Faculty of Electrical Engineering

WEST POMERANIAN UNIVERSITY OF TECHNOLOGY
IN SZCZECIN, POLAND

THE OFFER FOR INTERNATIONAL STUDENTS
FOR THE YEAR 2021/2022
SECOND DEGREE

	Course title	Person responsible for the course	Semester (winter/summer)	ECTS points	Hours
1	Adaptive Signal Processing	Piotr Okoniewski	summer	2	30
2	Advanced 32-bit microcontrollers	Witold Mickiewicz	winter/summer	3	45
3	Antennas and EM wave propagation	Stanisław Gratkowski	winter/summer	3	45
4	Artificial Intelligence in Automation and Robotics	Krzysztof Jaroszewski	winter/summer	3	45
5	Augmented Reality	Przemysław Mazurek	winter/summer	4	60
6	Basic Course of Metrology	Artur Wollek	winter/summer	4	45
7	Biomedical Signal Processing and Analysis	Joanna Górecka	winter/summer	4	45
8	Biomedical Technology Equipment	Joanna Górecka	winter/summer	3	45
9	Biosensing	Sławomir Kocoń	winter/summer	4	45
10	Computer Animation	Przemysław Mazurek	winter/summer	4	60
11	Computer Graphics and Visualisation	Krzysztof Okarma	winter/summer	5	60
12	Computer Networks	Piotr Lech	winter	4	45
13	Computer Vision and Image Processing	Krzysztof Okarma	winter/summer	6	60
14	Control of 3D Printers	Adam Łukomski	winter/summer	3	45
15	Control of Mobile Robots	Adam Łukomski	winter/summer	3	45
16	Diagnostics and operation of HV power equipment	Szymon Banaszak	winter/summer	4	60
17	Digital Technique	Joanna Górecka	winter/summer	4	60
18	Electrical Circuit Analysis with Matlab	Marcin Ziółkowski	winter/summer	4	45
19	Electrical Power Engineering	Michał Zeńczak	winter/summer	6	60
20	Electric Power Network	Michał Zeńczak	winter/summer	3	30
21	Electromagnetic, Ultrasonic and Radiographic Nondestructive Testing	Marcin Ziółkowski	winter/summer	6	75
22	Electromagnetic Field and the Human Body	Stanisław Gratkowski	winter/summer	3	45
23	Electromagnetic Methods of Non-destructive Testing	Tomasz Chady	winter/summer	4	75
24	Electronic Devices and Circuits	Witold Mickiewicz	winter/summer	4	60
25	Elements of Laser Optics	Andrzej Ziółkowski	summer	3	30
26	Elements of Psychoacoustics and Electroacoustics	Witold Mickiewicz	winter/summer	4	60
27	Embedded Systems	Przemysław Mazurek	winter/summer	4	60
28	EM Fields Effects in Living Organisms	Michał Zeńczak	winter	2	30
29	Fiber Optic Access Networks (FOAN)	Grzegorz Żegliński	summer	4	60

	Course title	Person responsible for the course	Semester (winter/summer)	ECTS points	Hours
30	Fiber Optics Instalation	Grzegorz Żegliński	winter/summer	3	45
31	Finite Element Method in Electromagnetics	Marek Ziółkowski	winter/summer	6	75
32	Fundamentals of Engineering Electromagnetics	Stanisław Gratkowski	winter/summer	3	60
33	Fundamentals of Web Development	Przemysław Włodarski	winter/summer	5	60
34	High Voltage Engineering	Szymon Banaszak	winter/summer	4	60
35	Humanoid and Social Robotics	Adam Łukomski	winter/summer	3	30
36	Introduction to Control Engineering	Paweł Dworak	winter/summer	4	45
37	Introduction to Cryptography	Maciej Burak	winter/summer	3	45
38	Introduction to Electric Circuits - part 1	Tomasz Chady	winter/summer	4	75
39	Introduction to Electric Circuits - part 2	Tomasz Chady	winter/summer	4	75
40	Introduction to Infrared Thermography	Barbara Grochowalska	winter/summer	3	45
41	Introduction to Matlab	Przemysław Orłowski	winter/summer	5	60
42	Introduction to Microcontrollers	Witold Mickiewicz	winter	3	45
43	Introduction to Multisensor Data Mining and Fusion	Grzegorz Psuj	winter/summer	2	30
44	Introduction to Sound Recording Technology	Witold Mickiewicz	winter/summer	4	45
45	M.Sc. Thesis	- Nauczyciel WE	winter/summer	20	15
46	Machine Learning	Adam Krzyżak	summer	6	60
47	Magnetic Measurements Techniques	Grzegorz Psuj	winter/summer	2	30
48	Medical Imaging Systems	Piotr Okoniewski	winter/summer	3	45
49	Modern Electrical Machines	Ryszard Pałka	winter/summer	6	45
50	Modern Image Processing	Przemysław Mazurek	winter/summer	4	60
51	Multistructured Optical Fibres Applications	Ewa Weinert-Rączka	winter	2	30
52	Network Systems Administration	Piotr Lech	summer	4	45
53	Network Traffic	Przemysław Włodarski	winter/summer	5	45
54	Neural Networks and Deep Learning	Przemysław Mazurek	winter/summer	4	60
55	Non-Destructive Testing (NDT) using radiographic (X-ray) and terahertz method	Tomasz Chady	winter/summer	4	30
56	Nonlinear Control	Adam Łukomski	winter/summer	3	45
57	Object-Oriented Programming in C#	Marcin Ziółkowski	winter/summer	5	60
58	Optimization Theory	Marcin Ziółkowski	winter/summer	5	60

	Course title	Person responsible for the course	Semester (winter/summer)	ECTS points	Hours
59	Optoelectronic sensors	Grzegorz Żegliński	winter/summer	5	60
60	Pattern Recognition and Classification	Adam Krzyżak	summer	4	60
61	Power System Protection	Michał Zeńczak	winter/summer	2	30
62	Problem-Solving Workshop	Joanna Górecka	winter/summer	5	60
63	Programmable Automation System Based on PLC and HMI	Krzysztof Jaroszewski	winter/summer	3	45
64	Programmable Logic Devices	Witold Mickiewicz	winter/summer	4	45
65	Renewable Energy Sources	Olgierd Małyszko	winter/summer	2	30
66	Selected Topics in Nonlinear Photonics	Ewa Weinert-Rączka	summer	2	30
67	Signal Processing	Joanna Górecka	winter/summer	4	60
68	Sound System Design	Witold Mickiewicz	winter/summer	4	60
69	Statistical Methods in ICT	Przemysław Włodarski	winter/summer	5	60
70	Telemedicine	Sławomir Kocoń	winter/summer	3	60
71	Terahertz Technique	Przemysław Łopato	winter/summer	2	30
72	Visual Programming in LabVIEW	Paweł Dworak	winter/summer	3	45
73	Wireless Power Transfer (WPT) for electromobility	Konrad Woronowicz	winter/summer	4	45

Course title	Adaptive Signal Processing		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Piotr Okoniewski	**E-mail address to the person**	Piotr.Okoniewski@zut.edu.pl
Course code (if applicable)	WE-2-01	**ECTS points**	2
Semester	summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	Knowledge about adaptive signal processing Knowledge about modern adaptive algorithms Practical skills in the adaptive processing area		
Entry requirements	Basic knowledge of Matlab Basic knowledge of Signal Processing		
Course contents	Matlab tools for adaptive filtering Wiener filters in Matlab Active Noise Cancellation techniques Image adaptive filtering Course summary Introduction to adaptive filtering concept Random processes Wiener filters Least Mean Square (LMS) algorithm Normalized Least Mean Square (NLMS) algorithm Applications of adaptive filtering Course summary		
Assessment methods	Lectures Lab reports Summary test Lab reports		
Recommended readings	1. Haykin, Simon, Adaptive Filter Theory., Prentice Hall, 2002		
Knowledge	During this course students will get knowledge about modern adaptive signal processing algorithms		
Skills	During this course students will acquire practical skills in modern adaptive signal processing algorithms		

Course title	Advanced 32-bit microcontrollers		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WE-2-02	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	acquire the knowledge in architecture and features of 32-bit microcontrollers acquire basic skills in programming of 32-bit microcontrollers acquire basic skills in programming peripheral modules in STM-family microcontrollers acquire basic skills in implementation of digital signal processing algorithms in 32-bit microcontrollers		
Entry requirements	basic skills in programming of 8-bit microcontrollers basic knowledge about digital signal processing		
Course contents	Development board and software used in laboratory – basic informations. Clock system in STM32 microcontroller. Input/output ports operations. HAL and CMSIS libraries - comparison. Hardware debugger, analysis of program execution, step by step execution, observation of registers content. Timers configuration in different operating modes. Interrupt system. Analog to digital converter. DMA controller. Switches and keyboards. Alphanumerical and graphical LCD displays. Communication interfaces (1) - USART. Communication interfaces(2)- I2C, SPI. Audio processing system (1) – IIR filter implementation. Audio processing system (2) – audio effects (reverberation, echo). Frequency analyses – FFT implementation. Reading and processing data from analog sensors (e.g. accelerometers, gyroscopes) Exam 32-bir architecture: its advantages compared to 8-bit. RISC and ARM architecture types on the example of the STM32 family of microcontrollers. Memory organisation. Microcontroller clock circuits, internal and external sources of clock signal, its propagation in the microcontroller. Core and peripheral circuits, frequency division and multiplication circuits (PLL). The control registers responsible for the timing configuration. Interrupt system of the STM32 microcontroller, interrupt sources (from core, bus and peripherals), NVIC controller and control registers. Timers: 24-bit SysTick timer and its basic functions, general purpose and advanced timers, operationg modes e.g.: PWM, capture mode, encoder interface mode, cooperation with Hall sensors, external trigger synchronization. General-purpose and alternate-function input/output ports (GPIO, AFIO). Port configurations: digital input/output, analog, alternate functions. Control registers. Cooperation with peripherals (e.g. ADC, timers, USART) Analog to digital converter (ADC). Internal ADCs of STM32 microcontroller. Basic parameters. Operating modes and its applications: single and continuous conversion, analog watchdog, scan mode, regular and injection conversion, dual modes. ADC calibration, timing and trigger sources. Direct memory Access (DMA). DMA controller in STM32 microcontrollers, types of transfer (memory to memory, memory to peripheral, peripheral to memory, peripheral to peripheral). Circular buffer management, priorities. Digital to analog converter (DAC). Internal DACs of STM32 microcontroller. Basic parameters. Timing and calibration. Cooperation with DMA. Generation of additional signal (pseudorandom noise or triangle signal). Using PWM signal as digital to analog converter. Communication interfaces in STM32 microcontrollers. Hardware realization of communication interfaces: SPI, I2C, USART, CAN, USB 2.0- full speed. Examples of applications. Floating- Point Unit(FPU). FPU in Cortex-M4 and Cortex-M7 core microcontrollers. Advantages of using hardware implementation of floating point calculations especially in signal processing. Available FPU operations and its calculation cost. Control registers. Advanced peripherals in STM32 microcontrollers: noise generators, internal operational amplifiers, accelerators for enhanced graphic content creation, camera interfaces, real time clock (RTC), I2S bus and others.		

	Implementation of digital signal processing algorithms in STM32 microcontrollers. Basic instructions used in digital filters realisation and its optimal implementation in STM32 microcontrollers. Multiple and accumulate (MAC) and Single instruction multiple data (SIMD) instructions. Examples of implementation of: finite and infinite impulse response filters(IIR, FIR), Proportional-Integral-Derivative controller(PID), Fast Fourier Transform (FFT) in STM32 microcontroller. Floating and fixed point operations. Comparison of performance of STM32 family microcontrollers with: Cortex M3, Cortex M4, Cortex M7 cores. Selection of microcontroller for a specific application. Current development trends. Software using for STM32 microcontrollers programming. CMSIS and HAL libraries, Cube interface. Advantages and disadvantages in low- and high-level programming of STM32 microcontrollers. Real time operating systems(RTOS).
Assessment methods	Lectures Laboratory exercises Written test Reports assessment
Recommended readings	1. STM32 microcontrollers reference manual – online publication, free access 2. STM32 microcontrollers programming manual – online publication, free access 3. STM32F10x DSP library, User Manual, UM0585 - online publication, free access 4. Richard G. Lyons, Understanding Digital Signal Processing
Knowledge	To provide knowledge in 32-bit microcontrollers
Skills	To provide skills in microcontrollers engineering

Course title	Antennas and EM wave propagation		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Stanisław Gratkowski	**E-mail address to the person**	Stanislaw.Gratkowski@zut.edu.pl
Course code (if applicable)	WE-2-03	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	During the course, students will gain a basic knowledge of the operation, design and modeling of antenna and microwave systems utilized in electrotechnics, electronics and telecommunication.		
Entry requirements	Basic course of mathematics and physics (electromagnetics)		
Course contents	Numerical modeling and measurements of antennas structures Electromagnetic waves, Maxwell's equations Antenna parameters, types of antennas Antenna arrays, smart antennas Transmission lines, waveguides, reflection coefficient, SWR, impedance matching, Smith chart, S-parameters Active and passive microwave devices Computer aided analysis of antennas and microwave instruments (numerical techniques review) Measurements of antennas and microwave devices		
Assessment methods	Lectures with simple experiments; laboratory –measurements and computer simulations of antenna structures Lectures - written test and/or discussion laboratory – continuous assessment		
Recommended readings	1. Balanis Constantine A., Antenna Theory: Analysis and Design, John Wiley & Sons, 2005 2. Bansal Rajeev, Fundamentals of engineering electromagnetics, CRC Press Taylor & Francis, 2006 3. Collin Robert E., Foundations for microwave engineering, John Wiley & Sons, 2001		
Knowledge	During the course, students will gain a basic knowledge of the operation, design and modeling of antenna and microwave systems utilized in electrotechnics, electronics and telecommunication.		
Skills	During the course, students will gain a basic knowledge of the operation, design and modeling of antenna and microwave systems utilized in electrotechnics, electronics and telecommunication.		

Course title	Artificial Intelligence in Automation and Robotics		
Level of course	second cycle		
Teaching method	laboratory course / project course / lecture		
Person responsible for the course	Krzysztof Jaroszewski	**E-mail address to the person**	Krzysztof.Jaroszewski@zut.edu.pl
Course code (if applicable)	WE-2-04	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Delivering the basic knowledge about AI, especially in the area of GA, FL and NN Delivering basic skills in using Matlab AI toolboxes		
Entry requirements	The basic knowledge in the area of Mathematics		
Course contents	Neural network in the task of classification Neural network in the task of characters recognition Fuzzy logic in the task of control Design of the function implementing the functionality of a classical genetic algorithm 1. Introduction to AI Genetic algorithms: definitions, area of using, example of working classical GA Neural networks: types of the nets, methods of learning, example of teaching the net Experts systems Fuzzy logic: definiotion of FL system, example of calculating output of the FL system		
Assessment methods	prelection individual work, with using a computer validation of the raport exam		
Recommended readings	1. Stuart Russell, Artificial Intelligence: A Modern Approach, Pearson Education Limited, England, 2014, 3rd, ISBN-13: 978-0136042594 ISBN-10: 0136042597		
Knowledge	Ability to define basic subjects connected with artificial intelligence.		
Skills	Skills in implementing and using proper method of artificial intelligence.		

