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	**Applied Electronics and Information Engineering**
1.4 Domain of studies	Computers and Information Technology
1.5 Cycle of studies	Bachelor/Undergraduate
1.6 Programme of studies	Information Engineering

2. Date despre disciplină

2.1 Course name (ro) (en)				Teoria transmisiunii informaţiei Information Transmission Theory			
2.2 Course Lecturer				Conf. Dr. Anamaria RĂDOI			
2.3 Instructor for practical activities				Conf. Dr. Anamaria RĂDOI			
2.4 Year of studies	3	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		S	2.9 Course code	04.S.05.O.001		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	2.00	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	56.00	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.					61
Tutoring					0
Examinations					8
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	Completion of the following disciplines: Mathematical analysis Linear algebra, analytic and differential geometry Probability theory and mathematical statistics Signals and systems Computer programming languages 1,2
4.2 Results of learning	Notions of probabilities Notions of information theory Notions of coding theory

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 blackboard, projector and laptop
5.2 Seminary/ Laboratory/Project	The laboratory will take place in a room equipped with desktop 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)*

This discipline is studied within the CTI field / specialization II and aims to familiarize students with the main approaches, models and explanatory theories of the field, used in solving practical applications and problems related to coding techniques for compression, respectively the transmission of information on channels affected by noise.

The discipline addresses general notions of information processing, specific concepts and principles, such as the amount of information, the entropy of a source, conditional entropy, mutual information, the capacity of a transmission channel, source and channel coding techniques. All these notions contribute to the formation of an overview of the methodological and procedural benchmarks related to the field.

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	Understanding and using fundamental concepts in the field of communications and information transmission
Transversal (General) Competences	The ability to take decisions in order to solve current, or unpredicted, problems that appear in the process of operating the computer system The ability to ensure the planning and management of information engineering projects The ability to constantly inform and document for personal and professional development by reading specialized literature The ability to communicate and present technical content both in Romanian and in English Flexibility in using new systems and technologies within a team where members together achieve a well-defined goal while assuming different roles or 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.* Lists the most important stages that marked the development of Information Theory. Defines domain-specific notions such as entropy, Kullback-Leibler divergence, mutual information, channel capacity, source coding efficiency. Describes/classifies transmission channels affected by noise. Highlight consequences of the existence of channel noise. Has knowledge about channel encoding techniques for retrieving the messages transmitted by a source.
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 relevant information in a concrete information transmission context. Uses reasoned specific principles in order to recover the messages transmitted by the source on a channel affected by noise. Works in the team through discussions related to solving some requirements within the laboratory. Experimentally verifies identified solutions through tests on Moodle (VPL environment). Solves applications both in the seminar and in the laboratory. Analyzes and compares various types of information transmission channels and information encoding techniques (channel encoding & source encoding). Formulates conclusions to the experiments carried out.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* Selects suitable bibliographic sources. Respects the principles of academic ethics. Demonstrates responsiveness of learning in new contexts. Shows collaboration with other colleagues and teaching staff during the teaching activities. Demonstrates autonomy in solving problems. Shows social responsibility through active involvement in the events of the academic community. Realizes the value of his contribution to the field of engineering to identifying solutions to real social and economic problems, demonstrating social responsibility. Applies principles of ethics/professional deontology in identifying optimal solutions. Demonstrates effective time management skills.

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.)*

The teaching process will explore both expository (lecture, exposition) and conversational-interactive teaching methods, based on discovery learning models facilitated by direct and indirect exploration of reality, but also on action-based methods, such as exercise, practical activities and solving problems. The oral communication methods used are exposition, problematization and conversation.

Lectures will be used in the teaching activity, based on presentations in .pdf format and notes written on the blackboard. Each course will begin with the recapitulation of the chapters already covered, with an emphasis on the concepts covered in the last course.

The presentations use images / diagrams and connections with current technology so that the information presented is easy to understand, assimilate and apply in various contexts.

Active listening and assertive communication techniques will be applied, as well as bi-directional feedback mechanisms.

Teamwork skills will be practiced to solve different learning tasks in seminars and laboratories.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	1. Introduction: 1.1. Define information theory: basic notions 1.2. Applications of information transmission theory 1.3. Measure information: basic notions.	2
2	2. Sources of information 2.1. Probabilistic modelling and information characterization of discrete memoryless channels and channels with memory: entropy, redundancy, efficiency, Markov sources, applications 2.2. Continuous sources of information: information characterization	4
3	3. Transmission channels 3.1. Discrete transmission channels: definitions and classifications 3.2. Information modelling of discrete channel: entropy, error probability, capacity; applications 3.3. Continuous transmission channel: information characterization, error probability, capacity	4
4	4. Source encoding for channels without noise 4.1. Definitions and classifications 4.2. Performance parameters of codes for channels without noise 4.3. Optimal codes 4.4. First Shannon theorem 4.5. Encoding algorithms: Shannon-Fano, Huffman, applications	2
5	5. Channels encoding for channels with noise (Error detection and correction codes) 5.1. Error detection and correction principle 5.2. Definitions and classifications 5.3. Second Shannon theorem 5.4. Distance proprieties for error detection and correction, dimension of block codes (Hamming margin)	1

