Program Overview – Telecommunications

No.	M/E	Courses	L	NE	Lab	ECTS	Teacher
Year I							
Semester I			Hours/week				
No.	M/E	Courses	L	NE	Lab	ECTS	Teacher
1.	M	Computer Networking	2	0	3	6	Blerim Rexha
2.	M	Statistical Signal Processing and Applications	2	2	0	6	Ilir Limani
3.	M	Theory and Coding techniques	2	2	0	5	Rexhep Hasani
4.	M	Project management	2	1	0	4	Driton Statovci
5.	M	Radio wave propagation	2	2	0	5	Luan Ahma
6.	Z	Elective courses:					
		1. Digital image processing	2	2	0	6	1.Rexhep Hasani
		2. Safety Management Systems	2	2	0	4	2.Arianit Islami
Semester II							
1.	M	Wireless Communications	2	2	0	7	Enver Hamiti
2.	M	Network Security	2	1	0	6	Blerim Rexha
3.	M	Network Planning and Optimization	2	2	0	7	Bujar Krasniqi
4. and 5.	E	Elective courses (2 courses):					
		1. Antennas	2	2	0	6	1.Enver Hamiti
		2. Wireless Communications Laboratory	1	2	0	5	2.Enver Hamiti
		3. Data Compression	2	2	0	6	3.Ilir Limani
		4. Software for Telecommunication	2	0	2	5	4.Driton Statovci
		5. Methodology of scientific research	2	2	0	6	5. Mimoza Ibrani
Year II							
Semester III			Hours/week				
No.	M/E	Courses	L	NE	Lab	ECTS	Teacher
1.	M	Telecommunication Regulation and Economics	2	2	0	6	Bujar Krasniqi
2.	M	Network performances	2	2	0	6	Salem Lepaja

3.	E	Elective courses(3 courses):					
		1. Cryptography	2	2	0	6	1.Blerim Rexha
		2. Microwave Engineering	2	2	0	6	2.Enver Hamiti
		3 Satellite communications	2	2	0	6	3.Shkelzen Cakaj
		4.Ultra Wideband Communications	2	2	0	6	4.Enver Hamiti
		5. Multimedia communications	2	2	0	6	5. Myzafere Limani
		6. Cellular and Wireless Networks	2	2	0	6	6. Salem Lepaja

Semester IV				
1.	M	Master Thesis	30	

1.1.1. Course descriptions

Course title: **Computer Networking** (Mandatory, Sem I. 6 ECTS)
The aim of the course (module): Introduction to ISO model layers, familiarity with communication protocols, description and operation of services at the application, transport, network, and physical layers.
Learning outcomes: After completing this course (course) the student will be able: (1) gain a basic knowledge of protocol layers and services, (2) have basic knowledge of TCP / IP protocols (3) be able to apply protocols, (4) be able to make network configuration, (5) have a basic knowledge of distributed applications in networks, (6) to be able to make management networks, (7) to understand applications based on TCP / IP protocols.
Course content: layer protocols and services, Internet Service Provider (ISP), Internet History. Principles of network applications, Web, HTTP, FTP, email, DNS and web server. Introduction to the transport layer services, multiplexing and de-multiplexing, reliable data transfer, TCP Protocol, wireshark tool for monitoring traffic, routing, network service model, virtual circuits and datagram networks, ports, IP protocol, routing algorithms, routing in the internet, link layer services, error detection codes, CRC, MAC, LAN, Ethernet Hubs & Switches, PPTP protocol, CDMA, WiFi, Mobile IP, cellular architecture, small offices home office network configuration (SOHO)
Methods of teaching:30 hours for lectures, 15 hours for numerical exercises and 15 hours for laboratory exercises. Approximately 90 hours of independent work including seminar paper.
Grading System: Attendance and classroom activity: 10%, intermediate evaluations 30%, final exam 60%
Literature:
1. James F. Kurose& Keith W. Ross, "Computer Networking", 6th Ed., Pearson Inc.., 2012
2. Douglas Comer, "Internetworking with TCP / IP, Principles, Protocols, and Architecture"

Course title: Statistical Signal Processing and Applications (Mandatory, Sem I., 6 ECTS)
Course objectives: To introduce students with methods of signal processing that can recover useful information from observations usually interfered by noise random in nature, described by their statistical properties.
Learning outcomes: Students learn advanced statistical methods and algorithms for parameter estimation, signal modeling, design of optimum filters (Wiener and Kalman filter), and spectrum estimation methods.
Course content: Random variables and principles of parameter estimation (bias and consistency); random processes and filtering of random processes. Spectral factorization. Signal modeling; the least squares method, Pade approximation, Prony's method, finite data records, stochastic models. The Levinson-Durbin recursion; the lattice filter. FIR and IIR lattice filters; lattice methods for all-pole signal modeling, stochastic modeling. Optimal (Wiener) filtering, and its applications. Discrete Kalman filter. Spectrum estimation; nonparametric methods, parametric methods, frequency estimation, principal components spectrum estimation.
Teaching methodology: 30 hours of lectures+30 hours of supervised exercises. Approximately 75 hours of personal study, including homework exercises.
Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:
1. Hayes M.; "*Statistical Digital Signal Processing and Modeling*", John Wiley & Sons, Inc., 1996.
2. Todd M., and & Stirling W.; "*Mathematical Methods and Algorithms for Signal Processing*", Prentice Hall, 2000.