Course title	Augmented Reality		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Przemysław Mazurek	**E-mail address to the person**	Przemyslaw.Mazurek@zut.edu.pl
Course code (if applicable)	WE-2-05	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Basic knowledge related to augmented reality		
Entry requirements	Computer Graphics		
Course contents	Project related to selected AR topic 2D and 3D modelling Techniques for tracking objects Techniques for tracking camera Keying techniques Image and video compositing techniques Test of knowledge		
Assessment methods	Instructional method/informative lecture Practical method/project Passing the project Pass/fail test		
Recommended readings	1. Blender Videotutorials 2. K. Babilinski, J. Linowes, Augmented Reality for Developers, Packt Publishing, 2017 3. D.Schmalstieg, T.Hollerer, Augmented Reality: Principles and Practice, Addison-Wesley Professional, 2016 4. Photoshop Videotutorials		
Knowledge	Knowledge related to augmented reality		
Skills	Basic skills related to AR		

Course title	Basic Course of Metrology		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Artur Wollek	**E-mail address to the person**	Artur.Wollek@zut.edu.pl
Course code (if applicable)	WE-2-06	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	To provide a basic knowledge in the field of metrology. The student learns: typical methods of measurement methods and tools necessary for analyzing the results of the measurements, as well as the current state and development trends in the field of sensors, transducers and measurement systems.		
Entry requirements	Mathematics, Physics		
Course contents	Voltage and current measurement Frequency, period and time measurement Oscilloscope as a measurement instrument Resistance measurement Measurement of impedance components Measurement methods of compensation Magnetic measurements Rotational speed measurement Strain gouge measurement Temperature measurement Basic concepts of metrology, units and the measurement system, measurement standards. Measuring scales. Basic methods of measurement. Analysis of accuracy of measurement: systematic and random errors, the uncertainty of measurement. Electrical quantities measurement. Measurement of the frequency, period and time. Measurement of voltage and current. Measurement of resistance and impedance. Non-electrical quantities measurement. Classification of sensors and transducers for measuring non-electrical values. Static and dynamic properties of sensors and transducers. Temperature measurement methods. Measurement of rotational speed. Pressure measurements. Measurement of the magnetic properties of solids. Measuring systems. DAQ cards in measuring systems.ADC and DAC converters. Interfaces in measuring systems. Software of the measurement systems.		
Assessment methods	Lecture, Lab Lectures: grade, Lab: accomplishment of Lab tasks		
Recommended readings	1. Evaluation of measurement data — Guide to the expression of uncertainty in measurement, JCGM, 2008 2. Northrop R.B., Introduction to instrumentation and measurements, CRC Press, 2005 3. Sidor T., Electrical and Electronic Measurement and Instrumentation, AGH, 2006 4. Sydenham P.H., Handbook of Measurement Science, John Wiley & Sons Ltd., 1983 5. The Metrology Handbook, ASQ Quality Press, 2004		
Knowledge	The student can choose the typical measurement methods and appropriate sensors and transducers, as well as to assess the usefulness of new solutions for the implementation of the tasks associated with electrical engineering.		
Skills	The student can choose the typical measurement methods and appropriate sensors and transducers, as well as to assess the usefulness of new solutions for the implementation of the tasks associated with electrical engineering.		

Course title	Biomedical Signal Processing and Analysis		
Level of course	second cycle		
Teaching method	laboratory course / project course / lecture		
Person responsible for the course	Joanna Górecka	**E-mail address to the person**	Joanna.Gorecka@zut.edu.pl
Course code (if applicable)	WE-2-07	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
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	Biosignal acquisition, processing and analysis using specialized equipment (sensors, transducers, amplifiers etc.) and software tools - LabView. Chosen biosignals analysis using software tools: MATLAB. Chosen biosignals analysis using software tools - LabView. Using computer tools in processing and analysis of biological signals Implementing algorithms applied to different biosignals. Biosignals: definitions, classification. Bio-measurements: (bio)sensors, electrodes, transducers, amplifiers. Methods and techniques of biosignal acquisition, processing and analysis. Electrophysiology systems: ECG, EEG, EMG, ERG/VEP/P300. Biosignal analysis in time and frequency domain: spectral analysis, FFT, STFT, time-frequency analysis, Wavelet Transformation. Methods of statistical biosignal analysis. MATLAB and LabView environments in biosignal processing and analysis, dedicated toolboxes. Examples of advanced ECG, EEG, VEP/P300 processing and analysis.		
Assessment methods	oral presentation (lectures), practical work in lab grade, accomplishment of lab tasks		
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		
Knowledge	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.		
Skills	The student has practical skills useful in this area regarding bio-measurements (instrumentation, specialized software tools).		

Course title	Biomedical Technology Equipment		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Joanna Górecka	**E-mail address to the person**	Joanna.Gorecka@zut.edu.pl
Course code (if applicable)	WE-2-08	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
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	Biosignals and biomeasurements Biosignal acquisition, processing and analysis using specialized transducers, amplifiers, equipment and software tools: MATLAB and LabView. Demonstration of medical equipment in hospitals (e.g. brain systems) Biomeasurements, biomedical instrumentation, biosignals (1-D, 2-D) acquisition, processing and analysis Equipment: ECG, EEG, EMG, VEP/P300. Basic medical imaging systems. Medical telematics, IT in e-Health Computer aided medical diagnosis		
Assessment methods	oral presentation (lectures), practical work in lab Lectures: grade, Lab: accomplishment of lab tasks		
Recommended readings	1. Bronzino J. D. (ed.), Biomedical Engineering Handbook, CRC Press, IEEE Press, Boca Raton, Florida, USA, 1995 2. Bemmel, van J. H., Musen M. A., Handbook of Medical Informatics, Bohn Stafleu Van Loghum, Springer, Germany, 1997 3. Christensen D. A., Ultrasonographic Bioinstrumentation, J. Wiley & Sons, New York, USA, 1988 4. Huang H. K., PACS in Biomedical Imaging, VCH Publ. Inc., New York, USA, 1996		
Knowledge	The student has basic knowledge on biomedical technology (instrumentation, equipment, software, specialized systems and standards used in this field).		
Skills	The student has practical skills useful in the area of biomedical technologies regarding their development, implementation, exploitation and assessment.		

Course title	Biosensing		
Level of course	second cycle		
Teaching method	laboratory course / project course / lecture		
Person responsible for the course	Sławomir Kocoń	**E-mail address to the person**	Slawomir.Kocon@zut.edu.pl
Course code (if applicable)	WE-2-09	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	To provide actual knowledge on measurements 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	Basic principles in electrical bio measurements. Impedance measurements of biosensors electrodes. Assembly and test of heart rate monitor. Assembly and test circuit of EMG sensor. Wireless biomedical signal transfer. Filtration of recorded biomedical signals. Course summary. Design and measurements of bio sensor electrodes. Introduction to biosensing technology. Principles of bio measurement. Heart rate biosensors. EMG sesnors. ECG and pulsometers. Noise cancallation in biomedical signals. Future trends in bio measurement		
Assessment methods	Lectures with cases presentations Laboratory exercises Project. Lectures – written exam Labs - accomplishment of lab tasks Project - report		
Recommended readings	1. Pier Andrea Serra, Biosensors, InTech, 2010 2. John G. Webster, Medical Instrumentation. Application and Design., Wiley, 2009 3. Yuan-Ting Zhang, Werable Medical Sensors and Systems, Springer, 2018		
Knowledge	To provide actual knowledge on sensors in biomedical applications		
Skills	To provide actual develop design skills in sensors in biomedical applications		

Course title	Computer Animation		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Przemysław Mazurek	**E-mail address to the person**	Przemyslaw.Mazurek@zut.edu.pl
Course code (if applicable)	WE-2-11	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Basic knowledge related to computer animation		
Entry requirements	Computer Graphics		
Course contents	Animation project using selected techniques: keyframes, morphing, motion-capture, generators 3D Modelling Animation techniques: keyframes, morphing Motion capture systems Virtual humans Test of knowledge		
Assessment methods	Instructional method/informative lecture Practical method/project Passing the project A pass in the form of a choice test		
Recommended readings	1. Blender Videotutorials 2. AxisNeuron Motion Capture (videotutorials) 3. Adobe Photoshop CS3 Manual, 2008 4. B.Fleming, D.Dobbs, Animating Facial Features & Expressions, Charles River Media, 1998		
Knowledge	Knowledge related to computer animation		
Skills	Skills related to CG, compositing, matchmoving, chromakeying		

Course title	Computer Graphics and Visualisation		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Krzysztof Okarma	**E-mail address to the person**	Krzysztof.Okarma@zut.edu.pl
Course code (if applicable)	WE-2-12	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	This course is intended to present the fundamental algorithms in computer graphics as well as some more advanced techniques used in image synthesis		
Entry requirements	Fundamentals of computer engineering, mathematics (a short introduction to 3-D geometry is provided)		
Course contents	Software project in chosen environment related to some specific computer graphics or visualisation 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). 3-D images synthesis methods. Light modelling and shading methods. Ray-tracing and radiosity methods in computer visualisation.		
Assessment methods	lectures based on presentations nad case studies project based learning written test and/or oral discussion project assessment		
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		
Knowledge	knowledge about typical computer graphics algorithms and visualisation methods		
Skills	ability to solve a chosen problem related to computer graphics or visualisation		

Course title	Computer Networks		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Piotr Lech	**E-mail address to the person**	Piotr.Lech@zut.edu.pl
Course code (if applicable)	WE-2-13	**ECTS points**	4
Semester	winter	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Describing the network structure, equipment and transmission lines. Modelling of the network. Describing the role of network protocols. Describing the role of network services. Acquainted with a TCP / IP and the Web. The basic skills in using tools for configuration, control and network analysis.		
Entry requirements	Basic computer skills and computer applications.		
Course contents	Collecting basic information about the computer network. Configuring network interfaces. Analysis of the network protocol stack. Encapsulation. Testing the network. The use of IP, UDP, TCP network applications. Differences implementing TCP UDP. The network project - the application layer switches 2 and 3. Splitting a network and design IP network using routers. Access devices and WiFi. Core Network Services - e-mail, ftp, etc. HTML Basics - design and implement a simple web page. Simple CMS - instalation. Introduction to network security. The hazard analysis. Basic concepts. Splitting a network. Network topologies. The model ISO / OSI. Encapsulation. The model of the Internet network. Introduction to TCP / IP. Ethernet standard. IP addressing. Distribution of IP networks. TCP/IP stack. Network equipments of the second layer. The third layer switches. Virtual Networks. Spanning Tree Protocol. Routing. Routing protocols.		
Assessment methods	lecture discussion laboratory exercises test evaluation reports		
Recommended readings	1. Rod Scrimger (Author), Paul LaSalle (Author), Mridula Parihar (Author), Meeta Gupta (Author), TCP/IP Bible		
Knowledge	Knowledge of basic configuration of computer networks and IP networks.		
Skills	Addressing in computer networks. Understanding of layered models in networking. Understanding of protocols.		

Course title	Computer Vision and Image Processing		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Krzysztof Okarma	**E-mail address to the person**	Krzysztof.Okarma@zut.edu.pl
Course code (if applicable)	WE-2-14	**ECTS points**	6
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	This course is intended to present a unified approach to image processing techniques with introduction to image analysis and its applications		
Entry requirements	Basic knowledge of Matlab or Mathcad environments, basic knowledge about programming and signal processing		
Course contents	Software project in chosen environment related to some specific computer vision algorithms Digital image – classes, representations and conversion methods. Digital image acquisition. Arithmetic and logic operations on digital images. Geometric operations, matrix notation. Colour models. Methods for reduction of the number of colours. Local processing and filtration using convolution filters. Frequency-based image processing methods. Deformations, bilinear projection and morphing. Histogram and histogram-based operations. Binarization. Morphological operations. Image segmentation. Labelling 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. Basics of photogrammetry and 3D Vision. Applications of machine vision in automation and robotics.		
Assessment methods	lectures based on presentations nad case studies project based learning written test and/or oral discussion project assessment		
Recommended readings	1. Pratt W.K., Digital Image Processing, Wiley Interscience, New York, 1991, 2nd Edition (or later) 2. Foley J.D. et al, An Introduction to Computer Graphics, Addison-Wesley, 2000 3. Pavlidis T., Algorithms for Graphics and Image Processing, Computer Science Press,, Rockville, 1982 4. Russ J.C., The Image Processing Handbook, CRC Press, 1999		
Knowledge	knowledge about typical image processing and analysis methods and their applicability		
Skills	ability to solve a chosen problem related to image processing or analysis		

Course title	Control of 3D Printers		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Adam Łukomski	**E-mail address to the person**	Adam.Lukomski@zut.edu.pl
Course code (if applicable)	WE-2-15	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Gaining skills connected with 3D printer design and control Gaining knowledge about 3D printers		
Entry requirements	General knowledge of C and Matlab programmming		
Course contents	Introducation, 3D printing examples Modelling in Blender/OpenSCAD and slicing 3D parts GCode introduction 3D printer setup in Marlin firmware Arduino-compatible boards programming basics Stepper motor control Serial communication Matlab interface over a serial port Inverse kinematics for a parallel printer Temperature measurement Hotend control using PID regulator Printing session using custom firmware GUI development introduction GUI for a 3D printer Final firmware and GUI integration testing Introduction to 3D printing Available firmware overview Slicing software Common errors in 3D printing 3D printer design considerations Control boards and electronics		
Assessment methods	Lecture Laboratory course Final exam on the last lecture meeting Grades based on performance during laboratory meetings		
Recommended readings	1. Marlin Firmware GCode Documentation, http://marlinfw.org/meta/gcode/		
Knowledge	Knowledge about design and control of a 3D printer.		
Skills	Ability to design a control system for a 3D printer.		

Course title	Control of Mobile Robots		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Adam Łukomski	**E-mail address to the person**	Adam.Lukomski@zut.edu.pl
Course code (if applicable)	WE-2-16	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Gaining skills connected with general control of a mobile robot		
Entry requirements	General knowledge of mathematics: matrix operations, derivatives, integrals General knowledge of basic linear control theory		
Course contents	Introduction to ROS Arduino and servo control, buttons, communication Arduino and ROS - compile, C language, servo control Handling messages - subscribers and topics with a web camera MATLAB with ROS Two wheeled robot - design, electronics assembly 3D printing a robot chassis ESP8266 WiFi microcontroller with ROS introduction Basic Android programming for mobile robots Robot manipulator modelling and control Gazebo simulator for planning robot movements Introduction to mobile robotics Overview of the most common mobile robots ROS as a robotic platform Robot kinematics and simulation techniques Feedback linearisation control for a unicycle model Lyapunov stabilisation for a unicycle model		
Assessment methods	Project meetings Lectures Final exam on the last lecture meeting Presentation of results on the last laboratory meeting		
Recommended readings	1. Murray, Richard M and Li, Zexiang and Sastry, S Shankar, A mathematical introduction to robotic manipulation, CRC Press, 1994		
Knowledge	Ability to create a kinematic and dynamic model of the mobile robot. Ability to create, analyse and implement a model-based control system.		
Skills	Ability to create a kinematic and dynamic model of the mobile robot. Ability to create, analyse and implement a model-based control system.		

