

Transilvania University of Braşov, Romania

Study program: Telecommunications Systems and Technologies

Faculty: Electrical Engineering and Computer Science

Study period: 4 years

1st Year - 1st Semester

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Communication Skills	ETTI101	3	1	2	-	-

Course description (Syllabus): Interpersonal Perception; Communication - general issues; Verbal and nonverbal communication; Communication from the transactional analysis perspective; Communication in conflict situations; Ethics and etiquette in communication; Personal development within the organization

Seminar: The topics of the lectures are taken again in the form of practical examples; Also, are exposed details and completions for topics of the lectures.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Applied Informatics I	ETTI102	4	1	-	2	-

Course description (Syllabus): Use of Computer Hardware and Software; Internet links: packet switching, modes of access; Internet links: Addressing in Internet (IP address, port, proxy servers), client server architecture, domain name and DNS service; E-mail service: Main features, Access modes (POP3, IMAP), SPAM, Mailing Lists; WWW service: Hypertext, URL, HTML, CSS, XML, interactive web pages (CGI, ASP, PHP, JavaScript), portals, search engines, cookies; FTP service: FTP service operation, peer-to-peer networks; Security in Internet: Firewall and packet filtering, public and private key cryptography, PGP (Pretty Good Privacy), secure web servers, VPN (Virtual Private Network).

Laboratory: Working under the Linux O.S.; File-system; Control of the work environment; Filtering messages; Programming in shell; WWW; E-mail Service; Files transfer; Web pages; Web Hosting

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Mathematical Analysis	ETTI103	6	3	2	-	-

Course description (Syllabus): Relations. Ordered sets. The set of real numbers; Sequences and series of real numbers; Convergence criteria for series; Real functions: limits, continuity, derivatives; Taylor's formula; Riemann integrability. Improper integrals; Sequences and series of real functions. Power series; The Euclidian space R^n . Functions of several variables; Limits, continuity and differential calculus on R^n . Extreme values of differentiable functions of several variables; Parameter-dependent integrals. Euler's functions; Line integrals. Multiple integrals. Integral formulas.

Seminar: The topics of the lectures are taken again in the form of practical examples; Also, are exposed details and completions for topics of the lectures.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Linear Algebra, Analytical and Differential Geometry	ETTI104	7	3	2	-	-

Course description (Syllabus): Vectors in two- and three-dimensional Cartesian coordinates. Vector products and applications; Line and plane in space, angles and distances; Coordinate transformations in plane and in space; Vectorial spaces, subspaces; Radix. Transferring a number from one radix to another; Linear binary codes. Matrix

generators, application coding; Boolean algebras; Boolean functions; Minimisation of Boolean functions - Quine-McCluskey method, Karnaugh map, Reed-Muller structures, Post structures Post; Elements of graph theory. Graph representation in computer memory.

Seminar: The topics of the lectures are taken again in the form of practical examples; Also, are exposed details and completions for topics of the lectures.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Computers Programming and Programming Languages	ETT1105	5	2	-	2	1

Course description (Syllabus): C++ syntax and semantics; Arithmetic expressions, function calls and outputs; Entries in the program. Writing applications; Conditions, logical expressions and selection control structures; Loops; Functions; Tables; Other control structures: switch, do-while, for; Scope. Lifetime. Namespace; Pointers; Function templates. Exception handling.

Laboratory: Working in C and C++ programming language

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Computer Assisted Graphics	ETT1106	3	-	-	2	-

Course description (Syllabus): Graphics theory techniques; Organizing a work session in Auto CAD 2000; General aspects of computer graphics, two-dimensional and three-dimensional modeling in AUTOCAD; Realistic representations of 2D and 3D assemblies, using geometric modeling software (CAD); Making design objects by drawing commands; Dimensional representations: interactive and generative techniques, organizing the virtual representation space, graphical objects - properties, scales of representation, virtual paper formats; Concepts of blocks, attributes; Creating three dimensional models: geometric principles and parametrical type engineering principles based on characteristics, techniques of sketching and constraining drawings, forms generation space.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
English 1	LE01	2	1	1		

Course description (Syllabus): Introduction & Objectives; Classification of verbs; Tenses of the indicative mood; Tenses Seminar: Electrical and electronics engineering ; Careers in electronics; Electronics; Verb and Verb phrase

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Physical Training I	EFO1	1	-	1		

Course description (Syllabus): Techniques with and without the ball, football and / or basketball; Individual and collective tactical actions in attack and defense in football and / or basketball; Exercises and effective learning complex structures, strengthening and perfecting the game of football and / or basketball; Technical structures in collaboration between 2-3 players in attack and defense in football and / or basketball; Acquiring rules of the game of football and / or basketball; Two teams match 5 x 5 and / or 3 x 3.

1st Year - 2nd Semester

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Special Mathematics	ETT1207	4	2	1	-	-

Course description (Syllabus): Differential Equations (Mathematical methods which lead to differential equations, Equations of the first order and degree. Cauchy Problem. Existence and uniqueness Theorem, Separation variables. The homogeneous type. Linear equations. Bernoulli equations. Exact equations. Integrating factors. Linear equations

of higher degree, with variable coefficients and with constant coefficients); Differential systems (Linear systems with constant coefficients, Prime integral. Symmetric systems. Stability Theory. Basic concept. Stability of linear and non-linear systems); Complex Functions (Complex number. Complex plane. Sequences. Series. Elementary functions. Continuity, derivability, Cauchy-Riemann conditions. Complex Integral. Cauchy's Integral Formulas. Taylor and Laurent series. Residues. Applications); Laplace Transform (Definition, properties and theorems. Inverse of the Laplace Transform. Applications in solving differential and integral equations). Fourier series (Basic results on Fourier series. Fourier Transform. Applications.) Z – Transform (Basic results and applications)

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
The Equations of Mathematical Physics	ETTI208	6	3	2	-	-

Course description (Syllabus): Fundamental equations of the electromagnetic field. Functions and eigenvalues for the Laplace operator. Wave propagation equation. Boundary and initial conditions. Equations with separable variables. Homogeneous and inhomogeneous equations. Fourier's method. Higher order differential equations. Operational method. Nonlinear equations. Nonlinear circuit applications. Applications of derivatives. Gradient Operators. Divergence. Rotor. Models for capacitors, coils, dc motors, etc. Equations with partial derivatives of second order. Equation of heat propagation. Boundary and initial conditions.

