Universitatea Națională de Știință și Tehnologie Politehnica București

Facultatea de Electronică, Telecomunicații și Tehnologia Informației

COURSE DESCRIPTION

1. Program identification information

1.1 Higher education institution	**National University of Science and Technology Politehnica Bucharest**
1.2 Faculty	**Electronics, Telecommunications and Information Technology**
1.3 Department	**Electronic Devices, Circuits and Architectures**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Bachelor/Undergraduate
1.6 Programme of studies	Microelectronics, Optoelectronics and Nanotechnologies

2. Date despre disciplină

2.1 Course name (ro) (en)				Teoria transmisiunii informaţiei Information transmission theory			
2.2 Course Lecturer				Lecturer Dr. Cristian Constantin DAMIAN			
2.3 Instructor for practical activities				Lecturer Dr. Cristian Constantin DAMIAN			
2.4 Year of studies	3	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		D	2.9 Course code	04.D.05.O.002		2.10 Tipul de notare	Nota

3. Total estimated time (hours per semester for academic activities)

3.1 Number of hours per week	4	Out of which: 3.2 course	2	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	56	Out of which: 3.5 course	28	3.6 seminary/laboratory	28
Distribution of time:					hours
Study according to the manual, course support, bibliography and hand notes Supplemental documentation (library, electronic access resources, in the field, etc) Preparation for practical activities, homework, essays, portfolios, etc.					53
Tutoring					0
Examinations					2
Other activities (if any):					0

3.7 Total hours of individual study	69.00
3.8 Total hours per semester	125
3.9 Number of ECTS credit points	5

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Linear algebra, Probability theory and mathematical statistics, Signals and systems
4.2 Results of learning	Algebraic calculus and probabilities

5. Necessary conditions for the optimal development of teaching activities (where applicable)

5.1 Course	The course will take place in a room equipped with a video projector, internet access, and a writing board.
5.2 Seminary/ Laboratory/Project	The laboratory will take place in a room equipped with computers.

6. General objective *(Reffering to the teachers' intentions for students and to what the students will be thought during the course. It offers an idea on the position of course in the scientific domain, as well as the role it has for the study programme. The course topics, the justification of including the course in the currcula of the study programme, etc. will be described in a general manner)*

1. Acquiring the basic notions of Information Theory and the ability to use these notions in practical applications related to the transmission, processing, and storage of information, with emphasis on integrated solutions.
2. Developing skills to apply in practice the theoretical elements regarding the modeling of information sources and transmission channels.
3. Ability to evaluate, based on learned performance criteria, which error-detecting/correcting codes are applicable under specific conditions determined by channel noise level, acceptable error rate, hardware constraints, etc.

7. Competences *(Proven capacity to use knowledge, aptitudes and personal, social and/or methodological abilities in work or study situations and for personal and proffesional growth. They refflect the empolyers requirements.)*

Specific Competences	C2 - Applying basic methods for signal acquisition and processing C2.1 Characterizing signals in the time and frequency domains C2.3 Using simulation environments (Matlab) for digital signal analysis and processing C2.4 Using specific methods and tools for signal analysis C3 Applying basic knowledge, concepts, and methods regarding computer architecture, microcontrollers, and programming languages and techniques
Transversal (General) Competences	CT1 - Methodical analysis of problems encountered in activity, identifying elements for which established solutions exist, thus ensuring the fulfillment of professional tasks

8. Learning outcomes *(Synthetic descriptions for what a student will be capable of doing or showing at the completion of a course. The learning outcomes reflect the student's acomplishments and to a lesser extent the teachers' intentions. The learning outcomes inform the students of what is expected from them with respect to performance and to obtain the desired grades and ECTS points. They are defined in concise terms, using verbs similar to the examples below and indicate what will be required for evaluation. The learning outcomes will be formulated so that the correlation with the competences defined in section 7 is highlighted.)*

Knowledge	*The result of knowledge aquisition through learning. The knowledge represents the totality of facts, priciples, theories and practices for a given work or study field. They can be theoretical and/or factual.* Demonstrating knowledge and understanding of the fundamental notions of Information Theory (information, entropy, channel capacity, data compression, error detection and correction). Understanding the limits of communication systems. Demonstrating the ability to apply information theory concepts in applications from different fields.