Course title	Diagnostics and operation of HV power equipment		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Szymon Banaszak	**E-mail address to the person**	Szymon.Banaszak@zut.edu.pl
Course code (if applicable)	WE-2-17	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The aim of the subject is to acquaint students with technical problems in HV insulation systems and their failures. The aim of the subject is to acquaint students with diagnostics methods of HV equipment.		
Entry requirements	It is necessary to have basic information in the field of physics, electrical engineering, material engineering. It is necessary to have basic information in the field of high voltage engineering.		
Course contents	Introduction to the laboratory and safety regulations Thermography of HV equipment Tests of cables in operation Frequency Response Analysis of transformers Assessment of paper-oil insulation in transformer by RVM method Subject credit 1 HV motor insulation diagnostics with SVM method Assessment of paper-oil insulation of transformer with FDS method Bushing insulation assessment with FDS method Partial discharges detection with UHF method Partial discharges detection in cable with electric method Assessment of transformer insulation with PDC method Technical reports assessment Final subject's credit Introduction to diagnostics and operation of HV devices HV insulation systems (transformers, bushings, cables) Failures in HV grids and devices Diagnostic methods of HV equipment Polarization methods in HV insulation: RVM, PDC and FDS Frequency Response Analysis (FRA) of transformers Step Voltage Method (SVM) for insulation tests Tests of cables in operation Partial discharges detection (electric method, UHF) Thermography of HV equipment Management of power systems		
Assessment methods	Lecture Laboratory Partial grade based on students reports. Final grade of laboratories Final grade of the lecture		
Recommended readings	1. E. Kuffel, W. S. Zaengl, J. Kuffel, High voltage engineering: fundamentals, Newnes (An imprint of Elsevier), 2004 2. Peek F.W., Dielectric Phenomena in HIgh Voltage Engineering, McGraw-Hill Book Company, Inc., 1915 3. M.S. Naidu, V. Kamaraju, High Voltage Engineering, Tata McGraw-Hill, 2009 4. H.M. Ryan, High Voltage Engineering and Testing, The Institution of Electrical Engineers, 2001		
Knowledge	The student has knowledge of the devices included in power systems, as well as their material characteristics and diagnostic methods. The student has knowledge in the operation and diagnosis of high voltage networks and equipment.		
Skills	The student is able to prepare documentation of the results of an experiment, a project or a research task and to prepare a paper including a discussion of these results taking into account the information obtained from the literature, based on conclusions and justified opinions. Students will be able to analyze, plan, and perform experiments on high-voltage electrical systems, modifying existing methods or tools as necessary, including measurements and computer simulations.		

Course title	Digital Technique		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Joanna Górecka	**E-mail address to the person**	Joanna.Gorecka@zut.edu.pl
Course code (if applicable)	WE-2-18	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
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 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.		
Entry requirements	Mathematics, Informatics, Fundamentals of semiconductor electronics		
Course contents	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. 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.		
Assessment methods	oral presentation (lectures), practical work in lab Written exam, accomplishment of practical lab tasks		
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., 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		
Knowledge	The student has knowledge on digital circuit theory, methods and techniques of digital circuit analysis and synthesis, as well as digital circuit design.		
Skills	The student has skills in the field of analysis, testing and designing digital circuits using product data sheets, application notes as well as dedicated software tools.		

Course title	Electrical Circuit Analysis with Matlab		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Marcin Ziółkowski	**E-mail address to the person**	Marcin.Ziolkowski@zut.edu.pl
Course code (if applicable)	WE-2-19	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	This course is intended to present a modern approach to electrical circuit simulation and analysis using numerical method based on Matlab environment.		
Entry requirements	Numerical Methods, Mathematics, Physics		
Course contents	DC Analysis Transient Analysis Network Equations Solution of Linear Algebraic Circuit Equations Solution of Nonlinear Algebraic Circuit Equations Solution of Differential Circuit Equations Application to Circuit Simulation DC Analysis Transient Analysis Network Equations Solution of Linear Algebraic Circuit Equations Solution of Nonlinear Algebraic Circuit Equations Solution of Differential Circuit Equations Application to Circuit Simulation		
Assessment methods	Traditional lecture Computer laboratory In-class assessment		
Recommended readings	1. John O. Attia, Electronics and circuit analysis using Matlab, CRC Press LLC, 1999		
Knowledge	Students will get the knowledge about electrical circuits’ simulations methods based on network approach.		
Skills	Student is able to simulate electrical circuits with the help of network approach.		

Course title	Electrical Power Engineering		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Michał Zeńczak	**E-mail address to the person**	Michal.Zenczak@zut.edu.pl
Course code (if applicable)	WE-2-20	**ECTS points**	6
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Knowledge about composition and operation of power system, Skills of calculation in power system: load flows, short-circuits Skills of investigation of basic phenomena in power system.		
Entry requirements	Basis of electrical engineering Mathematics Physics		
Course contents	Calculation of load flow study Calculation of voltage losses and drops Calculation of short-circuits currents, Measurements of currents and voltages in power system Measurements of voltage drops Investigation of radial networks Investigation of voltage control in power system Investigation of short-circuits Investigation of non-homogeneous network. Composition of power system Methods of generation of electrical energy Power stations Equivalent diagrams, voltage loss and voltage drop, vector diagrams Load flow study, power losses Control of active power and frequency Control of voltage and reactive power Basic interferences in power system		
Assessment methods	Informative lecture Problem-based lecture Subject exercises Laboratory exercises Continuous assessment in laboratory Final test on the end of classes and lectures		
Recommended readings	1. Grigsby L.L., The Electric Power Engineering Handbook, CRC Press, New York, 1998 2. Grigsby L.L., Electric Power Generation, Transmission and Distribution, CRC Press, New York, 2007		
Knowledge	Student has knowledge for understanding processes of generation of electrical energy. Student has knowledge for basic calculation in power system.		
Skills	Student is able to calculate different state in power system.		

Course title	Electric Power Network		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Michał Zeńczak	**E-mail address to the person**	Michal.Zenczak@zut.edu.pl
Course code (if applicable)	WE-2-21	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	Knowledge about structure and functioning of electric power networks in normal and fault conditions, Skills of designing of overhead lines and basic calculation for wires		
Entry requirements	Basis of electrical engineering Mathematics Physics		
Course contents	Requirements for networks Towers and wires Current-carrying capacity of wires, HTLS wires Cable lines Standards for designing of overhead transmission lines, environmental problems Structure of electrical power network Requirements for networks Quality of energy Towers and wires current-carrying capacity of wires, HTLS wires Standards for designing of overhead transmission lines, environmental problems. Cable lines		
Assessment methods	Informative lecture Problem-based lecture Demonstration Project method Project work Final test on the end of lectures		
Recommended readings	1. KiesslingF., Nefzger P., Nolasco J.F., Kaintzy U., Overhead Power Lines, Springer, Germany, 2002 2. Grainger J.J., Stevenson W.D., Power System Analysis, McGAW-HILL, International Edition, 1994		
Knowledge	Student has knowledge for analysis of functioning and designing of electrical power network.		
Skills	Student is able to design electrical power network.		

Course title	Electromagnetic, Ultrasonic and Radiographic Nondestructive Testing		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Marcin Ziółkowski	**E-mail address to the person**	Marcin.Ziolkowski@zut.edu.pl
Course code (if applicable)	WE-2-24	**ECTS points**	6
Semester	winter/summer	**Language of instruction**	english
Hours per week	5	**Hours per semester**	75
Objectives of the course	This course is intended to present a unified approach to ultrasonic and radiographic nondestructive testing		
Entry requirements	Mathematics Physics		
Course contents	Software project in chosen environment related to some specific problems in non-destructive testing 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 Applications of Radiography Penetration and Absorption Radiographic Sensitivity Structure of the Atom X and Gamma Rays X-Ray Equipment Subject and Film Contrast Radiographic Film & Processing Techniques Radiation Hazard		
Assessment methods	Traditional lecture with the use of a multimedia projector In-class assessments		
Recommended readings	1. D. Van Hemelrijck, A. Anastassopoulos, Non Destructive Testing, A.A. Balkema, Rotterdam, 1996		
Knowledge	Students will get the knowledge about Ultrasonic and Radiographic Nondestructive Testing theory and practice. They will also know what kind of objects can be inspected with such techniques.		
Skills	Student is able to use relevant Ultrasonic, Radiographic Nondestructive Testing theory and practice.		

Course title	Electromagnetic Field and the Human Body		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Stanisław Gratkowski	**E-mail address to the person**	Stanislaw.Gratkowski@zut.edu.pl
Course code (if applicable)	WE-2-22	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	To provide up to date knowledge on analysis and modeling of EM fields in the human body, and to develop practical skills in this area		
Entry requirements	Mathematics, physics		
Course contents	Numerical modeling of electromagnetic field in the human body; magnetic induction tomography and magnetoacoustic tomography with magnetic induction for biomedical applications; examples of medical applications of electromagnetic fields; biological effects of electromagnetic fields; calculation of Specific Absorption Rate (SAR). Basic concepts of electric and magnetic fields; Maxwell's equations; electromagnetic waves; dosimetry; numerical modeling of electromagnetic field in the human body; magnetic induction tomography and magnetoacoustic tomography with magnetic induction for biomedical applications; examples of medical applications of electromagnetic fields; biological effects of electromagnetic fields; magnetic resonance imaging (MRI).		
Assessment methods	Lectures laboratory – computer simulations Written test and/or discussion Continuous assessment		
Recommended readings	1. Cheng D. K., Fundamentals of Engineering Electromagnetics., Addison-Wesley Publishing Company, Inc., New York, 1993 2. Durney C.H., Basic Introduction to Bioelectromagnetics, CRC Press LLC, Boca Raton, 2001 3. Malmivuo J., Plonsey R., Bioelectromagnetism, Oxford University Press, New York, 1995 4. Chari M. V. K., Salon S. J., Numerical Methods in Electromagnetism, Academic Press, San Diego, 2000 5. Sadiku M.N.O., Numerical Techniques in Electromagnetics, CRC Press LLC, Boca Raton, 2001		
Knowledge	On successful completion of this course students will have knowledge on methods for analysis and modeling of EM fields in living systems.		
Skills	On successful completion of this course students will have practical skills useful in this area.		

Course title	Electromagnetic Methods of Non-destructive Testing		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Tomasz Chady	**E-mail address to the person**	Tomasz.Chady@zut.edu.pl
Course code (if applicable)	WE-2-23	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	5	**Hours per semester**	75
Objectives of the course	To teach basics of electromagnetic methods of NDT To teach how to apply specific method of NDT in practical applications Upon successful completion of this course, the student will be able to: - 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, - work independently and collaboratively to understand and formulate problems, and solve these problems using the provided tools and methods.		
Entry requirements	Academic course of mathematics Academic course of physics Academic course of electrotechnics or circuit theory Basic knowledge of Matlab programming		
Course contents	Magnetic field sensing DC and AC magnetic field methods of ferromagnetic materials testing and evaluation Eddy current testing of conductive materials Numerical modeling in NDT (eddy current, microwave/terahertz methods) Terahertz testing of dielectric and composite materials Digital radiography 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 using Matlab and Comsol 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		
Assessment methods	Informative lecture Laboratory exercises Written exam (Lect.) Continuous assessment (Lab)		
Recommended readings	1. Blitz J., Electrical And Magnetic Methods Of Non-Destructive Testing, Springer- Verlag, 1997		
Knowledge	Upon successful completion of the course, the student will be able to: identify, formulate, and solve engineering problems in the field of NDT, explain the principles of the major NDT methods, identify advantages and limitations of nondestructive testing methods and to select the appropriate techniques for inspections in specific application, use selected software for numerical modelling of NDT systems, use selected hardware for practical NDT (i.e. THz TDS or digital detectors for X-ray testing, critically evaluate their chosen problem solving techniques and the accuracy of their answers.		
Skills			

Upon successful completion of the course, the student will be able to: identify, formulate, and solve engineering problems in the field of NDT, explain the principles of the major NDT methods, identify advantages and limitations of nondestructive testing methods and to select the appropriate techniques for inspections in specific application, use selected software for numerical modelling of NDT systems, use selected hardware for practical NDT (i.e. THz TDS or digital detectors for X-ray testing, critically evaluate their chosen problem solving techniques and the accuracy of their answers.

Course title	Electronic Devices and Circuits		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WE-2-25	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	To provide knowledge on electronic semiconductor devices selected topics on analog electronic circuits.		
Entry requirements	Mathematics Physics		
Course contents	Static and dynamic characteristics of diodes and transistors. Transistor biasing and stabilization of operating point. Transistor amplifiers. Applications of operational amplifiers. Active filters. Oscillators. Rectifiers. Electronic voltage regulators. DC voltage stabilizers. Conduction in semiconductors. Diodes. Bipolar Junction Ttransistors characteristics. Transistor biasing and thermal stabilization. Small-signal low-frequency transistor model. Low-frequency transistor amplifier circuits. The high-frequency transistor. Field-effect transistors. Integrated circuits. Operational amplifiers. Feedback amplifiers and oscillators. Active filters circuits. Large-signal amplifiers. Optoelectronics devices. Rectifier and power supplies.		
Assessment methods	Lectures Laboratory exercises Written test Raports assessments		
Recommended readings	1. Boylestad R.L., Nashelsky L., Electronic devices and circuit theory, Pearson, 2013, 11		
Knowledge	The student has knowledge on basic electronic devices and circuit, methods and techniques of analog circuit analysis.		
Skills	The student has skills in the field of analysis, testing and designing simple electronic circuits using product data sheets, application notes as well as dedicated software tools.		

Course title	Elements of Laser Optics		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Andrzej Ziółkowski	**E-mail address to the person**	Andrzej.Ziolkowski@zut.edu.pl
Course code (if applicable)	WE-2-26	**ECTS points**	3
Semester	summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	To provide knowledge on selected topics in the field of laser physics and laser construction.		
Entry requirements	Basics of optics, solid state physics and numerical methods.		
Course contents	Student performs a project in the form of an labratory setup or numerical task in the area of laser optics. Absorption and emission of light. Gain of light and pumping processes. Optical resonators. Laser beam. Construction and operation of selected types of lasers: gas lasers, semiconductor lasers and solid state lasers. Nonlinear optical phenomena and their application to light generation.		
Assessment methods	Lectures Project task Final report and design presentation.		
Recommended readings	1. William T. Silfvast, Laser Fundamentals, Cambridge University Press, Cambridge, 2004 2. E. Rosencher, B. Vinter, Optoelectronics, Cambridge University Press, Cambridge, 2002 3. B. E. A. Saleh, M. C. Teich, Fundamentals of Photonics, Wiley Series in Pure and Applied Optics,, 2007		
Knowledge	Student will be able to describe construction and application of modern laser systems.		
Skills	Student will be able to design, build and test simple photonic setup.		