3. Manolakis D., Ingle V., and Kogon S.; "*Statistical and Adaptive Signal Processing*", McGraw-Hill Inc., 2000.

Course title: Theory and Coding techniques (Mandatory, Sem. I. 5 ECTS)
Course objectives: The main purpose of this course is to introduce students with the basic concepts of information theory, to provide them with an overview of the different coding techniques and their fitness for a specific application.
Learning outcomes: On successful completion of this course the student will be able: to analyse 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.
Content: Introduction: Review of probability theory; 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).
Teaching methodology: lecture, discussion, seminar paper.
Evaluation Methods: Seminar paper: 40%. Attendance 5%, Final Exam: 55%
Literature:

1. Essentials of error-control coding, Jorge Castiñeira Moreira, Patrick Guy Farrell, 2006 John Wiley & Sons Ltd.
2. Fundamentals of Information Theory and Coding Design, Roberto Togneri, Christopher J.S. deSilva, 2005 Chapman &Hall/CRC.
3. Telecommunications Demystified, Carl Nassar, by LLH Technology Publishing, 2001.

Course title: Project management (Mandatory, Sem. I, 4 ECTS)
The goal: The objective of this course is to introduce students the general principles of project management including tools and techniques used to managing projects in the telecommunication industry.
Learning outcomes: On successful completion of the course, students will be able to:
1.Understand the tools and techniques of project management and how these tools and techniques are used to ensure projects are delivered successfully on time and within budget; 2. Understand the importance of a structured project management; 3. Create project plans for project scenarios that includes key tasks, critical path, dependencies, timelines, and budget analysis; 4. Discuss strategies for managing their own projects through simple project planning examples; 5. Understand the specifics on managing research projects.
Course content: Evolution of the telecommunications industry and importance of project management in telecommunications.Project management basics. Getting started on your project.Setting business and project objectives. Going outside the company for products and services. Managing risk, creating the timelines, and managing the costs in telecom projects. Managing the developments and managing the people. Project management tools. Project documentation. Management of research projects: study some use cases on EU and international projects.

Methods of teaching: 30 hours of lectures + 15 hours of exercises. Approximately 75 hours of personal study and exercises including a seminar.
Grading System: Seminar 40 %, Final Exam 60 %
Literature:

1. Celia Desmond, "The ComSoc Guide to Managing Telecommunications Projects," Wiley-IEEE Press, September 2010, ISBN: 978-0-470-28475-9
2. Harold Kerzner, "Project Management: Case Studies," John Wiley & Sons, Februar 2013, ISBN-10: 1118022289.
3. Different literature on managing research projects.

Course title: Radio wave propagation (Mandatory, Sem I, 5 ECTS)
The goal of the course: The goal of the course is to introduce the basic principles of radio wave propagation, especially in analysis of events in radio channel during propagation in ideal and real conditions.
Learning outcomes: On successful completion of the course, students will be able to: Understand basic principles of radio wave propagation, Apply the knowledge from the theory of electromagnetic fields and waves on understanding of radio wave propagation. Understand all phenomenon's that are affecting on the quality of the transmission of information with the radio channel. 4. Understand influence of the atmospheric conditions in radio wave propagation, 5. Understand and explain physical background of propagation of EM waves in free space, 6. Apply gained knowledge of wave radio propagation in other fields 7. Draft a paper on a particular topic in the field of radio wave propagation
Course Content: Introduction. Modes of propagation – Line of sight propagation, NON LOS propagation. Atmospheric effects – atmospheric refraction, the radio horizon, ducting, atmospheric attenuation. Wave propgation in ionosphere. Communication Systems and the Link Budget-path loss, Near earth porpagation models-Weissberger's model, ITU model, Egli nmodel, Longley-Rice model. Porpagation in built-up areas – Young model, Okumura model, Hatta model, COST 231 model, Lee model. Outdoor mobile propagation – empirical path loss models, the Okumura-Hatta model, the COST 231 –Hatta model, the Ikegami model. Fading and multipath characerization – large scale or normal fading, Surface Roughness, Fresnel Zones, difraction, Quantifying Diffraction Loss. Small scale fading – delay spread, doppler spread, chanel modeling. Indoor Propagation Modeling – Interference, indoor propagation effects, indoor propagation modeling.
Teaching methodology:
30 hours lectures, 30 hours tutorials,and approximately 40 hours independent work, including seminar.
Assesment: First assesment: 30%, Second assesment: 25%, Home work 10%, Attendance: 5%, Final exam, 30%, Total:100%
Literature:
1.J. Seybold, *Introduction to RF propagation*, John Wiley & Sons, Inc. New Jersey, 2005
2.Ch. Haslett, *Essentilas of radio wave propagation,* Cambridge University Press, New York, 2008
3.Th. Rappaport*, Wireless communications*, *Principles and Practice*, Prentice Hall, New Jersey, 2002

Course title: Digital image processing (Elective, Sem. I. 6 ECTS)
Course objectives: The ultimate goal is to develop a thorough understanding of the subject and familiarity with the most common techniques.
Learning outcomes: After completing this course the student will be able:to provide development of skills to effectively integrate new concepts in digital image processing;to study computer algorithms and data structures which are important to represent 2-D data.

