement, sound processing).		

Entry requirements	Basic knowledge in Physics
Course contents	**Lectures:** Electroacoustics as a science and its scope of interest. Basic terms and phenomena concerning sound generation, propagation and acoustic field. Human auditory system. Elements of psychoacoustics – monaural and binaural hearing effects. Spatial hearing. Fundamentals of room acoustics and perceiving sound in different environments. Reverberation time. Electroacoustical transducers and electroacoustical systems. Microphones. Microphone stereo technique. Loudspeakers design. Hearing aids. Digital sound processing. Reinforcement systems. **Seminar:** complementary calculation exercises **Labs:** Recording technology. Electroacoustical systems measurements and design. Microphones and loudspeaker measurements. Audiometry. Measurement of reverberation time.
Assessment methods	Written exam, accomplishment of practical labs
Learning outcomes	Students will be able to explain the mechanisms of sound generation, propagation and receiving by humans in free and closed space. Students will be able to design, chose proper elements, connect them and operate simple electroacoustic systems.
Recommended readings	1. Howard D. H.: Acoustics and psychoacoustics. Focal press, 2001. 2. Blauert J.: Spatial Hearing - Revised Edition: The Psychophysics of Human Sound Localization. MIT Press, 1999. 3. Everest F. A.: Master handbook of acoustics. McGraw-Hill, 2001.
Additional information	

Course title	**INTRODUCTION TO MULTISENSOR DATA FUSION**		
Teaching method	Lectures with simple cases presentations, project – design and implementation of data fusion algorithm		
Person responsible for the course	Grzegorz Psuj	**E-mail address to the person responsible for the course**	gpsuj@zut.edu.pl
Course code (if applicable)	WEL_30	**ECTS points**	2
Type of course	Obligatory	**Level of course**	master
Semester	Winter or summer	**Language of instruction**	English
Hours per week	1L / 1Project	**Hours per semester**	15L / 15Project
Objectives of the course	This course is intended to present an introduction to the multisensor data fusion concept and theory followed by the case study.		
Entry requirements	Academic course of mathematics and informatics.		

Course contents	1. Introduction: motivation, concepts and theory of data fusion. 2. Data fusion models and architectures. 3. Sensors types. 4. Levels of data fusion. 5. Data registration: concepts and theory, algorithms partition and basic description, examples. 6. Data fusion algorithms: concepts and theory, algorithms partition and basic description. 7. Quality assessment factors of performance evaluation. 8. Case study of data fusion applications.
Assessment methods	Lectures – written exam; project – report assessment
Learning outcomes	Student knows: • the basic theory about the data fusion concept, • the rules of data fusion models, architectures and levels division, • the procedure of the data registration process, • the commonly used quality factors, • examples of most commonly used algorithms. Student can design, adopt, proceed and assess the data fusion algorithm for exemplary cases.
Recommended readings	1. D. L. Hall, Sonya A. H. McMullen: *Mathematical Techniques in Multisensor Data Fusion*, Artech House Publishers, 2004 2. M. E. Liggins, D. L. Hall, James Llians: *Handbook of Multisensor* Data *Fusion*, CRC Press LLC, 2nd ed., 2009 3. L. A. Klein: *Sensor and Data Fusion. A tool for Information assessment and Decision Making.*, SPIE Press, 3rd ed., 2010 4. X. E. Gros: *Application of NDT Data Fusion*, Kluwer Academic Publishers, 2001
Additional information	

Course title	**MEDICAL IMAGING SYSTEMS**		
Teaching method	lectures, labs (also in hospitals)		
Person responsible for the course	Krzysztof Penkala	**E-mail address to the person responsible for the course**	Krzysztof.Penkala@zut.edu.pl
Course code (if applicable)	WEL_31	**ECTS points**	3
Type of course	compulsory	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	2L / 1Lab	**Hours per semester**	30L / 15Lab
Objectives of the course	To provide up to date knowledge on various modalities of biomedical imaging technologies, systems and archiving/transmission standards and to develop practical skills useful in this area		
Entry requirements	Mathematics, Physics, Informatics, Electronics, Signal theory, Image processing, Biomedical Engineering		

Course contents	Lectures: Human factors in biomedical imaging. Medical imaging systems – physical principles of image formation and equipment in Thermography (TG), Ultrasonography (USG), Nuclear Medicine (Gamma-camera, SPECT, PET), Digital Radiography (DR), Digital Subtraction Angiography (DSA), Computed Tomography (CT), Magnetic Resonance Imaging (MRI). Bio-optical imaging. Biomolecular imaging. Special techniques, e.g. ultra-fast data acquisition systems in MRI (EPI), Functional and Interventional MRI. Principles of image reconstruction (2-D, 3-D). Image processing, analysis and measurement; software tools. Image fusion. Virtual endoscopy. Image transmission and archiving – PACS, standard DICOM 3. DICOM validation tools Labs: Bioelectrical signals mapping: TBM, mfERG and mfVEP systems. Gamma AT and Gamma Vision systems. USG - Transcranial Doppler (TCD). Image browsing& analysis tools: systems OSIRIS/PAPYRUS and PC-Image. DICOM validation tools. MATLAB, IDL and LabView systems in image processing. Demonstration of medical imaging systems in hospitals and diagnostic centres.
Assessment methods	Lectures: grade, accomplishment of lab tasks
Learning outcomes	The student has increased knowledge on methods and techniques used in medical diagnostic imaging, on various modalities of biomedical imaging technologies, systems and archiving/communication standards as well as on research methodology used in this field. He has practical skills useful in this area regarding biomedical imaging systems testing, development, and exploitation
Recommended readings	1. Bronzino J. D. (ed.): "Biomedical Engineering Handbook". CRC Press, IEEE Press, 1995 2. Robb R. A.: "Three Dimensional Biomedical Imaging: Principles and Practice". Wiley-Liss, N.Y., 1998 3. Christensen D. A.: "Ultrasonographic Bioinstrumentation". J. Wiley & Sons, N.Y., 1988 4. Shellock F. G., Kanal E.: "Magnetic Resonance. Bioeffects, Safety and Patient Management". Raven Press, N.Y., 1994 5. Huang H. K.: "PACS in Biomedical Imaging". VCH Publ. Inc., N.Y., 1996 6. IT-EDUCTRA. FUNDESCO, Commission of the EC, 1998
Additional information	

Course title	**MODERN ELECTRICAL MACHINES**		
Teaching method	Lecture, project		
Person responsible for the course	Ryszard Pałka	**E-mail address to the person responsible for the course**	rpalka@zut.edu.pl
Course code (if applicable)	WEL_34	**ECTS points**	6
Type of course	Obligatory or optional	**Level of course**	master
Semester	winter / summer	**Language of instruction**	English
Hours per week	2L / 1Project	**Hours per semester**	30L, 15Project
Objectives of the course	The course gives the fundamental and expert knowledge about construction, development, numerical calculation and optimization of modern electrical machines.		

