INFORMATION AND COMMUNICATION TECHNOLOGIES

MSc PROGRAM

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INTRODUCTION

Information and Communication Technologies (ICT) is a master level program offered from Faculty of Electrical and Computer Engineering at University of Prishtina.

The mission of this program is in compliance with the mission of faculty and university, in:

- Educating and providing to candidates the knowledge and competencies to solve difficult engineering problems,
- Designing complex systems,
- Acting as a leader of a team and
- Conducting research and development in the field of Information and Communication Technologies.

This MSc program integrates the theory developed with modern teaching methods as well as the lab and experimental research assignments carried out in the relevant ICT laboratories.

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ICT MSc PROGRAM

This study program will contribute to the formation of a modern profile of graduates in ICT engineering by meeting the demands of the labor market.

In particular, the proposed MSc ICT program by FECE is the unique study program in Kosovo that offers:

- A combination of Information processing technologies,
- Communication technologies,
- Innovation, transfer of technology and research methods courses,
- Fostering development of a new generation of researchers and ICT engineers that will impact the national and regional technological development.

The exponential growth and widespread application of Information and Communication Technologies (ICT) in all fields of modern society has positioned this sector as one of the main supports/pillars of the country economy and beyond, thus creating the need for more of ICT professionals with master of science university degree. These universities graduate professionals should not only be able to fulfill the current market needs but also have the ability to exploit research and development opportunities that new technologies offer.

Selected part of the program was developed based on the ERSAMUS+ DIMTV project.

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PROGRAM OBJECTIVES

The definition of objectives of the ICT MSc study program has been done in accordance with FECE mission as well as labor market requirements and scientific research in this field.

- The field of Information and Communication Technologies (ICT) study will prepare potential students for a successful career in the modern world of connected devices, wireless communications, Internet and multimedia.
- The graduates will be prepared to continue further doctoral studies in ICT and related fields.

The basic program objectives are:

- To provide to candidates the high quality master level education in the field of ICT comparable with EU universities,

- To develop creative and innovative capacities in problems consideration, solution proposals and critical thinking in ICT,

- To produce candidates for further scientific, research and development work assignments, prepared for 3rd cycle studies and other lifelong study patterns,

- To ensure that students obtain knowledge and skills matched to the industry requirements.

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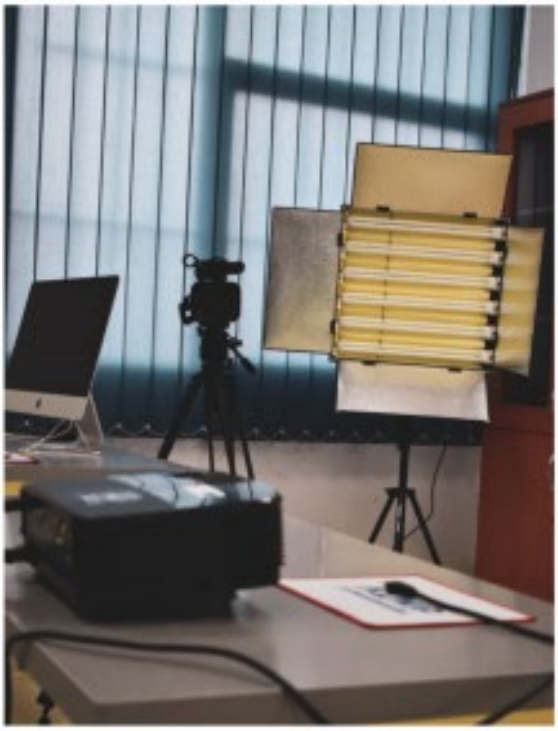
PROGRAM LEARNING OUTCOMES

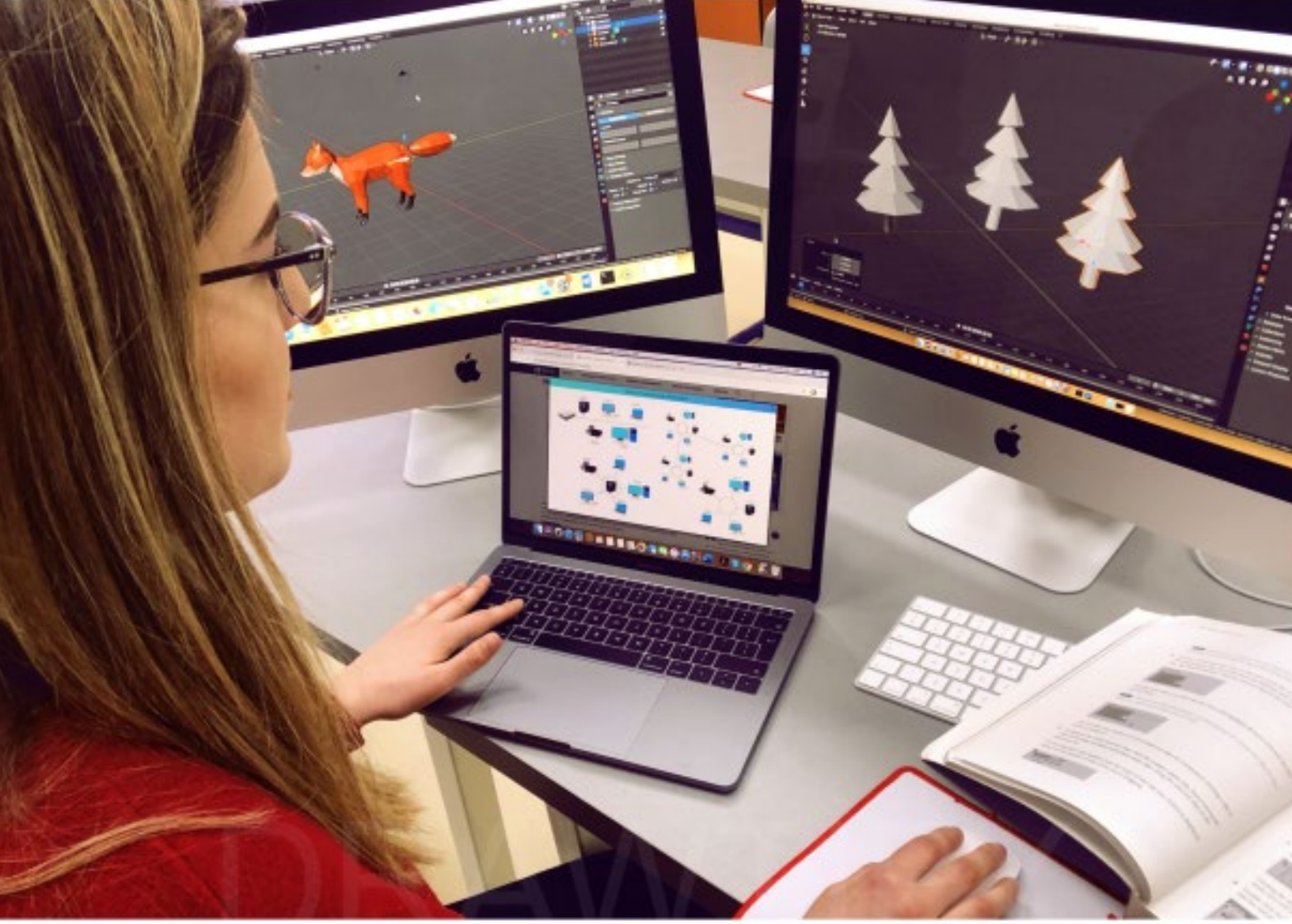


The general competences obtained through this study program are:

- The ability to apply the knowledge of more abstract concepts to identify, and solve problems in the ICT field
- The ability to develop critical judgment about proposed concepts and solutions in the ICT field
- The ability achieve a sufficient level of knowledge of radio communication software, communication networks
- To be able to gain sufficient knowledge of information theory and network security
- to be able to obtain adequate knowledge of information systems and wireless communications
- get advanced knowledge of wireless network planning and optimization as well as RF engineering.
- To be able to provide professional experience, advice and expertise on the labor market as well as relevant institutions and organizations.
- Be ready to start independent ICT research and/or development project in one of the emerging ICT sub-diciplines.

Upon the completion of this program the student will be able to:

- Identify, define, understand and analyze complex problems in the field of ICT
- Find solutions for challenges in ICT by using proper methodologies and tools
- Design or validate a system to meet requirements of the state of the art in ICT
- Communicate efficiently and persuasively, in oral and written form with the ICT community
- Work efficiently as an individual or in teams
- Develop projects in the field of ICT that bring solutions with benefits to society
- Track and evaluate the technology advancements and progress in the field of ICT



These graduate of this program are expected to fulfill the current market needs and also have the ability to exploit research and development opportunities that new technologies offer.