Contents: Genesis and applications of digital image processing; Digital image processing an analysis; Complexity of operations in the image; The basic notions of the image; The main problems of digital image processing; Presentation of the image; Image restoration and registration; Reconstruction of the image from the projection; The image and video compression; Elements of visual perception; The physical characteristics of light; The properties of the visual system; Time characteristics of the visual system; Objective and subjective measures of image quality; Spectrum of the colors; The image sensors with electron beam; Image scanning methods; Semiconductor image sensors; Image sampling; Quantization of the image; Digitalization of the color image; The need for compression of image and tips redundancy; Different compression methods; Image enhancement; Linear filtering.
Teaching methodology: lecture, discussion, seminar paper.
Evaluation Methods: Seminar paper: 40%. Attendance 5%, Final Exam: 55%
Literature:

1. Rafael C. Gonzalez and Richard E. *Woods, Digital Image Processing.*
2. William K. Pratt*, Digital Image Processing.*
3. Roger L. Easton, *Fundamentals of Digital Image Processing.*

Course title: Safety Management Systems (Elective, Sem.I, 4 ECTS)
The goal : The purpose of the course is to introduce students to the systematic management of safety by describing the limitations of traditional methods to manage safety and describing new methods and best practices for managing safety, especially in safety-critical engineering systems.
Learning outcomes: On successful completion of the course, students will:
1.Gain knowledge of safety management concepts which will enhance their management skills and knowledge about the human, technical, organizational and environmental factors that determine the safety of the system as a whole. 2. Develop knowledge on the implementation of key components of a Safety management system in an organization. 3. Understand that Safety management systems are based on the fact that there will always be hazards and risks, so proactive management is needed to identify and control these threats to safety before they lead to mishaps. To understand the impact of the change on the System and determine how safe the change needs to be. 4. Be ableto validate the system architecture by showing that the proposed system architecture can reasonably be expected to be acceptably safe. 5. To understand whether the System as being implemented achieves an acceptable (or at least a tolerable) level of risk. 6. Be able to apply best practices in hazard identification and safety and risk assessment and mitigation.
Course content: Safety management systems Course introduction. Basic safety concepts. Introduction to safety management. Hazards. Risks. Safety management systems regulation. Introduction to Safety management systems. Safety management systems planning. Safety management systems operation. Phased approach to Safety management systems implementation. Safety assessment methodology. Hazard Identification and Safety Objectives (Functional Hazard Assessment). Risk Assessment and Mitigation Strategy (Preliminary System Safety Assessment). Safety aspects during system implementation: system verification and validation (System Safety Assessment) . Safety Documentation..
Methods of teaching: 30 hours of lectures + 30 hours of practical exercises. Approximately 100 hours of personal study and exercise including seminars.
Grading System: Progress evaluation 40 %, Final Exam 60 %
Literature:

1. Lecture slides prepared bythe lecturer combining material from documents prepared by the International Civil Aviation Organization (standards and recommended practices that member statesmust meet), materials from University of Civil Aviationof France, materials from Singapore CivilAviation Academy, International Air TransportAssociationandlecturer’s own lengthy experiencein Safety Management Systems.
2. J.T. Reason, “Managing the risk of organizational accidents”, Ashgate, 1997

Course title: **Wireless Communications** (Mandatory, Sem. II, 7 ECTS)
The goal : The purpose of the course is to provide students with fundamental treatment about practical and theoretical concepts that form the basis of wireless communications .
Learning outcomes: On completion of this course, students will be able to: 1. Have fundamental knowledge about wireless communications 2. Solve theoretical and practical problems 3. Analyzevarious aspects ofplanninganddesigninwirelesscommunicationsand propose solutions.
Course content: Introduction to wireless communication systems. Modern wireless communication systems . The cellular concept –System design fundamentals. Modulation techniques for mobile radio. Equalization, diversity and channel coding. Multiple access techniques for wireless communications.
Methods of teaching: 30 hours of lectures + 30 hours of auditorial exercises . Approximately 100 hours of personal study and exercise, including seminars.
Grading System Seminar 10%, Project 30 %, Final Exam 60 %
Literature:

1. Theodore S. Rappaport, "Wireless Communications" , Principles and Practice, Prentice Hall,Inc., 2002
2. David Tse, Pramod Wiswanath " Fundamentals of Wireless Communications" Cambridge university press, 2005
3. S. Haykin and M. Moher "Modern Wireless Communications", Prentice Hall,Inc., 2005 .