Course title	Elements of Psychoacoustics and Electroacoustics		
Level of course	second cycle		
Teaching method	laboratory course / seminars / lecture		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WE-2-27	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	To provide knowledge on psychoacoustics basics and selected topics on electroacoustics (sound fields, transducers, sound reinforcement, sound processing). The basic knowledge on psychoacoustics and selected topics on acoustics and electroacoustics. The skills to use and measure basic electroacoustical systems.		
Entry requirements	Basic knowledge in Physics		
Course contents	Human hearing sense models and properties Audio signal analysis methods Sound wave parameters measurement Microphones measurements Loudspeaker measurements Loudspeaker cabinet design Reverberation time measurements and acoustical adaptation design Speech intelligibility measurement Introduction to sound processing in Matlab Compression and enhancement of audio signal 3-D audio enhancements of 2-channel sound. Filtering and sound effects. Complementary calculation exercises 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. Elements of building acoustics. Electroacoustical transducers and electroacoustical systems. Hearing aids. Digital sound processing. Audio compression. HRTF technology and 3-D audio systems.		
Assessment methods	Lectures Laboratory exercises Written test Reports assessment		
Recommended readings	1. Everest F. A., Master handbook of acoustics, McGraw-Hill, 2001 2. Howard D. H., Acoustics and psychoacoustics, Focal press, 2001		
Knowledge	To provide knowledge in various sound systems engineering		
Skills	To provide skills in various sound systems engineering		

Course title	Embedded Systems		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Przemysław Mazurek	**E-mail address to the person**	Przemyslaw.Mazurek@zut.edu.pl
Course code (if applicable)	WE-2-28	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Basic knowledge related to embedded systems		
Entry requirements	Computer science		
Course contents	Implementation of selected embedded system Embedded system based on Linux Microcontrollers in embedded systems FPGA based embedded systems Test of knowledge		
Assessment methods	Instructional method/informative lecture Practical method/project Passing the project A pass in the form of a choice test		
Recommended readings	1. W. R. Stevens, S. A. Rago, Advanced Programming in the UNIX Environment, Addison-Wesley Professional, 2013 2. J. Catsoulis, Designing Embedded Hardware, O'Reilly, 2005 3. Jivan S. Parab, Rajendra S. Gad, G.M. Naik, Hands-on Experience with Altera FPGA Development Boards, Springer, 2018 4. Nios® II Software Developer's Handbook, Intel, 2018		
Knowledge	Knowledge related to embedded systems		
Skills	Skills related to the design of embedded systems		

Course title	EM Fields Effects in Living Organisms		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Michał Zeńczak	**E-mail address to the person**	Michal.Zenczak@zut.edu.pl
Course code (if applicable)	WE-2-29	**ECTS points**	2
Semester	winter	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
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 of electric power engineering structures according to standards for electromagnetic fields in natural and occupational environment.		
Entry requirements	Mathematics Physics Theoretical electrical engineering Theory of electromagnetic fields		
Course contents	Measurements of EM fields Computer simulations in EM fields Designing electric power engineering structures according to standards for EM fields 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 master Electromagnetic fields inside living systems Mechanism of interaction of non-ionising electromagnetic fields with living systems		
Assessment methods	Informative lecture Problem-based lecture Demonstration Laboratory exercises Continuous assessment in laboratory Final test on the end of lectures		
Recommended readings	1. Bronzino J.D., Biomedical Engineering Handbook, CRC Press, IEEE Press, New York, 1995 2. Polk C., Postow E., CRC Handbook of biological effects of electromagnetic fields, CRC Press, Boca Raton, Florida, 1986		
Knowledge	Student has knowledge on bioelectromagnetism, electromagnetic fields in natural environment and interaction of living systems with electromagnetic fields.		
Skills	Student is able to design electric power engineering structures according to standards for electromagnetic fields in natural and occupational environment.		

Course title	Fiber Optic Access Networks (FOAN)		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Grzegorz Żegliński	**E-mail address to the person**	Grzegorz.Zeglinski@zut.edu.pl
Course code (if applicable)	WE-2-31	**ECTS points**	4
Semester	summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The primary objective of this course is to obtain fundamental knowledge on FOAN design rules and factors influencing decisions along the design process. This is to be preceded by getting familiar with FOAN components as well as architectural and topological options for FOANs. The secondary objectives of this course are: to understand the economics of FOANs; to get familiar with various relevant job profiles through face-to-face networking with professionals in the field of optical access networks; to exercise students' presentation skills by orally reporting their project results.		
Entry requirements	Academic courses: Math, Physics. Moreover, it is recommended that course participants are familiarized with the basics of fiber optics e.g. through attending the course Fiber Optics Installation or alike. Although, essentials with this respect will be recalled during the course.		
Course contents	Project work- FOAN Network Design. Project report and presentation. FOAN Applications: Drivers and Business Needs. Bandwidth Requirements in Access Networks and Evolution of Access Networks. Generic FOAN Network Planning. FOAN Economics and Its Impacts onto FOAN Design. FOAN Terminology, Fiber Optic Symbols and FOAN-related Standards. Access Network Architectures and Transmission in FOAN. Passive Optical Network Essentials and Next Generation FOAN Outlook. FOAN Topologies, Components, Subsystems and Devices. FOAN Node Positioning. FOAN Network Design Optional: Fiber-To-The Building Design Deep-dive. Loss Budget and Passive Optical Network Class.		
Assessment methods	Lectures- multimedia presentations Project report and presentation (seminar)		
Recommended readings	1. FTTH Handbook, 2016, v7, http://www.ftthcouncil.eu/documents/Publications/FTTH_Handbook_V7.pdf		
Knowledge	At successful completion of this course the students will be familiar with Fiber Optic Access Network: architecture of networks, transmission parametres, ITU-T standards, FOAN components as well as architectural and topological options for FOANs.		
Skills	At successful completion of this course the students will be familiar with Fiber Optic Access Network: architecture of networks, transmission parametres, ITU-T standards, FOAN components as well as architectural and topological options for FOANs.		

Course title	Fiber Optics Instalation		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Grzegorz Żegliński	**E-mail address to the person**	Grzegorz.Zeglinski@zut.edu.pl
Course code (if applicable)	WE-2-30	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The aim of course is to give basic concepts relating to optical fiber instalations, designing and measurements.		
Entry requirements	Academic courses: Mathematics and Physics.		
Course contents	Optical fibers and optical cables Passive optical elements Fusion splicing Optical Fiber Line preparing Optical Time Domain Reflectance (OTDR) measurements Budget power Line Final Report Fiber Optic Transmission Optical Fiber Characteristic Fiber Optic Cables Fiber Splicing Optical Fiber Connectors Optical Fiber Spliters and Couplers Budget Of Optical Fiber Line Fiber Optic Light Sources Fiber Optic Detectors and Receivers Cable Installation and Hardware Optical Time Domaind Reflectometry Optical Fiber Telecommunicaion Standards Optical Spectrum Measurements Chromatic and Polarization Dispersion Measurements Fiber Optics Instalation Documentation		
Assessment methods	Lectures- multimedia presentations Lab presentations - instalation setups. Final report		
Recommended readings	1. Govind P. Agrawal, Fiber-Optic Communication Systems, Wiley, 2010, 4th edition 2. G. Keiser, Optical Fiber Communications, McGraw-Hill Education, 2008, 4th ed		
Knowledge	At successful completion of this course the students will be familiar with application of optical fiber measurement methods to installation problem solving, application of installation techniques, tools and resource.		
Skills	At successful completion of this course the students will be able to calculate the system bandwidth, budget of optical fiber line noise, probability of error and maximum usable bit rate of a telecom fibre system.		

Course title	Finite Element Method in Electromagnetics		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Marek Ziółkowski	**E-mail address to the person**	marek.ziolkowski@zut.edu.pl
Course code (if applicable)	WE-2-32	**ECTS points**	6
Semester	winter/summer	**Language of instruction**	english
Hours per week	5	**Hours per semester**	75
Objectives of the course	This course is intended to present a unified approach to FEM in Electromagnetics.		
Entry requirements	Math, Physics, Fundamentals of Electromagnetics		
Course contents	Software project in chosen environment related to some specific problems of FEM in Electromagnetics Basic Electromagnetic Theory Introduction to the Finite Element Method Variational Principles for Electromagnetics Finite Element Analysis a) Boundary-Value Problem b) Variational Formulation c) Galerkin Formulation d) Application to Static Problems e) Application to Quasistatic Problems f) Application to Time Harmonic Problems g) Higher-Order Elements h) Isoparametric Elements Vector Finite Elements Finite Element Analysis in the Time Domain		
Assessment methods	Traditional lecture Passing the lecture, passing the project		
Recommended readings	1. Finite Element Method in Electromagnetics, Jin Jianming, John Wiley & Sons Inc, 2014		
Knowledge	Students will get the knowledge about FEM in Electromagnetics theory and practice.		
Skills	Students are able to use FEM in Electromagnetics practice.		

Course title	Fundamentals of Engineering Electromagnetics		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Stanisław Gratkowski	**E-mail address to the person**	Stanislaw.Gratkowski@zut.edu.pl
Course code (if applicable)	WE-2-33	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
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	Electrostatics: calculation of electric potential, energy and forces. Calculation of capacitances. Static magnetic fields: calculation of magnetic field, inductances, magnetic energy and forces. Time-varying electromagnetic fields: electromagnetic induction, skin effect, proximity effect, eddy currents. 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 with simple experiments, laboratory – computer simulations Lectures – written and oral exam; laboratory – continuous assessment		
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		
Knowledge	On successful completion of this course: Students will be familiar with the different vector operators used in Maxwell's equations. Students will have an understanding of Maxwell's equations.		
Skills	Students will be able to describe and understand the basic concepts underpinning electricity and magnetism such as potential and field. Students will be able to select the most appropriate laws/theorems/ solution techniques for electromagnetic field analysis.		

Course title	Fundamentals of Web Development		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Przemysław Włodarski	**E-mail address to the person**	Przemyslaw.Wlodarski@zut.edu.pl
Course code (if applicable)	WE-2-34	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	This course is intended to present a set of technologies that enable creation of the fully functional web page, working seamlessly on mobile, tablet and large screen browsers		
Entry requirements	Some programming experience (helpful but not necessary)		
Course contents	Software project based on selected problem related to the web development technology HTML5 and CSS3: syntax, images, hyperlinks, tables, multimedia, etc. Box model, positioning Essential components of JavaScript: variables, arrays, loops, functions JQuery: chaining, DOM elements, ajax, plugins Server-side scripting language (PHP, Python): dynamic content, form processing, file handling, objects Design and implementation of database for web projects using MySQL (keys, data types, privileges system) Interacting with file system, generating images, session control user authentication and personalization, responsive design		
Assessment methods	Lectures based on presentations and solutions of selected problems Project based learning Written test and / or oral discussion Project assessment		
Recommended readings	1. Welling L., Thomson. L., PHP and MySQL Web Development, 4th Edition, 2009 2. Duckett J., JavaScript and JQuery: Interactive Front-End Web Development, 1st Edition, 2014		
Knowledge	Knowledge of web development basics, including front-end as well as back-end side		
Skills	Ability to create web pages from scratch		

Course title	High Voltage Engineering		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Szymon Banaszak	**E-mail address to the person**	Szymon.Banaszak@zut.edu.pl
Course code (if applicable)	WE-2-35	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
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	Introduction to high voltage laboratories Safety in high voltage laboratory Testing the dielectric strength of air in various electric field distributions Testing the dielectric strength of insulator under AC and impulse voltage Testing the voltage distibution in multielectrode systems Testing the influence of barriers on the dielectric strength of air Mid-semester test Observation of the initial voltage of partial discharges Measurements of the parameters of the ferroresonance Testing the voltage distribution of series layered solid dielectrics under AC and DC voltage Testing the parameters of the surge arrester Measuring methods for high voltage Final test Introduction to high voltage engineering 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 Final test		
Assessment methods	Lecture Laboratories Written test. Written test.		
Recommended readings	1. E. Kuffel, W. S. Zaengl, J. Kuffel, High voltage engineering: fundamentals, Newnes (An imprint of Elsevier), 2004 2. Peek F.W., Dielectric Phenomena in HIgh Voltage Engineering, McGraw-Hill Book Company, Inc., 1915 3. M.S. Naidu, V. Kamaraju, High Voltage Engineering, Tata McGraw-Hill, 2009 4. H.M. Ryan, High Voltage Engineering and Testing, The Institution of Electrical Engineers, 2001		
Knowledge	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.		
Skills	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.		

Course title	Humanoid and Social Robotics		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Adam Łukomski	**E-mail address to the person**	Adam.Lukomski@zut.edu.pl
Course code (if applicable)	WE-2-36	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	Learning how humanoid robots work - their design and application Learning how to design a control system for a humanoid robot		
Entry requirements	Modelling and simulation of complex mechanical systems Nonlinear control theory		
Course contents	Introduction to YARP simulation software Basic iCub control using Matlab ROS robot control Using Gazebo for robot simulation Micro humanoid robot control - Robotis Bioloid Introduction to humanoid robotics Current standards in human-robot interaction Humanoid robot modelling and simulation Walking robot control methods Object recognition and manipulation		
Assessment methods	Lecture Laboratory course Exam (written and oral questions) Presentation of the results on the last laboratory meeting		
Recommended readings	1. Chevallereau, Christine, et al., Bipedal Robots: Modeling, Design and Walking Synthesis, John Wiley & Sons, 2013 2. Murray R. M., Li Z., Sastry S., A Mathematical Introduction to Robotic Manipulation, CRC Press, 1994		
Knowledge	Knowledge about the human-robot interaction and control of humanoid robots.		
Skills	Ability to design a control system for a social humanoid robot.		

Course title	Introduction to Control Engineering		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Paweł Dworak	**E-mail address to the person**	Pawel.Dworak@zut.edu.pl
Course code (if applicable)	WE-2-37	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Students will be able to analyze a simple process and design control loops.		
Entry requirements	Basics knowledge of physics, mathematics and signal processing.		
Course contents	Characteristics of basic elements and elementary systems. Transfer function approach. Determination of transfer functions for simple systems. P, PI, PD and PID control. Closed loop systems. Feedforward and feedback systems. Fuzzy logic and neural networks in control engineering. Control history and state of the art. Classification of control systems. Principles of automatic control. Closed loop systems. Feedback systems. Characteristics of basic elements and elementary systems. Frequency response representation – frequency domain specifications. Transfer function approach. Determination of transfer functions for simple systems. Stability of linear systems. Introduction to design – compensation techniques – P, PI, PD and PID control. Gain scheduling, fuzzy logic, neural networks in control engineering.		
Assessment methods	Lectures and practical presentations. Practical exercises. Continuous assessment. Final assessment.		
Recommended readings	1. Control System Design, Goodwin G., Graebe S.F., Salgado M.E., Prentice Hall		
Knowledge	Students will be able to analyze a simple process and design the control loops		
Skills	Students will be able to analyze a simple process and design the control loops		

Course title	Introduction to Cryptography		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Maciej Burak	**E-mail address to the person**	Maciej.Burak@zut.edu.pl
Course code (if applicable)	WE-2-38	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The course explains the workings of basic cryptographic primitives and protocols and how to use them in real world applications. Students will learn how to choose and apply basic cryptographic techniques to real-world applications.		
Entry requirements	The course is self contained, however basic knowledge of probability theory will be helpful. In order to complete the labs, basic programming knowledge is required (preferably in the C language).		
Course contents	Vigenere (XOR) and Vernam (OTP) ciphers Block ciphers, modes of operations, semantic security. Stream ciphers. Cryptographic hash functions, passwords and their weaknesses, brute force dictionary attacks, salt. Data integrity, authenticated encryption. Key management and distribution. Public key systems PKI, TLS/SSL, Certificates Unix security, authentication, authorisation, secure network protocols Overview and history of cryptography Vigenere (XOR) and Vernam (OTP) ciphers. Perfect security. Stream ciphers. Cryptographic hash functions, passwords and their weaknesses, brute force dictionary attacks, salt. Block ciphers, modes of operations, semantic security. Data integrity, authenticated encryption. Key management and distribution. Public key systems, certificates. SSL/TLS. OS Security, integrity, authorisation, authentication protocols		
Assessment methods	Lecture Labs Self study Labs outcome/reports assesment written tests		
Recommended readings	1. Alfred J. Menezes, Paul C. van Oorschot, Scott A. Vanstone, Handbook of Applied Cryptography, CRC Press 2. William Stallings, Cryptography and Network Security: Principles and Practice, Pearson Education, 2016 3. Ross Anderson, SECURITY ENGINEERING, Wiley, 2010		
Knowledge	Students understand basic cryptographic prymitives and their application in operating systems and application security		
Skills	Students choose and apply cryptographic techniques to real-world applications.		