Seminar: Applications and examples of linear algebra. Systems of linear equations. Incompatible equation systems. Comprehensive applications and examples. Calculation of electrical quantities. Applications for solving nonlinear equations. Graphic method. Solving differential equations from electronic circuits in transient mode (direct integration method, spectral analysis method, Duhamel integral, operational method). Checking Kirchhoff's formulas. Applications and examples of derivative calculations. Use of the oscilloscope for practical demonstrations. Applications of derivative calculation for error propagation. Determination of some parameters using the slope method - application in the laboratory

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Basics of Electrotechnics	ETTI209	4	2	1	-	-

Course description (Syllabus): Introduction: mathematical models and methods, phenomena, applications; Electrostatics - charge, force, field, potential, voltage; Electrodynamics: principles and relations; Electromagnetic fields. Maxwell equations - the vector field formalism; Electromagnetic waves. Propagation - media and modes; Lumped and distributed circuit elements; Kirchhoff's laws; DC and AC circuits with discrete circuit elements; Laws and theorems for the functioning of electrical apparatus and machines.

Seminar: Lumped and distributed circuit elements; Kirchhoff's laws; DC and AC circuits with discrete circuit elements.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Theory of Probabilities and Mathematical Statistics	ETTI210	4	2	1	-	-

Course description (Syllabus) – main issues; Probability field; Probabilistic schemes; Random variables; Numerical characteristics of random variables; Random vectors; Characteristic function; Theory of selection. Selection. Mean data distribution and selection dispersions; Theory of estimates; Methods for estimates determination; Testing statistical hypothesis.

Seminar: The topics of the lectures are taken again in the form of practical examples. Also, are exposed details and completions for topics of the lectures.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Physics	ETTI211	6	3	1	1	-

Course description (Syllabus): Oscillations and waves; Electromagnetism; Electromagnetic waves. Optics; Notions of quantum mechanics and physics of the atom; Solid State Physics and Semiconductor; Semiconductors at thermal equilibrium.

Laboratory: The topics of the lectures are taken again in the form of practical examples in different laboratories rooms: laboratory of electricity, laboratory of optics, laboratory of atomic and molecular physics, laboratory of solid state physics

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Object Oriented Programming	ETT1212	4	2	-	2	-

Course description (Syllabus): Classes. Data abstraction; Operators overloading; Class inheritance; Polymorphism; Class templates; Standard Template Library; Processing strings; Standard C ++.

Laboratory: The structure of a C++ class; Class constructor, getter and setter functions; Constructors using arguments with default values; Composition of classes; Operators overloading; Class inheritance; Constructors and destructors; Virtual functions and polymorphism; Class Templates; Standard Template Library; Consolidation.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
English 2	LE02	2	1	1		

Course description (Syllabus): Electronic components; Analogue and digital electronic circuits; Telecommunications; Telecommunications operation principles; Communication networks; Telecommunications systems; Data transmission and computer networks.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Physical Training 2	EF02	1	-	1		

Course description (Syllabus): Technical basic liaison steps and aerobic; Technical structures for labor education and elasticity of muscle; Technical education structures joint mobility; Methodical and practical skills composing and teaching an aerobics maintenance complex; Methodical and practical skills to compose a set aerobic sports; Skills and habits related to the use of methods in educating motive bodybuilders; Skills related to correct body attitude, and correcting poor attitudes.

2nd Year - 1st Semester

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Measurements in electronics and telecommunications	ETT1301	5	2	0	1	0

Course description (Syllabus): **Basics of Measurements:** accuracy, precision, resolution, reliability, repeatability, validity; Sensors and Actuators, Signals and measurement; **Bridge Measurement:** DC bridges; **Electronic Instruments for Measuring Basic Parameters:** Amplified DC meter, AC Voltmeter; **USB instrumentation;** Remote laboratories and modules. **Circuit general laws and devices;** Quadripoles; Signal amplifiers; **Measurements methods;** **Oscilloscope measurement Techniques;** Special Oscilloscopes – Storage Oscilloscope, Sampling Oscilloscope; Signal Generators. Signal Analysis: Wave Analyzer, Spectrum Analyzer. **Frequency Counters:** Simple Frequency Counter; **Digital Data Acquisition System;** Interfacing transducers to Electronics Control and Measuring System. **Introduction to Computer-Controlled Test Systems.:** IEEE-488 GPIB Bus; LXI systems. Synthetic instruments. Laboratory: Introduction to measurements and measuring methods; Practical skills with measuring equipment and systems; Computer-aided measurement systems.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Signals and Systems I	ETTI302	6	3	2	1	0

Course description (Syllabus): Fourier analysis of signals; Sampling; Random variables (probabilities, random variables, probability density functions, cumulative distribution functions, distributions, statistical moments); Pairs of random variables; Random signals; Signal filtering (ideal low-pass filter, ideal band-pass filter, filter design, statistical analysis of input-output dependency); Signal detection; Parameters estimation; Integral transforms (definition, properties, the Karhunen Loeve transform); Signal quantization.

Seminar: Fourier series; Fourier transform for signals of interest; Properties of Fourier transform; Continuous random variables; Discrete random variables; Theorem of mean; Pairs of random variables; Random processes; The Wiener-Khinchin theorem; Signal filtering (convolution theorem); Signal detection; Parameter estimation.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Electronic Devices	ETTI303	6	3	2	1	-

Course description (Syllabus): Functional introduction in electronic devices - Simple models and applications; Elements of semiconductor physics; Diodes; Bipolar transistors; Field effect transistors; Optoelectronic devices; Multi-junction devices; Miller theorem; Methods of open-circuit and short-circuit time-constants

Seminar: Introduction – main concepts of electrical engineering applied to electronics – voltage divider rule / current divider rule; Thevenin equivalence; Norton equivalence; Problems – applications of electronic devices, on various models and equivalent schemas, in DC & AC (small signal) calculation of simple circuits with two-ports.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
JAVA Programming	ETTI304	5	2	-	2	-

Course description (Syllabus): Introduction; The JVM mechanism; Java and OOP; Collections; I/O for Java; Threads; Applets; Graphical user interfaces; Communication with Data Bases in Java.