- In the first semester the students will acquire the necessary knowledge from: radio communication software, information theory, wireless and advanced communications networks as well as the application of advanced signal processing.
- The second semester of master studies provides students with practical and scientific knowledge of wireless networks as well as their planning and optimization with the possibility of advancement of their knowledge through the choice of four courses from two different group of courses. The first group of supplementary courses is mainly composed of lab oriented courses, while the second group are the courses related to project management, scientific research methodologies and standardization as well as IoT.
- In the third semester students have information security as a compulsory course, while in the elective group they can choose up to four courses from specialized areas of ICT such as vehicular communication, multimedia communications, special topics in networking and communications, satellite and millimeter

Content of the educational process

	Course	Hours	ECTS	Category
1	Network Planning and Optimization	3+0+1	6	**Mandatory**
2	Advanced Communication Networks	3+0+1	6	**Mandatory**
3	Information theory and Coding	3+0+1	6	**Mandatory**
4	Applied digital signal processing	3+0+1	6	**Mandatory**
5	Wireless Communications 1	3+0+1	6	**Mandatory**

Sem 2

	Course	Hours	ECTS	Category
1	Software defined radio	3+0+1	6	**Mandatory**
2	Wireless Communications II	3+0+1	6	**Mandatory**
3	**Elective course** (2):			
4	Wireless Communications - LAB	2+0+2	5	**Elective**
5	Advanced Computer Networks lab	2+0+2	5	**Elective**
6	Advanced programming for ICT	2+0+2	5	**Elective**
7	Image processing and Computer Vision	2+0+2	5	**Elective**
8	3D Animation	2+0+2	5	**Elective**
9	**Elective course** (2):			**Elective**
10	Advanced project management in ICT	2+0+1	4	**Elective**
11	Methodology of scientific research in ICT	2+0+1	4	**Elective**

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	Course	Hours	ECTS	
12	Internet of Things	2+0+1	4	**Elective**
13	Regulation and standardization in ICT	2+0+1	4	**Elective**

Sem 3

	Course	Hours	ECTS	Category
1	Networks and Communications Security	3+0+1	6	**Mandatory**
2	**Elective course**(4):			
3	Cognitive radio	3+0+1	6	**Elective**
4	Vehicular Communications	3+0+1	6	**Elective**
5	Selected topics in Multimedia Communications	3+0+1	6	**Elective**
6	Selected topics in networking and communications	3+0+1	6	**Elective**
7	mmWave Communications	3+0+1	6	**Elective**
8	Satellite Communications	3+0+1	6	**Elective**
9	Microwave systems	3+0+1	6	**Elective**
10	Advanced Optical Communications	3+0+1	6	**Elective**
11	Innovation and Technology Transfer	3+0+1	6	**Elective**

Sem 4

	Course	Hours	ECTS	Category
1	Diploma thesis		30	To be appointed by faculty council

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Raspberry Pi 3
Model B
2.5A Power Supply

COURSE SYLLABUSES

Course syllabus: **NETWORK PLANNING AND OPTIMIZATION**
Course status: **Mandatory** **6 ECTS**
Course description
This course describes planning and optimization of wireless networks. The course begins with the business plan of a wireless network, continuing with 3rd generation network planning aspects including resource allocation, performance evaluation and optimization. In the second part student recognize 4th generation network planning including dimensioning of LTE and LTE- Advanced, network performance evaluation using key performance indicators and optimization. In the last part student solve co-planning of wireless networks (2G, 3G and 4G) as well as 5G planning in coordination with existing networks.
Expected learning outcomes:
Upon completion of this course the student will be able to: • ***report business plan (Caper and Opex)*** • ***demonstrate detailed planning and optimization of wireless networks (2G, 3G, 4G and 5G)*** • ***implement resource optimization algorithms and use methods to enhance coverage and capacity*** • ***distinguish malfunctioning of a planned network through key performance indicators evaluation*** • ***argue methodology used for planning and optimization of a wireless network*** • ***develop new methodologies for planning, evaluation, optimization and resource allocation of a wireless network***
Teaching Methodology:
Lectures, Discussion, Practical work
Course subjects
Week 1: Introduction to radio network planning and optimization **Week 2:** The business plan for a wireless network **Week 3:** Market modeling **Week 4:** Heterogeneous networks **Week 5:** HSPA+ performance **Week 6:** 3G radio network planning **Week 7:** 3G radio network optimization **Week 8:** 4G radio network planning **Week 9:** 4G radio network optimization **Week 10:** 3G and LTE coo planning and interworking **Week 11:** Smartphone performance evaluation **Week 12:** Resource optimization for coverage and capacity enhancement **Week 13:** 5G network planning **Week 14:** LTE/5G interworking and coexistence **Week 15:** Algorithms for optimizing wireless network performance
Literature
1. **H. Holma, A. Toskala, P. Tapia (2014): HSPA+ Evolution to Release 12 Performance and Optimization, Publishing House "Wiley", USA.** 2. **L. Korowajczuk (2011): LTE, WiMAX and WLAN Network Design, Optimization and Performance Analysis 1st Edition, Publishing House Willey, USA** 3. **X. Zhang (2018): LTE Optimization Engineering Handbook Publishing House Willey, USA** 4. **E. Dahlman, S. Parkvall, J. Skold (2018): 5G NR: The Next Generation Wireless Access Technology 1st Edition, Publishing House Academic Press Elsevier**

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Course syllabus: **ADVANCED COMMUNICATION NETWORKS**
Course status: **Mandatory** **6 ECTS**
Course description
Basic techniques for modeling and analyzing communication networks. Fairness and utility functions, routing, congestion control, pricing, queuing models, loss networks, multi-class queues and scheduling. IP traffic generation, TCP connection control. Packet filtering; Network monitoring and management; TCP connection management scheme and congestion control mechanisms. Multimedia Networking and Protocols for Real-Time Interactive Applications. Design issues for high speed networks including network characterization, application performance guarantees, traffic policing and congestion control. Introduction to techniques for performance modeling and analysis of computer systems and communication networks. Analysis of measurements. Performance Study: estimating one or more metrics via measurement, simulation and analysis. Fairness and network utility maximization. Optimization based routing and **congestion control. Basic queueing models and their application to switching and scheduling in networks. Quality of Service, reliability and availability.**
Expected learning outcomes:
After successful completion of the course, students should be able to: • ***Understand the analytical tools and conceptual models used in network performance analysis.*** • ***Select appropriate network performance evaluation techniques.*** • ***Design experiments for measurement or simulation-based network performance study.*** • ***Utilize statistical techniques to compare performance results from several alternatives.*** • ***Use a simulation tool to conduct a network performance study.*** • ***Compare different solutions for given information networks.***
Teaching Methodology:
Lectures for theoretical aspects, laboratory exercises and team-work for real-case scenarios and problem solving through project work.
Course subjects
Week 1: Information networks. IF traffic generation. **Week 2: Network monitoring and management; TCP connection management scheme** **Week 3: Firewalls and Intrusion Detection Systems. SNMP operation and the MIB structure** **Week 4: Signaling protocols for VOIP services, and Web-based services configuration.** **Week 5: Case-studies. Project team-work presentations** **Week 6: Multimedia Networking and Protocols for Real-Time Interactive Applications.** **Week 7: Design issues for high speed networks including network characterization** **Week 8: Mid- term evaluation** **Week 9: Introduction to techniques for performance modeling and analysis** **Week 10: Analysis of network parameter measurements** **Week 11: Performance Study: estimating one or more metrics via measurement** **Week 12: Metrics: One-way delay &packet loss metric, Round-trip& Packet delay variation.** **Week 13: Quality of Service, reliability and availability.** **Week 14: Case-studies. Project team-work presentations** **Week15: Final evaluations**
Literature
1. Thomas Bonald, Mathieu Feuillet " Network Performance Analysis ", Willey, 2011 **2. Kurose, J. F., & Ross, K. W. (7th Edition) (2016). *Computer networking: a top-down approach*.** **3. Selected survey and original papers published in ISI indexed journals**