Course title	Introduction to Electric Circuits - part 1		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Tomasz Chady	**E-mail address to the person**	Tomasz.Chady@zut.edu.pl
Course code (if applicable)	WE-2-39	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	5	**Hours per semester**	75
Objectives of the course	To teach basics of electrical circuit theory To teach how to solve electrical circuits in various conditions Upon successful completion of this course students should be able to: - perform design and analysis of AC and DC circuits, - select optimal method of circuit analysis for the specific case, - use electric circuit simulator, - work independently and collaboratively to understand and formulate problems, and solve these problems using the provided tools and methods.		
Entry requirements	Academic course of mathematics and physics		
Course contents	Basic resistive circuits analysis DC circuits analysis Basic AC circuits analysis AC sinusoidal circuits analysis Resistive circuits DC circuit analysis Ideal and real energy storage elements Sinusoidal steady-state analysis Ideal and real resonance, frequency characteristics 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 Computer simulators for circuit analysis (Spice and Matlab)		
Assessment methods	laboratory exercises practical exercises Informative lecture continous assessment final assessment		
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		
Knowledge	Upon successful completion of the course, the student will be able to: • think analytically and creatively to draw conclusions and solve problems, • apply Ohm's and Kirchhoff's laws to solve for unknown voltage and/or currents • simplify series and parallel combinations of passive and active elements • use nodal analysis to write simultaneous equations • use mesh analysis to write simultaneous equations • apply superposition to linear circuits analysis • use Thevenin / Norton equivalent circuits to analyze circuits linear and selected nonlinear circuits • analyze steady state sinusoidal circuits using the advanced circuit analysis techniques (phasor method) • use phasor diagrams to visualize responses of the circuits • analyze RLC circuits in case of resonance • use basic instruments to measure voltages and currents • identify and apply the most appropriate circuit analysis technique		
Skills	Student can solve electrical circuits under various conditions		

Course title	Introduction to Electric Circuits - part 2		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Tomasz Chady	**E-mail address to the person**	Tomasz.Chady@zut.edu.pl
Course code (if applicable)	WE-2-40	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	5	**Hours per semester**	75
Objectives of the course	To teach how to solve electrical circuits in various conditions To teach how to use computer simulators for circuits analysis Upon successful completion of this course, the student should 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.		
Entry requirements	Academic course of mathematics, physics, Introduction to electric circuits 1		
Course contents	Three phase circuits Self and mutual inductance Analysis of circuits in the transient state Two-port circuits analysis Passive and active filters 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) Filters (passive, active and digital) Computer simulators for circuit analysis (Spice and Matlab)		
Assessment methods	laboratory exercises Informative lecture continous assessment final assessment - written exam		
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		
Knowledge	Upon successful completion of the course, the student will be able to: • think analytically and creatively to draw conclusions and solve problems, • identify, formulate, and solve engineering problems • analyze steady state sinusoidal three phase circuits, • use phasor diagrams to visualize responses of the three phase circuits, • analyze transient state in the first and second order RLC circuits by solving the differential equations and using the Laplace transform. • identify and apply the most appropriate circuit analysis technique, • know the characteristics of the opamp, • use opamps in order to achieve the desired function, • use Fourier series to analyze circuits with no sinusoidal sources, • use the two port networks, • design passive and active filters with desired characteristics, • use computer simulators (SPICE) for numerical circuit modelling and analysis, • critically evaluate their chosen problem solving techniques and the accuracy of their answers.		
Skills	Student can solve the problems and simulate the operation of advanced AC circuits under various conditions.		

Course title	Introduction to Infrared Thermography		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Barbara Grochowalska	**E-mail address to the person**	Barbara.Szymanik@zut.edu.pl
Course code (if applicable)	WE-2-41	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Students will learn basics theoretical aspects of heat transfer and active infrared thermography. Students will learn how to use an active thermography in practice.		
Entry requirements	Course in mathematics and physics. Basic programming skills - C++, matlab		
Course contents	Chosen experimental problem - active infrared themography. Numerical modelling of the problem, experimental methodology, experiments, image and data processing. Introduction to thermal emission. Blackbody. Planck's Law. Wien Displacement Law. Stefan-Boltzmann Law. Reflection, absorption, transmission. Emissivity. Introduction to heat transfer. Thermal conductivity. Conduction, radiation, convection heat transfer. Analitycal approach - one dimentional heat transfer. Numerical modelling - FEM. Infrared sensors. Introduction to image and data processing. Active and passive thermography. Other NDT techniques, comparison. Thermal wave theory. Pulsed, stepped heating, lock-in thermography. Heating sources. Quantitative data analysis in active thermography. Thermal contrast. Defect evaluation. PPT, statistical methods, neural network, wavelets. Concept of thermal tomography. Active thermography - case studies.		
Assessment methods	Lecture. Presentation. Self study. Continous assessment. Final assessment. Exam, project report assessment.		
Recommended readings	1. X. Maldague, Theory and practice of infrared technology for nondestructive testing, Wiley, 2001 2. W. Minkina, S. Dudzik, Infrared Thermography: Errors and Uncertainties, Wiley, 2009		
Knowledge	After this course the student will be able to: - think analytically to solve the complex engineering problems, - use the theory of heat transfer and infrared radiation to solve the chosen problems, - design and conduct the experiment in the field of active thermography, - use dedicated laboratory devices and software, - use COMSOL software to create numerical models analysing heat transfer and infrared radiation phenomena - use Matlab to process experimental data - prepare scientific reports, - draw the conclusions from the experiments, analyse critically the results.		
Skills	After this course the student will get the skills about: - solving the complex engineering problems concerning , heat and infrared radiation, designing and conducting experiments in the field of active thermography, using dedicated laboratory devices and software, using COMSOL software to create numerical models and preparing scientific reports.		

Course title	Introduction to Matlab		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Przemysław Orłowski	**E-mail address to the person**	Przemyslaw.Orlowski@zut.edu.pl
Course code (if applicable)	WE-2-42	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	polish
Hours per week	4	**Hours per semester**	60
Objectives of the course	Understanding the MATLAB environment Being able to do simple calculations using MATLAB Being able to carry out simple numerical computations and analyses using MATLAB Understand the main features of the MATLAB development environment Use the MATLAB GUI effectively Design simple algorithms to solve problems Write simple programs in MATLAB to solve scientific and mathematical problems		
Entry requirements	Basic skills in mathematics		
Course contents	Introduction to Matlab - Getting Started Making variables, vectors, tables and matrices Vectors, tables and matrices - basics operations 2D Graphics 3D Graphics Making scripts and functions Visualization of statistics data Operations on series and functions Brown motions simulation, vizualization and analysis Polynomial approximation and interpolation GUI design Solving difference and differential equantions in Simulink Introduction to MATLAB: Getting Started, Scripts, Making Variables, Manipulating Variables, Basic Plotting Visualization and Programming: Functions, Flow Control, Line Plots, Image/Surface Plots, Efficient Codes, Debugging Solving Equations, Curve Fitting, and Numerical Techniques: Linear Algebra, Polynomials, Differentiation/Integration, Differential Equations Difference Equations, Graphical User Interfaces, Simulink		
Assessment methods	Lectures and practical presentations Practical exercises Continuous assesment Final assesment		
Recommended readings	1. Matlab Manuals, Mathworks Inc., 2019 2. SIMULINK Model-Based and System-Based Design Using Simulink, Mathworks Inc., 2019 3. MATLAB Getting Started Guide, Mathworks Inc., 2019, http://www.mathworks.com/help/pdf_doc/matlab/getstart.pdf		
Knowledge	Understand the main features of the MATLAB development environment		
Skills	Being able to carry out simple numerical computations and analyses using MATLAB		

Course title	Introduction to Microcontrollers		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WE-2-43	**ECTS points**	3
Semester	winter	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The student will know the internal structure of microcontrollers and microprocessor systems, will understand the principles of their operation and programming. Will know the principles of designing the electronic devices based on microcontrollers. The student will know, how to write the programs for microcontrollers in C language and run and test it on educational kit.		
Entry requirements	Mathematics, Informatics, Digital Technique		
Course contents	Description of didactic work station. Presentation of software tools for AVR - Atmel Studio. Introduction to C language for microcontrollers. Simple examples programs in C. Programming of I/O ports of ATmega microcontroller. Timers in ATmega microcontroller. Use of Normal and CTC modes for generating time intervals. Revision programming exercise. Interrupt system of ATmega microcontroller. Use of timer PWM mode based on selected examples. Control of 7-segment multi digit numeric LED display. Revision programming exercise. Entering digital data into microcontrollers with use of electric contacts, switches and matrix keyboard. Data transmission through serial communication devices UART. Analog to Digital converter programming. End of term revision programming exercise. Practical exam. General microprocessor construction, block diagram of microprocessor system. Microprocessor vs microcontroller. Architecture of microprocessor systems. Microprocessor instructions: structure, methods of writing instructions, execution cycle, 1-byte and multi-byte instructions. List of microprocessor instructions, types of instructions. Assembler language, translating programs. General information about high level languages used in microcontrollers programming. I/O port as basic communication channel in microprocessor system. Construction of I/O port based of selected examples microcontroller families. Electric and timing parameters of I/O port. Examples of connecting external devices to I/O port. I/O port programming examples. Timers in microcontrollers. Construction, modes of work, use and programming. Review of typical solutions. Pulse Width Modulation - PWM mode of timers. Basic concepts of microprocessor technology: data bus, tri-state buffer etc. Interrupt system - operating principle, use of interrupts in microcontrollers programming Synchronous and asynchronous serial communication. Communication device USART, serial interfaces: SPI, Microwire, I2C, 1-Wire, CAN. Parameters, areas of using. Review of serial interfaces in various microcontroller families. Analog to Digital converters and Digital to Analog converters in microprocessor system. Characteristics, parameters of converters. Review of A/D and D/A converters in various microcontroller families. Clock system of microprocessor, clock signal distribution. Microprocessor and microcontroller supervisory circuits - watchdog. Power-down, Power-save modes. RTC circuits.		
Assessment methods	oral presentation (lectures), practical work in lab Written exam Accomplishment of practical lab tasks		
Recommended readings	1. Kernighan B., Ritchie D., The C programming language, Prentice Hall, New Jersey, 1998 2. Williams E., AVR Programming: Learning to write software for hardware, Maker Media Inc., 2014, 1 3. M. Ali Mazidi, S. Naimi, S.Naimi, AVR microcontroller and embedded systems: Assembly and C, Pearson Education Limited, 2014		
Knowledge	To provide basic knowledge in 8-bit microcontrollers.		
Skills	To provide skills in creating application software using C language for 8-bit microcontrollers.		

Course title	Introduction to Multisensor Data Mining and Fusion		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Grzegorz Psuj	**E-mail address to the person**	Grzegorz.Psuj@zut.edu.pl
Course code (if applicable)	WE-2-44	**ECTS points**	2
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
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. Academic course of informatics (knowlegde and skills in the programming, basics of Matlab programming)		
Course contents	Design and implementation of data processing algorithm (in Matlab, Python, etc.) for the specified by teacher case. Presentation of the final solution and the report. Introduction: motivation, concepts and theory of data mining and data fusion. Data mining process and data fusion models and architectures. Data registration: concepts and theory, algorithms partition and basic description, examples. Data mining and data fusion algorithms: concepts and theory, algorithms partition and basic description. Quality assessment factors of performance evaluation. Case study of data fusion applications.		
Assessment methods	Lectures with simple cases presentations Project – design and implementation of data fusion algorithm Lectures – oral exam Project – report assessment		
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, J. Llians, Handbook of Multisensor Data Fusion, CRC Press LLC, 2009, 2nd ed. 3. Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Elsevier Inc., 2011		
Knowledge	Student knows the basic theory about the data fusion concept, models, architectures and levels division, as well as the data registration general procedure and basic algorithms quality assessment factors.		
Skills	Student can design, adopt, proceed and assess the data fusion algorithm for exemplary cases.		

Course title	Introduction to Sound Recording Technology		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WE-2-45	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	To provide knowledge on selected topics on sound engineering, recording technology and electroacoustical measurements. Students will be able to explain the basic techniques of recording, processing and play back audio signals. Also gain the skills in electroacoustic and sound recording system use, design and measurements.		
Entry requirements	Basic knowledge in Physics		
Course contents	Measurements of sound field parameters Audio signal analysis methods Microphones measurements Loudspeaker measurements Mixing desk applications Reverberation time measurements and acoustical adaptation design stereo recordings using AB, *XY*, MS and ORTF methods Recordings session in studio and on location, non-linear sound editing, mastering Recordings session on location Non-linear sound editing, mastering Objectives of sound engineering and recording technology. Basics of musical sound descriptions. Sound sources properties. Two- and multichannel reproduction systems. Electroacoustical transducers and electroacoustical systems. Microphone technique. Analog and digital recording systems. DAW. Digidal audio signal processing. Production of speech and music recordings. On location recording techniques. Mastering		
Assessment methods	Lectures Laboratory exercises Written test Reports assessment		
Recommended readings	1. Everest F. A., Master handbook of acoustics, McGraw-Hill, 2001 2. Howard D. H., Acoustics and psychoacoustics, Focal press, 2001		
Knowledge	To provide knowledge in various sound systems engineering		
Skills	To provide skills in various sound systems engineering		

Course title	M.Sc. Thesis		
Level of course	second cycle		
Teaching method	null		
Person responsible for the course	- Nauczyciel WE	**E-mail address to the person**	a@b
Course code (if applicable)	WE-2	**ECTS points**	20
Semester	winter/summer	**Language of instruction**	english
Hours per week	1	**Hours per semester**	15
Objectives of the course	The main goal of the thesis is to check the degree of obtaining engineering competences at the master's level during the studies. Teaching a student the methodology of searching for source materials and the proper use of them. Teaching the student to prepare extensive reports describing the work being carried out. Teaching how to write a technical text with scientific elements and in particular to present in it the assumptions, purpose and methodology of solving the problem posed in the diploma thesis. Understanding the practical aspects of the application of copyright and related rights.		
Entry requirements	The work is of research or design nature with scientific elements. Its result may be, for example, a computer program or the results of tests carried out with the use of professional devices or programs. It is to prove that the student acquired the engineering competences at master's level related to the studied subject during his studies. Knowledge of basic issues related to the subject of the diploma thesis. Knowledge of copyright in the area related to the use of sources when writing a diploma thesis. The ability to write technical texts and to make drawings and graphs illustrating the results obtained.		
Course contents	Methodology of preparation of the M.Sc. Thesis, its illustrative and text part, scope of the design, description and the legal issues. Methods of information selection by the contemporary scientific methods. Methods of analytical studies, plagiarism prevention. Students presentation on selected topics related to their M.Sc. Thesis.		
Assessment methods	Individual work with the diploma thesis supervisor. Successive, orally transmitted evaluation of the progress of the diploma thesis to the student. Substantive evaluation of the diploma paper is contained in reviews prepared by the supervisor and the reviewer. The formal form of the review is defined in the appropriate regulation of the Rector of ZUT.		
Recommended readings	1. ZUT Study Regulations (Regulamin studiów obowiązujący od 1 października 2019 roku), 2017 2. Zarządzenie Rektora Zachodniopomorskiego Uniwersytetu Technologicznego w Szczecinie w sprawie dyplomowania (Decree of the Rector of the West Pomeranian University of Technology in Szczecin on graduation), 2017		
Knowledge	Has the deepened knowledge in the field of electrical engineering necessary to understand the relationships occurring in circuits, networks, devices and electrotechnical systems.		
Skills	The student is able to search for relevant source materials and use them correctly, while integrating information obtained from various sources, he is able to take into account during the diploma thesis related to its subject matter various problems in other fields.		
Other social competences	The student is able to plan the schedule of the implementation of a complex task, is able to take into account during the diploma thesis related to its subject matter various problems in other fields.		