Laboratory: Applets development; GUI development.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Applied Informatics II	ETTI305	3	2	-	-	-

Course description (Syllabus): Computer systems architecture. Computer networks. Operating systems. Collaborative platforms and cloud computing for application development Getting started with embedded systems and their programming Introduction to Visual Programming. History, strategies in visual programming, classification of visual programming languages. Examples of visual programming languages. Arduino platform. Platform programming. Arduino Web Editor, Arduino Desktop IDE, Arduino Snap!

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
English Language III	LE03	2	1	1	0	0

Course description (Syllabus): Websites. Language work: Giving advice. Reading: Understanding the writer's purpose; Interview: Webpage Creator. Word study: definitions and collocations; Communications Systems; Computing Support. Diagnosing a fault and giving advice on technical problems.

Seminar: Exchanging information. Evaluating; Exchanging information. Advising; Exchanging information to complete a diagram. Describing a system.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
CAD Techniques in the Design of Electronic Modules	ETTI306	3	1	-	2	-

Course description (Syllabus): Computer-Aided Design and the OrCAD Design Suite; Printed Circuit Board Fabrication; Project Setup and Design in Capture; Using PSpice to Simulate the Circuit; Designing the PCB with Layout; Postprocessing and Board Fabrication
 Laboratory: Project Setup and Design in Capture

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Spice Models	ETTI307	3	1	-	2	-

Course description (Syllabus): Creating a Circuit Design with Capture; Understanding the SPICE Models Description; Using PSpice to Simulate the Circuit; Making and Editing Capture Parts; Importing the Design into Layout; Making and Editing Layout Footprints

Laboratory: Drawing circuits using OrCAD Capture; DC Analysis; Transient Analysis; Frequency Analysis; Load an existing project and editing circuits; Circuits preparation for making PCB; Automatic routing; Creating and editing a symbol; Creating and editing a footprint; Associate SPICE models to created symbols

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Physical Training 3	EF03	1	-	1		

Course description (Syllabus): Game without the ball and foot hitting the ball; Mini football; Dispossess the opponent's ball, protect the ball and head hitting the ball; Strengthening specific techniques in volleyball game; Elementary collective tactical combinations in the game of volleyball; Two teams match 5 x 5 and / or 3 x 3

2nd Year – 2nd Semester

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Fundamental Electronic Circuits	ETTI408	5	2	2	1	-

Syllabus – main issues of Course and Seminar: Systemic introduction in electronic circuits (Graphs for electronic circuits analysis, Two-port matrices, Nullator-norator-nullor model and synthesis of basic amplifiers); Feed-back amplifiers (Block schematic. Sampling and comparison circuits), General formula of negative feed-back, Calculation of $A_{u, i, y, z}$ in circuits with transistors and/or op-amp-s; Oscillators (Oscillators with non-linear devices or with negative resistance; a-stable "multi-vibrator" with transistors, Harmonic oscillators; positive feed-back; Barkhausen condition; frequency-dependant two-ports; "three-points" HF oscillators); Rectifiers with semiconductor diodes– mono- and multi-phase, in bridges ; voltage multipliers; Voltage and current stabilizers– architecture ; voltage references ; error amplifiers and output adjustment ; protection circuits.

Laboratory: *manual and semi-automated measurement, local and on the remotely –accessible „Virtual Electro-Lab“ platform <http://vlab.unitbv.ro/velab>* Experimental and computer-aided study of : circuit models for main electronic device; feed-back amplifiers with transistors – basic topologies; diode rectifiers with low-pass filters; voltage stabilizers with integrated-circuits including error amplifiers, voltage references and over-current protection.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Signals and Systems II	ETTI409	6	3	2	1	-

Syllabus – main issues of Course and Seminar: Ideal models for analogic components, uni-ports and two-ports; Graphs (Topologic analysis of circuits - linear oriented graphs; Flow graphs - Mason); Multi-port (" n – port ") circuits (Matrix analysis of two-ports; Models of propagation and reflection in telecom two-ports; image parameters and work parameters, composed attenuation; Bartlett theorem; division theorem; Synthesis of analog linear circuits; realizability; positive-real functions of energy; passive imittance (Synthesis of passive uni- / two- ports: LC, RC (RL), RLC – Foster and Cauer methods; Synthesis of active circuits; the nullator-norator-nullor model; synthesis of amplifiers, negative impedance converters, gyrators; Switched capacitors); Approximation methods and synthesis of

Butterworth, Cebyshev, Bessel and elliptic filters ; Analysis and synthesis of numeric linear circuits: numeric filters; dividers with combinational feedback ; coders and sequence generators

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Analog Integrated Circuits	ETTI410	6	3	2	2	-

Course description (Syllabus): Ideal operational amplifier (op amp); Real op amp analyzed in DC and very low frequency; The internal structure of the op amp; Static limitations of the op amp: Dynamic limitations of the op amp: Stability of negative feedback circuits: Circuits with resistive feedback network: Active filters: Single-supply op amp: Nonlinear circuits.

Seminar and laboratory: Ideal op amp; Real op amp analyzed in DC and very low frequency; Static and dynamic limitations of the op amp; Stability of negative feedback circuits; Circuits with resistive feedback network; Active filters; Single-supply op amp

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Digital Integrated Circuits	ETTI411	7	3	2	2	-

Course description (Syllabus): Boolean Algebra; Combinatorial Logic Circuits; Sequential Logic Cicuits: Logic Design Seminar and laboratory: Exercises and practical work based on course curricula.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
English Language 4	LE04	2	1	1	-	-

Course description (Syllabus): Data Security 1. Cause and effect. Causative verbs. Reading: scanning; Data Security 2. Reading a table. Cause and effect using *allow* and *prevent* links; Interview: The ex-hacker. Phrasal verbs. Word study: semantic groups.