Entry requirements	Basics of electrical engineering, basics of electrical machines, electromagnetic field theory, numerical methods
Course contents	The course gives the knowledge about construction and optimization of modern electrical machines: • Permanent magnet excited synchronous machines, • Transverse flux machines, axial flux machines, • Switched reluctance machines, • Different electrical machines for hybrid and pure electric vehicles.
Assessment methods	written exam, project work
Learning outcomes	
Recommended readings	1. Gieras J. F., Wing M.: Permanent magnet motor technology. John Wiley&Sons 2008 2. Austin Hughes; Electric Motors and Drives. Elsevier Ltd. 2006 3. Gieras J. F., Chong Wang, Joseph Cho Lai: Noise of Polyphase Electric Motors. CRC Press 2006 4. Chiasson J.: Modeling and high-performance control of electric machines. John Wiley&Sons 2005 5. Larminie J., Lowry J.: Electric Vehicle Technology Explained. John Wiley&Sons 2003
Additional information	

Course title	**MOVIE SPECIAL EFFECTS**		
Teaching method	Lecture / laboratory / project		
Person responsible for the course	Przemyslaw Mazurek	**E-mail address to the person responsible for the course**	przemyslaw.mazurek@zut.edu.pl
Course code (if applicable)	WEL_35	**ECTS points**	4
Type of course	obligatory / optional (depending on chosen speciality)	**Level of course**	bachelor
Semester	winter or summer	**Language of instruction**	English
Hours per week	2L / 2 Project	**Hours per semester**	30 L / 30 Project
Objectives of the course	This course is intended to present fundamental techniques in special effects dedicated to movie production		
Entry requirements	Fundamentals of computer engineering, computer visualization		
Course contents	3D modeling techniques. Computer animation techniques. Special effects using 2D, 2.5D and 3D techniques. Compositing. Keying techniques. Object tracking. Matchmoving including tracking camera movements in 3D space. Color correction. Integration of 3D and composting tools.		

Assessment methods	Written exam (test), project work / continuous assessment (laboratory)
Learning outcomes	Knowledge about 3D modeling and digital special effects applied techniques.
Recommended readings	• Combustion tutorials • AfterEffects tutorials • 3DS Max tutorials • Matchmover Manual
Additional information	

Course title	**NETWORK SYSTEMS ADMINISTRATION**		
Teaching method	Lecture / laboratory		
Person responsible for the course	Piotr Lech	**E-mail address to the person responsible for the course**	Piotr.lech@zut.edu.pl
Course code (if applicable)	WEL_	**ECTS points**	4
Type of course	obligatory	**Level of course**	bachelor
Semester	winter	**Language of instruction**	English
Hours per week	1L / 2 Lab	**Hours per semester**	15 L / 30 Lab
Objectives of the course	The course introduces students to the fundamentals of network management, primarily for TCP/IP networks. Students are introduced to networking protocols, hardware, architecture, media, and software and experience hands-on management of typical network components.		
Entry requirements	Prerequisites and additional requirements not specified		
Course contents	Determine the network design most appropriate for a given site. Installation and configuration of network services. Differentiate among network standards, protocols, and access methods. Master local area network concepts and terminology. Network planning, network equipment (hub, switch, router). Ptotocol TCP/IP, IP nets, IP subnets, VLAN . Protocol analysis. Network administration (SNMP, RMON)		
Assessment methods	Written exam (test), continuous assessment (laboratory)		
Learning outcomes	Working knowledge of networking terms and concepts pertaining to system administration,terms that characterize the attributes of networks and aspects of network operation. Ability to observation of system behavior. Ability actions taken to accomplish sysadmin related to administration tasks.		
Recommended readings	1. Tony Bautts, Terry Dawson, Gregor N. Purdy Linux Network Administrator's Guide, 3rd Edition O'Reilly Media 2005 ISBN: 978-0-59600-548-1 2. AEleen Frisch Essential System Administration, 3rd Edition O'Reilly Media 2002 ISBN:978-0-59600-343-2		

	3. Sander van Vugt Pro Ubuntu Server Administration Apress 2008 ISBN: 978-1-4302-1622-3
Additional information	

Course title	**NONLINEAR CONTROL**		
Teaching method	Lectures covering basic modelling of nonlinear systems, dynamics, control methods. Laboratory course covering various applications and control design.		
Person responsible for the course	Adam Łukomski	**E-mail address to the person responsible for the course**	lukomski@zut.edu.pl
Course code (if applicable)	WEL_37	**ECTS points**	3
Type of course	optional	**Level of course**	bachelor
Semester	winter / summer	**Language of instruction**	English
Hours per week	1 L, 2 Lab	**Hours per semester**	15 L, 30 Lab
Objectives of the course	The Student will learn to design and apply nonlinear control methods.		
Entry requirements	Linear control, Dynamic systems, Mathematics, Physics		
Course contents	This course covers basic information about nonlinear control systems. Main topics are nonlinear ordinary differential equations, planar mechanical systems, analysis of nonlinear systems, stability and equilibria by Lyapunov's methods, feedback linearisation and implementation of control systems.		
Assessment methods	Written exam (on last lecture), Continuous assessment during laboratory course		
Learning outcomes	Ability to model, analyse and control a nonlinear system.		
Recommended readings	1. Slotine, Li, "Applied Nonlinear Control" 2. Khalil "Nonlinear Systems"		
Additional information			

Course title	**OPTIMIZATION THEORY**
Teaching method	Lectures, Laboratory

Person responsible for the course	Marcin Ziółkowski	**E-mail address to the person responsible for the course**	Marcin.ziolkowski@zut.edu.pl
Course code (if applicable)	WEL_38	**ECTS points**	4
Type of course	Obligatory	**Level of course**	master
Semester	Winter or summer	**Language of instruction**	English
Hours per week	2 L / 2 Lab	**Hours per semester**	30 L / 30 Lab
Objectives of the course	This course is intended to present a unified approach to various optimization methods. (advanced undergraduate level)		
Entry requirements	Physics, Mathematics		
Course contents	1. Unconstrained Optimization a. One-Dimensional Search Methods (Golden Section Search, Fibonacci Search, Newton's Method, Secant Method) b. Gradient Methods (The Method of Steepest Descent, Analysis of Gradient Methods) c. Newton’s Method (Analysis of Newton's Method, Levenberg-Marquardt Modification, Newton's Method for Nonlinear Least-Squares) d. Conjugate Direction Methods (The Conjugate Direction Algorithm , The Conjugate Gradient Algorithm, The Conjugate Gradient Algorithm for Non-Quadratic Problems) e. Solving Ax = b (Least-Squares Analysis, Recursive Least-Squares Algorithm, Solution to Ax = b Minimizing ||x|| f. Unconstrained Optimization and Neural Networks g. Genetic Algorithms 2. Linear Programming a. Simplex Method b. Non-Simplex Methods 3. Nonlinear Constrained Optimization a. Problems with Equality Constraints b. Problems with Inequality Constraints c. Convex Optimization Problems 4. Algorithms for Constrained Optimization a. Introduction b. Projections c. Projected Gradient Methods d. Penalty Methods		
Assessment methods	Lectures – written exam; laboratory – continuous assessment		
Learning outcomes	Students will get the knowledge about various optimization methods. They will be able to use an appropriate method to the given practical problem.		
Recommended readings	1. Edwin K.P. Chong, Stanislaw H. Żak: An Introduction to Optimization, Second Edition, Wiley & Sons, Inc, 2001, New York, USA 2. R. Fletcher: Practical Methods of Optimization, second Edition, Wiley, 2000		
Additional information			