Course title: **Network Security** (Mandatory, Sem. II, 6 ECTS)
The goal: To provide students with practical survey of principles and practice of cryptography and network security.
Learning outcomes: On completion of this course, students will be able to:
1. Apply classical and modern symmetric encryption algorithms, 2. Apply public key algorithms, use and understand digital signatures and public key infrastructure, 3. Use cryptographic protocols to provide security over network and Internet, and 4. Use security devices to protect network and network devices from different security threats.
Course content: Will include: Symmetric encryption algorithm: Data Encryption Standard (DES), Advanced Encryption Standard (AES), Asymmetric encryption algorithm: Rivest Shamir Addelman (RSA) , elliptic curve, Public key infrastructure (PKI), digital signatures, User authentication, e-mail security , IP security, physical security, web security, wireless security, Threats and virus handling, Vulnerabilities in Operating Systems (OS) and Applications, Quality of service, denial of service attacks, malware, and buffer overflow attacks, spoofing, Security and firewall policies, Hands on: digital certificates X.509 and PKI, web server security, file and directory permissions, providing physical security, ports and proxies, spoofing, virtual private network (VPN)
Methods of teaching: 30 hours of lectures + 10 hours of tutorials exercises + 5 hours of laboratory exercises. Approximately 100 hours of personal study and exercise including seminars.
Grading System: Classroom Assessment 10%, Projects 15%, Practice 15 %, Final assessment 60 %
Literature:

1. Applied Cryptography, by Bruce Schneier, ISBN=0-471-12845-7, or ISBN=0-471-11709-9, published by John Willey & Sons, 1996
2. Cryptography and Network Security, by William Stallings, ISBN=0-13-187316-4, published by Prentice Hall, 2006
3. Network Security, by Jan L. Harrington, ISBN=0-12-311633-3, published by Elsevier, 2005
4. Recommended:
5. Cryptography Decrypted, by Cary Meltzer and Doris Baker, ISBN=0-201-61647-5, published by Addison Wesley, 2001

Course title: Network Planning and Optimization (Mandatory, Sem. II, 7 ECTS)

The goal : The purpose of the course is describe the fundamentals of Radio Resource Management such as Radio Network Planning and Radio Network Optimization, including also the interference management in Wireless Networks.

Learning outcomes: On successful completion of the course, students will be able to:1. Understand the fundamentals of Radio Resource Management 2. Understand the Radio Resource Allocations 3. Understand Convex Optimization theory for Wireless Communications 4. Understand the Interference Mitigation in Wireless Communication Network 5. Understand the Power Control in 3G and 4G mobile networks 6. To be able to make the planning of a wireless network 7. Optimize the planned wireless network

Course content: Wireless Network models. Principles of Cellular Systems. Convex Optimization Methods for Wireless Communications (Dual Decomposition Methods and Geometric Programming), Transmit Power Control, Dynamic Channel Allocation, Interference Mitigation, Planning an indoor and Outdoor Network. Optimizing a Planned Network.

Methods of teaching: per week are 2 hours lectures and 2 hours exercises. A seminar work is supposed to be done by students in group of 2 max. The practical work will be realized in cooperation with one of the mobile providers in Kosova.

Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. J. Zander and S.L. Kim "Radio Resource Management for Wireless Networks " Artech House,INC 2001
2. J. Laiho, A. Wacker, T. Novosad , "Radio Network Planning and Optimization for UMTS", A John Wiley & Sons, inc. publication, 2006
3. S. Boyd and L. Vanderberghe. "Convex optimization" , Cambridge, 2004

Course title: Antennas (Elective, Sem. II, 6 ECTS)

The goal : To provide students with theoretical and practical survey of antennas and antenna arrays.

Learning outcomes: On completion of this course, students will be able to: 1. Have advanced knowledge about antenna parameters, basic models, practical models and array of antennas and antenna arrays 2. Use software tools to analyze and design antennas, 3. Analyze and propose solutions for practical communication systems 4. Make antenna measurements.

Course content: Overview .Antenna parameters : Resonant frequency, Gain, Radiation pattern, Impedance, Efficiency, Bandwidth, Polarization, Transmission and reception. Basic antenna models .Practical antennas. Effect of ground. Mutual impedance and interaction between antennas. Microwave antennas. Antenna arrays.

Methods of teaching: 30 hours of lectures + 30 hours of auditorial exercises. Approximately 90 hours of personal study and project.

Grading System: Seminar 10%, Project 30 %, Final Exam 60 %

Literature:

1. C. A. Balanis, *Antenna Theory Analysis and Design (2nd Edition),* John Wiley & Sons, Inc.,1997.
2. John D. Kraus, Ronald J. Marhofka:" Antennas for all Application", Third Edition , McGraw Hill.2002
3. David Pozar, Daniel Schaubert " MICROSTRIP ANNTENAS" The Analysis and Design of Microstrip Anntenas and Arrays, IEEE PRESS, New York, 1995.