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Course syllabus: **INFORMATION THEORY AND CODING**
Course status: **Mandatory** **6 ECTS**
Course description
Review of basic concepts of probability theory. Introduce students to basic concepts of information theory: uncertainty, information, and entropy, mutual information, channel capacity, information rate, Shannon's noiseless coding theorem and Shannon's fundamental coding theorem; modelling of information sources: zero-memory and Markov models; modelling of information channels: binary symmetric channel (BSC) and binary erasure channel (BEC) channels, additivity of information and cascaded channels; construction of compact source codes: Kraft inequality, compact codes, Data compression, Huffman and Lempel-Ziv-Welch (LZW) compression codes; analysis and design of error-control channel codes: Hamming distance, binary linear codes and the parity-check matrix, Hamming codes, cyclic codes and cyclic redundancy codes (CRC).
Expected learning outcomes:
After successful completion of this course, the student will be able to: • ***Analyze the fundamental parameters relevant to information theory;*** • ***Construct codes capable of correcting a specified number of errors;*** • ***Explain the operating principles of block codes, cyclic codes and convolutional codes;*** • ***Design an error correcting code for a given application;*** • ***Understand the fundamental limits of error correction.***
Teaching Methodology:
Lecturer, research-based learning and presentations
Course subjects
Week 1: **Basic concepts of probability theory** **Week 2:** **Uncertainty, information, and entropy, mutual information** **Week3:** **Channel capacity and information rate** **Week 4:** **Shannon's noiseless coding theorem and Shannon's fundamental coding theorem** **Week 5:** **Modelling of information sources: zero-memory and Markov mode** **Week 6:** **Modelling of information channels: binary symmetric channel (BSC) and binary erasure channel (BEC) channels** **Week 7:** **Additivity of information and cascaded channels** **Week 8:** **Construction of compact source codes: Kraft inequality, compact codes** **Week 9:** **Data compression** **Week 10:** **Huffman and Lempel-Ziv-Welch (LZW) compression codes** **Week 11:** **Analysis and design of error-control channel codes** **Week 12:** **Hamming distance** **Week 13:** **Binary linear codes and the parity-check matrix** **Week 14:** **Hamming codes** **Week 15:** **Cyclic codes and cyclic redundancy codes (CRC)**
Literature
1. T. M. Cover, J. A. Thomas, "Elements of Information Theory", Wiley, 2nd Edition, 2006. ***2. Roberto Togneri, Christopher J.S. deSilva, "Fundamentals of Information Theory and Coding Design", 2005 Chapman &Hall/CRC.*** ***3. Essentials of error-control coding, Jorge Castiñeira Moreira, Patrick Guy Farrell, 2006 John Wiley & Sons Ltd.***

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Course syllabus: APPLIED DIGITAL SIGNAL PROCESSING
Course status: **Mandatory** **6 ECTS**
Course description
The rapid development in the field of integrated circuits has had a significant impact on digital signal processing methods. Knowledge digital processing fundamentals has become essential in all disciplines where there is a need for signal processing, such as wireless communications, biomedical engineering, audio/video signal processing. This course introduces students to the concept and basic principles of discrete-time processing. Concepts are illustrated through examples of algorithms and standardized technologies.
Expected learning outcomes:
After successful completion of this course, the student will be able to: • ***understand the concepts of sampling and over sampling, A / D quantization and conversion, digital filtering, Discrete Fourier Transform and FFT*** • ***design digital filters according to the application*** • ***assess the application of digital processing techniques for various purposes, such as audio / video signal processing, biomedical signal processing, application of digital filters to wireless networks and autonomous vehicles, etc.***
Teaching Methodology:
Lecturer, research-based learning, labs and presentations
Course subjects
Week 1: Signals and Systems **Week 2: Review of linear algebra** **Week 3: Random variables** **Week 4: Random processes** **Week 5: Random process filtering and spectral factorization** **Week 6: Signal modeling: Least squares method** **Week 7: Pade Approximation** **Week 8: Signal modelling with Prony's method** **Week9: Stochastic models for signal modelling** **Week 10: The Levinson-Durbin recursion** **Week 11: FIR and IIR lattice filters** **Week 12: FIR and IIR Wiener filtering** **Week 13: Spectrum Estimation (Barttlet, Welch, Blackman-Tukey approaches)** **Week 14: Frequency Estimation (Eigendecomposition, Autocorrelation methods, MUSIC)** **Week 15: Adaptive Filtering (FIR adaptive filters, Recursive LS)**
Literature
1. ***Hayes M.; "Statistical Digital Signal Processing and Modeling", John Wiley & Sons, Inc., 1996.*** 2. ***Manolakis D. G., Ingle V. K.," Applied Digital Signal Processing: Theory and Practice", Cambridge University Press, New York, 2011.***

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Course syllabus: WIRELESS COMMUNICATIONS 1
Course status: **Mandatory** **6 ECTS**
Course description
Introduction. Modes of propagation – Line of sight propagation, NON LOS propagation. Atmospheric effects – atmospheric refraction, the radio horizon, ducting, atmospheric attenuation. Wave propagation in ionosphere. Communication Systems and the Link Budget-path loss, Near earth propagation models-Weissberger's model, ITU model, Egli model, Longley-Rice model. Propagation in built-up areas – Young model, Okumura model, Hatta model, COST 231 model, Lee model. Outdoor propagation models – empirical path loss models, the Okumura-Hata model, the COST 231 –Hata model, the Ikegami model. Fading and multipath characterization – large scale or normal fading, Surface Roughness, Fresnel Zones, diffraction, Quantifying Diffraction Loss. Small scale fading – delay spread, Doppler spread, channel modeling. Indoor Propagation Models – Interference, indoor propagation effects, indoor propagation modeling.
Expected learning outcomes:
After successful completion of this course, the student will be able to: • ***Describe basic principles of radio wave propagation*** • ***Elaborate all phenomenon's that are affecting on the quality of the transmission of information on the radio channel.*** • ***Explain influence of the atmospheric conditions in radio wave propagation,*** • ***Apply gained knowledge of wave radio propagation in other professional courses*** • ***Write a research seminar paper on RF propagation based on case-study***
Teaching Methodology:
Lectures for theoretical aspects, laboratory exercises and team-work for real-case scenarios and problem solving through project and seminar work.
Course subjects
Week 1: Introduction. Modes of propagation – Line of sight & NON LOS propagation **Week 2:** Atmospheric effects – refraction, ducting, attenuation. **Week 3:** Distribution of seminars and team work projects **Week 4:** Communication Systems and the Link Budget-path loss **Week 5:** Near earth propagation models-Weissberger's, ITU, Egli , Longley-Rice **Week 6:** Case-studies. Project team-work presentations **Week 7:** Propagation in built-up areas models– Young, Okumura, Hatta, COST 231, Lee **Week 8:** Outdoor propagation models: The Okumura-Hata, the COST 231 –Hata, the Ikegami **Week 9:** Mid- term evaluation **Week 10:** Fading and multipath characterization – large scale or normal fading **Week11:** Small scale fading – delay spread, Doppler spread, channel modeling. **Week 12:** Interference, indoor propagation effects, indoor propagation modeling. **Week 13:** Chanel modeling for emerging wireless systems **Week 14:** Case-studies. Project team-work presentations **Week 15:** Final evaluations
Literature
1. **Th. Rappaport, *Wireless communications*, *Principles and Practice*, 2nd edition Prentice Hall, NewJersey, 2019.** 2. **J. Seybold, *Introduction to RF propagation*, John Wiley & Sons, Inc. New Jersey, 2005.** 3. **Ch. Haslett, *Essentials of radio wave propagation,* Cambridge University Press, New York, 2008.**

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for Raspberry Pi
Code
Software

Course syllabus: **SOFTWARE DEFINED RADIO**
Course status: **Mandatory** **6 ECTS**
Course description
This course is designed for students that have a background in signal & systems and computer engineering area, and also for students that have knowledge in communication systems. **The course contains theoretical explanations about different devices that comprise a communication system, and also practical examples that helps in understanding of theoretical concepts.**
Expected learning outcomes:
After successful completion of the course, students should be able to: • ***Understand the basic concepts of communication systems and SDR technology;*** • ***Explain concepts that are related with digital signal processing, filters design and their application in communication systems and also digital communication principles: modulation, digital transmissions and receiver structure;*** • ***Understand SDR hardware;*** • ***Design and analyze a communication system;*** • ***Design and implement some equalization methodology***
Teaching Methodology:
Lecturer, research-based learning, labs and presentations
Course subjects
Week 1: **Introduction to Software Defined Radio** **Week 2:** **Signal and systems: time and frequency domain, sampling theory** **Week 3:** **Digital signal processing techniques for SDR: discrete convolution, digital filtering** **Week 4:** **Transmit Techniques for SDR: filters, Nyquist pulse-shaping theory** **Week 5:** **Probability in Communications** **Week 6:** **Student's project work. Team work.** **Week 7:** **Fundamentals of digital communications** **Week8:** **Midterm evaluation, 30 %** **Week 9:** **SDR Hardware: Communication system components,** **Week 10:** **Timing Synchronization: Matched filtering, timing error** **Week 11:** **Carrier Synchronization** **Week 12:** **Student's project work.** **Week 13:** **Chanel estimation and equalization** **Week 14:** **Application for Software defined radio** **Week 15:** **Final evaluation, 30 %**
Literature
1. Travis F. Collins, Robin Getz, Di Pu, dhe Alexander M. Wyglinski; "Software-Defined Radio for Engineers" Artech House, ISBN-13: 978-1-63081-457-1, 2018 **2. T. Reymund "Software Defined Radio with User Interface " Vienna 2008**