Skills	*The capacity to apply the knowledge and use the know-how for completing tasks and solving problems. The skills are described as being cognitive (requiring the use of logical, intuitive and creative thinking) or practical (implying manual dexterity and the use of methods, materials, tools and intrumentation).* **Selects** and groups relevant information in a given context. **Uses specific principles with justification** to support results, apply coding algorithms, or dimension codes. **Experimentally verifies** identified solutions. **Solves** practical applications. **Interprets** causal relationships appropriately. **Analyzes and compares** various coding algorithms, channel models, etc. **Identifies solutions** and develops resolution plans/projects. **Formulates** conclusions for the experiments carried out. **Argues for** the identified solutions/methods of resolution.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* **Selects** suitable bibliographic sources and analyzes them. **Respects academic ethics principles,** correctly citing the bibliographic sources used. **Demonstrates openness** to new learning contexts. **Collaborates** with colleagues and teaching staff in conducting educational activities. **Demonstrates autonomy** in organizing the learning context or the problem situation to be solved. **Shows social responsibility** through active involvement in student social life/involvement in events within the academic community. **Promotes/contributes with new, domain-specific solutions** to improve the quality of social life. **Becomes aware of the value of their contribution in engineering** to identifying viable/sustainable solutions to solve problems in social and economic life (social responsibility). **Applies principles of professional ethics/deontology in analyzing the technological impact** of the proposed solutions in the specialty area on the environment. **Analyzes and leverages business opportunities**/entrepreneurial development in the specialty area. **Demonstrates** management skills for real-life situations (time management, collaboration vs. conflict).

9. Teaching techniques *(Student centric techniques will be considered. The means for students to participate in defining their own study path, the identification of eventual fallbacks and the remedial measures that will be adopted in those cases will be described.)*

In course teaching activities, systematic exposition will be used, employing a video projector and board, conversation, and problematization. At the beginning of each course, the concepts from the previous course are revisited, framing the topic within the discipline as a whole, and explaining the need and usefulness of the subject to be taught next.
Course notes, problem sets, and applications are in electronic format and are available to students. On the Moodle platform there are complementary materials—videos, demonstrations, problems. Digital courses include images and diagrams, as well as videos to facilitate students’ assimilation of information. Students are asked for feedback at the end of each course about the concepts presented; after the midterm and at the end of the semester, after the final exam, feedback is requested on the correlation of topics with the syllabus, the manner of presentation, and the availability of teaching staff to respond to their needs.
During practical activities (seminar and laboratory), the aim is to practice active listening and assertive communication skills, as well as mechanisms for constructing feedback as ways to regulate behavior in diverse situations and to adapt the pedagogical approach to students’ learning needs.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Notions of probability theory: Random experiment; Random variable; Probabilities and distributions; Conditional probabilities; Bayes' theorem; The law of total probability; Statistical independence;	2
2	Information source; Memory, stationarity, ergodicity; Markov source (definitions, state diagrams, transition matrices, memory reduction by decorrelation).	2
3	Information: Amount of information; Units of measure; Mutual information; Entropy: Definition; Properties; The binary source case; Rate and redundancy; Entropy of a Markov source; Multiple sources (joint entropies, conditional entropies, mutual information, Venn diagrams).	2
4	Source coding: Definitions and classifications; Role of source coding; Instantaneous codes; Kraft–McMillan inequality; Lower bound of the average length; Optimal codes; Capacity, efficiency, redundancy; Source extensions; Coding theorem for noiseless channels.	2
5	Entropic algorithms: Shannon–Fano–Elias; Huffman; Arithmetic coding; Applications in image compression.	4
6	Discrete information transmission channels: Definitions and classifications; Noise matrix; Graphical representation; Characteristic entropies (equivocation, average error, mutual information); Capacity computation; Redundancy and rate; Channel models (input-uniform, output-uniform, symmetric and weakly symmetric channels); Example channels (binary symmetric channel, erasure channel, error-and-erasure channel).	4
7	Channel coding: Definitions and classifications; Role of channel coding; Minimum-error-rate receiver; Repetition coding; Coding theorem for noisy channels; Codeword space; Hamming distance; Specifying codewords; Error-detecting and error-correcting codes.	2
8	Block codes (group codes): Definitions and classifications; Coding using the parity-check matrix; Coding using the generator matrix; Syndrome computation; Error correction and decoding; Properties of the parity-check matrix; Hamming code (single-error-correcting group code) — parity-check matrix, encoding, correction, decoding.	4
9	Burst-error correction. Interleaving technique. Convolutional codes: Convolution operation; Constraint length, code rate; Generator polynomials; Correction capability, free distance; Viterbi decoding; Sequential decoding. Reed–Solomon (RS) codes: RS code alphabet; RS code parameters; Properties; Encoding by evaluating the information polynomial; Generator-polynomial encoding; Correction and decoding; Correction capability.	4
10	Continuous information sources and channels: Entropy of a continuous source; Maximum-entropy cases; Entropy variation with representation space; Continuous channels; Mutual information and other characteristic entropies; Properties of mutual information and capacity of the continuous channel.	2
	Total:	28