Course title	**POWER ELETRIC ENGINEERING**		
Teaching method	The lectures and laboratories are going in parallel. During lectures, the teacher, using classic whiteboard and presentation, will teach about power electric system in Poland. During laboratories students will have possibility to verify their knowledge about power electric system and simulate its behavior using real models of network in laboratory.		
Person responsible for the course	Michał Balcerak	**E-mail address to the person responsible for the course**	mbalc@zut.edu.pl
Course code (if applicable)	WEL_39	**ECTS points**	4
Type of course	Obligatory	**Level of course**	bachelor
Semester	winter/summer	**Language of instruction**	English
Hours per week	2 L / 2 Lab	**Hours per semester**	30 L / 30 Lab
Objectives of the course	Student has knowledge on power electric network – how it works, how to generate power for electric consumer, what the properties of electric load are and witch of them are important for the power system.		
Entry requirements	Student should know math (trigonometric and complex numbers) and basics of Electric Engineering.		
Course contents	Electric loads: power factor, current distortion factor, Electric grid properties: impedance of electric grid, voltage drop, voltage losses and power loses on the wires, Correct methods of current, voltage and power measurement in three phase grid, Generation and distribution of power		
Assessment methods	Laboratories measurement report assessment and final test on the end of the course Lectures final written exam		
Learning outcomes	Students will know: - types of power plant, methods to produce energy in conventional and unconventional power plant - typical and distributed types of electric power grid - method of reactive power compensation (Q), influence of Q to a loos of voltage and power in power electric grid - how to stabilize frequency and voltage in grid - methods to decrease levels of higher harmonics of voltage and current in power electric systems - about power electronics devices in power electric grid: HVDC grids, PFC, distortion reduction		
Recommended readings			
Additional information	Maximum 12 persons in one laboratory group.		

Zachodniopomorski Uniwersytet Technologiczny w Szczecinie

Faculty of Electrical Engineering

Course title	**POWER ELETROCNICS FOR RENEWABLE ENERGY SOURCES**		
Teaching method	lecture / project		
Person responsible for the course	Marcin Hołub	**E-mail address to the person responsible for the course**	mholub@zut.edu.pl
Course code (if applicable)	WEL_40	**ECTS points**	3
Type of course	Obligatory or optional	**Level of course**	bachelor
Semester	winter / summer	**Language of instruction**	English
Hours per week	1L / 2Project	**Hours per semester**	15L 30Project
Objectives of the course	Student will be able to: - recognize and distinguish basic types of renewable electrical energy sources. - distinguish basic characteristics of different sources. - distinguish basic types of photovoltaic modules and their main properties, will be able to draw basic waveforms. - distinguish basic types of solar converters. - give basic properties and characteristics for main types of switched mode power supplies. - perform basic calculations for main circuit components and adjust component type and kind. - use CAD software for basic simulations and basic types of projects. - perform basic project for a small scale power converter. - analyze basic structures of power converters and draw main schematics for system components.		
Entry requirements	Electronics, basics of electrical engineering		
Course contents	Power electronics for renewable energy sources: past and present of energy production and consumption, perspectives, connections with other technical branches. Basic electrical and eletromechanical properties of photovoltaic panels and modules. Fuel cells – construction, properties, dynamic response. Wind energy – basics, Betz's limit, basic constructions. Power electronic converters for energy conversion. Switched mode power supplies, MPP tracking. Single and three phase inverters. Converter groups for photovoltaic systems, wind energy converters. Grid connection. Summary.		
Assessment methods	Written tests Project work assessment		
Learning outcomes	Ability to distinguish properties and characteristics of various renewable energy sources. Ability to define proper power electronic converter chain. Ability to construct small – scale converters for PV modules. Ability to construct simple simulation models. Ability to prepare, set-up and conduct measurements and draw conclusions.		
Recommended readings	1. K. Billings, T. Morey "Switching power supply design", ISBN 978-0-07-148272-1McGrawHill 2009 2. K. Billings "Switchmode power supply handbook", ISBN 0-07-006719-8McGrawHill 1999 3. M. H. Rashid "Power Electronics Handbook", Elsevier 2007, ISBN-13: 978-0-12-088479-7		
Additional information			

Course title	**PROGRAMMABLE LOGIC DEVICES**		
Teaching method	lectures, laboratory		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person responsible for the course**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WEL_41	**ECTS points**	4
Type of course	compulsory	**Level of course**	master
Semester	winter	**Language of instruction**	English
Hours per week	1L/1Lab/1Project	**Hours per semester**	15L/ 15Lab/ 15Project
Objectives of the course	To provide knowledge on programmable logic devices and its use in modern digital system design		
Entry requirements	Basic knowledge on digital circuits and informatics		
Course contents	**Lectures:** Categorization of programmable logic devices. Design systems for SPLD and CPLD. Configuration memory. ABEL. Properties and configuration of logic blocks (LUT, FF) and I/O in FPGA. Specialized blocks – RAM, multipliers. Distribution of clock signals (PLL, DLL). Metastability. Abstraction levels in digital systems description. Elements of VHDL. Elements of Verilog. Designing paths. Design environments for FPGA design. JTAG. Systems on Chip. Structured ASIC. **Labs:** PLD synthesis using VHDL and ABEL. **Project:** Design and testing of various digital systems designed using FPGA laboratory boards.		
Assessment methods	Written exam, accomplishment of practical labs		
Learning outcomes	Student will be able to describe the building blocks in modern CPLD and FPGA integrated circuits. Student will be able to design and test simple digital apliances using programmable IC's and hardware description language.		
Recommended readings	• Skahill K.: VHDL. Design of programmable logic devices. Prentice Hall 2001 • Sunggu Lee, Design of computers and other complex digital devices, Prentice Hall 2000		
Additional information			

Course title	**RADIOGRAPHIC NONDESTRUCTIVE TESTING**		
Teaching method	Lectures		
Person responsible for the course	Marcin Ziółkowski	**E-mail address to the person responsible for the course**	Marcin.ziolkowski@zut.edu.pl

Course code (if applicable)	WEL_42	**ECTS points**	1
Type of course	Optional	**Level of course**	bachelor/master
Semester	Winter or summer	**Language of instruction**	English
Hours per week	1L	**Hours per semester**	15L
Objectives of the course	This course is intended to present a unified approach to Radiographic Nondestructive Testing.		
Entry requirements	Physics, Mathematics		
Course contents	Applications of Radiography. Penetration and Absorption. Radiographic Sensitivity. Structure of the Atom. X and Gamma Rays. X-Ray Equipment. Isotopes. Subject and Film Contrast. Radiographic Film & Processing Techniques. Radiation Hazard. Permissible Radiation Dose. Radiation Effects. Protection Against Radiation. Specialized Radiographic Equipment. X-Ray Exposure Charts. Specialised Techniques. Discontinuities. Practical Problem Solving.		
Assessment methods	Written exam/ continuous assessment		
Learning outcomes	Students will get the knowledge about Radiographic Nondestructive Testing theory. They will also know, what kind of objects can be inspected with such a technique.		
Recommended readings	http://www.ndt.org/ http://www.ndt-ed.org/EducationResources/CommunityCollege/communitycollege.htm http://www.ndt.net/		
Additional information			

Course title	**SOUND ENGINEERING**		
Teaching method	lectures, seminar, laboratory, project		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person responsible for the course**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WEL_43	**ECTS points**	4