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Course syllabus: **WIRELESS COMMUNICATIONS 2**
Course status: **Mandatory** **6 ECTS**
Course description
The course deals in general with modern wireless communication systems and in particular2G, 3G and 4G mobile systems. Also, the focus of the treatment is on modulation techniques and multiple access techniques.
Expected learning outcomes:
Upon completion of this course the student will be able to: • ***Have fundamental knowledge about wireless communications.*** • ***Solve theoretical and practical problems*** • ***Analyze different aspects of design in wireless communications and propose solutions.***
Teaching Methodology:
Lectures, Discussion, Independent work
Course subjects
Week 1: **Introduction to wireless communication systems.** **Week 2:** **Modern wireless communication systems, 1G, 2G.** **Week 3:** **Modern wireless communication systems 3G.** **Week 4:** **Modern wireless communication systems 4G.** **Week 5:** **The cellular concept –System design fundamentals –1** **Week 6:** **The cellular concept –System design fundamentals --2** **Week 7:** **Modulation techniques for mobile radio: BPSK, QPSK, DPSK** **Week 8:** **Modulation techniques for mobile radio: BFSK, MSK, GMSK** **Week 9:** **Modulation techniques for mobile radio: M-ary PSK, M-ary QAM** **Week 10:** **Equalization** **Week 11:** **Diversity and channel coding** **Week 12:** **Multiple access techniques for wireless communications-TDMA** **Week 13:** **Multiple access techniques for wireless communications-CDMA** **Week 14:** **Multiple access techniques for wireless communications-OFDMA** **Week 15:** **Presentation-seminar**
Literature
1. **Theodore S. Rappaport, "**Wireless Communications" , **Principles and Practice, Prentice Hall,Inc.,2002** 2. **Andreas F Molisch,** "Wireless Communications" **- Wiley – IEEE, 2nd Edition, © 2011 John Wiley &Sons Ltd.**

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Course syllabus: **WIRELESS COMMUNICATIONS- LAB**
Course status: **Elective** **5 ECTS**
Course description
Introduction to software defined radio communications. Analysis of communication channels when using modulation schemes such as PSK and QAM. Advanced modulation techniques such as OFDM and DSSC. Signal representation in time and frequency domain. Analysis and design parameters for communication systems. Signal processing with different sampling speed. Modeling of communication systems in MATLAB. Practical implementation of simple communication systems.
Expected learning outcomes:
After successful completion of this course, the student will be able to: • ***Understand advanced modulation techniques*** • ***Understand signal processing techniques with varying sampling speed*** • ***Apply signal processing techniques in wireless communications*** • ***Conduct simulations of simple wireless communication systems***
Teaching Methodology:
Lectures, Discussion, Lab work
Course subjects
Week 1: **Introduction to the Software Defined Radio (SDR) concept** **Week 2:** **Analog Modulation and Pulse-Shaping Methods** **Week 3:** **Digital Modulation Methods (PSK, FSK, CPM, QAM, OFDM, Spread Spectrum)** **Week 4:** **Memoryless Nonlinearity and Distortion** **Week 5:** **Transceiver System Analysis and Design** **Week 6:** **Receiver design (Selectivity and Dynamic Range)** **Week 7:** **Frequency Bands, Accuracy and Tuning** **Week 8:** **Adjacent Channel Leakage Ratio (ACLR)** **Week 9:** **Uniform Sampling of Signals** **Week 10:** **Automatic Gain Control** **Week 11:** **Oversampling converters** **Week 12:** **Multirate Digital Signal Processing** **Week 13:** **Filter Design and Implementation** **Week 14:** **Implementation and Verification of a simple communication system on SDR** **Week 15:** **Implementation and Verification of a simple communication system on SDR**
Literature
1. ***T. Reymund "Software Defined Radio with User Interface " Vienna 2008*** 2. ***T Rouphael. "Rf and Digital Signal processing for Software Defined Radio'' Elsevier 2009***

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Course syllabus: **ADVANCED COMPUTER NETWORKS LAB**
Course status: **Elective** **5 ECTS**
Course description
In this course we treat advanced topics in computer. Special attention is paidto the principles,architecture and protocols of modern network systems.
Expected learning outcomes:
After finishing this course student will be able to: • ***Implement LAN and WAN networks using different networking protocols such as: OSPF,BGP and MPLS.*** • ***Analyze and correct configuration errors through multiple approaches.*** • ***Compare different technologies for building tunnels and virtual private networks (L3VPN,GRE, 6PE,L2TPv3, MPLS-VPLS, OTV) in vast and complex networks spread internationally.*** • ***Configuration and Evaluation of security for public and private networked systems (VACL,PACL, PortSecurity, Private, VLAN, RA guard, DHCP guard, 802.1x, EAP).*** • ***Implement Quality of Service (QoS) for networks at layer II dhe III, and increasing the reliability andavailability of networks via different protocols (HSRP, GLBP, VRRP).*** • ***Understand and implement the programmable network concepts (SDN), virtualized ones (NFVi, VNF)and cloud networks (XaaS)*** • ***Understand and implement technologies, protocols, standards and security in IoT networks.***
Teaching Methodology:
Lectures, exercises during class using different materials, one project work in group of 2-3 students (independent work)
Course subjects
Week 1: Implementing of OSPF and MPLS networks **Week 2: Implementing of BGP and MPLS network** **Week 3: Troubleshooting OSPF** **Week 4: Troubleshooting BGP** **Week 5: Troubleshooting MPLS** **Week 6: Implementing MPLS-VPLS and OTV tunnels** **Week 7: Implementing of 6PE and L2TPv3 tunnels** **Week 8: Implementing of L3VPN and GRE tunnels** **Week 9: Implementing security through RA guard and Port Security** **Week 10: Implementing security through DHCP guard and EAP** **Week 11: Implementing QoS through HSRP, GLBP and VRRP** **Week 12: Implementing SDN networks** **Week 13: Implementing virtualized function networks** **Week 14: Implementing cloud networks** **Week 15: Configuration and implementation of IoT network**
Literature
1. ***Doyle, J. , Caroll, J(2016): Routing TCP/IP, Volume II, USA*** 2. ***Aziz, Z., Liu J., Martey A., Shamim F.(2002): Troubleshooting IP Routing Protocols, USA.*** 3. ***Pepelnjak, I, Gouchard, J, Apcar, J (2003) MPLS and VPN Architectures, Volume II, USA.*** 4. ***Saboowala, H., Abid, M., Modali S. (2013) Designing Networks and Services for the Cloud:*** 5. ***Delivering business-grade cloud applications and services, USA***

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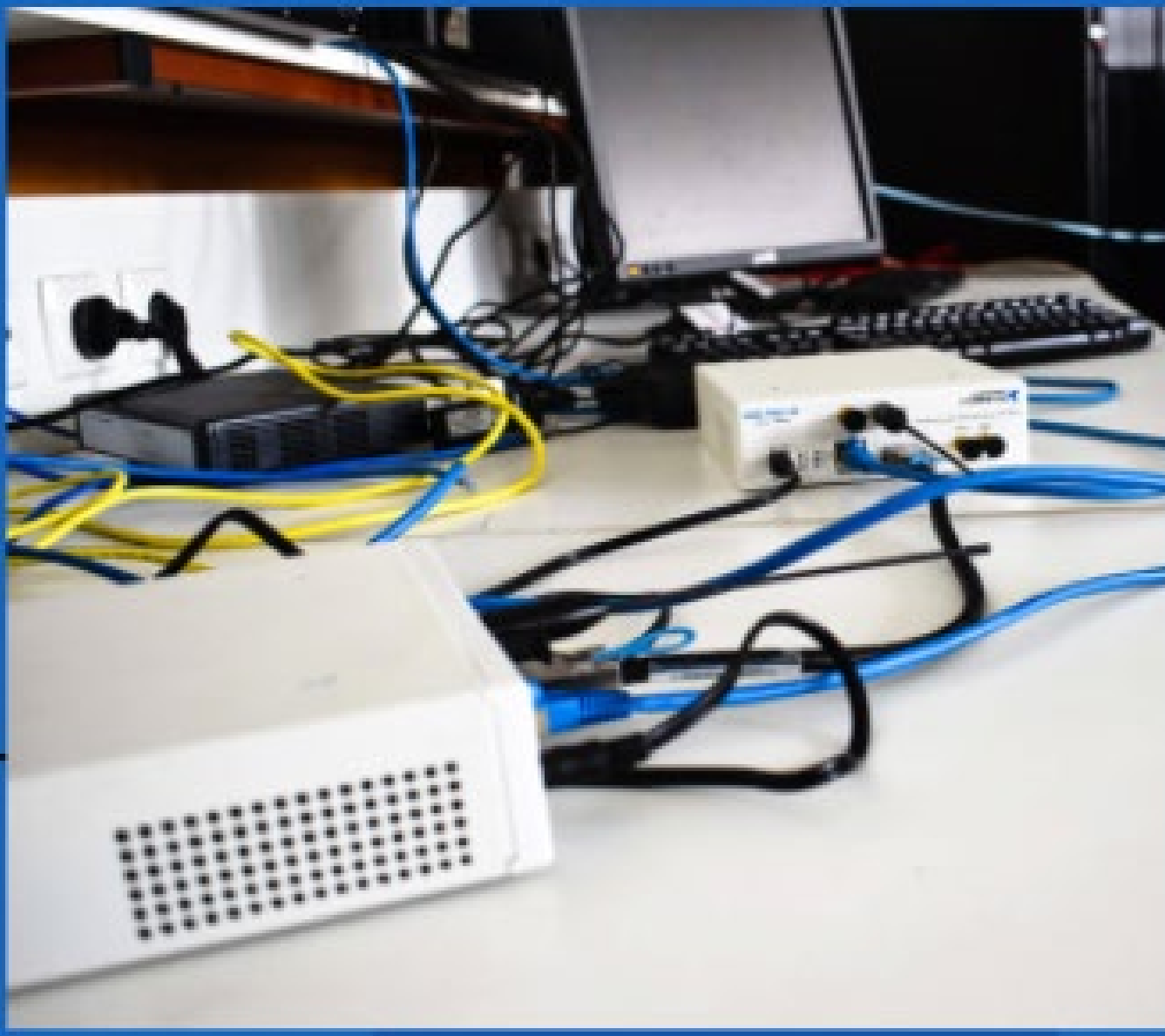