Course title	Machine Learning		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Adam Krzyżak	**E-mail address to the person**	Adam.Krzyzak@zut.edu.pl
Course code (if applicable)	WE-2-46	**ECTS points**	6
Semester	summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	This course is intended to present a unified approach to machine learning techniques and algorithms and their applications in practical problems.		
Entry requirements	Basic knowledge of Matlab or Mathcad environments Basic knowledge about programming Basic knowledge of linear algebra, probability and statistics		
Course contents	Students prepare individual project with the requirements given by the teacher. Classification. Generative vs. discriminative learning. Naive Bayes. Gaussian discriminant analysis. Linear models: linear and polynomial regression. L2 and L1 regularization. Sparse models, logistic regression. Non-linear models: decision trees, instance-based learning, boosting, neural networks. Support vector machines and kernels. Computational learning theory. Unsupervised learning: clustering. K-means, mixture models, density estimation, expectation maximization. Autoencoder, PCA Structured models: graphical models, Bayes nets. Learning in dynamical systems: Hidden Markov Models and other types of temporal/sequence models. Approximate inference. Gibbs sampling. Deep belief learning.		
Assessment methods	Traditional lecture. Students prepare individual projects and reports. Written exam (test) / project work		
Recommended readings	1. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006		
Knowledge	Knowledge of basic machine learning algorithms. Ability to implement some machine learning algorithms in chosen environment (e.g. Matlab).		
Skills	Students will get the skills about creating algorithms related to the machine learning theory and also ability to implement some machine learning algorithms in chosen environment (e.g. Matlab).		

Course title	Magnetic Measurements Techniques		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Grzegorz Psuj	**E-mail address to the person**	Grzegorz.Psuj@zut.edu.pl
Course code (if applicable)	WE-2-47	**ECTS points**	2
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	This course is intended to present a basic knowledge of magnetic measurements and and their practical application.		
Entry requirements	Academic course in mathematics and physics.		
Course contents	Introduction to the topic of the project. Implementation of a project task in the laboratory. Presentation of the results and discussion of the achieved solutions. Fundamentals of magnetic measurements. Sources of magnetic fields. Magnetic materials and their properties. Magnetic sensors. Magnetic field measurement. Systems for measurements of magnetic materials.		
Assessment methods	Lectures with multimedia presentation. Project – design, analysis and practical implementation of magnetic measurements systems. Lectures – oral exam Project – continous assessment with final report evaluation.		
Recommended readings	1. Tumanski S., Handbook of magnetic measurements, CRC Press, Taylor & Francis Group, Boca Raton, 2011 2. Bozorth R. M., Ferromagnetism, IEEE Press, New Jersey, 2003		
Knowledge	Student will gain the basic knowledge about magnetic measurements concept, magnetic materials, sensing device and measuring systems.		
Skills	Student is able to design / adopt and analyze the operation of the measuring system and carry out the magnetic measurements.		

Course title	Medical Imaging Systems		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Piotr Okoniewski	**E-mail address to the person**	Piotr.Okoniewski@zut.edu.pl
Course code (if applicable)	WE-2-48	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	To provide up to date knowledge on various modalities of biomedical imaging technologies and algorithms. Tto develop practical skills useful in the area of biomedical imaging systems.		
Entry requirements	Mathematics, Informatics, Signal processing, Image processing, Biomedical Engineering		
Course contents	Image browsing & analysis tools: systems OSIRIS/PAPYRUS and PC-Image. DICOM validation tools. MATLAB and LabView systems in image processing. Medical imaging systems – physical principles of image formation and equipment in Thermography (TG) Medical imaging systems – physical principles of image formation and equipment in Ultrasonography (USG) Medical imaging systems – physical principles of image formation and equipment in Nuclear Medicine (Gamma-camera, SPECT, PET) Medical imaging systems – physical principles of image formation and equipment in Digital Radiography (DR) Medical imaging systems – physical principles of image formation and equipment in Computed Tomography (CT) Medical imaging systems – physical principles of image formation and equipment in Magnetic Resonance Imaging (MRI). Special techniques, e.g. ultra-fast data acquisition systems in MRI (EPI), Functional and Interventional MRI Image processing, analysis and measurement; software tools. Image fusion. Image transmission and archiving – PACS, standard DICOM 3. DICOM validation tools		
Assessment methods	Lectures Lab tasks grade assigned at the end of the lectures on the basis of a written test grade assigned for submission of reports of the laboratory exercises.		
Recommended readings	1. Bronzino J. D., Biomedical Engineering Handbook, CRC Press, 1995 2. Robb R. A., Three Dimensional Biomedical Imaging: Principles and Practice, Wiley-Liss, 1998 3. Shellock F. G., Kanal E., Magnetic Resonance. Bioeffects, Safety and Patient Management, Raven Press, 1994		
Knowledge	The student has increased knowledge on methods and techniques used in medical diagnostic imaging, systems and archiving/communication standards as well as on research methodology used in this field.		
Skills	The student has practical skills useful in this area regarding biomedical imaging systems testing, development, and exploitation		

Course title	Modern Electrical Machines		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Ryszard Pałka	**E-mail address to the person**	Ryszard.Palka@zut.edu.pl
Course code (if applicable)	WE-2-49	**ECTS points**	6
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The course gives the fundamental and expert knowledge about construction, development, numerical evaluation 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 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. The course gives the knowledge about construction 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	Lecture Project Written exam Project work		
Recommended readings	1. Gieras J. F., Wing M., Permanent magnet motor technology, Wiley&Sons, 2008 2. Austin Hughes, Electric Motors and Drives, Elsevier Ltd., 2006 3. Chiasson J., Modeling and high-performance control of electric machines, Wiley&Sons, 2005 4. Larminie J., Lowry J., Electric Vehicle Technology Explained, Wiley&Sons, 2003 5. Gieras J. F., et al., Noise of Polyphase Electric Motors, CRC Press, 2006 6. Pyrhoenen J., et al., Design of Rotating Electrical Machines, Wiley & Sons, 2008		
Knowledge	The student has increased knowledge of new solutions on methods and techniques used in modern electrical machines as well as on research methodology used in this field.		
Skills	The student has practical skills useful in this area regarding design, calculation and optimizaton of electrical machines.		

Course title	Modern Image Processing		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Przemysław Mazurek	**E-mail address to the person**	Przemyslaw.Mazurek@zut.edu.pl
Course code (if applicable)	WE-2-50	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Basic knowledge related to image processing		
Entry requirements	Computer science		
Course contents	Design of system with selected image processing algorithms Pattern recognition techniques for image processing Tracking algorithms for image processing Medical images and volumes enhacement Test of knowledge		
Assessment methods	Instructional method/informative lecture Practical method/project Passing the project A pass in the form of a choice test		
Recommended readings	1. V. Madisetti, Wireless, Networking, Radar, Sensor Array Processing, and Nonlinear Signal Processing, CRC, 2009 2. V. Madisetti, Digital Signal Processing Fundamentals, CRC, 2017 3. I. Bankman, Handbook of Medical Image Processing and Analysis, Academic Press, 2008		
Knowledge	Knowledge related to image processing algorithm		
Skills	Skills related to the application of modern image processing algorithms		

Course title	Multistructured Optical Fibres Applications		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Ewa Weinert-Rączka	**E-mail address to the person**	Ewa.Weinert-Raczka@zut.edu.pl
Course code (if applicable)	WE-2-51	**ECTS points**	2
Semester	winter	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	At successful completion of this course the students will be familiar with special optical fiber- propagation, modelling and design. The course will also provide the basic knowledge of methods of propagation modeling in Microstructured Optical Fibres and their applications.		
Entry requirements	Academic courses: Informatics, Mathematics, Physics.		
Course contents	Project work- multistructured optical fiber numerical designing Introduction to optical fiber theory. Fabrication of fibres Modes of Optical Fibers . Single Mode and Multimode Fibres. Chromatic Dispersion. Polarization Mode Dispersion. Holey and Photonic Crystal Fibers. Photonic Bandgap Guidance. SuperContinnuum Generation. Optical Fibers for sensors Fiber Bragg Gratings Multicore Fibres Polymer Optical Fibers Optical Fiber Interferomers Modelling and Design of Microstructured Fibers		
Assessment methods	Lectures- multimedia presentations Final report		
Recommended readings	1. A. Argyros, Microstructures in Polymer Fibres for Optical Fibres, THz Waveguides, and Fibre-Based Metamaterials, Institute of Photonics and Optical Science, School of Physics, The University of Sydne, Sydney, Australia, 2006 2. Ziemann O., Krauser J., Zamzow P.E., Daum W, POF Handbook, Optical Short Range Transmission Systems. Springer-Verlag, Springer-Verlag, 2008		
Knowledge	At successful completion of this course the students will be familiar with the properties of special optical fibers. The course will also provide the basic knowledge of methods of propagation modeling in Microstructured Opticial Fibres and applications of special optical fibres.		
Skills	At successful completion of this course the students will be familiar with the selected special optical fibers modelling and design methods.		

Course title	Network Systems Administration		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Piotr Lech	**E-mail address to the person**	Piotr.Lech@zut.edu.pl
Course code (if applicable)	WE-2-52	**ECTS points**	4
Semester	summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The ability to use administrative tools. Familiarization with the administration type networks LAN and WAN. Understanding the issues related to the administration of selected network services, user accounts and computer systems caused or information.		
Entry requirements	Basic knowledge of computer networks and support for applications and operating systems.		
Course contents	Selected aspects of network administration with devices Layer 2 and Layer 3 ISO / OSI model. Administration and managage access networks and WAN - simulation. Creating a virtual network environment. IP network design. Configuration and management of virtual devices and serwerwerami. Differences in administacji network systems on the network example, Linux and Windows. Managing user accounts and resources. Administration selected network services Installation, configuration and administration of the web server. Installation, configuration and administration of Joomla. Web-based tools to assist the administration of network devices and services. Design scenarios and implementation backup for given parameters. Examination of the laboratory The network administrator. Managing user accounts and resources depending on the operating system. Administrator Tool observation network traffic, network protocol analysis, selected aspects of network security. Simulations. Selected aspects of configuration, management and administration of network devices. Configuration and administration of access devices, access to adminstracji WAN. Configuration and management of network services such as: mail, FTP, SQL, Web. Construction, administration and management of advanced content management systems. Backups, backup scenarios. Management and administration of multimedia networks.		
Assessment methods	lecture discussion labolatory tasks test evaluation report assessment of laboratory tasks		
Recommended readings	1. Thomas A. Limoncelli, The Practice of System and Network Administration, Second Edition		
Knowledge	Working knowledge of networking terms and concepts pertaining to system administration, terms that characterize the attributes of networks and aspects of network operation.		
Skills	Ability to observation of system behavior. Ability actions taken to accomplish sysadmin related to administration tasks.		

Course title	Network Traffic		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Przemysław Włodarski	**E-mail address to the person**	Przemyslaw.Wlodarski@zut.edu.pl
Course code (if applicable)	WE-2-53	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	This course is intended to present selected issues of ICT network traffic and performance evaluation		
Entry requirements	Fundamentals of computer networks		
Course contents	Computer network configuration for different network setups Capturing, filtering and inspecting of L2 and L3 layers Traffic synthesis based on stochastic processes Delay and loss analysis based on selected generation models Collecting data using SNMP Traffic shaping for different queueing disciplines (TBF, HTB, SFQ, etc.) Analysis of basic queues in real computer networks Configuration of multicast and real-time applications Configuration and performance evaluation for different network setups Delay and loss analysis Network traffic generation model Synthesis of traffic flows based on stochastic processes Collecting data using SNMP Traffic shaping and control using classless (SFQ, GRED, TBF) and classful (HTB, CBQ, PRIO) queueing disciplines Basic queues and their impact on network traffic		
Assessment methods	Lectures based on presentations and solutions of selected problems Laboratory tasks and exercises Written test and / or oral discussion Assessment of accomplished tasks and exercises test		
Recommended readings	1. Armitage G., Quality of Service in IP Networks: Foundations for a Multi-service Internet, 2000		
Knowledge	Knowledge of network traffic issues and performance evaluation		
Skills	Ability to configure and control network traffic in various applications (best effort, real-time)		

Course title	Neural Networks and Deep Learning		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Przemysław Mazurek	**E-mail address to the person**	Przemyslaw.Mazurek@zut.edu.pl
Course code (if applicable)	WE-2-54	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Basic knowledge related to neural networks and deep learning		
Entry requirements	Computer science		
Course contents	Design of system with neural network Fundamentals of Pattern Recognition Artificial Neural Networks Convolutional Neural Networks Test of Knowledge		
Assessment methods	Instructional method/informative lecture Practical method/project Passing the project A pass in the form of a choice test		
Recommended readings	1. I. Goodfellow, Y. Bengio, A.Courville, Deep Learning, MIT Press, 2016 2. Ch.C. Aggarwal, Neural Networks and Deep Learning: A Textbook, Springer, 2018 3. T. Masters, Practical Neural Network Recipes in C++, Morgan Kaufmann, 1993		
Knowledge	Knowledge related to neural networks and deep learning		
Skills	Skills related to design systems with neural networks and deep learning		

Course title	Non-Destructive Testing (NDT) using radiographic (X-ray) and terahertz method		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Tomasz Chady	**E-mail address to the person**	Tomasz.Chady@zut.edu.pl
Course code (if applicable)	WE-2-55	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	To teach basics of selected methods of NDT To teach how to apply specific method of NDT in practical applications Upon successful completion of this course, the student will be able to: - use THz imaging system, computer and digital XRay system, - use the numerical XRay simulator, - select appropriate NDT method for specific case, - work independently and collaboratively to understand and formulate problems, and solve these problems using the provided tools and methods.		
Entry requirements	Academic course of mathematics Academic course of physics Academic course of electrotechnics or circuit theory		
Course contents	Terahertz testing of dielectric and composite materials Digital radiography Numerical modeling in NDT (Xray) Non-destructive testing - the introduction, the basic idea, the historical background Evaluation of low conductivity materials using electromagnetic waves of high frequency Computer and digital radiography Numerical modeling in NDT Algorithms for identification in NDT		
Assessment methods	Informative lecture laboratory exercises Written exam (Lect.) Continuous assessment (Lab)		
Recommended readings	1. Hellier C. J., Handbook of Nondestructive Evaluation, McGrown-Hill, 2003 2. Sakai K., Terahertz Optoelectronics, Springer-Verlag, Berlin Heidelberg, 2005 3. Peter J. Shull, Nondestructive Evaluation Theory, Techniques, and Applications, Marcel Dekker, Inc, 270 Madison Avenue, New York, NY 10016, 2002, ISBN: 0-8247-8872-9		
Knowledge	Upon successful completion of the course, the student will be able to: • identify, formulate, and solve engineering problems in the field of NDT, • explain the principles of the major NDT methods, • identify advantages and limitations of nondestructive testing methods and to select the appropriate techniques for inspections in specific application, • use selected software for numerical modelling of NDT systems, use selected hardware for practical NDT (i.e. THz TDS or digital detectors and IP scanner for X-ray testing).		
Skills	Upon successful completion of the course, the student will be able to: • identify, formulate, and solve engineering problems in the field of NDT, • explain the principles of the major NDT methods, • identify advantages and limitations of nondestructive testing methods and to select the appropriate techniques for inspections in specific application, • use selected software for numerical modelling of NDT systems, use selected hardware for practical NDT (i.e. THz TDS or digital detectors and IP scanner for X-ray testing).		