Type of course	compulsory	**Level of course**	master
Semester	winter	**Language of instruction**	English
Hours per week	1L/1Sem/2Lab/15Project	**Hours per semester**	15Lect. 15Sem 30Lab 15Project
Objectives of the course	To provide knowledge on selected sound engineering, recording technology and electroacoustic measurements. To gain some skills in sound recording and processing using modern technology.		
Entry requirements	Basic knowledge in Physics		
Course contents	**Lectures:** The scope of sound engineering and recording technology. Basic musical sound description. Characteristics of sound sources. 2- and multichannel reproduction systems. Microphones and microphone technique. Analog and digital recording systems. DAW. Analog and digital audio signal processing. Reproduction systems. Recording studio design. Recording studio equipment. Production of speech and music recordings. On location recording. Mixing and Mastering. **Seminar:** calculus exercise connected with lectures **Labs:** measurements of sound intensity, microphones and loudspeakers polar characteristics, stereo recordings with AB, XY and MS method, recording session with speaker, music ansamble etc. Multitrack recording, mixing of the recordings, recordings editing, reverberation time measurement. Project: sound recording production in studio and on location, sound editing.		
Assessment methods	Written exam, accomplishment of practical labs and projects.		
Learning outcomes	Students will be able to explain the basic techniques of recording and processing and play back audio signals. Students will be able to measure, record process and play back audio signals using specialized profi-audio equipment.		
Recommended readings	1. Howard D. H.: Acoustics and psychoacoustics. Focal press, 2001. 2. Blauert J.: Spatial Hearing - Revised Edition: The Psychophysics of Human Sound Localization. MIT Press, 1999. 3. Everest F. A.: Master handbook of acoustics. McGraw-Hill, 2001.		
Additional information			

Course title	**TERAHERTZ TECHNIQUE**		
Teaching method	Lectures in form of multimedia presentation; project – designing, measurements and computer simulations of terahertz devices/systems		
Person responsible for the course	Przemyslaw Lopato	**E-mail address to the person responsible for the course**	plopato@zut.edu.pl
Course code (if applicable)	WEL_46	**ECTS points**	2
Type of course	Obligatory	**Level of course**	bachelor/master

Semester	Winter or summer	**Language of instruction**	English
Hours per week	1L/1Project, other organization is possible)	**Hours per semester**	15L/15Project
Objectives of the course	This course is intended to present basic knowledge of terahertz technique and its application in modern industry		
Entry requirements	Basic course of mathematics and physics (electromagnetics)		
Course contents	Generation and detection of EM waves in the THz frequency range. Passive devices in terahertz technology. Materials properties and metamaterials in THz frequency range. Application of terahertz technique in spectroscopy, imaging, biomedical engineering, public safety and short-range wireless transmissions. Numerical modeling of terahertz systems. Overview of available terahertz systems.		
Assessment methods	Lectures – oral exam; project – report assessment		
Learning outcomes	Student after the course will have basic knowledge about terahertz technology and its applications as well as the ability to perform basic measurements in terahertz frequency band.		
Recommended readings	1. Sakai K.: *Terahertz optoelectronics*, Springer, Berlin 2005 2. Miles R. E., Harrison P., Lippens D.: *Terahertz sources and systems*, Kluwer, Dordrecht 2001 3. Yun-Shik Lee: *Principles of Terahertz Science and Technology*, Springer, New York 2009		
Additional information			

Course title	**ULTRASONIC NONDESTRUCTIVE TESTING**		
Teaching method	Lectures		
Person responsible for the course	Marcin Ziółkowski	**E-mail address to the person responsible for the course**	Marcin.ziolkowski@zut.edu.pl
Course code (if applicable)	WEL_47	**ECTS points**	1
Type of course	Optional	**Level of course**	bachelor/master
Semester		**Language of instruction**	English
Hours per week	1L	**Hours per semester**	15L
Objectives of the course	This course is intended to present a unified approach to Ultrasonic Nondestructive Testing.		
Entry requirements	Physics, Mathematics		

Course contents	Ultrasonic Principles. Equipment Controls. Wave Propagation. Couplants, Material Characteristics, Beam Spread. Attenuation, Impedance and Resonance. Screen Presentations, Angle Beam Inspection with UT Calculator. Transducers, Standard Reference Blocks. Immersion Inspection. Contact Testing, Longitudinal & Shear Waves, Snell's Law.
Assessment methods	Written exam/ continuous assessment
Learning outcomes	Students will get the knowledge about Ultrasonic Nondestructive Testing theory. They will also know, what kind of objects can be inspected with such a technique.
Recommended readings	http://www.ndt.org/ http://www.ndt-ed.org/EducationResources/CommunityCollege/communitycollege.htm http://www.ndt.net/
Additional information	

Course title	**VISUAL PROGRAMMING IN LABVIEW**		
Teaching method	Lectures, demonstrations, laboratory exercises		
Person responsible for the course	dr inż. Paweł Dworak, mgr inż. Paweł Waszczuk	**E-mail address to the person responsible for the course**	pawel.dworak@zut.edu.pl
Course code (if applicable)	WEL_48	**ECTS points**	3
Type of course	optional	**Level of course**	bachelor
Semester	winter, summer	**Language of instruction**	English
Hours per week	1L/ 2Lab	**Hours per semester**	15L/ 30Lab
Objectives of the course	Teach students a graphical way of programming in LabVIEW. Preparation of students to the CLAD certificate.		
Entry requirements	Basics of programming.		
Course contents	Introduction to LabVIEW environment. Navigating LabVIEW, Troubleshooting and Debugging Vis, Implementing a VI, Developing Modular Applications, Creating and Leveraging Data Structures, Managing File and Hardware Resources, Using Sequential and State Machine Algorithms, Solving Dataflow Challenges with Variables, Moving Beyond Dataflow, Implementing Design Patterns, Controlling the User Interface, File I/O Techniques, Improving an Existing VI, Deploying an Application.		
Assessment methods	Continuous assessment.		

Learning outcomes	Students will be able to write programs in a graphical LabVIEW environment. Should be able to pass the CLAD certification exam.
Recommended readings	National Instruments documentation, NI forum
Additional information	

Course title	**B.SC. THESIS**		
Teaching method	Individual work with the thesis supervisor		
Person responsible for the course	Depends on the subject of the thesis	**E-mail address to the person responsible for the course**	
Course code (if applicable)	WEL_49	**ECTS points**	15
Type of course	Obligatory	**Level of course**	bachelor
Semester	Winter or summer	**Language of instruction**	English
Hours per week		**Hours per semester**	12 hours
Objectives of the course	This course is intended to help students with their B.Sc. thesis. The work is either a project or a research. It can result in e.g. creating a computer program, laboratory work station, a device-model or presenting results of research carried out using professional devices or programs.		
Entry requirements	- Knowledge of basic issues related to the subject of the thesis - Ability to formulate technical texts and prepare drawings and diagrams presenting gained results		
Course contents	Doing a B.Sc. thesis is in fact realization of a typical engineering task that starts with formulating a problem and making assumptions, analyzing current state of the art and defining the method of realizing the aim of the work. At the end of the task, the student formulates conclusions and prepares written description of performing the task, its results and analysis.		
Assessment methods	Continuous assessment and instructions given by the supervisor		
Learning outcomes	Knowledge of modern solutions related to the subject of the thesis, ability to write technical reports and prepare related multimedia presentations, ability to find the necessary information in the literature and technical documentation		
Recommended readings	Depends on the subject of the thesis		
Additional information	Please contact the faculty Erasmus coordinator to discuss the details of the course.		