Course syllabus: **ADVANCED PROGRAMMING FOR ICT**
Course status: **Elective** **5 ECTS**
Course description
This course will introduce students to the application of software in the field of ICT, with particular emphasis on the application of software packages for simulation, design and performance evaluation of communication systems. Topics to be covered include: modeling of digital communication systems, basic concepts from estimation theory and its application to communication systems simulation, semi-analytical techniques for error probability estimation, and simulation and modeling of advanced modulation techniques and transmission.
Expected learning outcomes:
After successful completion of this course, the student will: • ***know the basic modeling techniques and the basic blocks of communication systems*** • ***understand the different techniques for evaluating the performance of a communicationsystem*** • ***be able to utilize various software tools for simulating and modeling communication systems.*** • ***be able to design and optimize a communication system through these software tools.***
Teaching Methodology:
Lectures, discussions, laboratory, seminar.
Course subjects
Week 1: **Introduction to MATLAB** **Week 2:** **Evaluation by Computer Simulation** **Week 3:** **General Definition of Simulation Tools** **Week 4:** **Data Generation and definition of Bit Error Probability** **Week 5:** **Transmission Channels (AWGN and Rayleigh fading channels)** **Week 6:** **PSK-based digital transmission schemes –BPSK, QPSK** **Week 7:** **OQPSK, MSK, GMSK, QAM** **Week 8:** **Orthogonal Frequency Division Multiplexing (OFDM) Transmission System** **Week 9:** **OFDM Transmission Technology** **Week 10:** **Pilot Symbol-Aided OFDM Modulation Scheme** **Week 11:** **Code Division Multiple Access Transmission Technology;** **Week 12:** **CDMA Transmission Scheme. Generation of Spreading Codes.** **Week 13:** **Cellular System and Channel Assignment Algorithm** **Week 14:** **Simulation Results of Cellular System with DCA Algorithm.** **Week 15:** **Beamforming Techniques Using Array Antennas for Cellular Systems**
Literature
• ***Michel C. Jeruchim, Philip Balaban, K. Sam Shanmugan, "Simulation and Software Radio for MobileCommunications", ISBN: 1580530443, Artech House (Fitchburg, MA, USA), 2002.***

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Course syllabus: **IMAGE PROCESSING AND COMPUTER VISION**
Course status: **Elective** **5 ECTS**
Course description
The course is designed to give the graduate students all the fundamental concepts in digital image processing with emphasis in filtering, enhancement, restoration, compression, segmentation and recognition of images. In this course, lots of technology will be explored and will learn to understand and rebuild the complex visual world. Computer vision is designed for students who are interested in learning about basic principles and important computer vision applications.
Expected learning outcomes:
After successful completion of the course, students should be able to: • ***Understand image formation and the role human visual system plays in perception of greyand color image data;*** • ***Get broad exposure to and understanding of various applications of image processing inindustry, medicine, and defense;*** • ***Learn the signal processing algorithms and techniques in image enhancement and image restoration;*** • ***Acquire an appreciation for the image processing issues and techniques and be able toapply these techniques to real world problems; and*** • ***Be able to conduct independent study and analysis of image processing problems andtechniques.***
Teaching Methodology:
Lectures for theoretical aspects, laboratory exercises and team-work for real-case scenarios and problem solving through project work. Study visits and industry invited lecturers.
Course subjects
Week 1: **Fundamentals and basic concepts of image processing and computer vision** **Week 2:** **Image based visual computing, linear systems and filters** **Week 3:** **Spectral analysis, Fourier transform, Extension for 2D interpretation** **Week 4:** **Image loading and rendering, creation of image histograms** **Week 5:** **Image Compression** **Week 6:** **Student's project work. Team work.** **Week 7:** **Industry invited lecturers.** **Week 8:** **Midterm evaluation, 30 %** **Week 9:** **Geometric visual computing, geometric transformations, the pinhole camera** **Week 10:** **Radiometric visual computing, color reproduction** **Week 11:** **Photometric processing** **Week 12:** **Student's project work.** **Week 13:** **Image transition** **Week 14:** **Summary** **Week 15:** **Final evaluation, 30 %**
Literature
1. **Digital Image Processing: Practical Approach. B. Furht, E. Akar, A. Andrews, Springer 2018, ISBN: 3319966332, 9783319966335** 2. **Digital Image Processing. R. C. Gonzalez, R. E. Woods, 4th Edn, Pearson 2017. ISBN-10: 1292223049, ISBN-13: 978-1292223049.**

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Course syllabus: **3D ANIMATION**
Course status: **Elective** **5 ECTS**
Course description
This course focuses on advanced work in the practical principles and techniques of 3D software animation environments. Includes quad mesh design and editing for complex motions, shading techniques and lighting, different camera projection models, rendering techniques, and efficient use of GPU resources for photo realistic real-time 3D animation.
Expected learning outcomes:
After successful completion of the course, students should be able to: • ***Demonstrate a complete workflow for 3D character animation in film and game industry.*** • ***Articulate the differences between animation pipelines for films and for video games.*** • ***Create a simple dynamic simulation in Maya.*** • ***Create a key framed animation with a complex body motion.*** • ***Export game-biped animation for video games.***
Teaching Methodology:
Lectures for theoretical aspects, laboratory exercises and team-work for real-case scenarios and problem solving through project work. Study visits and industry invited lecturers.
Course subjects
Week 1: Introduction to animation, Fundamentals and basic concepts of 3D animations **Week 2:** 3D Space **Week 3:** Polygonal Geometry, definition of a model, creation and edition of polygonmodels **Week 4:** NURBS and Curve-Based Geometry **Week 5:** Lighting, Materials, Textures, and UVs, realistic effects for cloth, fur, and fluids **Week 6:** Student's project work. Team work. Creation of a polygonal form **Week 7:** Industry invited lecturers. **Week 8:** Midterm evaluation, 30 % **Week 9:** Applying techniques used in film, TV, and games **Week 10:** Modeling hard-surface objects. **Week 11:** Using mental ray shading techniques **Week 12:** Student's project work. Modeling an object **Week 13:** Creating and animating hair and clothing **Week 14:** Final animation **Week 15:** Final evaluation, 30 %
Literature
1. **Mastering Autodesk Maya 2016: Autodesk Official Press. T. Palamar, Sybex 2015. ISBN-10: 1119059828, ISBN-13: 978-1119059820.** 2. **Essential skills for 3D modeling, rendering, and animation. NB. Zeman, Taylor & Francis2015. ISBN: 9781482224122, 1482224127, 1482224143, 9781482224146.**

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Course syllabus: **ADVANCED PROJECT MANAGEMENT IN ICT**
Course status: **Elective** **4 ECTS**
Course description
This course will outline advanced project management methods and strategies, including toolsand techniques used for project management in the area of information and communication technology (ICT).
Expected learning outcomes:
Upon completion of this course the student will be able to: • ***Understand how to start, evaluate, plan, execute, control and successfully complete projects;*** • ***Understand the tools and techniques used to manage ICT projects;*** • ***Understand the importance of project management in a structured manner;*** • ***Create project plans for project scenarios that includes key tasks, critical paths, dependencies, timeframes, and budget analyses;*** • ***Discuss the project management strategies and concretize them through a case study during planning of an actual project;*** • ***Understand the specifics of managing research projects.***
Teaching Methodology:
Lectures, discussions, case studies, seminar work and practical project management examples.
Course subjects
Week 1: Projects in contemporary organizations **Week 2: Strategic management** **Week 3: Project selection** **Week 4: Project manager** **Week 5: Negotiation** **Week 6: Management of conflict** **Week 7: Project in the organizational structure** **Week 8: Project activity planning** **Week 9: Budget and cost estimation** **Week 10: Scheduling** **Week 11: Resource allocation** **Week 12: Monitoring and information systems** **Week 13: Project control** **Week 14: Project auditing** **Week 15: Project termination**
Literature
1. ***Jack R. Meredith, Scott M. Shafer, Samuel J. Mantel Jr., "Project Management: A StrategicManagerial Approach," Wiley, 10-th edition, Dec. 2017, ISBN-13: 978-1119369097.*** 2. ***Celia Desmond, "The ComSoc Guide to Managing Telecommunications Projects," Wiley-IEEE Press, May 2011, ISBN-13: 978-0470284759.***