Course title: Wireless Communications Laboratory (Elective Sem II, 5 ECTS)
The goal : The purpose of the course is to provide students with theoretical and practical knowledge of Software Defined Radio for evaluating the Wireless Communication Systems
Learning outcomes: On successful completion of the course, students will be able to:1. Understand the fundamentals of Software Defined Radio 2. Understand the multi rate signal processing 3.Understand the application of the signal processing methods in Wireless Communication systems 4 Simulate the wireless communication system.
Course content: Software Defined Radio Introduction. Analyze the communication channel using PSK and QAM modulation schemes. Represent signals in time and frequency domain. Transmission System Analysis and Design Parameters. Multirate Signal Processing. Program in MATLAB the communication systems which is able to transmit and receive data.
Methods of teaching: per week are 1 hours lectures and 2 hours laboratory exercises.
Grading System: Laboratory exercise 70 %, Mid-term exam 30%
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

Course title: Data Compression (Elective, Sem II., 6 ECTS)
Course objectives: The objective of the course is to introduce fundamental theories and techniques of data compression.
Learning outcomes: To understand various coding schemes suitable for particular types of signals, using internal signal structures (physical, probabilistic, etc.), and user limitations. Being able to do basic tasks in coding, both, through problem solving and computer algorithm implementation.
Course content: Introduction to data compression methods; lossless and lossy compression algorithms, the components of a data compression system, performance metrics. Introduction to information theory. Statistical compression methods: Huffman and arithmetic entropy coders, the JBIG standards, dictionary based compression methods, universal lossless source coding, model based compression methods, transform based text compression. Image compression methods; scalar and vector quantization, predictive coding, hierarchical vector quantization. Transform coding; DCT (JPEG/MPEG) and wavelet transform, sub-band coding, wavelet compression.
Teaching methodology: 30 hours of lectures+30 hours of supervised exercises. Approximately 75 hours of personal study, including homework exercises.
Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. Sayood, K.; "*Introduction to Data Compression*", Morgan Kaufman, 2005.
2. Salomon, D., Motta G., and Bryant D.; "*Data Compression: The Complete Reference*", Springer, 2006.

Course title: Software for Telecommunication (Elective, Sem. II, 5 ECTS)
The goal: The objective of this course is to introduce students the main software tools with a focus on Matlab as one of the main software packages used to model and simulate modern communication systems.
Learning outcomes: On successful completion of the course, students will be able to: 1. Understand the main software tools used to develop software for telecommunication systems;**2.** Develop concepts and methodologies to evaluate the performance of communication systems; 3. Understand the practical abilities of Matlab and Simulink and their applications in analyzing and evaluating telecommunication

systems; 4. Write Matlab scripts and functions as well as build Simulink blocks to simulate and model communication systems.

Course content: Introduction to software for telecommunication: using of software in telecommunications, and illustrative examples. Simulation and modeling methodology: methodology of problem solving for simulation, basic concepts of modeling, performance evaluation techniques, error sources in simulations, validation, and simulation environment and software issues. Maltab and Simulink: Matlab, toolboxes, communications toolbox, and signal processing toolbox. Modeling and simulation of communication systems: signals and linear systems, random processes, analog modulation, analog-to-digital conversation, baseband digital transmission, digital transmission through bandlimited channels, digital transmission via carrier modulation and spread spectrum communication systems.

Methods of teaching: 30 hours of lectures + 30 hours of laboratory exercises. Approximately 75 hours of personal study and exercises including homework.

Grading System: Homework exercises 40 %, Final Exam 60 %

Literature:

1. Michel C. Jeruchim, Philip Balaban, and K. Sam Shanmugan, "Simulation of Communication Systems: Modeling, Methodology and Techniques," 2e, ISBN: 0-306-46267-2.
2. John G. Proakis, Masoud Salehi, and Gerhard Bauch, "Contemporary Communication Systems using Matlab", 2e, ISBN: 0-534-40617-3.
3. Different books on the latest versions of Matlab and Simulink.

Course title: Methodology of scientific research (Elective, Sem II., 6 ECTS)

Course objectives: To introduce some key elements of research methodology to first time research students.

Learning outcomes: At the end of this course, the students should be able to: understand some basic concepts of research and its methodologies, identify appropriate research topics, select and define appropriate research problem and parameters, prepare a project proposal (to undertake a project), organize and conduct research (advanced project) in a more appropriate manner, write a research report and thesis, write a research proposal (grants).

Course content: Overview of experimental and engineering methodological approaches to research; Basics of research design (e.g., hypothesis formulation); The research process: documenting research, sources of information, research funding, creativity and intellectual discovery; Guidelines and a framework for efficient development of research; legal and ethical issues; protecting and exploiting research; Intellectual Property rights; Managing the research project: supervision, planning and organization; problems and pitfalls; Presentation skills (written, oral); Use of relevant research tools (technology, experimental infrastructure, mathematical methods, etc.).