Course title	**M.SC. THESIS**		
Teaching method	Individual work with the thesis supervisor		
Person responsible for the course	Depends on the subject of the thesis	**E-mail address to the person responsible for the course**	
Course code (if applicable)	WEL_50	**ECTS points**	20
Type of course	Obligatory	**Level of course**	master
Semester	Winter or summer	**Language of instruction**	English
Hours per week		**Hours per semester**	15 hours
Objectives of the course	This course is intended to help students with their M.Sc. thesis. The work is either a project or a research. It can result in e.g. creating a computer program, laboratory work station, a device-model or presenting results of research carried out using professional devices or programs.		
Entry requirements	- Knowledge of basic issues related to the subject of the thesis - Ability to formulate technical texts and prepare drawings and diagrams presenting gained results		
Course contents	Doing a M.Sc. thesis is in fact realization of a complex engineering task containing scientific elements, that starts with formulating a problem and making assumptions, analyzing current state of the art and defining the scientifically justifiable method of realizing the aim of the work. At the end of the task, the student formulates conclusions and prepares written description of performing the task, its results and analysis.		
Assessment methods	Continuous assessment and instructions given by the supervisor		
Learning outcomes	Knowledge of modern solutions and the scientific achievements related to the subject of the thesis, ability to write detailed technical reports and prepare related multimedia presentations, ability to find the necessary information in the scientific literature and technical documentation		
Recommended readings	Depends on the subject of the thesis		
Additional information	Please contact the faculty Erasmus coordinator to discuss the details of the course.		

Zachodniopomorski Uniwersytet Technologiczny w Szczecinie

Faculty of Electrical Engineering

Postgraduate one-semester study programme in English on

ADVANCED TECHNIQUES OF SIGNAL PROCESSING, ANALYSIS AND TRANSMISSION IN BIOMEDICAL APPLICATIONS (SPE-1)

Course Supervisor: Dr. Krzysztof Penkala

A. Compulsory courses .... 210 h (105 L + 105 P) – 17 pt (ECTS)

Course code	Course name	Course leader	Course hours	Lecture hours	Hours of practicals	Credit points
WEL_2	Advanced biosignal processing and analysis	Dr. Marek Jaskuła, Dr. Krzysztof Penkala	45	15	30	4
WEL_10	Biomedical imaging – equipment, image processing and analysis	Dr. Krzysztof Penkala, Dr. Wojciech Chlewicki	45	30	15	3
WEL_45	Telemedicine, IT&T in Health Care	Dr. Krzysztof Penkala, Dr. Marek Jaskuła	45	30	15	3
WEL_32	Medical informatics	Dr. Krzysztof Penkala, Dr. Marek Jaskuła	30	15	15	3
WEL_7	ASIC&DSP in biomedical applications	Dr. Witold Mickiewicz, Dr. Krzysztof Penkala	45	15	30	4

B. Optional courses (2 electives) .... 90 h (60 L + 30 P) – 8 pt (ECTS)

Course code	Course name	Course leader	Course hours	Lecture hours	Hours of practicals	Credit points
WEL_22	Elements of psychoacoustics and electroacoustics	Dr. Witold Mickiewicz	45	30	15	4
WEL_3	Advanced methods of medical image reconstruction	Dr. Wojciech Chlewicki	45	30	15	4
WEL_21	EM fields effects in living organisms	Dr.Sc. Michał Zeńczak	45	30	15	4
WEL_33	Modelling of EM fields in human body	Prof. Stanisław Gratkowski	45	30	15	4
WEL_44	Sound system design	Dr. Witold Mickiewicz	45	30	15	4
WEL_4	Advanced methods of speech processing and transmission	Dr. Jerzy Sawicki	45	30	15	4

C. Research activities .... 60 h (60 P) – 5 pt (ECTS)

Course code	Course name	Course leader	Course hours	Lecture hours	Hours of practicals	Credit points
WEL_Lab	Research lab	Dr. Krzysztof Penkala	60	-	60	5

Total A + B + C .... 360 h (165 L + 195 P) – 30 pt (ECTS)

Notation: h - hours, L - lectures, P - practicals (lab, project, seminar), pt - credit points (ECTS)

Course title	**ADVANCED BIOSIGNAL PROCESSING AND ANALYSIS**		
Teaching method	lectures, lab training, project, computer simulations		
Person responsible for the course	Marek Jaskuła, Krzysztof Penkala	**E-mail address to the person responsible for the course**	Marek.Jaskula@zut.edu.pl
Course code (if applicable)	WEL_2	**ECTS points**	4
Type of course	compulsory	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	3 (1L, 1Lab, 1P)	**Hours per semester**	45 (15L, 15Lab, 15P)
Objectives of the course	To provide knowledge and skills on advanced methods and techniques used in processing and analysis of biosignals		
Entry requirements	Signal theory, Signal processing, Fundamentals of Biomedical Engineering		
Course contents	**Lectures:** Windowing technique (different window functions, criterion of optimization), parametric filter and filter design, spectral analysis: STFT, time-frequency analysis, wavelet, statistical signal processing. Introduction to Matlab and biosignal toolbox, biosignal analysis in time and frequency domain, filtering of brainstem auditory evoked potentials (BAEP) with parametric filter, windowing techniques, FFT, STFT, time-frequency analysis, using different kernel, kernel optimization, wavelet, ECG and EEG signal processing, ERG and VEP signal analysis. **Labs, Proj:** Using computer tools in processing and analysis of biological signals, implementing algorithms applied to different biosignals.		
Assessment methods	Written exam, accomplishment of practical labs and project work		
Learning outcomes			
Recommended readings	1. Oppenheim, A.V. and Schafer W.: Discrete-time signal processing. Prentice Hall,1999 2. Cohen L.: Time-frequency analysis, 1995 3. Qian S., Chen D.: Joint time-frequency analysis. Methods and Applications. Prentice-Hall, 1996 4. Vetterli M. and Kovacevic J.: Wavelets and subband coding. Prentice Hall, 1996		
Additional information			

Course title	**BIOMEDICAL IMAGING - equipment, image processing and analysis**		
Teaching method	lectures, lab training (also in hospitals), computer simulations		
Person responsible for the course	Krzysztof Penkala, Wojciech Chlewicki	**E-mail address to the person responsible for the course**	Krzysztof.Penkala@zut.edu.pl