Bibliography:
1. Al. Spătaru, Fondaments de la Theorie de la Transmission de l'Information, Presses Polytechnique Romandes, 1987.
2. F. Auger, Introduction a la théorie du signal et de l'information, Edition Technip, Paris, 1999.
3. A. Papoulis, Probability, Random Variables and Stochastic Processes, McGrow Hill, 1987.
4. Thomas M. Cover, Joy A. Thomas, Elements of Information Theory, John Wiley & Sons, 1991.

LABORATORY		
Crt. no.	**Content**	**No. hours**
1	Introduction to Python	2
2	Information sources	2
3	Source coding	2
4	Lossless image compression	2
5	Discrete transmission channels	2
6	Error-correcting block codes	2
7	Assessment	2
	Total:	14
SEMINARY		
Crt. no.	**Content**	**No. hours**
1	Statistics notions	2
2	Markov sources	2
3	Entropy calculations	2
4	Entropic codes: Huffman and arithmetic coding	2
5	Discrete channels	2
6	Hamming group codes	2
7	Cyclic Hamming codes	2
	Total:	14
Bibliography:		

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Learning the concepts taught in all chapters	Written exam at the end of the semester	40%
	Ability to use them in problem solving	One assessment during the semester	20%
11.5 Seminary/laboratory/project	Understanding the experiments and their connection to practical situations	Grading during the laboratory	20%
	Applying the notions learned in the course	Grading during the seminar	20%
11.6 Passing conditions			

Obtaining 50% of the total score

12. Corroborate the content of the course with the expectations of representatives of employers and representative professional associations in the field of the program, as well as with the current state of knowledge in the scientific field approached and practices in higher education institutions in the European Higher Education Area (EHEA)

This course provides the foundations necessary for telecommunications applications (compression, noise protection, transmission capacity) and offers notions used in fields such as signal analysis, pattern recognition, authentication.

Date	Course lecturer	Instructor(s) for practical activities
	Lecturer Dr. Cristian Constantin DAMIAN	Lecturer Dr. Cristian Constantin DAMIAN
Date of department approval	Head of department	
	Prof. Dr. Claudius Dan	
Date of approval in the Faculty Council	Dean	
	Prof. Mihnea UDREA	