Seminar: Information transfer from telephone call to form. Reporting a problem; Explaining a computer crime. Exchanging information; Describing how a system operates. Exchanging explanations; Role play based on prompts. Writing a short news item . Making a flow chart.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Physical Training 4	EF04	1	-	1		

Course description (Syllabus): Techniques for running and jumping exercises; Techniques for speed running speed; Technique of resistance running in varied terrain; Techniques of jumps; Organizing and participating in athletic competitions

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Practical Placement	ETTI412	4	90 hours			

Course description (Syllabus) – main issues- Laboratory: Aspects of safety and health in practice activities; Soldering technology; Technology of printed circuit board; Small signal bipolar transistor amplifier; Adjustable power source; Dual power source; Virtual implementation using open-source software FRITZING; Resistors colour-coding.

3rd Year - 1st Semester

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Software for Telecommunications	TST.5.01	4	2	-	2	-

Course description (Syllabus): Introduction - evolution of software development in telecom (from proprietary, monolithic applications, to microservices). Cloud Computing architecture and design models. Service oriented architectures. REST services. API development and management. Microservices. Linux containers (Docker). Services for the Internet of Things (IoT) and specific communication protocols (MQTT).

Laboratory work: Installation environment for development (Eclipse, Java, Spring Boot). Accommodation with the Spring Boot software platform (Java). Implementation of an application based on the client-server model. Development of REST services. Using Linux containers. Implementation of IoT services using the MQTT protocol.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Microcontrollers	TST.5.02	5	2	-	2	1

Course description (Syllabus): Introduction into microcontrollers architecture. Instruction set architecture. General purpose processors – Organization and operation. Control units. Pipelining. Memory. Timers. Interfaces.

Laboratory work on: Addressing modes ; Stack-memories ; Pipelining – hazard analysis / prevention ; I/O transfer modes ; Microcontroller-registers with functions.

Project: implementation of a microcontroller-based system using the lab development boards and emulators. The implemented system will use a minimum of 3 peripheral functions of the development board (eg parallel controller, keyboard, 7-segment display), counter, PIO and memory.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Antennas, Lines and Propagation	TST.5.03	5	3	-	2	-

Course description (Syllabus): Propagation of electromagnetic waves. Propagation in wave-guides with TE, TM & TEM modes. Transmission of power through lines and guides. Antennas; Antennas networks. Microwave passive and active components and circuits . Microwave network parameters.

Laboratory works on: open-space propagation parameters ; transmission lines parameters ; wave-guides parameters ; characterisation of antennas ; experiments on antenna-guide transmission.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Modulation and Demodulation of Signals	TST.5.04	5	2	-	2	-

Course description (Syllabus): Introduction in mo-dem for telecom. Communications with linear modulation. Phase modulation (exponential modulation). Digital modulation - ASK, FSK, MSK, GMSK, PSK & QAM. Pulse modulation - PAM, PWM/PPM, PCM, Delta. Multiple access technologies - FDMA, TDMA & CDMA.

Laboratory works on: Heterodyne transceivers – AM – DS, SS ; FM. Transmission chains with digital modulation. Transmission chains with pulse modulation.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Circuit- Packet- and Service- Switching	TST.5.05	5	2	-	2	

Course description (Syllabus): Introduction. The evolution of telecommunications technologies and services. Modeling of systems with waiting times. Protocols for flow control. Errors' control. Networking topologies. Layered architectures for telecommunications networks. 4. Switching function in telecommunications networks. Circuit switching. The main characteristics of primary multiplex PCM 30/32. Identification of the channels. Methods of access to multiplexed support. Circuit switching. Switching via multiplexed bus. Temporal switching. Message switching. Packet switching. The complete structure of a packet: data, address, sequence checking, error indicators, etc. Universal networks for a better range of services: speed; concentration of transport functions at the ends of the network; adaptability to new services; optimal distribution of resources between all services; standard operating; efficient use of the frequency bands. Routing techniques. Fixed routing, routing through flooding, adaptive, isolated. ATM networks. interfaces, cell structure, virtual connections, service classes, reference model. Synchronous digital

hierarchy (SDH). SDH networks - levels, architecture, interfaces and basic concepts, concatenation of virtual containers. Signaling system #7. Architecture, types of connections, SS7 protocol layers, message structures, level 4 protocols. INAP. Architecture, the relationship between SCF-SSF, SRF, SDF, INAP protocol, evolution, interaction between ISUP and INAP, INAP and SIP

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Audio engineering	TST.5.06	3	0	0	0	2

Project (Syllabus) – main issues: Design of an analog audio frequency signal processing system based on an amplifier with high-input impedance; Designing of an amplifier with NAB or RIAA correction; Analog mixer design; Tone correction or graphic Equalizer circuit design; Designing the PCB of the operational amplifiers: SPICE simulation and PCB designing using OrCAD Layout.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Virtual Instrumentation	TST.5.07	3	2	0	1	0

Course description (Syllabus):

MEASUREMENT SYSTEMS – analog systems – digital systems. DATA ACQUISITION – Data acquisition boards – Serial ports: RS-232, USB – Parallel ports: IEEE-1284 – GPIB standard IEEE-488.2. VIRTUAL INSTRUMENTATION IN LABVIEW – Introduction (Front Panel, Block Diagram) – Data Types, Operators – Instructions – Graphics. Simulation of the resistor, capacitor and inductor operation; Simulation of some ADCs; Simulation of some DACs; Saving and restoring the signals. Signal fitting; Virtual instrumentations: functions generator, periodic signal measurements, spectral analyzer; Acquisitions and commands with NI modules.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Sensor Networks	TST.5.08	3	2	0	1	0

Course description (Syllabus): Smart sensors fundamentals: Basic sensor technology Sensor systems; Smart sensors definitions; Smart sensors: Characteristics; Smart sensors architectures; Smart sensors buses and interfaces; Smart sensors software; Data acquisition methods for smart sensors; Virtual sensor systems; Smart sensors for electrical and non-electrical variables; Sensor networks architectures: Single node architecture; Multi node architectures; Design principles; Energy efficient topologies; Wired sensor networks and wireless sensor networks; Applications; Communication protocols: Physical layer; MAC protocols; Link layer protocols; Localization and positioning; Routing protocols; Transport layer; Data gathering and processing: Protocols for gather information; Data processing techniques; Energy management: Energy consumption of sensor nodes; Techniques for reducing consumption and communication energy; Energy aware routing; Security, reliability and fault-tolerance: Security and privacy protection; Reliability support; Fault-tolerance; Sensor networks standards;