Course code (if applicable)	WEL_10	**ECTS points**	3
Type of course	compulsory	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	3 (2L, 1Lab)	**Hours per semester**	45 (30L, 15Lab)
Objectives of the course	To provide up to date knowledge on various modalities of biomedical imaging technologies, systems and archiving/transmission standards		
Entry requirements	Signal theory, Image processing, Fundamentals of Biomedical Engineering		
Course contents	**Lectures:** Human factors in biomedical imaging. Medical imaging systems – physical principles of image formation and equipment in Thermography (TG), Ultrasonography (USG), Nuclear Medicine (Gamma-camera, SPECT, PET), Digital Radiography (DR), Digital Subtraction Angiography (DSA), Computed Tomography (CT), Magnetic Resonance Imaging (MRI). Bio-optical imaging. Biomolecular imaging. Special techniques, e.g. ultra-fast data acquisition systems in MRI (EPI), Functional and Interventional MRI. Principles of image reconstruction (2-D, 3-D). Image processing, analysis and measurement; software tools. Image fusion. Virtual endoscopy. Image transmission and archiving – PACS, standard DICOM 3. DICOM validation tools **Labs:** Bioelectrical signals mapping: TBM, mfERG and mfVEP systems. Gamma AT and Gamma Vision systems. USG, Transcranial Doppler (TCD). Image browsing&analysis tools: systems OSIRIS/PAPYRUS and PC-Image. DICOM validation tools. MATLAB, IDL and LabView systems in image processing. Demonstration of medical imaging systems in hospitals and diagnostic centres		
Assessment methods	Written exam, accomplishment of practical labs		
Learning outcomes			
Recommended readings	1. Bronzino J. D. (ed.): Biomedical Engineering Handbook. CRC Press, IEEE Press, 1995 2. Robb R. A.: Three Dimensional Biomedical Imaging: Principles and Practice. Wiley-Liss, N.Y., 1998 3. Christensen D. A.: Ultrasonographic Bioinstrumentation. J. Wiley & Sons, N.Y., 1988 4. Shellock F. G., Kanal E.: Magnetic Resonance. Bioeffects, Safety and Patient Management. Raven Press, N.Y., 1994 5. Huang H. K.: PACS in Biomedical Imaging. VCH Publ. Inc., N.Y., 1996 6. IT-EDUCTRA. FUNDESCO, Commission of the EC, 1998		
Additional information			

Course title	**TELEMEDICINE, IT&T IN HEALTH CARE**		
Teaching method	lectures, lab training (also in hospitals), computer simulations		
Person responsible for the course	Krzysztof Penkala, Marek Jaskuła	**E-mail address to the person responsible for the course**	Krzysztof.Penkala@zut.edu.pl
Course code (if applicable)	WEL_45	**ECTS points**	3

Type of course	compulsory	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	3 (1L, 1Lab)	**Hours per semester**	45 (30L, 15Lab)
Objectives of the course	To provide up to date knowledge on advanced information technologies in biomedical applications and to develop design skills in this field		
Entry requirements	Informatics, Computer systems, Telecommunications, Networking, Fundamentals of Biomedical Engineering		
Course contents	**Lectures:** Telemedicine – history and development of telematics in Health Care. Classification of telemedicine services. Review of technologies. The Internet and GSM, UMTS, LTE in e-Health. Specific fields: cardio-tele systems, teleradiology, medical teleconsultations. Telematics in rescue services. Telemonitoring and teleassistance in care of disabled and elderly people. Wireless and mobile medical systems (Wi-Fi and Bluetooth standards, RF-ID, Zigbee, Z-Wave and other platforms). Wearable technologies, Biomedical Intelligent Clothing. Tele-service of medical equipment. Assessment of new IT technologies in Health Care **Labs:** Operation of cardio-tele systems. WWW and video-conference applications for telemedicine. Wireless transmission of biomedical signals. Biosensors integration with RF-ID, Bluetooth and other modules. Wireless networks in hospital environment as well as in telemonitoring and teleassistance at home. Tele-service of medical equipment in hospitals		
Assessment methods	Written exam, accomplishment of practical labs		
Learning outcomes			
Recommended readings	1. Gordon C., Christensen J. P. (ed.): Health Telematics for Clinical Guidelines and Protocols. IOS Press, Ohmsha, 1995 2. Mantas J. (ed.): Health Telematics Education. IOS Press, Ohmsha, 1997 3. Coiera E.: Guide to Medical Informatics. The Internet and Telemedicine. Arnold, London, 1997 4. Field M. J. (ed.): Telemedicine. A Guide to Assessing Telecommunications in Health Care. National Academy Press, Wash. D.C., 1996 5. IT-EDUCTRA. FUNDESCO, Commission of the EC, 1998		
Additional information			

Course title	**MEDICAL INFORMATICS**		
Teaching method	lectures, lab training (also in hospitals), computer simulations		
Person responsible for the course	Krzysztof Penkala, Marek Jaskuła	**E-mail address to the person responsible for the course**	Krzysztof.Penkala@zut.edu.pl
Course code (if applicable)	WEL_32	**ECTS points**	3
Type of course	compulsory	**Level of course**	master

Semester	winter or summer	**Language of instruction**	English
Hours per week	2 (1L, 1Lab)	**Hours per semester**	30 (15L, 15Lab)
Objectives of the course	To provide knowledge on advanced informatics methods and techniques in biomedical applications and to develop design skills in this field		
Entry requirements	Mathematics, Informatics, Computer systems, Fundamentals of Biomedical Engineering		
Course contents	**Lectures:** Medical knowledge representation. Basics of data models and DB systems. Elements of SQL language. Medical data bases. Electronic patient record. Methods of computer aided medical diagnosis. AI in medicine (expert systems, ANN). VR and AR in medical applications. Systems and standards: HIS, PACS and HL 7, DICOM 3. Problems of systems integration and interoperability. Elements of bioinformatics **Labs:** Medical data bases. Computer systems for medical diagnosis support. Computer radiotherapy planning systems. HIS, RIS, PACS systems		
Assessment methods	Written exam, accomplishment of practical labs		
Learning outcomes			
Recommended readings	1. Bemmel, van J. H., Musen M. A.: Handbook of Medical Informatics. Bohn Stafleu Van Loghum, Springer, 1997 2. Shortliffe E. H., Perreault L. E.: Medical Informatics. Computer Applications in Health Care. Addison-Wesley Publ. Comp., Readng, Mass., 1990 3. Coiera E.: Guide to Medical Informatics. The Internet and Telemedicine. Arnold, London, 1997 4. Huang H. K.: PACS in Biomedical Imaging. VCH Publ. Inc., N.Y., 1996 5. IT-EDUCTRA. FUNDESCO, Commission of the EC, 1998		
Additional information			

Course title	**ASIC&DSP IN BIOMEDICAL APPLICATIONS**		
Teaching method	lectures, lab training, project, computer simulations		
Person responsible for the course	Witold Mickiewicz, Krzysztof Penkala	**E-mail address to the person responsible for the course**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WEL_7	**ECTS points**	4
Type of course	compulsory	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	3 (1L, 1Lab, 1P)	**Hours per semester**	45 (15L, 15Lab, 15P)
Objectives of the course	To provide knowledge and design skills in application of ASIC&DSP in biomedical engineering.		