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Course syllabus: **METHODOLOGY OF SCIENTIFIC RESEARCH IN ICT**
Course status: **Elective** **4 ECTS**
Course description
Research methodology: An Introduction Meaning of research, Objectives of research, Motivation in research, Types of research, Research methods vs. methodology, Research process, Science vs. pseudoscience?! Defining the research problem & research design. Techniques involved in defining a problem, Meaning and need of research design, Different research design, Basic principles of experimental design, developing a research plan. Types of publications, Measures of research impact, Bibliographic databases, Literature review, Reference managers, Patents. Scientific writing, Manuscripts: research papers and review articles. Research ethics, Intellectual properties, Authorship. Conference Communication: Poster and Conference Abstracts, Oral presentations. Scientific assignments: Draft a manuscript, review colleague's manuscript, present a paper on course mini-conference.
Expected learning outcomes:
After successful completion of the course, students should be able to: • ***Identify basic principles of scientific thinking and research*** • ***Explain and apply scientific methodologies in engineering*** • ***Practice searching bibliographic databases, gather and interpret data, summarize otherswork*** • ***Prepare and present the scientific paper*** • ***Perform opposition and review others scientific work***
Teaching Methodology:
Lectures for theoretical aspects, practical assignment on manuscript writing, manuscript review and paper presentation.
Course subjects
Week 1: Research methodology: Meaning of research, Objectives of research, Motivation **Week 2:** Types of research, Research methods vs. methodology, Research process, **Week 3:** Distributing scientific assignment for students **Week 4:** Defining the research problem & research design. **Week 5:** Meaning and need of research design, Different research design, **Week 6:** Basic principles of experimental design, developing a research plan **Week 7:** Intermediary exam -25 % of grade **Week 8:** Types of publications, Measures of research impact, Bibliographic databases **Week 9:** Literature review, Reference managers, Patents, Scientific writing, Manuscripts; **Week 10:** Research ethics, Intellectual properties, Authorship **Week 11:** Conference Communication: Poster and Conference Abstracts, Oral presentations **Week 12:** Final exam -35% of grade **Week 13:** Manuscript drafting 20 %; **Week 14:** Manuscript reviewing 10 % **Week 15:** Manuscript presentation 10%
Literature
1. Kothari B.L., (2009). "*Research Methodology: Tools and Techniques*", New Age International Publishers, **2. Booth, W. C., Colomb, G. G., & Williams, J. M. (2008).*The Craft of Research*. University of Chicago Press.**

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Course syllabus: **REGULATION AND STANDARDIZATION IN ICT**
Course status: **Elective** **4 ECTS**
Course description
This course describes standardization in ICT field, including standardization bodies. Also, important part of the course are ICT regulation issues such as> spectrum management, interconnection and competition. The last part of the course is focused on exploring directives for regulation.
Expected learning outcomes:
Upon completion of this course the student will be able to: • ***distinguish the necessity for standardization and standardization bodies*** • ***describe issues of spectrum regulation, interconnection and competition*** • ***apply in practice methodologies for analyzing and monitoring of spectrum usage*** • ***describe issues related to content liability transmitted over ICT infrastructure*** • ***interpret law of electronic communication***
Teaching Methodology:
Lectures, Discussion, Practical work
Course subjects
Week 1: Introduction to telecommunication regulationWeek 2: Standardization bodies in ICT **Week 3: Spectrum regulation Week 4: Spectrum managementWeek 5: Completion in ICT** **Week 6: Spectrum monitoring and usage** **Week 7: Content liability over ICT infrastructure** **Week 8: Network neutrality** **Week 9: Access and Interconnection RegulationWeek 10: Consumer protection** **Week 11: Technology convergence and the role of competitionWeek 12: Regulatory authority policies** **Week 13: European communication law and regulationWeek 14: Kosovo communication law and regulation** **Week 15: ICT law interpretation**
Literature
1. Walden (2018): Telecommunication Law and Regulation, 5th Edition, Publishing House "Oxford", UK

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Course syllabus: **INTERNET OF THINGS**
Course status: **Elective** **4 ECTS**
Course description
Internet of Things (IoT) provides advanced data collection, connectivity, and analysis of data information, which thing has lead Machine-to-Machine communication concepts further than ever before. This course includes explanations on the architecture and design of software and hardware solutions for Internet of Things, and the application of these solutions in many areas. This course integrates the fields of Electronics, Information Technology, and Communication and Management of potential IoT products.
Expected learning outcomes:
Upon completion of this course the student will be able to: • ***Explain the architecture and characteristics of IoT.*** • ***Understand the limitations, opportunities, and differences between technologies that support IoT.*** • ***Explain IoT communication protocols.*** • ***Discuss the architecture, operations and business benefits of IoT solutions.*** • ***Explore the relationships between IoT, cloud computing, and big data.*** • ***Apply acquired knowledge to connect IoT devices.*** • ***Apply acquired knowledge to implement IoT solutions for different application areas.***
Teaching Methodology:
Lectures, exercises during class using different materials, one final project work in group of 3 students (independent work), individual homework.
Course subjects
Week 1: **Internet of Things fundamentals: basic terms, architecture and application areas.** **Week 2:** **Components and devices in IoT environments.** **Week 3:** **Physical layer in IoT.** **Week 4:** **Communication protocols for device communication data link layer.** **Week 5:** **Communication protocols for device communication network layer.** **Week 6:** **Application layer in IoT.** **Week 7:** **Revision.** **Week 8:** **Midterm exam.** **Week 9:** **Standards: standardization bodies and referent architectures.** **Week 10:** **Characteristics, components, and architecture of IoT platforms.** **Week 11:** **IoT applications: real-time services, smart city, smart home and office** **Week 12:** **Localization.** **Week 13:** **Different techniques used for localization.** **Week 14:** **Revision.** **Week 15:** **Final Exam.**
Literature
1. **David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry (2017.), IoT Fundamentals, Cisco Press**

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Course syllabus: **NETWORKS AND COMMUNICATIONS SECURITY**
Course status: **Mandatory** **6 ECTS**
Course description
This course describes the basics information security beginning with necessity of information security, ethical, legal and professional issues, intrusion detection and at the end implementation and maintenance of information security
Expected learning outcomes:
Upon completion of this course the student will be able to: • ***recognize the need for security, legal, ethical and professional issues of information security*** • ***describe the planning of a concept for security and risk management*** • ***apply in practice information security tools (Firewall, Controlled Access, VPN) and detection tools for intrusion in information*** • ***use cryptographic algorithms*** • ***implement information security and system maintenance***
Teaching Methodology:
Lectures, Discussion, Practical work
Course subjects
Week 1: **Introduction to information security** **Week 2:** **The need for security** **Week 3:** **Legal, ethical and professional issues in information security** **Week 4:** **Planning for security** **Week 5:** **Risk management** **Week 6:** **Access control security** **Week 7:** **Firewalls and VPN security** **Week 8:** **Intrusion detection** **Week 9:** **Cryptographic algorithms application** **Week 10:** **Physical security of ICT systems** **Week 11:** **Implementing information security** **Week 12:** **3G, 4G and 5G networks security** **Week 13:** **Wireless Sensor network security** **Week 14:** **IoT communication security** **Week 15:** **Intelligent transport communication security**
Literature
1. M. Whitman, H. Mattord (2018): Principles of Information Security, 6th Edition, Publishing House "Cengage", USA

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Course syllabus: **COGNITIVE RADIO**
Course status: **Elective** **6 ECTS**
Course description
The rapid development of information technology and the increasing number of portable devices in use, has caused a significant increase in the demand for internet access at any time and from any location. As a consequence, wireless networks are increasingly facing lack of frequency spectrum. Next generation networks must accommodate these demands through efficient management of resources and application of new technologies such as cognitive radio and software defined radio (SDR). The combination of intelligent methods for spectrum access and cognitive radios has opened up several research paths and opportunities for further development.
Expected learning outcomes:
After successful completion of this course, the student will be able: • ***distinguish between long-term static spectrum access and dynamic and opportunistic access*** • ***Understand the working concepts of cognitive radios and SDRs*** • ***know the architecture of wireless cognitive networks*** • ***to perform a simple analysis for detecting primary users*** • ***demonstrate knowledge of MAC protocols developed for cognitive networks*** • ***be familiar with standards on cognitive radios, SDRs and cognitive networks***
Teaching Methodology:
Lectures, Discussion, Practical lab work
Course subjects
Week 1: **Introduction to Cognitive Radio** **Week 2:** **Adaptive wireless communication systems** **Week 3:** **Cognitive Radio and CR Network Architectures** **Week 4:** **Cognitive Radio Capabilities** **Week 5:** **CR Network and Main Components. Overlay/Underlay Network Architectures** **Week 6:** **Parameter estimation for adaptation of wireless communication systems** **Week 7:** **Primary Transmitter, Matched Filter, Energy, Feature (Cyclostationary) Detection** **Week 8:** **Interference awareness** **Week 9:** **Sensing control. In-band sensing control. Out-of-band sensing control** **Week 10:** **Cooperation in Spectrum Sensing. Compressive Sensing** **Week 11:** **Dynamic Spectrum Access** **Week 12:** **Spectrum Decision** **Week 13:** **Spectrum Sharing** **Week 14:** **Centralized, Distributed and Cooperative Spectrum Access** **Week 15:** **CR standards and regulations**
Literature
1. ***L. E. Doyle, "Essentials of Cognitive Radio". Cambridge: Cambridge University Press, 2009.*** 2. ***Di Benedetto M-G, Cattoni A. F., Fiorina J., Bader F., De Nardis L., "Cognitive Radio and Networking for Heterogeneous Wireless Networks:. Springer, 2015.*** 3. ***Setoodeh P., Haykin S., "Fundamentals of Cognitive Radio". John Wiley & Sons, Inc., 2017.***