Course title	Nonlinear Control		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Adam Łukomski	**E-mail address to the person**	Adam.Lukomski@zut.edu.pl
Course code (if applicable)	WE-2-56	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Gaining skills connected with general nonlinear control theory Gaining knowledge about nonlinear control theory		
Entry requirements	General knowledge of mathematics: matrix operations, derivatives, integrals General knowledge of basic linear control theory		
Course contents	Nonlinear system modelling Analysis of a nonlinear system Control design Stability of a nonlinear control system Examples of highly nonlinear systems Introduction to nonlinear control Analysis of a nonlinear system Control methods design for nonlinear systems Stability of a nonlinear system Summary and exam		
Assessment methods	Lecture Laboratory course Final exam on the last lecture meeting Grades based on performance during laboratory meetings		
Recommended readings	1. Slotine, Jean-Jacques E and Li, Weiping and others, Applied nonlinear control, 1991		
Knowledge	Ability to model, analyse and control a nonlinear system		
Skills	Ability to model, analyse and control a nonlinear system		

Course title	Object-Oriented Programming in C#		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Marcin Ziółkowski	**E-mail address to the person**	Marcin.Ziolkowski@zut.edu.pl
Course code (if applicable)	WE-2-57	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	This course is intended to present object-oriented programming techniques in C# language.		
Entry requirements	Mathematics		
Course contents	Application structure in C# Data Types Loops Static Methods Exceptions Files and Streams Arrays Structures Classes Constructor Inheritance Application structure in C# Data Types Loops Static Methods Exceptions Files and Streams Arrays Classes Constructor Structures Inheritance Abstract Classes Polymorphism Collections Windows Forms		
Assessment methods	Traditional lecture Computer laboratory In-class assessment		
Recommended readings	1. A. Hejlsberg, M. Torgersen, S. Wiltamuth, P. Gold, The C# Programming Language, Addison-Wesley, 2011		
Knowledge	Students will get the knowledge about modern object-oriented language		
Skills	Students are able to write a program based on object-oriented language.		

Course title	Optimization Theory		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Marcin Ziółkowski	**E-mail address to the person**	Marcin.Ziolkowski@zut.edu.pl
Course code (if applicable)	WE-2-58	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Students will get the knowledge about various optimization methods. They will be able to use an appropriate method to the given practical problem.		
Entry requirements	Numerical Methods, Mathematics, Physics		
Course contents	One-Dimensional Search Methods (Golden Section Search, Fibonacci Search, Newton's Method, Secant Method) Gradient Methods Genetic Algorithms Simplex Methods, Non-Simplex Methods Single Objective Optimization and Multi Objective Optimization Problems Single Objective Optimization of an Exciter for Magnetic Induction Tomography Multi Objective Optimization of an Exciter for Magnetic Induction Tomography Magnetic Field Synthesis on a Solenoid's Axis Transport of chemicals - benchmark problem Topology Optimization of a Magnetic Field in a Three-dimensional Finite Region One-Dimensional Search Methods (Golden Section Search, Fibonacci Search, Newton's Method, Secant Method) Gradient Methods Genetic Algorithms Simplex Methods, Non-Simplex Methods Single Objective Optimization of an Exciter for Magnetic Induction Tomography Multi Objective Optimization of an Exciter for Magnetic Induction Tomography Magnetic Field Synthesis on a Solenoid's Axis Transport of chemicals - benchmark problem Topology Optimization of a Magnetic Field in a Three-dimensional Finite Region		
Assessment methods	Traditional lecture Computer laboratory In-class assessment		
Recommended readings	1. Edwin K.P. Chong, Stanislaw H. Żak, An Introduction to Optimization, Wiley & Sons, New York, USA, 2001		
Knowledge	Students will get the knowledge about various optimization methods.		
Skills	Students are able to use various optimization methods. They will be able to use an appropriate method to the given practical problem.		

Course title	Optoelectronic sensors		
Level of course	second cycle		
Teaching method	laboratory course / project course / lecture		
Person responsible for the course	Grzegorz Żegliński	**E-mail address to the person**	Grzegorz.Zeglinski@zut.edu.pl
Course code (if applicable)	WE-2-59	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	At successful completion of this course the students will be familiar with optoelectronic and optical fiber sensors, modelling and design. The course will also provide the basic knowledge of modelling methods of IR optoelectronic sensor and their applications. The students will get ability to design of modern optoelectronic sensor systems with emphasis on advanced fiber-optic sensor systems.		
Entry requirements	Academic courses: Mathematics, Physics.		
Course contents	The sensor software tools- lab training. The distance optical fiber sensor. The Light intensity-modulated fiber-optic displacement sensor. The fiber optic interferometric device. The characteristics of VIS diode lasers. The detector measurements for IR aplications. The laser driver. The amplificators for detectors. Temperature measurements by pirometer. The optical strain sensor based on fiber. Optoelectronic sensors for arduino platform. The subbsision tiime deadline for lab reports Project work- The simple microcontroler circuit with a optoelectronic sensor for industrial application. Optoelectronic sensor technologies. Multimode and singlemode fiber optic sensors. The birefringe in optical fibers. PM fiber sensors. Bragg fibers. Holey and Photonic Crystal Fibers. Photonic Bandgap Guidance. Diode lasers for sensors. Detectors. Electronic drivers for sensor transmitters and receivers. Splitters and couplers for sensor systems. Optoelectronic sensors in the medicial applications. Industrial applications (The robotic industrial line, gas sensors, automotive sensors). Sensor for IoT . Health monitoring. New optoelectronic sensors for environment monitoring.		
Assessment methods	Lectures- multimedia presentations Lab exercises Final report lab report lecture project report		
Recommended readings	1. Giancarlo C Righini , Antonella Tajani, Antonello Cutolo, An Introduction to Optoelectronic Sensors, Series in Optics and Photonics: Volume 7 , World Scientific, Singapore, 2009 2. Asit Baran Maity, Optoelectronics and Optical Fiber Sensors, University Bookstore, B-74,New delhi, India,, New delhi, India,, 2013		
Knowledge	At successful completion of this course the students will be familiar with special optical fiber and optolectronic devices - modelling and design. The course will also provide the basic knowledge of optoeletronic sensors and their applications.		
Skills	At successful completion of this course the students will be familiar with special optical fiber and optolectronic devices - modelling and design. The course will also provide the basic knowledge of optoeletronic sensors and their applications.		

Course title	Pattern Recognition and Classification		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Adam Krzyżak	**E-mail address to the person**	Adam.Krzyzak@zut.edu.pl
Course code (if applicable)	WE-2-60	**ECTS points**	4
Semester	summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	This course is intended to present a unified approach to pattern recognition and classification techniques and their applications in real life problems		
Entry requirements	Basic knowledge of Matlab or Mathcad environments Basic knowledge about programming Basic knowledge of linear algebra, probability and statistics		
Course contents	Students prepare individual project with the requirements given by the teacher. Introduction to the subject of pattern recognition. Bayesian decision theory, discriminant functions for normal class distributions. parameter estimation and supervised learning, nonparametric techniques (nearest neighbor rules, Parzen kernel rules, tree classifiers). Adaboost, Breiman random forest, linear discriminant functions. Fisher linear discriminant and learning including perceptron learning. LMS algorithms and support vector machines, unsupervised learning and clustering. Neural networks including multilayer perceptrons and radial basis networks Elements of machine learning. Feature selection and dimensionality reduction including PCA. SOM and Laplacian maps. Applications of pattern recognition in biometrics including handwriting recognition, face recognition and fingerprint recognition.		
Assessment methods	Traditional lecture. Students prepare individual projects and reports. Written exam (test) / project work		
Recommended readings	1. R. O. Duda, P. E. Hart and D. G. Stork, Pattern Classification, Wiley, Second Edition, 2001		
Knowledge	Knowledge of basic pattern recognition algorithms.		
Skills	Ability to implement some pattern recognition algorithms in chosen environment (e.g. Matlab).		

Course title	Power System Protection		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Michał Zeńczak	**E-mail address to the person**	Michal.Zenczak@zut.edu.pl
Course code (if applicable)	WE-2-61	**ECTS points**	2
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	Knowledge about principles of power system protection Skills of selection of protection for basic components of power system		
Entry requirements	Mathematics Physics Basis of electrical engineering		
Course contents	Investigation of overcurrent protection Investigation of overvoltage protection Investigation of undervoltage protection Investigation of distance protection Investigation if differential protection. Investigation of short-circuits Interferences in power system Overload protection, overcurrent protection Overvoltage protection, undervoltage protection Differential protection Directional protection Distance protection Protection of transformers Protection of lines Protection of busbars Protection of generators Protection of electrical motors		
Assessment methods	Informative lecture Problem-based lecture Laboratory exercises Continuous assessment in laboratory Final test on the end of lectures		
Recommended readings	1. Grainger J.J., Stevenson W.D., Power System Analysis, McGRAW-HILL INTERNATIONAL EDITIONS, NTERNATIONAL EDITIONS, 1994 2. Grigsby L.L., Electric Power Generation, Transmission, and Distribution, CRC PRESS, USA, 2007		
Knowledge	Student has knowledge for understanding principles of protection for basic components of power system.		
Skills	Student is able to choice the protections for basic components of power system.		

Course title	Problem-Solving Workshop		
Level of course	second cycle		
Teaching method	laboratory course / project course / seminars		
Person responsible for the course	Joanna Górecka	**E-mail address to the person**	Joanna.Gorecka@zut.edu.pl
Course code (if applicable)	WE-2-62	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
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, Biomedical Engineering, fundamentals of semiconductor electronics		
Course contents	Research work 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. Research work 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. Presentation of topics Consultations Final presentations of chosen topic		
Assessment methods	oral presentation Continuous assessment of lab and project work, evaluation of the written report and of oral/poster presentation of the project results during the final seminar.		
Recommended readings			
Knowledge	The student has knowledge on research and design methodology, and on performing project work.		
Skills	The student has practical skills useful in solving interdisciplinary problems in the field of biomedical engineering.		

Course title	Programmable Automation System Based on PLC and HMI		
Level of course	second cycle		
Teaching method	laboratory course / project course / lecture		
Person responsible for the course	Krzysztof Jaroszewski	**E-mail address to the person**	Krzysztof.Jaroszewski@zut.edu.pl
Course code (if applicable)	WE-2-63	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	To form skills of programming automation system consists of: Programming Logical Controllers (PLC's) - in the control level and Human Machine Interfaces (HMI's) – in operation level. Moreover, subject with diagnostic and fault tolerant control algorithms will be brought closer. During practical parts of the course SIMATIC by SIEMENS devices will be used: PLC: S7-1200, HMI: KTP600. To form skills of programming automation system consists of: Programming Logical Controllers (PLC's) - in the control level and Human Machine Interfaces (HMI's) – in operation level. Moreover, subject with diagnostic and fault tolerant control algorithms will be brought closer. During practical parts of the course SIMATIC by SIEMENS devices will be used: PLC: S7-1200, HMI: KTP600 to build controll system.		
Entry requirements	Basic of mathematical logic. Basic of electrical engineering. Basic of information technology.		
Course contents	Introductin to Totally Integrated Automation Portal, Siemens Operation of digital I/O Signal edges Counting number of events Time counting Analog signals PLC and HMI connection Introduction - task explanation Concept of control system PLC programming Visualization design System validation Documentation preparation Presentation of achievemets Introduction Programmable Automation Systems Programmable Logic Controlers - introduction PLC - software environment PLC - I/O - hardware PLC - I/O - software PLC - basic logic - digital I/O PLC - signal edge PLC - counters PLC - timers PLC - special bloks PLC - analog chanels PLC - other functions Human Machine Interface - basic knowledge Exam		
Assessment methods	Lecture with usig PC Practical tasks with using PC, PLC and HMI devices Exam Task realisation marking		
Recommended readings	1. Nebojsa Matic, Introduction to PLC controllers, MikroElektronika, 2009 2. SIEMENS, manuals, SIEMENS		
Knowledge	Ability to design automation system including elementary diagnostics and built project on PLC and HMI.		
Skills	Ability to design automation system including elementary diagnostics and built project on PLC and HMI.		

Course title	Programmable Logic Devices		
Level of course	second cycle		
Teaching method	laboratory course / project course / lecture		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WE-2-64	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	To provide knowledge on programmable logic devices and their use in modern digital system design 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.		
Entry requirements	Basic knowledge on digital circuits and informatics		
Course contents	Introduction to the programming environment and laboratory board Implementation of combinational circuits. Part 1. Implementation of combinational circuits. Part 2. Register circuits. Part 1 – synchronous flip-flops and shift register. Register circuits. Part 2 – counters. The implementation of synchronous machines in programmable logic devices. Elimination of switches contact debouncing. VGA video generator in the FPGA structure. Final test. Design and testing of various digital systems designed using FPGA laboratory boards. Categorization of programmable logic devices. Design systems for SPLD and CPLD. Configuration memory. 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. Designing paths. Design environments for FPGA design. JTAG. Systems on Chip. Structured ASIC.		
Assessment methods	Lectures work in laboratory Projects design Reports written assessment written test		
Recommended readings	1. Skahill K., VHDL. Design of programmable logic devices, Prentice Hall, 2001 2. Sunggu Lee, Design of computers and other complex digital devices, Prentice Hall, 2000 3. Zwolinski Mark, Digital System Desin withVHDL., Pearson Education Limited, 2004, 2		
Knowledge	Student will be able to describe the building blocks in modern CPLD and FPGA integrated circuits.		
Skills	Student will be able to design and test simple digital apliances using programmable IC's and hardware description language.		