Entry requirements	Basic knowledge in Signal theory, Digital technique and Microprocessor technique
Course contents	**Lectures:** Programmable logic devices. A systematic approach to logic design. Introduction to VHDL. Architecture and programming methods of digital signal processors (DSP). DSP and FPGA implementation of signal processing algorithms used in biomedical applications: filtering, frequency analysis and signal-to-noise enhancement. ASIC and DSP in medical diagnostics, therapy and rehabilitation equipment. Neuroprocessing. **Labs, Proj:** Course in DSP and FPGA programming using assembler, C, VHDL and Verilog programming languages. Implementing filtering, FFT and other algorithms applied to biosignals on Analog Devices DSPs and Xilinx and Altera CPLDs & FPGAs.
Assessment methods	Written exam, accomplishment of practical labs and project work
Learning outcomes	
Recommended readings	1. Lee Sunggu: Design of computers and other complex digital devices. Prentice Hall, 2000 2. Perry D. L.: VHDL. McGrawHill, 1997 3. Smith S. W.: The Scientist and Engineer's Guide to Digital Signal Processing, California Technical Publishing, 1997 4. Oldfield J. V., Dorf R. C.: FPGAs. Reconfigurable Logic for Rapid Prototyping and Implementation of Digital Systems. John Wiley&Sons, Inc., N.Y., 1995 5. Analog Devices DSP data sheets and programmer literature at www.analog.com 6. Xilinx data sheets and programmer literature at www.xilinx.com
Additional information	

Course title	**ELEMENTS OF PSYCHOACOUSTICS AND ELECTROACOUSTICS**		
Teaching method	lectures, lab training, computer simulations		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person responsible for the course**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WEL_22	**ECTS points**	4
Type of course	optional	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	3 (2L, 1Lab)	**Hours per semester**	45 (30L, 15Lab)
Objectives of the course	To provide knowledge on psychoacoustics basics and selected topics on electroacoustics (sound fields, transducers, sound reinforcement, sound processing)		
Entry requirements	Basic knowledge in Physics		
Course contents	**Lectures:** Sound waves properties. Human auditory system. Musical sounds, notes and harmony. Elements of psychoacoustics – monaural and binaural hearing effects. Spatial hearing. Fundamentals of room acoustics and perceiving sound in different environments. Electroacoustical transducers and electroacoustical systems. Hearing aids. Digital sound processing. Audio compression. HRTF technology and 3-D audio systems		

	Labs: Models of human auditory system. Experiments in hearing. Hearing aids, software support. MATLAB in processing, compression and enhancement of audio signal. 3-D audio enhancements of 2-channel sound. Hard disc recording systems. Recording technology. Electroacoustical systems measurements and design. Filtering, sound effects
Assessment methods	Written exam, accomplishment of practical labs
Learning outcomes	
Recommended readings	1. Howard D. H.: Acoustics and psychoacoustics. Focal press, 2001 2. Blauert J.: Spatial Hearing - Revised Edition: The Psychophysics of Human Sound Localization. MIT Press, 1999 3. Everest F. A.: Master handbook of acoustics. McGraw-Hill, 2001
Additional information	

Course title	**ADVANCED METHODS OF MEDICAL IMAGE RECONSTRUCTION**		
Teaching method	lectures, lab training, computer simulations		
Person responsible for the course	Wojciech Chlewicki	**E-mail address to the person responsible for the course**	Wojciech.Chlewicki@zut.edu.pl
Course code (if applicable)	WEL_3	**ECTS points**	4
Type of course	optional	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	3 (2L, 1Lab)	**Hours per semester**	45 (30L, 15Lab)
Objectives of the course	To provide up to date knowledge and to develop skills on various methods and techniques of biomedical image reconstruction		
Entry requirements	Mathematics, Informatics, Digital signal processing, Image processing, Fundamentals of Biomedical Engineering		
Course contents	**Lectures:** Principles of tomography: the Radon transform, Fourier Slice Theorem. Direct Fourier methods. Analytical methods – Filtered Backprojection. Iterative methods: algebraic methods (ART, SART, SIRT, MART) and statistical methods (ML-EM, OS-EM, ISRA). Iterative Bayesian image reconstruction. Image representation in iterative methods – local basis function approach. Possible realizations of projection/backprojection operators. Problems of limited angle and limited number of views. Fully 3D image reconstruction: multi row and cone beam CT, 3D PET mode. The exact 3D reconstruction issues: helical and saddle trajectories **Labs:** This will include writing (assembling) of image reconstruction procedures and their evaluation using software simulated and real phantom data. Additionally reconstructions will be performed using real clinical data		
Assessment methods	Written exam, accomplishment of practical lab tasks		
Learning outcomes			

Recommended readings	1. Robb R. A.: Three Dimensional Biomedical Imaging: Principles and Practice. Wiley-Liss, N.Y., 1998 2. Kak C. and Slaney M.: Principles of Computerized Tomographic Imaging. Philadelphia, PA: SIAM, 2001 3. Natterer F.: The Mathematics of Computerized Tomography. Volume 32 of Classics in Applied Mathematics. SIAM, 2001
Additional information	

Course title	**EM FIELDS EFFECTS IN LIVING ORGANISMS**		
Teaching method	lectures, lab training, computer simulations		
Person responsible for the course	Michał Zeńczak	**E-mail address to the person responsible for the course**	Michal.Zenczak@zut.edu.pl
Course code (if applicable)	WEL_21	**ECTS points**	4
Type of course	optional	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	3 (2L, 1Lab)	**Hours per semester**	45 (30L, 15Lab)
Objectives of the course	To provide up to date knowledge on bioelectromagnetism, electromagnetic fields in natural environment and interaction of living systems with electromagnetic fields, to develop skills in designing electric power engineering structures according to standards for electromagnetic fields in natural and occupational environment		
Entry requirements	Mathematics, Physics, Theoretical electrical engineering, Theory of EM fields		
Course contents	**Lectures:** Basis of theory of electromagnetic fields in application for biology. Natural and technical sources of electromagnetic fields. Standards for electromagnetic fields. Electrical properties of living matter. Electromagnetic fields inside living systems. Mechanism of interaction of non-ionising electromagnetic fields with living systems. Infrared, visible and ultraviolet radiation. Influence of ionising radiation on living systems. Dosimetry of ionising radiation **Labs:** Measurements and computer simulations in EM fields, designing electric power engineering structures according to standards for EM fields		
Assessment methods	Written exam, accomplishment of lab tasks		
Learning outcomes			
Recommended readings	1. Bronzino J.D.: Biomedical Engineering Handbook. CRC Press, IEEE Press, 1995 2. Carstensen E.: Biological effects of transmission line fields. Elsevier, New York, Amsterdam, London 1987 3. Malmivuo J., Plonsey R.: Bioelectromagnetism. Oxford University Press, 1995 4. Polk C., Postow E.: CRC Handbook of biological effects of electromagnetic fields. CRC Press, Boca Raton, Florida 1986 5. Wadas R.S.: Biomagnetism. PWN, Warsaw 1978		
Additional information			