Teaching methodology: 30 hours of lectures+30 hours of supervised exercises. Approximately 75 hours of personal study, including homework exercises.

Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. Kothari B.L., "*Research Methodology: Tools and Techniques*", New Age International Publishers, 2009.
2. Boot C. W., "*The Craft of Research*", University Of Chicago Press, 2008.

Course title: **Telecommunication Regulation and Economics** (Mandatory, Sem. III, 6 ECTS)
The goal : The purpose of the course is describe the fundamentals of Regulations in the field of telecommunications and the economic aspects.
Learning outcomes: On successful completion of the course, students will be able to:1. Understand the fundamentals of Telecommunication policy in theoretical and practical objective 2. The economical aspects of telecommunication network 3. The role of US, European and Kosova governmental agencies in the development of telecommunication environment 4. Role of organizations in telecommunication standardization 5. Competition and regulation in telecommunication.
Course content: A historical review of telecommunications policy, including both theoretical objectives and practice. The role of the various U.S. governmental agencies in the development of the telecommunications environment. Recent developments in telecommunications. Issues in international telecommunications. Survey of key organizations, e.g., ITU, FCC, 3GPP, HCM-Agreement etc. Telecommunications and economic development in US, EU and Kosova. International trade in services. Competition and regulation. Standards and trans-border data flow issues. Spectrum Auction.
Methods of teaching: per week are 2 hours lectures and 2 hours exercises. A seminar work is supposed to be done by students in group of 2 max.
Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. M. Cave "Handbook of Telecommunications Economics Volume 1 " Elsevier 2002
2. S. Majmudar, I. Vogelsang, M. Cave, "Handbook of Telecommunications Economics Volume 2", Elsevier 2005

Course title: Network performances (Mandatory, Sem III, 6 ECTS)
The goal: The purpose of the course is to provide students with a theoretical and practical knowledge on performance analyses of communication networks.
Learning outcomes: On successful completion of the course, students: 1. Will have a good understanding of stochastic processes, queueing theory, queiueing models and simulation techniques. 2. Will be able to build and analyse queueing models of network components. 3. Will be able to build and analyse queueing models of networks. 4. Will be able to use simulation tools to design components of communication networks and protocols. 5. Will be able to use a simulation tool to conduct a performance study.
Course content: *Probability Theory*. Random Variables. Basic probability distributions.Confidence Intervals. S*tochastic processes*. The Poisson process. Markov chains. Birth and death process. *Queueing theory*. Analytical model of a system. Basic Queueing models.Kendell's Notation. The M/M/1 queue. Variants of the M/M/1 queue. M/M/C - Erlang C. M/M/C/C - Erlang B.The M/G/1 queue. Queueing networks. *Simulation*. Introduction to simulation. Basic concepts and simulation techniques. Discrete event simulations. Performance metrics. Simulation tools (network simulator- NS).
Methods of teaching: 30 hours of lectures + 15 hours of auditorial exercises + 15 hours of computer exercises. Approximately 100 hours of personal study and exercise including assignments.
Gradig System: Assignment 15%, Mid-term exams 30 %, Final Exam 55 %
Literature:

1. P.V. Miegham, "Performance analysis of communication networks and systems", Delft University of Technology, 3rd Ed, Cambridge University Press 2006.
2. A. M. Law and W.D. Kelton, "Simulation Modeling and Analyses", McGrow Hill 2004.
3. The *ns* Manual. The VINT Project. Kevin Fall hkfall@ee.lbl.govi, Editor. Kannan Varadhan hkannan@catarina.usc.edui, Editor.May 9, 2010.
4. Leonard Kleinrock: Queueing theory (Volume 1)

Course title: Cryptography *(*Elective, Sem. III, 6 ECTS)

The goal: To provide students with practical survey of principles and practice of cryptography and data security, smart cards and their practical use.

Learning outcomes: On completion of this course, students should:

(1) Have basic knowledge about cryptography, (2) have knowledge about symmetric and asymmetric encryption (3) be able to apply advanced cryptographic algorithms (AES, RSA and DSA), (4) have basic knowledge about smartcards and their usage in real life applications, (5) be able to manage public keys, and (6)be able to analyze application that use cryptographic algorithms.

Course content: Will include: Symmetric encryption algorithm: Advanced Encryption Standard (AES), Asymmetric encryption algorithm: Rivest Shamir Addelman (RSA), Digital Signature Algorithm, elliptic curve, Public key infrastructure (PKI), digital signatures, User authentication, e-mail security , Smart cards, Threats and virus handling, attacks, malware, and buffer overflow attacks, spoofing, Hands on: digital certificates X.509 and PKI,

Methods of teaching:30 hours of lectures + 20 hours of tutorials exercises + 10 hours of laboratory exercises. Approximately 100 hours of personal study and exerciseincluding seminars.