3rd Year - 2nd Semester

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Transmission of Information Theory	TST.6.09	5	2	1	2	-

Course description (Syllabus): Transmission of information; mathematical foundations. Measurements for information, Entropy, Information sources. Markov sources. Information transmission channels, channel capacity. Codes for noiseless channels, Compact codes. Shannon theorem. Huffman codes. Noisy channel coding. Linear codes, group codes, cyclic codes, convolutional codes.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Operating Systems	TST.6.10	4	2	-	2	-

Course description (Syllabus): Introduction: what is an operating system, history of operating systems, basic concepts of operating systems, processes, files, system calls, shell, operating system structure, monolithic systems, layered systems. Processes: process implementation, inter-process communication, race conditions, critical sections, mutual exclusion, semaphores, event counters, monitors, classic IPC problems, process scheduling, scheduling policy and mechanism, threads. Memory management: memory management without swapping and paging, with swapping, memory management with bitmaps, buddy systems, space allocation for swapping, virtual memory, paging, page tables, paging algorithms, paging policies, segmentation, combining segmentation and paging. File system: files, file names, file structure, file types, file attributes, file operations, implementation of file systems, files and directories, shared files, file system reliability, performance and security. I/O devices: device controllers, DMA access, I/O software, device drivers, hard-disks, disk scheduling algorithms. Operating systems security considerations: viruses, worms, generic attacks, mechanisms and methods for protection.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Digital Signal Processing	TST.6.11	4	2	1	2	-

Course description (Syllabus): Signals and signal processing. Time representation of discrete signals. Frequency representation of discrete signals and systems. Digital filters. Digital signal processors: properties, architectures, DSP classes. Linear and nonlinear operators for image enhancement, histogram equalization, smoothing filters, JPEG compression.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Networks Architecture & Internet	TST.6.12	5	2	1	2	-

Course description (Syllabus): Internet components, network core. Computer network classification. Standards (ISO-OSI, Internet models). Network devices. Data link layer - general aspects ; errors control. Medium access sublayer. Aloha, CSMA/CD, Ethernet. Data link layer switching, VLANs. Network layer. Routing in the Internet. Routers architecture. Transport layer - multiplexing/demultiplexing.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Telephony and Streaming Systems	TST.6.13	4	2	-	2	1

Course description (Syllabus): Introduction in telephony. Basics of PCM for telephony Digital transmissions on copper and optic-fiber lines. DSL technologies. ISDN - architecture, network access, services. PBX - the role of the network architecture, classification, connections, evolution. Switching methods - Circuit switching in telephone networks. Packet switching in telephony - connection (non-/) orientation ; virtual circuit switching. ATM concepts - datagram routing ; switching hardware. Switching of packet flows – Streaming (OSI layered): P2P protocols, sliding window protocols, ARQ, Stop & Wait, Go Back N, SRP, data link protocols - HDLC, PPP. Switching in IP environment - interconnection of IP communication protocols, fragmentation and reassembly of datagrams, global addressing, subnets, TCP-IP reference model, RTP and RTCP protocols, Voice over IP, QoS - requirements, models, real-time services.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Measurement in RF and microwaves	TST.6.14	4	2	-	2	1

Course description (Syllabus): Introduction in the measurement of signals. Signal levels measurement. Signals shape measurement. Spectral analysis of signals. Measurement on signal transfer circuits. Measuring linear circuits for microwaves: Junctions and terminations. Determination of the properties of T and double T junctions. Measurement of

the quadripole equivalent parameters for junctions without and with losses. Measurement of electromagnetic resonators. Measurement of the circuit elements and devices for microwaves. Characterization of electronic tubes for microwaves: Reflex clistron. Magnetron. The tube with progressive wave. Characterization of the semiconductor devices for microwaves: tunnel diode, varactor, Gunn, IMPATT, microwave transistors. Analysis of amplifiers and multi-frequency multipliers. Parametric amplifier with upper and lower converters. The noise of the parametric amplifier. Characterization of the frequency multipliers. Multiplication circuits.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Artificial Intelligence	TST.6.15	4	2	-	2	1

Course description (Syllabus): Preliminaries in neural computing; Fundamental concepts; The perceptron; Feedforward neural networks; Feedback neural networks; Associative memories; Self-organizing neural networks; Radial basis function neural networks; Fuzzy neural networks; Genetic algorithms.

Laboratory: The implementation of the learning rules; The training algorithm of a perceptron; The „Backpropagation of error“ training algorithm; The „Winner takes all“ training algorithm; Training the fuzzy neural networks; The implementation of a genetic algorithm; Homeworks.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Databases	TST.6.16	4	2	-	2	1

Course description (Syllabus): Data Bases (DB) - Fundamental concepts. Utility. Data independence. Fundamental objectives of telecom DB. DB Management Systems (DBMS). DB environment – DB architecture with 3 levels. DB languages. Conceptual data modeling. Functions and components of a DBMS. Multiuser architectures. The system catalog. Relational data models - Terminology. Relational integrity. Relational languages. Relational DBMS. SQL. Normalization of relations - The purpose of normalization. Functional dependencies. Normalization process - relationship breakdown schemes. 1st, 2nd and 3rd normal forms. Boyce-Codd Normal Form (BCNF). 4th normal form . Concurrent operations on telecom DB

Course title	Code	No. of credits	Number of hours per week			
Practical Placement	TST.6.17	4	3 weeks x 30 hours			

Course description (Syllabus): Electronic technology – handling, (dis-/) mounting components and devices. Testing and measurement - parameters of electronic components and devices. Office equipment: Personal computers, printers, copiers – functionality, characteristics, operation, manipulation, maintenance; Enterprise telephone switches - manipulation, transferring and recording messages. Computer Networks: configuration, assembly, verification and testing, software integration, wireless networks administration. Software used in communications: management and administration, process control, testing. Assistance and contributions to host company communications projects and Internet services administration.