6	6. Group codes 6.1. Vector-based characterization of group codes: generator matrix G and control matrix H; relation between the columns of matrix H in case of error detection and correction 6.2. Encoding with matrices G and H 6.3. Decoding based on syndrome vector with matrices G and H and based on neighboring classes; 6.4. Hamming group codes: proprieties, encoding and decoding algorithms, implementation schemes, applications 6.5. Iterated codes.	4
7	7. Cyclic codes 7.1. Finite Galois fields 7.2. Polynomial characterization and vector-based characterization of cyclic codes; applications 7.3. Encoding and decoding cyclic codes using the generator polynomial for error detection and correction; applications 7.4. Implementation schemes of encoding and decoding operations with division circuits and linear shift feedback registers for error detection and correction; applications 7.5. Particular cases: Hamming cyclic codes, BCH codes, Golay codes, applications	6
8	8. Convolutional codes 8.1. Structure of convolutional codes; applications 8.2. Encoding using recursive and non-recursive linear shift feedback registers; encoding using the diagram of a finite state machine; applications 8.3. Decoding using Viterbi algorithm; applications.	3
9	9. Lossless compression 9.1. Arithmetic encoding 9.2. Common compression schemes	2
	Total:	28

Bibliography:

1. Anamaria Radoi, Information theory and coding. From theory to applications, Matrix Rom, 2019
2. Al. Spătaru, Teoria Transmisiunii Informaţiei, Editura Didactică şi Pedagogică, Bucureşti, 1983.misiunii Informaţiei, Editura Didactică şi Pedagogică, Bucureşti, 1983.
3. Thomas M. Cover, Joy A. Thomas, Elements of Information Theory 2nd Edition, Wiley-Interscience, 2006
4. A.T. Murgan, Principiile Teoriei Informaţiei în Ingineria Informaţiei şi a Comunicaţiilor, Editura Academiei Romane, Bucureşti, 1998.
5. Rodica Stoian, Lucian Andrei Perişoară, Teoria Informaţiei şi a Codurilor – Aplicaţii, Editura Politehnica Press, 2010.

LABORATORY

Crt. no.	Content	No. hours
1	Introduction in Python. Exercises with probabilities.	2
2	Discrete Markov sources	2
3	Discrete and continuous channels	2

4	Lossless compression schemes. Huffman encoding.	2
5	Hamming group codes	2
6	Hamming cyclic codes	2
7	Performance evaluation of error correcting codes. Final check.	2
	Total:	14
SEMINARY		
Crt. no.	**Content**	**No. hours**
1	Measuring information in the discrete case; sources of information	2
2	Discrete channels	2
3	Data compression through Shannon-Fano and Hamming encoding schemes.	2
4	Block codes, group codes	2
5	Cyclic codes	2
6	Convolutional codes	2
7	Complete transmission systems.	2
	Total:	14

Bibliography:

1. A. Rădoi, B. C. Florea, D. A. Stoichescu, Teoria Transmisiunii Informatiei – Indrumar de laborator, PRINTECH Publishing House, Bucharest, Romania, 2014
2. Al. Spătaru, Teoria Transmisiunii Informaţiei, Editura Didactică şi Pedagogică, Bucureşti, 1983.
3. A.T. Murgan, Principiile Teoriei Informaţiei în Ingineria Informaţiei şi a Comunicaţiilor, Editura Academiei Romane, Bucureşti, 1998.
4. R. Rădescu, Rodica Stoian, Teoria Informaţiei şi a Codurilor - îndrumar de laborator, Ed. Printech, 1998.
5. Thomas M. Cover, Joy A. Thomas, Elements of Information Theory 2nd Edition, Wiley-Interscience, 2006
6. Rodica Stoian, Lucian Andrei Perişoară, Teoria Informaţiei şi a Codurilor – Aplicaţii, Editura Politehnica Press, 2010

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade

11.4 Course	Rigorous knowledge of the basic theoretical notions (entropy, mutual information, capacity) and the methods of operating with these notions; Solving problems related to the entropies of sources and transmission channels;	Midterm exam	20%
	Solving problems related to the entropies of sources and transmission channels; Rigorous knowledge of basic theoretical notions (encoding efficiency, transmission rate, source and channel encoding / decoding techniques) and the methods of operating with these notions; Solving problems related to message encoding in the case of channels affected or not affected by noise;	Final exam	30%
11.5 Seminary/laboratory/project	Understand the experiments performed during the laboratory and solve problems during the semester	Grading during the semester	10%
	Correct interpretation of experimental results considering the theoretical information gained during the course	Laboratory final verification	15 %
	Problem solving	Tests during exercise sessions	25%
11.6 Passing conditions			
Obtaining 50% of the total score. Obtaining 50% of the laboratory 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)

Through the activities carried out, students develop skills to offer solutions to problems and to propose ideas for improving the existing situation in the CTI field, including in the field of Artificial Intelligence by expanding some notions and concepts.

The course has similar content to the courses held by the Ecole Politechnique Federale de Laussanne, Lausanne (Switzerland), Massachusetts Institute of Technology in Cambridge (Massachusetts).

Date	Course lecturer	Instructor(s) for practical activities
11.10.2024	Conf. Dr. Anamaria RĂDOI	Conf. Dr. Anamaria RĂDOI

Date of department approval	Head of department
16.10.2024	Conf. Dr. Bogdan Cristian FLOREA
Date of approval in the Faculty Council	Dean
01.11.2024	Prof. Dr. Mihnea Udrea