Grading System: Classroom Assessment 10%, Projects 15%, Practice 15 %, Final assessment 60 %

Literature:

1. BruceSchneier, AppliedCryptography, ISBN=0-471-12845-7, 1996
2. NielsFerguson, BruceSchneierand T. Kohno, CryptographyEngineering: DesignPrinciplesandPracticalApplications, ISBN= 978-0-470-47424-2, 2009
3. Alfred J. Menezes, Paul C. vanOorschotandScott A. Vanston, HandbookofAppliedCryptography , ISBN: 0-8493-8523-7 1996, po ashtu onlilne në: http://www.cacr.math.uwaterloo.ca/hac/
4. H.X. Mel &DorisBaker, CryptograpfyDecrypted, 2004
5. MatthewMacDonald&ErikJohansson: C# Data Security, 2003

Course title: Microwave Engineering (Elective, Sem. III, 6 ECTS)

The goal : The purpose of the course is to provide students with advanced theoretical and practical survey of microwaves, microwave circuits and system design.

Learning outcomes: On completion of this course, students will be able to: 1. Have advanced knowledge about microwaves, microwave circuits and systems. 2. Use advanced software tools to analyze and design microwave circuits and systems, 3. Analyze and design of practical microwave systems.

Course content: Transmission Lines. Waveguides. Smith Charts and Scattering Parameters applications . CAD tools- Microwave office, ect. Microwave Filters. Impedance-Matching Networks, and Coupling Structures. Microwave Amplifiers. Oscillators and Frequency Synthesizers . Microwave planning systems. Noise and distortion in Microwave systems .

Methods of teaching: 30 hours of lectures + 30 hours of auditorial exercises. Approximately 100 hours of personal study and exercise, including seminars.

Grading System

Seminar 10%, Project 30 %, Final Exam 60 %

Literature:

1. David M. Pozar, Microwave Engineering, 3rd Edition; Wiley; 2005; ISBN:0-471-44878-8
2. David M. Pozar, Microwave and RF Design of Wireless Systems, John Wiley & Sons, 2001
3. E. da Silva, "High Frequency and Microwave Engineering " Lineacre House, Jordan Hill, OXFORD OX2 8DP, First publish 2001

Course title: Satellite communications *(*Elective, Sem. III, 6 ECTS)

The goal : The purpose of the course is to introduce the basic principles of satellite communications.

Learning outcomes: On successful completion of the course, students will be able to:

1. Understand satellite systems and applications. 2. Compare satellite and ground communications. Understand the structure of the ground and the space segment 4. Understand the nature of orbits and launch of satelites. 5. Calculate the satellite link budget.

Course content: Introduction to satellite communication systems and their applications. Satellite systems architecture. Satellite network concepts. Basic principles and Kepler's laws. Trajectories and orbits. Space orbital parametrs. Cosmic velocity. Circular orbits. LEO, MEO and GEO orbits. Molnya orbit. Launching of satellite. Parking orbit. Satellite stabilization. Modification of orbital parameters. Satellite and ground station geometry. Propagation considerations for satellite communications. Basic link budget parameters. Signal to noise ratio. Architecture and ground station components. Ground stacion performance. Hardware structure and satellite subsystems. Multiple access techniques: FDMA, TDMA, CDMA, SDMA. Coverage area. Delay. Visibility and satellite tracking. Different applications aspects.

Methods of teaching: 30 hours of lectures + 10 hours of auditorial exercises.

Grading System: Written 50% and Oral 50%.

Literature:

1. A. Maini and V. Agrawal, "*Satellite technology*", Wiley 2011.
2. D. Roddy, "*Satellite communications*", McGraw Hill, New York 2006.
3. G.Maral and M.Bousquet, "*Satellite communication systems*", John Willey & Sons, Ltd, Chichester, England, 2002.
4. M. Richharia, "*Satellite communication systems*", McGraw Hill, New York 1999.
5. G.D. Gordon, W.L. Morgan, "*Principles of communication satellites*", John Willey & sons, Inc, 1993.

Course title: Ultra Wideband Communications (Elective, Sem. III, 6 ECTS)

The goal : The purpose of the course is describe the fundamentals of Ultra Wideband Communications and their applications in today's and future communication systems

Learning outcomes: On successful completion of the course, students will be able to:1. Understand the fundamentals of Ultra Wideband Communications 2. Ultra Wideband Channels 3. Ultra Wideband Modulation 4. Performance measurement of Ultra Wideband Communication using Bit-Error Rate 5. Application of Ultra Wideband Communications in today's and future systems.

Course content: Ultra Wideband Introduction. Ultra Wideband channel models. Ultra Wideband modulation. Ultra Wideband pulse shaper design. Timing Synchronization for Ultra Wideband impulse radios. Ultra Wideband receiver architecture. Mixed-Signal (analog and digital) Ultra Wideband Communication receivers. Ultra Wideband networks and applications. Low bit-rate Ultra Wideband networks.

Methods of teaching: per week are 2 hours lectures and 2 hours exercises. A seminar work is supposed to be done by students in group of 2 max.

Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. H. Arslan, Z.Chen, M. Benedetto ''Ultra Wide band Wireless Communications'' A John Wiley & Sons, inc. publication, 2006
2. X. Shen, M. Guizani, R. Qiu, T. Le-Ngoc, '' Ultra Wideband Wireless Communications and Networks'' A John Wiley & Sons, inc. publication, 2006

Course title: Multimedia communications (Elective, Sem III, 6 ECTS)
The goals: This course introduces technologies for multimedia communications. We will address how to efficiently represent multimedia data, including video, image, and audio, and how to deliver them over a variety of networks. In the coding aspect, state-of-the art compression technologies will be presented. Emphasis will be given to a number of standards, including H.26x, MPEG and JPEG. In th networking aspect, special considerations will be given for sending multimedia over ATM, wireless, and IP networks, such as error resilience and quality of services. The H.32x series, standards for audiovisual communication systems in various network environments, will be described. Current research results in multimedia communications will be reviewed through student seminars in the last weeks of course.
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.
Course content: Introduction of international standards. Image coding: DCT/subband/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
Methods of teaching: 30 hours lectures, 30 hours exercise. Approximately 100 hours of personal study and exercise.
Grading System: Seminar 50%, final exam 60 %.
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,
3. R. Steinmetz and K. Nahrstedt, Multimedia: Computing, Communications and Applications, Prentice Hall, 1995,
4. P. K. Andleigh and K. Thakrar, Multimedia Systems Design, Prentice Hall, 1996.

Course title: Cellular and Wireless Networks (Electtive, Sem. III 6 ECTS)
The goal: The purpose of the course is to provide students with a theoretical and practical knowledge on wide range of wireless communication technologies and networks.
Learning outcomes: On successful completion of the course, students:
1. Will have a good knowledge of wide range of wireless communication technologies. 2. Will have a good understanding of wireless networks based on: GSM, GPRS, UMTS, LTE, WiMAX, WLAN, and Satellite communication systems. 3. Will be able to carry out planning and dimensioning of wireless networks: GSM, GPRS, UMTS, WiMAX, and WLAN. 4. Will be able to use commercial planning tools such as software package Spectra and GIS (Geographic Information System). 5. Will be familiar with future trends of converging Wireless and Internet technologies toward the future All IP networks. 6. Will be able to setup, configure, and test WLANs.
Course content: *Introduction to wireless and mobile cellular networks.* Classification of wireless networks. *Terrestrial Mobile Communications Systems*. First generation systems – 1G. Short overview of 1G architecture. Second generation systems - 2G. GSM system architecture, protocols, and services. Second and a half generation systems - 2.5 G. GPRS system architecture, protocols and services. Third generation systems - 3G. UMTS system architecture, protocols and services. Beyond 3G systems: HSUPA and HSDPA. Fourth generation systems - 4G. LTE system architecture, protocols, and

services. Wireless *Network Planning*. Traffic engineering. Radio network planning for GSM/GPRS/UMTS. Planning tool Spectra and GIS (Geographic Information System). *WiMAX technology*. System overview and planning. *Satellite communication systems*. Short overview on GEO, MEO and LEO satellite systems. *Wireless Local Area Network - WLANs*. WLAN IEEE 802.11: standards, protocols, planning, and configuration. *Mobility management*: cepts and types of mobility management. Mobility management in GSM, GPRS, UMTS, LTE, WiMAX and WLAN networks.
Methods of teaching: 30 hours of lectures + 15 hours of auditorial exercises + 15 hours of computer exercises. Approximately 1 00 hours of personal study and exercise including assignments.
Gradig System: Assignment 15%, Mid-term exams 30 %, Final Exam 55 %
Literature:

1. F. Molisch, "Wireless Communications", Second Edition, John Wiley & Sons Ltd., 2011.
2. S. Lepaja, Mobility and QoS in Global Broadband Communication Networks, Ph.D. Dissertation, TU WIEN, March 2005.
3. J. Schiller, Mobile Communications, Addison-Wesley, 2000.

Course title: **Master Thesis** (Mandatory, Sem. IV, 30 ECTS)
The goal: Master thesis is the final scientific work that will prove the student capability to work on a scientific topic independently by using methodologically sound approaches.
Learning outcomes: At the end of this course, students will be capable to: 1. Read and understand state-of-the-art literature. 2. Independently specify, analyze and propose solutions. 3. Explain and discuss critically results. 4. Present and defend the thesis in a written and oral form.
Course content: The thesis could be proposed by the supervisor or can be chosen by the student, and should be in the accordance with the qualification profile. 1. Reading of the state of the art. 2. Understanding and specifying the problem. 3. Design and implement different solutions. 4. Analyze and discuss critically the results.
Methods of teaching: Compliant with the actual regulation at the faculty level on how to conduct a master thesis.
Literature:

1. Jean-Luc LeBrun. Scientific Writing. World Scientific, 2007.
2. Depending on the topic covered in thesis, different bibliographic resources will be recommended by the teachers.