4th Year - 1st Semester

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Terrestrial and Space Radio-Communications	TST.7.01	3	2	-	1	-

Course description (Syllabus): Generalities: Comparison of terrestrial / space communications, Electromagnetic spectrum and frequency band allocation, Radiocommunication services. Noises, Interferences and Inter-modulations Noise of a communications system: Temperature and noise factor, Noise temperature of a network, Antenna noise temperature), Noise colours. Interference in radiocommunication systems: The interference of two unmodulated signals / of two MF signals. Intermodulation in radiocommunication systems: Intermodulation in the base band and in the radio frequency band. Procedures for reducing the effects of noise. Energy balance of the transmitter-receiver

links: Equation of the link balance (with passive or active intermediate station), Signal / noise temperature ratio. The principles of distributed spectrum communications. Direct sequence spectrum distribution (DSSS), frequency hopping (FHSS), Fundamental techniques and advanced coding techniques, Code tracking procedures Terrestrial communications by radiorele: The principle of radio-relays, Classification, General technical characteristics, Obtaining the channels for a radio-relay line. Structure of a RR line, Terminal Stations, Intermediate Stations. The TETRA radio system: The principles of trunked radio. Services offered, Working modes, Modulations, data structure and synchronization of mobile stations based on TETRA systems. Principles of satellite communications. Operation of satellite communication systems, Particularities, Coverage area and satellite networks, Components of a satellite communication system. Orbits and constellations. Kepler's Laws and Newton's Improvements, VanAllen Centers, Types of Orbits, Satellite Orbits and Orbital Errors, Mission Planning, Orbit. The satellite. Satellite Geometry, Satellite Launching, Stabilization and Maintenance of Position, Transponder Component Blocks, Message Security, Onboard Processing and Switching Systems. Ground stations. Basic structure, Design considerations. Geo-communications satellites and their applications. Frequency spectrum, Types of applications (TV and video services, Air and cable TV, DTH, Trends in satellite voice communications, Digital information services, Mobile and personal communications).

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Television	TST.7.02	5	2	-	2	-

Course description (Syllabus): Principles of radio-TV communications: links, frequency bandwidth and services, domains and transmission bands for analog and digital broadcasting. Analog & digital receivers and their parameters. Image information transmission; transmission of TV signals – standards and transition to digital broadcasting (DVB-T and DAB-T). Image capture, processing and playback in TV: integrated video-capture devices, devices for image playback - CRT (Trinitron), LCD and Plasma. The TV raster. The TV complex signal: image decomposition and formation of the television signal, TV signal spectrum, TV spectrum limits, structure of the video-complex signal. Principles of color TV: colorimetry; compatibility of TV systems. PAL and SECAM. Modern television systems: digital TV, high definition TV, cable TV, 3D TV. Predictive co-dec systems, digitizing of analog signals and serialization of data flows. The MPEG principles. Digital transmission of signals – the ITR-R BT 601 standard. Processing and transmission of mono and stereo sound - NICAM-728. Digital terrestrial transmission with OFDM modulation: local terrestrial transmission; DVB-T – standard; system parameters. 3D TV.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Telecommunications Software Project	TST.7.03	4	-	-	-	3

Course description (Syllabus): Cloud Computing - the foundation of digital transformation: establishing the Cloud Computing implementation model; choosing the roles and mode of interaction in Cloud Computing. Realization of the Cloud architecture of the system: defining the functional requirements of the designed service system; design of the service oriented architecture; definition of the solution based on microservices; the MVC perspective, MVP 6. Life cycle management in the development of telecommunications services: choosing the software development model (V model, cascade model, Agile model). Implementation of DevOps techniques (continuous development and delivery) focused on quality. Development of REST services: the use of Spring Boot for service development; Docker microservices containerization; orchestrating Web Services in the Cloud (Kubernetes). System integration and testing (component - module - system): monitoring the service system and infrastructure in the eBusiness perspective.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Computer Networks	TST.7.04	6	2	-	2	1

Course description (Syllabus): (focusing on Protocols and Security): IPv4 and IPv6. IP subnetting, IP supernetting. ARP. Addresses assigning in the network - DHCP. UDP, TCP. CSMA/CA protocols, 802.11 WLANs. Application layer, DNS, HTTP. Case study: a day in the life of a web-page request. Practical works - Wireshark ; IXIA "optixia XM2" - IP Performance Tester, full IP protocol simulation / protocol synthesis based on IXNetwork (L2,L3) and IXLoad (L4-L7)

software licences - signaling, data transfer and multimedia streaming complex scenarios. Network security solutions - firewalls, VPNs, Intrusion Detection, and filters. Internet Protocol Security - the IPsec suite. TLS (Transport Layer Security). SSH (Secure Shell). ESP (Encapsulating Security Payload). Tunnelling. Cyber-attacks and specific measures - case study: denial of service. OpenSSL. Secure Authentication - Kerberos.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Programming in the Internet	TST.7.05	5	2	-	2	1

Course description (Syllabus): Introduction to Web Applications: concepts of dynamic and static web pages, applications, client-based and server based. Programming Languages for Web Applications: Introduction to PERL, CGI, Python, JavaScript, PHP. PHP: Writing PHP programs. Data Types. Constants and conversions. Blocks decision. Cycles and repetitive structures. Functions and Objects. Working with files. Errors in PHP. PHP and MySQL: Basic Concepts, interleaving PHP and MySQL. Data retrieval and manipulation. Web Applications - search engines: Operating principles. Implementation and use. Security of web applications: Principles of cryptography. Open-key coding of. Digital Signatures. Safety certificates. Web 2.0: Groupware. P2P networks. Social tagging - social networking. NodeJS - Programming of the communication with Google API (using AJAX & JSON).