Course title	**MODELLING OF EM FIELDS IN HUMAN BODY**		
Teaching method	lectures, lab training, computer simulations		
Person responsible for the course	Stanisław Gratkowski Katarzyna Cichon-Bankowska	**E-mail address to the person responsible for the course**	Stanislaw.Gratkowski@zut.edu.pl Katarzyna.Cichon-Bankowska@zut.edu.pl
Course code (if applicable)	WEL_33	**ECTS points**	4
Type of course	optional	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	3 (2L, 1Lab)	**Hours per semester**	45 (30L, 15Lab)
Objectives of the course	To provide up to date knowledge on bioelectromagnetism, analysis and modelling of EM fields in living systems, and to develop practical skills in this area		
Entry requirements	Mathematics, EM fields theory		
Course contents	**Lectures:** Anatomical and physiological basis of bioelectromagnetism. Bioelectric sources and conductors and their modelling – concepts of volume source and volume conductor – bioelectric source and its electric field – the concept of modelling – the human body as a volume conductor – source field models – equivalent volume source density – current dipoles, extended source models. Theoretical methods for analyzing volume sources and volume conductors – forward problems – Maxwell's equations for conducting media – Laplace and Poisson equations – basic solutions of potential fields in homogeneous, isotropic half-space and spherical, cylindrical volume conductors – solid angle theorem – Miller-Geselowitz model – lead field and reciprocity – inverse problems – boundary element method – finite element method – visualization. Biomagnetic instrumentation – SQUID sensor – magnetically and electrically shielded rooms – gradiometers – dewar/cryostat – commercial and non-commercial biomagnetic measurement systems. Magnetic resonance Imaging. Electromagnetic Therapy. Simulation of cardiac electrophysiology – phantoms – physical source modelling. Biological effects of magnetic and electromagnetic fields. Health effects of electromagnetic field. **Labs:** Calculations of analytical solutions of simple problems related to biomagnetism. Modelling of human organs using MRI data. Creation of BE meshes. Forward electric and magnetic problems – BEM. Inverse problems – localization of single dipoles, reconstruction of extended sources. Statistical analysis of results and visualization		
Assessment methods	Written exam, accomplishment of labs		
Learning outcomes			

Recommended readings	1. J. Malmivuo, R. Plonsey: Bioelectromagnetism. Oxford University Press, New York, Oxford, 1995 2. L.I. Titomir, P. Kneppo: Bioelectric and Biomagnetic Fields: Theory and Applications in Electrocardiography. CRC Press, 1994 3. W. Andrä, H. Nowak, eds.: Magnetism in Medicine. A Handbook. Wiley-VCH, Berlin, 1998 4. IEEE Transactions on Biomedical Engineering 5. George B.Benedek, Felix m.h. Villars: Physics with illustrative examples from medicine and biology, Electricity and magnetism. Springer, 2000 6. Shoogo Ueno: Biological Effects of Magnetic and Electromagnetic Fields. Springer-Verlag New York Inc.,2013 7. National Research Council, National Academy of Sciences, Committee on the Possible Effects of Electromagnetic Fields on Biologic Systems, Commission on Life Sciences, Division on Earth and Life Studies: Possible Health Effects of Exposure to Residential Electric and Magnetic Fields. National Academies Press, 1997
Additional information	

Course title	**SOUND SYSTEM DESIGN**		
Teaching method	lectures, lab training, computer simulations		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person responsible for the course**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WEL_44	**ECTS points**	4
Type of course	optional	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	3 (2L, 1Lab)	**Hours per semester**	45 (30L, 15Lab)
Objectives of the course	To provide knowledge and design skills in various sound systems engineering		
Entry requirements	Basic knowledge in Physics and Electronic circuits		
Course contents	**Lectures:** Acoustic wave propagation. The decibel scale. Directivity and angular coverage of loudspeakers. Microphones. Outdoor sound reinforcement systems. Fundamentals of room acoustics. Behavior of sound systems indoors. Sound system architectures. Multichannel hi-fi and cinema sound systems. Public address and conference systems. Car audio **Labs:** Loudspeaker measurements and design. Room acoustics measurements and acoustical adaptation design. Microphones measurements and setup. Various sound system design. Using microphones, loudspeakers, amplifiers, mixing console and sound effects in sound reinforcement system design. Case studies		
Assessment methods	Written exam, accomplishment of practical labs		
Learning outcomes			

Recommended readings	1. Davis D. and C.: Sound System Engineering. Second edition. Howard F. Sams, Indianapolis, 1987 2. Eargle J.: Electroacoustical Reference Data. Van Nostrand Reinhold, New York, 1994 3. JBL Professional, Sound System Design Reference Manual, pdf document available at www.jblpro.com
Additional information	

Course title	**ADVANCED METHODS OF SPEECH PROCESSING AND ANALYSIS**		
Teaching method	lectures, lab training, computer simulations		
Person responsible for the course	Jerzy Sawicki	**E-mail address to the person responsible for the course**	Jerzy.Sawicki@zut.edu.pl
Course code (if applicable)	WEL_4	**ECTS points**	4
Type of course	optional	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	3 (2L, 1Lab)	**Hours per semester**	45 (30L, 15Lab)
Objectives of the course	To provide knowledge on advanced techniques of speech processing and analysis as well as solving problems of speech transmission		
Entry requirements	Signal theory		
Course contents	**Lectures:** Acoustic theory of speech production. Equivalent circuit of the vocal tract. Perception of speech: the ear and hearing. Speech signal representation. Techniques for speech analysis: FFT, LPC, cepstral processing. Spectral and formant analysis. Analysis of voice pitch. Speech synthesis. Text-to-speech systems. Speech coding: PCM, DPCM, DM, ADM, CELP. Systems for analysis-synthesis in telecommunications: vocoders. Speech and speaker recognition: HMM models **Labs:** The complete speech analysis systems for PC: Multispeech (Kay Elemetrics) and Sonolab (Young Digital Poland). Editing and analysis of the speech samples. Glottal pulse and formants analysis. Spectrograms. Vowels and consonants analysis. Speech coding: quality and intelligibility		
Assessment methods	Written exam, accomplishment of labs		
Learning outcomes			
Recommended readings	1. Jurafasky D., Martin J.H.: Speech and language processing. Prentice Hall, 2000 2. Huang X., Acero A., Hon H.: Spoken language processing. Prentice Hall, 2001 3. O'Shaughnessy D.: Speech communication: human and machine. Inst. of Electrical and Electronics Engineers, New York, 2000 4. Owens F.J.: Signal processing of speech. Macmillan, London 1993		
Additional information			

Course title	**RESEARCH LAB**		
Teaching method	lab and project work, seminars		
Person responsible for the course	Krzysztof Penkala (course leader)	**E-mail address to the person responsible for the course**	Krzysztof.Penkala@zut.edu.pl
Course code (if applicable)	WEL_Lab	**ECTS points**	5
Type of course	compulsory	**Level of course**	master
Semester	winter or summer	**Language of instruction**	English
Hours per week	4 (2Lab, 1P, 1S-average)	**Hours per semester**	60 (30Lab, 15P, 15S)
Objectives of the course	To provide knowledge on research and design methods and to develop various skills useful in solving bioengineering problems		
Entry requirements	Physics, Informatics, Signal processing, Image processing, Telecommunications, Computer systems, Fundamentals of Biomedical Engineering		
Course contents	Research work (individual or in 2-3 students teams) is run on topics corresponding to the area of all courses. The topics are offered by the teachers and chosen by the students at the beginning of the semester, after consultations; the topics may be also proposed by the students. Projects are run using all facilities of the Department of Systems, Signals and Electronics Engineering and co-operating Departments (including rooms, laboratory equipment, computers & software, Internet access, library, copying facilities etc.). Consultations with supervisors – the teachers involved in all projects - are performed regularly during the semester, with presentation of the progress of research work in the mid of the semester, in a form of a seminar open for all students and teachers (6h). Final assessment of a particular project is made after evaluation of the written report by the supervisor and reviewer, on the basis of oral presentation or a poster during the second, final seminar (9h)		
Assessment methods	Continuous assessment of lab/project work, evaluation of the written report and of oral/poster presentation of the project results during the final seminar		
Learning outcomes			
Recommended readings	Recommended materials for all courses of the SPE-1		
Additional information			