Course title	Renewable Energy Sources		
Level of course	second cycle		
Teaching method	lecture		
Person responsible for the course	Olgierd Małyszko	**E-mail address to the person**	Olgierd.Malyszko@zut.edu.pl
Course code (if applicable)	WE-2-65	**ECTS points**	2
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	Student has a knowledge of power generation methods. Student has a knowledge of energy storage methods and smart grid technology. Student is able to design photovoltaic power plant. Student is able to design wind power plant.		
Entry requirements	Student should know math (trigonometric and complex numbers) and basics of Electric Engineering and Electric Motors.		
Course contents	Introduction to energy production – problems, challenges, changes of Earth climate Classic (coal/gas/oil) power plants Photovoltaic power plants Wind power plants Water power plants Energy storage methods and systems Smart grid Nuclear power plants, fusion power plants Biogas, waste incineration plant Geothermic power plants Final test		
Assessment methods	Instructional method/informative lecture. Summative assessment based on written credit and student interview.		
Recommended readings	1. Anne E. Maczulak, Renewable Energy: Sources and Methods, 2009 2. Mark E. Hazen, Alternative Energy: An Introduction to Alternative & Renewable Energy Sources, 1996 3. David Craddock, Renewable Energy Made Easy: Free Energy from Solar, Wind, Hydropower, and other alternative energy sources, 2008		
Knowledge	Students will know types of power plant, methods to produce energy in conventional and unconventional power plant. Students will know methods of storage the energy for small- and large-scale electric grid and smart grid technology.		
Skills	Student is able to design photovoltaic power plant. Student is able to design wind power plant.		

Course title	Selected Topics in Nonlinear Photonics		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Ewa Weinert-Rączka	**E-mail address to the person**	Ewa.Weinert-Raczka@zut.edu.pl
Course code (if applicable)	WE-2-66	**ECTS points**	2
Semester	summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	To give basic concepts related to nonlinear optical phenomena and their applications in photonics and optical telecommunication.		
Entry requirements	Basic knowledge on wave optics and fundamentals of material physics		
Course contents	Preparation of the selected experimental setup and measurements Numerical simulations on propagation of light in selected nonlinear optical systems Propagation of light in linear media. Basics of nonlinear optics. Nonlinear materials. New frequencies generation. Phase conjugating mirrors and wavefront reconstruction. All-optical switching. Nonlinear waveguides. Temporal and spatial soliton propagation. Nonlinear phenomena In optical communications. Reconfigurable photonic circuits. Supercontinuum generation.		
Assessment methods	Lectures and multimedia presentations Participation in work in the Photonics Laboratory Lectures: grade Labs: accomplishment of lab tasks		
Recommended readings	1. B. E. A. Saleh, M. C. Teich,, Fundamentals of Photonics, Wiley Series in Pure and Applied Optics, 2007 2. R. W. Boyd, Nonlinear optics, Academic Press, Boston, San Diego, London, 1992		
Knowledge	At successful completion of this course the students will be familiar with basics of nonlinear optics and nonlinear photonics applications.		
Skills	At successful completion of this course the students will be familiar with selected nonlinear optics experiments and numerical simulations.		

Course title	Signal Processing		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Joanna Górecka	**E-mail address to the person**	Joanna.Gorecka@zut.edu.pl
Course code (if applicable)	WE-2-67	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	To provide up to date knowledge on methods and techniques used in acquisition, processing and analysis of signals and to develop practical skills useful in this field.		
Entry requirements	Mathematics		
Course contents	Discrete-Time Signals Fourier Transform Theorems Discrete-Time Random Signals z-Transform properties Examples of filter design technique Computation of the Discrete Fourier Transform (FFT analysis) Fourier analysis of signals using the Discrete Fourier Transform Discrete Hilbert Transforms properties Introduction to Discrete-Time Signals and Systems Fourier Transform Theorems The z-Transform Sampling of Continuous-Time Signals Transform analysis of Linear Time-Invariant Systems Structures for Discrete-Time Systems Filter Design Techniques The Discrete Fourier Transform Discrete Hilbert Transforms		
Assessment methods	oral presentation (lectures), practical work in lab grade, accomplishment of lab tasks		
Recommended readings	1. Oppenheim A.V, Schafer R.W., Digital Signal Processing, 2001 2. Oppenheim A.V, Schafer R.W., Discrete-Time Signal Processing, Prentice Hall; 2 edition, 1999 3. Proakis J.G., Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall; 3rd edition, 1995		
Knowledge	The student has knowledge on methods and techniques used in acquisition, processing and analysis of signals as well as on research methodology used in this field.		
Skills	The student has practical skills useful in this area regarding signal measurements (instrumentation, specialized software tools).		

Course title	Sound System Design		
Level of course	second cycle		
Teaching method	laboratory course / seminars / lecture		
Person responsible for the course	Witold Mickiewicz	**E-mail address to the person**	Witold.Mickiewicz@zut.edu.pl
Course code (if applicable)	WE-2-68	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
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	Sound wave parameters measurement Human hearing sense properties Audio signal analysis methods Microphones measurements Microphones setup. Loudspeaker measurements Loudspeaker cabinet design Room acoustics measurements and acoustical adaptation design Speech intelligibility measurement Various sound system design. Using microphones, loudspeakers, amplifiers, mixing console and sound effects in sound reinforcement system design. Complementary calculation exercises 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.		
Assessment methods	Lectures Laboratory exercises Written test Reports assessment		
Recommended readings	1. Everest F. A., Master handbook of acoustics, McGraw-Hill, 2001 2. 1. Davis D. and C., 1. Sound System Engineering, 1. Howard F. Sams, 1987 3. JBL Professional, Sound System Design Reference Manual, pdf document available at www.jblpro.com, 2000		
Knowledge	To provide knowledge in various sound systems engineering		
Skills	To provide skills in various sound systems engineering		

Course title	Statistical Methods in ICT		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Przemysław Włodarski	**E-mail address to the person**	Przemyslaw.Wlodarski@zut.edu.pl
Course code (if applicable)	WE-2-69	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	This course is intended to present statistical methods in ICT for analysis and modeling purposes		
Entry requirements	Mathematics, basics of computer networks		
Course contents	Project based on selected problem in ICT using statistical methods and models Statistical data analysis, random variables, distributions, stochastic processes Traditional models in Telecommunication Networks: Poisson, Markov Modulated Poisson Process (MMPP) Estimation of self-similarity in computer networks: R/S analysis, variance-time plot, Index of Dispertion for Counts (IDC), peridogram and wavelet analysis, Whittle and local estimators Superposition of heavy-tailed on/off sources, FARIMA processes, Pareto Modulated Poisson Process (PMPP) Markov Modulated Bernouli Process (MMBP), circulant embedded matrix method, Spatial Renewal Processes (SRP) Methods based on power spectrum of fractional Gaussian noise Queueing models in telecommunication networks: M/M/1/(K), M/D/1/(K), M/G/1/(K), G/M/1/(K), G/G/1/(K) Generation of self-similar traffic using traditional and self-similar models		
Assessment methods	Lectures based on presentations and solutions of selected problems Project based learning Written test and / or oral discussion Project assessment		
Recommended readings	1. Medhi J., Stochastic models in queueing theory. Academic Press, 2nd edition, 2002 2. Gross D., Harris C.M., Fundamentals of queueing theory. Wiley-Interscience, 3rd edition, 1998 3. Park, K., Willinger, W., Self-similar network traffic and performance evaluation, 2000		
Knowledge	Knowledge of statistical methods in ICT for evaluation of network performance		
Skills	Ability to analyze and generate network traffic using statistical methods in ICT		

Course title	Telemedicine		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Sławomir Kocoń	**E-mail address to the person**	Slawomir.Kocon@zut.edu.pl
Course code (if applicable)	WE-2-70	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	To provide actual knowledge on 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	Introduction. Medical databases. HL7 systems. DICOM and PACS. WWW and video-conference applications for telemedicine Wireless transmission of biomedical signals. Biosensors integration with Bluetooth and other modules. Wireless networks in hospitals, in telemonitoring and teleassistance at home. Tele-service of medical equipment in hospitals Hospital information system (HIS), basic concepts of HIS on different levels of hospital. Communication systems in healthcare. Clinical communication in telemedicine. Electronic medical record. Transfer of biomedical signals in telemedicine and its use for stimulation devices. Internet applications in telemedicine. Reliability of health information systems, electrical safety of medical devices and equipment. Human and sociotechnical factors. Ethical and legal challenges. Evaluation of telemedicine systems. Future trends in telemedicine.		
Assessment methods	Lectures with cases presentations Laboratory exercises Lectures – written exam Labs - accomplishment of lab tasks		
Recommended readings	1. Gordon C., Christensen J. P. (ed.), Health Telematics for Clinical Guidelines and Protocols., IOS Press, Ohmsha, 1995 2. Coiera E., Guide to Medical Informatics. The Internet and Telemedicine., Arnold, London, 1997 3. . Field M. J. (ed.), Telemedicine. A Guide to Assessing Telecommunications in Health Care., National Academy Press, Wash. D.C., 1996 4. Dolin, R. H., Alschuler, L., Boyer, S., & Beebe, C., HL7 clinical document architecture. Release 2.0., HL7 Health Level Seven, Inc., Ann Arbor, MI., 2004		
Knowledge	To provide actual knowledge on information technologies in biomedical applications		
Skills	To provide actual develop design skills in information technologies in biomedical applications		

Course title	Terahertz Technique		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Przemysław Łopato	**E-mail address to the person**	Przemyslaw.Lopato@zut.edu.pl
Course code (if applicable)	WE-2-71	**ECTS points**	2
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	This course is intended to present a basic knowledge of terahertz technique and its application in modern industry		
Entry requirements	Basic course of mathematics and physics (electromagnetics)		
Course contents	Modeling and measurements of structures in terahertz technology Introduction to electromagnetic waves. Generation and detection of EM waves in the THz frequency range. Materials properties and metamaterials in THz frequency range. Passive devices in terahertz technology. CAD of terahertz systems. Overview of available terahertz systems. Application of terahertz technique in spectroscopy, imaging, biomedical engineering, public safety and short-range wireless transmissions.		
Assessment methods	Lectures in form of multimedia presentation Project – designing, measurements and computer simulations of terahertz devices/systems Lectures – oral exam Project – continous assessment		
Recommended readings	1. Sakai K., Terahertz optoelectronics, Springer, Berlin, 2005 2. Mittleman D. (Ed.), Sensing with terahertz radiation, Springer, Berlin, 2010 3. Miles R. E., Harrison P., Lippens D., Terahertz sources and systems, Kluwer, Dordrecht, 2001		
Knowledge	During the course, students will gain a basic knowledge of the operation, design and modeling of measurement systems that use electromagnetic waves in the terahertz range.		
Skills	During the course, students will gain a basic knowledge of the operation, design and modeling of measurement systems that use electromagnetic waves in the terahertz range.		

Course title	Visual Programming in LabVIEW		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Paweł Dworak	**E-mail address to the person**	Pawel.Dworak@zut.edu.pl
Course code (if applicable)	WE-2-72	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Students will be able to write programs in a graphical LabVIEW environment. Should be able to pass the CLAD certification exam.		
Entry requirements	Basics of programming.		
Course contents	Introduction to LabVIEW environment. Navigating LabVIEW. Troubleshooting and Debugging VIs. Implementing a VI, Developing Modular Applications. Using Sequential and State Machine Algorithms. File I/O Techniques. Moving Beyond Dataflow, Solving Dataflow Challenges with Variables. Controlling the User Interface, Event Programming. Creating and Distributing Aplications Introduction to LabVIEW environment. Navigating LabVIEW. Troubleshooting and Debugging VIs. Implementing a VI, Developing Modular Applications. Using Sequential and State Machine Algorithms. File I/O Techniques. Moving Beyond Dataflow, Solving Dataflow Challenges with Variables. Controlling the User Interface, Event Programming.		
Assessment methods	Lectures and practical presentations. Practical exercises. Continuous assessment. Final assessment.		
Recommended readings	1. NI, National Instruments documentation, NI forum, 2016		
Knowledge	Students will be able to write programs in a graphical LabVIEW environment. Should be able to pass the CLAD certification exam.		
Skills	Students will be able to write programs in a graphical LabVIEW environment. Should be able to pass the CLAD certification exam.		

Course title	Wireless Power Transfer (WPT) for electromobility		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Konrad Woronowicz	**E-mail address to the person**	konrad.woronowicz@zut.edu.pl
Course code (if applicable)	WE-2-73	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	- Understand basic principles of the Wireless Power Transfer (WPT) - Recognize WPT topologies in one phase and multiphase topologies - Understand the principles of resonance at and around the characteristic frequency in WPT - Understand the role of WPT transformer and learn its modelling technics - Learn compensation technics - Learn about reactive power flow within the WPT system - Learn how to calculate the parameters of the WPT transformer - Learn how to calculate electrical properties of WPT topologies - Learn how to derive transfer functions of WPT topologies in and off resonance - Learn how to select and analyze a WPT topology for the specific application		
Entry requirements	Electronics, basics of electrtical engineering		
Course contents	Introduction Design of the WPT system for fixed output load parameters with a fixed (given) WPT transformer. Calculation of the transformer's self, coupled, and mutual inductances Design of the WPT system for fixed output load parameters with a fixed (given) WPT transformer. SS design Design of the WPT system for fixed output load parameters with a fixed (given) WPT transformer. SP Design of the WPT system for fixed output load parameters with a fixed (given) WPT transformer. PP Design of the WPT system for fixed output load parameters with a fixed (given) WPT transformer. PS Design of a WPT transformer for fixed input-output load/supply parameters by means of adapting the transformer winding/ferrite design. For SS Design of a WPT transformer for fixed input-output load/supply parameters by means of adapting the transformer winding/ferrite design. For SP Design of a WPT transformer for fixed input-output load/supply parameters by means of adapting the transformer winding/ferrite design. For PP Design of a WPT transformer for fixed input-output load/supply parameters by means of adapting the transformer winding/ferrite design. For PS Modelling and calculation of self and coupled inductances of a primary side of the three phase WPT transformer WPT background, landscape and developmental perspective WPT transformer – one phase, three-phase, multioutput Introduction to WPT topologies SS, SP, PP, PS Analysis of WPT topologies at resonance Analysis of WPT topologies off resonance Analysis of WPT topologies in detuned conditions Consequences of square wave supply and rectification. First Harmonic Analysis Test		
Assessment methods	Auditorial lecture Project Final mark based on lab test results and exam results		
Recommended readings	1. K. Woronowicz, A. Safae, T. Dickson, Single-Phase Zero Reactive Power Wireless Power Transfer Topologies Based on Boucherot Bridge Circuit Concept, Canadian Journal of Electrical and Computer Engineering, 2015, Volume: 38, Issue: 4, Fall 2015; Page(s):323-337 2. A. Safaee, K. Woronowicz, Time-Domain Analysis of Voltage-Driven Series–Series Compensated Inductive Power Transfer Topology, IEEE Transactions on Power Electronics, 2017, Volume: 32, Issue: Page(s): 4981- 5003 3. M. K. Kazimierczuk and D. Czarkowski, Resonant Power Converters, New York, NY, USA: Wiley, 2012		
Knowledge	Clear understanding of the physical phenomena applicable to WPT Be able to recognize different WPT circuit topologies Be able to select a suitable WPT topology based on design requirements Be able to select design requirements for a WPT transformer for the selected WPT topology and input/output parameters Be able to determine lump electrical parameters of a WPT system Understand the effects of high frequency on coil design and the reactive power compensation and apply the knowledge in practical design Learn electromagnetic design tools and methods		
Skills			

Students will be able to recognize four basic topologies applicable to Wireles Power Transfer. At the end of the course student will have gained proper understanding of resonant circuits, their application and limitations of high frequency switching. Students will become familiar with an equivalent circuit of the WPT transformer and its function.