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Course syllabus: **VEHICULAR COMMUNICATIONS**
Course status: **Elective** **6 ECTS**
Course description
This course will introduce students to emerging communication technologies, in particular their application in vehicular communication networks, also known as VANETs. Topics such vehicle mobility modeling, vehicular technologies and communications standards in the physical and network layers, will be addressed. Examples of emerging applications of vehicular communications in Intelligent Transportation Systems will also be studied and discussed.
Expected learning outcomes:
After successful completion of this course, the student will be able to: • ***Understand and describe the basic principle, architecture and standards related to VANETs.*** • ***Analyze, design and assess vehicular communication platforms and their application in variousfields such as security and general communication.***
Teaching Methodology:
Lectures, Discussion, Practical lab work
Course subjects
Week 1: **Introduction to vehicular communications** **Week 2:** **Connected and automated vehicles** **Week 3:** **Applications and requirements** **Week 4:** **Wireless V2V and V2X communications** **Week 5:** **Vehicular networks** **Week 6:** **Modelling vehicular mobility** **Week 7:** **Channel propagation models** **Week 8:** **The protocol pillar** **Week 9:** **The physical layer: single carrier (L-ASK, M-QAM, L-PSK)** **Week 10:** **Multi carrier (OFDM) modulations, bit error rate and channel capacity,equalization** **Week 11:** **The MAC layer: (FDMA, TDMA, CDMA, OFDMA, CSMA, ALOHA).** **Week 12:** **V2X communications: cellular systems vs WiFi-based systems.** **Week 13:** **Visible Light Communications (VLC) and mmWaves** **Week 14:** **Standards: LTE-V2X, IEEE 802.11p** **Week 15:** **Intelligent transportation systems**
Literature
1. **C. Sommer, F. Dressler, Vehicular Networking, Cambridge University Press, 2015.** 2. **M. Emmelmann, B. Bochow and C. C. Kellum, Vehicular Networking: Automotive Applications andBeyond, Wiley, 2010.** 3. **H. Moustafa, Y. Zhang, Vehicular Networks: Techniques, Standards, and Applications, CRC Press,2009**

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Course syllabus: **SELECTED TOPICS IN MULTIMEDIA COMMUNICATIONS**
Course status: **Elective** **6 ECTS**
Course description
Introduction of international standards. Image coding: DCT/sub band/VQ. Image coding: JPEG. Video coding: ITU-T H.261, H.263, H.263 Version 2. Video coding: ISO MPEG-1, MPEG-2. MPEG audio coding. ITU-T speech coding: G.72x. MPEG-4 Video. Systems: ITU-T H.320, H.323, H.324, etc.MPEG-4 Systems. Networking issues: error resilience, network characteristics, Quality of Service (QoS). Error resilience in video codecs: H.26x and MPEG. Multimedia over IP: Multimedia over ATM. Multimedia over wireless/mobile networks
Expected learning outcomes:
At the end of the course the student will be able to: • ***have an excellent understanding of multimedia enabling technologies, services and applications;*** • ***master basic Internet concepts and protocols;*** • ***analyze analog and digital video signals and systems;*** • ***know the fundamental video processing techniques;*** • ***acquire the basic skill of designing video compression;*** • ***familiarize himself/herself with video compression standards;*** • ***know the basic techniques in designing video transmission systems: error control and rate control.***
Teaching Methodology:
Problem-based learning and Project-oriented approach.
Course subjects
Week 1: **Introduction of international standards** **Week 2:** **Image coding: DCT/sub band/VQ. Image coding: JPEG.** **Week 3:** **Video coding: ITU-T H.261, H.263, H.263, Video coding: ISO MPEG-1, MPEG-2.** **Week 4:** **MPEG audio coding. ITU-T speech coding: G.72x. MPEG-4 Video** **Week 5:** **Networking issues: error resilience, Quality of Service (QoS).** **Week 6:** **Error resilience in video codecs: H.26x and MPEG** **Week 7:** **Multimedia over IP: Multimedia over ATM** **Week 8:** **Multimedia over wireless/mobile networks** **Week 9:** **Project work** **Week 10:** **Project work** **Week 11:** **Project work** **Week 12:** **Project work** **Week 13:** **Project/Seminar presentation** **Week 14:** **Summary** **Week 15:** **Evaluation**
Literature
1. **R. Steinmetz and K. Nahrstedt, Media Coding and Content Processing, Prentice Hall, 2002,** 2. **G. Lu, "Communication and Computing for Distributed Multimedia Systems", Artech House, 1996**

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Course syllabus: **SELECTED TOPICS IN NETWORKING AND COMMUNICATIONS**
Course status: **Elective** **6 ECTS**
Course description
The course adopts a broad approach, where a student is encouraged to adopt the area as per the interest. Problem-based learning and Project-oriented approach will be adopted. We will be studying from many research papers. The core theme of the course is wireless communicationand networking. The course is run in a seminar style with a project component. Groups of 2-3 students will work on a project related to the course topics. Students are expected to pick a topic, read papers, implement and evaluate a system or propose and analyze a novel mechanism. Few of topics include: Ultra wide band communications, Personal Area Networks, IoT, Experimental assessment of Radio Frequency Electromagnetic Field Expose to emerging wireless systems and technologies, Multiparametric network planning and optimization etc. The topics will be either the ones emerged as hot topics in the industrial communications community in the last few years or which could be worthwhile research topics in the next few years.
Expected learning outcomes:
After successful completion of the course, students should be able to: • ***Refine their skills of quickly familiarizing themselves with new material.*** • ***Extracting relevant details, and presenting their results orally as well as in writing.*** • ***Modeling a communication network/system with software tool.*** • ***Experimental setup building and demonstration relevant to the topic.*** • ***Survey the state of the art in relevant research field and identify potential knowledge gaps.***
Teaching Methodology:
Problem-based learning and Project-oriented approach.
Course subjects
Week 1: Wireless communication and networking: State of the art **Week 2:** Ultra- wide band communications **Week 3:** Personal Area Networks, **Week 4:** IoT, **Week 5:** Experimental assessment of Radio Frequency Electromagnetic Field Expose to emerging wireless systems and technologies **Week 6:** Multiparametric network planning and optimization **Week 7:** Seminar/project topic pick-up **Week 8:** Project work **Week 9:** Project work **Week 10:** Project work **Week 11:** Project work **Week 12:** Project work **Week 13:** Project/Seminar presentation **Week 14:** Project/Seminar presentation **Week 15:** Evaluation
Literature
There is no text book for the course. The material would be covered from research papers fromleading conferences and journals. **Some of the publication venues we plan to explore are from:** • **ISI Web of Science** • **IEEE Communications Society** • **Elsevier and Springer**

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MATLAB
SIMULINK
MathWorks
M3X25 BOLTS