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Studio Equipment and Multimedia	TST.7.06	5	2	-	2	1

Course description (Syllabus): SEM - overview: characteristics, parameters. Principles of complex color video signal processing (analog/digital) on various supports (magnetic and optical - CD, DVD, BluRay). Servo-systems and main controls in SEM. Image processing and compression in SEM: color patterns, BW and grayscale image compression (RLE, BTS, Huffman). Compression of color images (TIFF, JPEG, JPEG2000). Image Processing. Compression and processing of sound: Sound digitizing. Sampling and quantization. Audio file formats. Lossless audio compression. Psychoacoustics and lossy audio compression. Multi-channel sound. Compression and processing of video sequences: H263, H264, MPEG1-7. Multimedia devices: Image sensors, audio input and output devices, SD and HD TV. Magnetic memories. Random Access Memories. Media Servers: Specific issues compared to traditional servers. Scheduling algorithms and disk access for media servers.

Laboratory work: Sound processing software - WAV Files - Sound compression - Processing sound; Image processing software - File formats - Vector and raster graphics - Image compression; Video processing software - File formats - Video compression ; Multimedia authoring software.

Project: Development of an interactive audio- video solution.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Integrated structures for specific applications	TST.7.07	5	2	-	2	1

Course description (Syllabus): Integration of hardware architectures in distributed systems. Service-oriented integration of resources: processing / storage / sensing / communication. SOA - service-oriented architectures. Design-flow of digital solutions: high-level synthesis / simulation / placing & routing. SoC - Systems on Chip. The embedded software sub-system. integration of afor distributed systems. Reconfigurable hardware - PLA/PLD, FPGA, ASIC, structured ASIC. Dynamic reconfiguration. Synergy of reconfigurable systems with ubiquitous and distributed computing. Hardware acceleration of services. Processes-tasks management. Integrating communications at cloud/board/chip levels. On-chip bus and crossbar. Network-on-Chip. Single Chip Cloud Computer. Embedded security. Cellular automata - hybrid & reversible. Case-studies: embedded servers / embedded Ethernet modules.

Practical work: Use of MATLAB Communications System Toolbox for modelling and testing radio communications using SDR - RTL and / or USRP. Manipulation and creation of basic IP core blocks: filters, DDC (Digital Downconverter), DDS (Direct Digital Synthesizer) digital sequence synthesizer, channel emulator (Gaussian noise addition, fading phenomenon), modular demodulation (BPSK, QPSK (4-QAM), 8-PSK, 16-PSK, DBPSK, DQPSK, D8PSK, D16PSK, QAM-

16, QAM-64, QAM256, -QPSK, -8-PSK, -DQPSK, -D8PSK, OAM, OFDM); PLL loops. Software Defined Radio (SDR) subsystems. The ASIC (VLSI) approach.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Operating Systems for Mobile Platforms	TST.7.08	5	2	-	2	1

Course description (Syllabus): Introduction: mobile computing versus mobile communications - Mobile applications industry. Mobile applications (APPS paradigm) and their development: native development (iOS, Android) ; cross-platform development (React Native, Ionic) ; responsive apps ; progressive web applications (PWA) ; development languages and utilities. Repositories (Git etc) and technology (Node.js, JavaScript). JavaScript as a development language. Introduction to Ionic as a development platform for hybrid applications. Designing the interfaces for mobile applications. System architectures and mobile application integration. Styling mobile applications: CSS, Bootstrap, responsiveness / reactivity. Testing mobile applications. Communication with data services. Development of data services (Backend): integration of SLQ, NO-SQL databases ; connection to IoT devices. Integration with third party "apps": Diversity Management - Mobile Platforms (Android Wear, Andoid Auto & Android Smartphome). Mobile application monetization.

4th Year - 2nd Semester

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Optical Communications	TST.8.09	3	2	-	1	-

Course description (Syllabus): Introduction: The elements of an optical connection;; Measurement of the attenuation; Modelling and simulation of optical communication systems. Behaviour of light: Dual nature; Reflection and Refraction; Refractive index; Diffraction and Interference; Polarization of light. Optical fibers: the advantages of use; applications; Light propagation in optical fibers; Propagation modes; Single-mode and Multimode Optical Fibers; Attenuation - Transmission windows; dispersion; Optical fiber standardization; Fiber optic cables. Light sources. Optical Transmitters: Light sources - general characteristics; L.E.D. sites; LASER diode; Optical transmitters; External modulators. Optical Receivers: Photodetectors - Features; Photodiode pin; Avalanche photodiode; Optical receivers - structures, characteristics. Passive / Active Optical Components: Connecting the optical components; couplers; insulation; circulation; Optical filters; Grating / MEMS technology; Variable optical attenuators; Tunable optical filters; Dynamic Gain Equalizers; Optical multiplexers; Polarization controllers; Chromatic dispersion compensators. Optical Amplifiers: Semiconductor optical amplifiers; Erbium doped fiber amp lifiers (EDFA); Raman amplifiers. Information transfer: Multiplexing of signals; TDM; SONET / SDH; WDM - operational principles; DWDM and CWDM standards. Design of the optical connection: System considerations; Power budget analysis; Information carrying capacity; Line coding; Modulation schemes - OOK, PPM; Applications. 10. Unguided Optical Communications: Transmission Parameters; System structure; Inter-satellite communication; Security requirements.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Mobile Communications	TST.8.10	5	3	-	2	-

Course description (Syllabus): Cellular architectures. Cellular systems optimization: zoning, division and sectorization. Cellular systems extension depending on traffic. Radio channel received power; estimations, averaging. Wireless communications channel electromagnetic effects: multipath, edge. Cellular systems noise and perturbations analysis. Noise effects eliminations possibilities. Mobile radio channel fading ; fading models. GSM introduction. GSM channels; GSM fixed network; signaling. GSM identifiers; RR, CM and MM procedures. GPRS: introduction, architecture, identifiers, logical channels. Spread spectrum communications principles: CDMA properties, DSSS and FHSS. UMTS. 4G introduction.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Software Engineering Applied in Data Communications	TST.8.11	3	2	-	0	1

Course description (Syllabus): Elements regarding the general theory of the systems. Information systems. Information flows. Information systems with automated components. The concept of methodology. The UML modeling language. Introduction to the ICT project management. Tools that assist the UML development of a problem's solution. The presentation of the tool Visual Paradigm for UML.