Course syllabus: **mmWAVE COMMUNICATIONS**
Course status: **Elective** **6 ECTS**
Course description
Millimeter Wave Wireless Communications and Implementation challenges. Emerging Applications of MmWave Communications. Wireless Communication Background. Radio Wave propagation for MmWave: Large-Scale Propagation Chanel Effects, Small -Scale Chanel Effects, Spatial Characterization of Multipath and Beam Combining. Outdoor Chanel Models, including Vehicle to Vehicle models. Indoor Chanel Models: Ray-Tracing, Rayleigh, Rician and Multiwave Fading Models. IEEE 802.15.3c and IEEE 802.11ad Chanel Models. Antennas and Arrays for MmWave Applications. MmWave devices and circuits. MmWave Applications. 60 GHz Spectrum regulations, Wireless HD.
Expected learning outcomes:
After successful completion of the course, students should be able to: • ***List potential MmWave emerging applications.*** • ***Identify MmWave implementation challenges.*** • ***Elaborate Radio Wave propagation effects for MmWave.*** • ***Conduct comparative analysis of MmWave channel models for outdoor and indoor environments.*** • ***Explain MmWave devices, circuits and standards.***
Teaching Methodology:
Lectures for theoretical aspects, laboratory exercises and team-work for real-case scenarios and problem solving through project work.
Course subjects
Week 1: Millimeter Wave Wireless Communications and Implementation challenges. **Week 2:** Emerging Applications of MmWave Communications. **Week 3:** Pick up of seminar topics and project work **Week 4:** Radio Wave propagation for MmWave: Large-Scale Propagation Chanel Effects, Small -Scale Chanel Effects, **Week 5:** Spatial Characterization of Multipath and Beam Combining. **Week 6:** Outdoor Chanel Models, including Vehicle to Vehicle models. **Week 7:** Indoor Chanel Models: Ray-Tracing, Rayleigh, Rician and Multiwave Fading Models. **Week 8:** Mid- term evaluation **Week 9:** IEEE 802.15.3c and IEEE 802.11ad Chanel Models. A **Week 10:** Antennas and Arrays for MmWave Applications. **Week 11:** MmWave Applications. 60 GHz Spectrum regulations, **Week 12:** Wireless HD. **Week 13:** Case-studies. Project team-work presentations **Week 14:** Case-studies. Project team-work presentations **Week 15:** Final evaluations
Literature
1. **T. S. Rappaport, R. W. Heath Jr., R. C. Daniels, and J. Murdock, *Millimeter Wave Wireless Communications*. Prentice Hall, September 2014.** 2. **Tutorials on MmWave topics**

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Course syllabus: **SATELLITE COMMUNICATIONS**
Course status: **Elective** **6 ECTS**
Course description
This course describes satellite communication beginning with orbits, satellite subsystems, the impact of atmospheric factors in signal propagation and multiple access schemes. Moreover, important part of the course are interference mitigation and innovation in the field of satellite communication.
Expected learning outcomes:
Upon completion of this course the student will be able to: • ***distinguish satellite communication, satellite orbits and satellite subsystems*** • ***classify challenges of link composing*** • ***interpret access schemes and interference mitigation*** • ***classify latest innovation in satellite communication***
Teaching Methodology:
Lectures, Discussion, Practical work
Course subjects
Week 1: **Introduction to satellite communication** **Week 2:** **satellite orbits** **Week 3:** **Satellite subsystems** **Week 4:** **Transmission impairments** **Week 5:** **Rain fade mitigation** **Week 6:** **The composite link** **Week 7:** **Satellite multiple access** **Week 8:** **Spectrum management in satellite communication** **Week 9:** **Interference mitigation in satellite communication** **Week 10:** **High throughput satellites and spot beam technologies** **Week 11:** **Satellite communications for M2M developments** **Week 12:** **DVB-S2 modulation extension** **Week 13:** **Satellite communications for ULTRAHD VIDEO/TV** **Week 14:** **Satellite communication for IOT** **Week 15:** **5G and satellite communication**
Literature
1. **L. Whitman, H. Ippolitto (2017): Satellite Communications Systems Engineering: Atmospheric Effects, Satellite Link Design and System Performance 2nd Edition, Publishing House Wiley USA.**

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Course syllabus: **MICROWAVE SYSTEMS**
Course status: **Elective** **6 ECTS**
Course description
The course deals with advanced concepts in the design of wireless communications systems withthe use of advanced software tools. The main focus is on the design of filters, amplifiers, oscillators, impedance matching circuits, etc.
Expected learning outcomes:
On completion of this course, students will be able to: • ***Have advanced knowledge about Microwaves, Microwave circuits and systems.*** • ***Use advanced software tools to analyze and design Microwave circuits and systems,*** • ***Analyze and design of practical Microwave systems.***
Teaching Methodology:
Lectures, Discussion, Practical work
Course subjects
Week 1: Transmission Lines. **Week 2: Waveguides.** **Week 3: Smith Charts applications.** **Week 4: Scattering Parameters application.** **Week 5: CAD tools- Microwave office** **Week 6: Matlab, Python programing** **Week 7: Microwave Filters** **Week 8: Impedance-Matching Networks** **Week 9: Coupling Structures** **Week 10: Microwave Amplifiers** **Week 11: Oscillators** **Week 12: Frequency Synthesizers** **Week 13: Microwave planning systems** **Week 14: Noise and distortion in Microwave systems** **Week 15: Presentation-seminar**
Literature
1. **Theodore S. Rappaport, "Wireless Communications" , Principles and Practice, Prentice Hall,Inc., 2002** 2. **Andreas F Molisch, "Wireless Communications" - Wiley – IEEE, 2nd Edition, © 2011John Wiley & Sons Ltd.**

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Course syllabus: **ADVANCED OPTICAL COMMUNICATIONS**
Course status: **Elective** **6 ECTS**
Course description
This course describes the light propagation in optical fiber, reflection and refraction of light in the border of two materials with different refraction index. Important part of the course are the techniques used to build the optical fiber, the material used, fabrication techniques, chromatic polarization dispersion and non-linear effects in optical fibers. Moreover, in this course, are presented the detailed characteristics of sources of light (longitudinal coherence and transversal, source modulation and type of source), optical receivers (thermal, photo-resistor, photo-diode), quantic efficiency, thermal noise etc as well as modulators (phase electro-optic, amplitude electro-optic and absorption electro-optic). At the end of the course student distinguish advanced modulation, coding and detection schemes in optical communication.
Expected learning outcomes:
Upon completion of this course the student will be able to: • ***argue advanced knowledge for optical communication systems*** • ***interpret in detail the physics of light propagation in optical fiber, optical sources and optical receivers*** • ***demonstrate appropriate knowledge for modulation, coding and detection of optical signal*** • ***organize measurements in existing optical networks and identify faults in that network.*** • ***defend satisfactory knowledge for optical communication and show that is prepared for academics and industrial work in optical communication***
Teaching Methodology:
Lectures, Discussion, Practical work
Course subjects
Week 1: **Introduction to optical communication** **Week 2:** **Optical components and modules** **Week 3:** **Signal propagation in optical fibers** **Week 4:** **Laser amplifiers** **Week 5:** **Semiconductor photon sources** **Week 6:** **Noise sources and channel impairments** **Week 7:** **Advanced modulation schemes** **Week 8:** **Advanced detection schemes** **Week 9:** **Advanced coding schemes** **Week 10:** **Advanced optical networking** **Week 11:** **Nonlinear and linear optics** **Week 12:** **Optical channel capacity and energy efficiency** **Week 13:** **5G and optical communication** **Week 14:** **Measurements in optical communication** **Week 15:** **Optical communication in practice**
Literature
1. **M. Cvijetic, I. Djordjevic (2013): Advanced Optical Communication: Systems and Networks,Publishing House: Artech house, USA** 2. **B.E.A. Saleh, M.C. Teich (2007): Fundamental of Photonics, Second Edition, New Jersey.** 3. **John M. Senior. (2009): Optical Fiber Communications: Principles and Practice. Third Edition,** **London.**

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Course syllabus: **INNOVATION AND TECHNOLOGY TRANSFER**
Course status: **Elective** **6 ECTS**
Course description
This course describes the importance of innovation and technology transfer as an important competitive support in the global knowledge economy. In particular will be analyzed the motivation of students for innovation, successful management of innovation and the importance of understanding when technology has a commercial potential.
Expected learning outcomes:
Upon completion of this course the student will be able to: • ***Understand concepts and theoretical models of innovation;*** • ***Critically evaluate the variety of theories and concepts related to innovation;*** • ***Communicate ideas and arguments of innovation fluently and effectively both in writing and inspeaking;*** • ***Understand the importance of innovation and competitive advantages in the market;*** • ***Analyze the use of research knowledge in innovation;*** • ***Understand the role of incubators and science parks in supporting new businesses;*** • ***Understand the significance of technology innovation to the sustainability of societies.***
Teaching Methodology:
Lectures, discussions, case studies from practice and if possible guest lecturers from industry and innovation centers
Course subjects
Week 1: Innovation – What it is and why it matters **Week 2: Innovation as a core business process** **Week 3: Building the innovative organization** **Week 4: Developing an innovation strategy** **Week 5: Sources of innovation** **Week 6: Search strategies for innovation** **Week 7: Innovation networks** **Week 8: Decision making under uncertainty** **Week 9: Making the innovation case** **Week 10: Creating new products and services** **Week 11: Exploiting open innovation and collaboration** **Week 12: Promoting entrepreneurship and new ventures** **Week 13: Capturing the business value of innovation** **Week 14: Capturing social value** **Week 15: Capturing learning from innovation**
Literature
1. ***Joe Tidd and John Bessant, "Managing Innovation: Integrating Technological, Market and Organizational Change," Wiley, 6-th edition, Sep. 2018, ISBN-13: 978-1119441090*** 2. ***Keith Goffin and Rick Mitchell, "Innovation Management: Effective strategy and implementation," Red Globe Press; 3rd editon. 2017, ISBN-13: 978-1137373434***

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