Laboratory: The structure and requirements regarding the documentation of a software system. The Visual Paradigm approach. An example of how users' requirements for a software system are identified and specified. An example of how an information system capable of computerization / optimization is implemented. Example of how the solution design for the software system related to the chosen theme is realized. Software system architecture. Visual Paradigm Perspective: Subsystems / Packages / Components / Nodes Diagrams. Detailed design. Visual Paradigm perspective (Class / object diagrams, other types of diagrams). Development of the individual theme. Iteration 1: Problem statement, application objectives, non-functional requirements. Iteration 2: Capture the functional requirements of users using use-case diagrams. Individual project development. Iteration 3: Class diagram / diagrams for the individual application.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Integration of Telecommunication and Computing Systems	TST.8.12	4	2	-	1	1

Course description (Syllabus): Soft-Switching in convergent networks. R4 softswitch architecture - case study UMTS 3GPP. The MEGACO protocol. Voice over IP - components of a VoIP network. SIP - Session Initiation Protocol. The H323 standard. Bandwidth allocation for SIP mobility. TDM to IP migration - channel capacity issues. IN - Intelligent Networks for telecom. IMS - IP Multimedia Subsystem of IN. IMS for all-IP LTE pentru rețele mobile networks. Open-source IMS. ATCA (Advanced Telecom and Computing Architectures). The PICMG standard. Case study - the AdvancedTCA 40G platform and the Broadcom/NetLogic XLR732 XLR732 packet processors. TMN - Telecommunications Management Networks. CMIP - Common Management Information Protocols. IPFIX - Internet Protocol Flow Information eXport. NETCONF - Network Configuration Protocol. Solutions for networks management: Net-SNMP, OpenNMS, Nagios, HP OpenView, IBM Tivoli. SNMP - Simple Network Management Protocol; architecture and specific data: MIB and SMI. SNMPv1, SNMPv2 / SNMPv2c, SNMPv3, SNMP4J. IP mobility in distributed environment. Mobile IPv6. PMIPv6 algorithms. Case study - mobility management in LTE networks. GTP and IETF PMIP for Evolved Packet Core networks. 3GPP to non-3GPP handover - Case study: UMTS to WiFi based on MIPv6.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Network Security	TST.8.13	3	2	-	1	-

Course description (Syllabus): **I. Introduction** 1. Need for Security 2. Security Attacks 3. Services and Mechanisms 4. Network Security **II. Symmetric Ciphers** 1. Substitution & Transposition Techniques 2. Block Cipher 3. DES 4. Triple DES 5. Stream Ciphers 6. RC4 **III. Public Key Cryptography** 1. Need and Principles of Public Key Cryptosystems 2. RSA Algorithm 3. Key Distribution and Management 4. Diffie-Hellman Key Exchange 5. Digital Signatures **IV. Authentication** 1. Authentication Requirements 2. Message Authentication Codes 3. Hashes 4. MD5 & SHA 5. User Authentication: Password, Certificate based & Biometric Authentication 6. Kerberos **V. Network Security** 1. Firewalls 2. IP Security 3. VPN 4. Intrusion Detection 5. Web Security 6. SSL 7. TLS

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
The Basics of Cryptology	TST.8.14	3	2	-	1	-

Course description (Syllabus): Overview of cryptography. One time pad and stream ciphers. Block ciphers. Pseudo Random Permutations (PRP); Pseudo Random Functions (PRF); security against chosen plaintext attacks (CPA); basic modes of operation: counter mode and CBC. Message integrity: definition and applications. CBC-MAC and PMAC. Authenticated encryption: security against active attacks. Properties and secure constructions. Digital signatures: definitions and applications. hash based signatures; certificates, certificate transparency, certificate revocation. password protocols, salts; one time passwords (S/Key and SecurID); challenge response authentication. Authenticated key exchange and SSL/TLS session setup.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
General Economy	TST.8.15	2	2	1	0	0

Course description (Syllabus): Economical context of Electronics, Communications and Information Technologies. Business - basic concepts. Business analysis and models; Business characteristics. Planning, organization, marketing; Decision and leadership in business. Business strategy; Entrepreneurship - concepts, features, tools; Entrepreneurial innovation - sources, success, failure, utility; Entrepreneurial strategies. Entrepreneurial company. Seminar: Business analysis. Porter model; Analysis of the company products and services.. The BCG model; Business strategies in conditions of certainty, risk and uncertainty; Entrepreneurial innovation. Sources of innovation opportunities; Entrepreneurial strategies.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Accomplishment of the Diploma Project	TST.8.16	4	0	2	0	4

Description (Syllabus): Documentary work on the state-of-the-art in the domain, using bibliography and web-graphy. Peer-to-peer cooperation moderated by the project coordinator - Discussions on: intellectual property, implementation costs, interest of potential beneficiaries. Drawing up the plan of the project - the Gantt diagram. Milestones - phases visas and quality checks. Modeling and simulation / emulation of specific project parts using industry-specific solutions: LabVIEW, Omnet, OpNet, GNS3, Mathcad, Matlab, Simulink, Spice, OrCAD, etc. Concept of the device / method / software / integrated system / set of measurements that will be implemented. Paperwork accomplishment: similar solutions on the market - performance and limits. Resource management: supplying the components / software needed. for the project. Design of the device / method / software, drawing diagram / organizational program / interfaces / integration procedure - TRL (technical realisation levels) model. DRC (design rules check) - verification of the schematic / program / integration method. Completing project documentation: description of the hardware or software solutions. Implementation, integration tests and validation (against initial functional specifications). Concluding the paperwork: presentation of the practical difficulties encountered and discussion of experimental results. Use-case scenarios involving the accomplished device / method / software. Conclusions, annexes and discussions on follow-up, dissemination and future research. The PowerPoint presentation of the project.

Course title	Code	No. of credits	Number of hours
Practical Activity for Preparation of the Diploma Project	TST.8.17	5	4 weeks x 30 hours

Description (Syllabus): Documentation. Elaboration of projects, operation of telecom systems. Drafting specific software. Design of network. Practical realization of communication systems. Configuration, testing and validation of complex telecom systems. Teamwork. Oral and written communication. Technical and organizational problem solving.