COURSE PROGRAMME

1. Information about the programme

1.1 University	**University "Alexandru Ioan Cuza" of Iaşi**
1.2 Faculty	**Faculty of Mathematics**
1.3 Department	**DEPARTMENT OF MATHEMATICS**
1.4 Domain	**MATHEMATICS**
1.5 Cycle	**Masters**
1.6 Programme / Qualification	**Applied Mathematics**

2. Information about the course

2.1 Course Name			**Coding Theory**				
2.2 Course taught by			**Conf. dr. Aurelian Claudiu VOLF**				
2.3 Seminary / laboratory taught by			**Conf. dr. Aurelian Claudiu VOLF**				
2.4 Year	I	**2.5** Semester	II	**2.6** Type of evaluation	E	**2.7** Course type*	Op

**OB – Obligatory / OP – Optionally / F – Facultative*

3. Total hours (estimated per semester and activities)

3.1 Number of hours per week	4	**3.2** course	2	**3.3** seminary/laboratory	2
3.4 Total number of hours	56	**3.5** course	28	**3.6** seminary/laboratory	28

Distribution	hours
Individual study using textbooks, course notes, bibliography items, etc.	65
Supplimentary study (library, on-line platforms, etc.)	20
Individual study for seminary/laboratory, homeworks, projects, etc.	30
Tutoring	
Examination	4
Other activities	

3.7 Total hours of individual activity	119
3.8 Total hours per semester	175
3.9 Credit points	7

4. Pre-requisites (if necessary)

4.1 Curriculum	Linear Algebra, Fundamental algebraic structures, Logic and set theory, Arithmetic and combinatorics
4.2 Competencies	Knowledge of and abilities to use basic linear algebra and fundamental algebraic structures

5. Conditions (if necessary)

5.1 Course	Classroom/lecture theater
5.2 Seminary / Laboratory	Classroom

6. Specific competencies acquired

Professional competencies	**CP1.**Knowing, understanding and using the fundamental concepts of mathematics and informatics, as well as the principles and methods used in the studied field (2 credits) - the study and the construction of families of error correcting codes using algebraic methods **CP2** Data processing, analysis and interpretation using mathematical, statistical and informatics tools (2 credits) - determining the parameters and capabilities of some error correcting codes used in practice **CP4.**Acquisition of research techniques in mathematical modeling and software development in various fields (1 credit) - the study and analysis of some noisy digital communication channels
Transversal	**CT1.**The ability to quickly acquire new concepts and technologies that appear in the field of mathematics and

competencies	computer science (1 credit) - writing and presenting a project or report on an error-correcting codes related subject, with a view towards using and developing the research, argumentation and communication abilities **CT3.**Basic knowledge to be employed as a mathematician, statistician or actuarial expert (1 credit) -researching information, papers and courses in English on the theory and applications of error correcting codes, in order to write a report or project

7. Course objectives (from the accumulated specific competency grid)

7.1 General objective	Introduce students to the fundamental concepts of the theory and practice of information transmission and error-correcting codes. Motivating the study of finite fields, linear algebra and polynomial rings by their applications to the theory of error-correcting codes. Assimilate methods, techniques and algorithms in error-correcting coding theory.
7.2 Specific objectives	Upon successful completion of this discipline, students will be able to: • Explain the necessity and uses of error-correcting codes, the basic principles of coding theory • Describe the essential concepts of coding theory: generating matrix, parity-check matrix, minimum distance, error-correcting capacity etc. • Use the specific techniques and methods for building codes with certain parameters and certain characteristics • Calculate various parameters of a given code

8. Contents

8.1	**Course**	**Teaching methods**	**Remarks** (number of hours, references)
1.	Concepts in information thory. Hamming distance. Error correcting codes, the rate and minimum distance	Lecture, euristic conversation, demonstration	2h
2.	Error detecting/correcting capacity of a code. Erasures. Shannon theorem	Lecture, euristic conversation, demonstration	2h
3.	Linear codes: linear spaces, subspaces, bases, linear maps and matrices, dimension, rank, scalar product, dual	Lecture, euristic conversation, demonstration	2h
4.	Linear codes: definitions, examples, generator matrix, parity check matrix, minimum distance. Dual codes. Hamming codes	Lecture, euristic conversation, demonstration	2h
5.	Bounds on codes: Singleton, Hamming, Gilbert, Varshamov, Plotkin. Perfect codes, MDS codes	Lecture, euristic conversation, demonstration	2h
6.	Irreducible polynomials over Zp, finite field constructions	Lecture, euristic conversation, demonstration	2h
7.	Finite fields: primitive elements, primitive polynomials. MacWilliams identities, applications	Lecture, euristic conversation, demonstration	2h
8	Standard form of a generating matrix, information set. Coding algorithms. Decoding, cosets, syndroms	Lecture, euristic conversation, demonstration	2h
9.	New codes from old. Reed-Muller codes	Lecture, euristic conversation, demonstration	2h
10.	Cyclic codes: connection with the ideals of F[X]/(Xn - 1), generator polynomial. Definition set of a cyclic code, Reed-Solomon codes	Lecture, euristic conversation, demonstration	2h
11.	BCH codes, BCH bound, connection with Hamming codes	Lecture, euristic conversation, demonstration	2h
12.	Peterson-Gorenstein Ziegler decoding algorithm	Lecture, euristic conversation, demonstration	2h
13.	Concatenation, interleaving. Compact disc error correcting scheme	Lecture, euristic conversation, demonstration	2h
14.	CRC. Other applications of codes: compression, cryptography	Lecture, euristic conversation, demonstration	2h

Bibliography

1. Huffman, W., Pless, V., *Fundamentals of Error-Correcting Codes*, Cambridge University Press 2003.
2. Ling, S., Xing, C., *Coding Theory. A First Course, Cambridge University Press,* 2004.
3. Volf, A. C, *Introducere în teoria codurilor,* Editura Al. Mylller, Iaşi, 2013.
4. Volf, A. C., *Algebră liniară*, Editura Universităţii "Al. I. Cuza" Iaşi, 2002.

8.2	**Seminary / Laboratory**	**Teaching methods**	**Remarks**

			(number oh hours, references)
1.	Examples of error-correcting codes. Hamming distance properties, rate. Repetition codes, parity codes	exercise, dialogue	2h
2.	Hamming bound, perfect codes, ISBN.	exercise, dialogue	2h
3.	Problems on linear spaces, linear mappings, matrices, rank, scalar product	exercise, dialogue	2h
4.	Codes defined by generator matrices, parity check matrices. Determining code parameters; dual codes. Examples of Hamming codes	exercise, dialogue	2h
5.	Bounds: Singleton, Hamming, Gilbert, Varshamov, Plotkin. Coduri perfecte, MDS	exercise, dialogue	2h
6.	Constructions of finite fields, applications	exercise, dialogue	2h
7.	Compute primitive elements and primitive polynomials. MacWilliams identities and dual codes	exercise, dialogue	2h
8.	Find standard forms of the generator matrix, applications. Compute syndrom tables	exercise, dialogue	2h
9.	Constructions of codes, determining best codes with given length and dimension	exercise, dialogue	2h
10.	Problems on cyclic codes	exercise, dialogue	2h
11.	Problems on BCH codes	exercise, dialogue	2h
12.	BCH codes and decoding	exercise, dialogue	2h
13.	Construction of concatenated and interleaved codes, burst error correcting codes	exercise, dialogue	2h
14.	Examples of CRC error-detection schemes, computation of various parameters	exercise, dialogue	2h

Bibliography

1. Huffman, W., Pless, V., *Fundamentals of Error-Correcting Codes*, Cambridge University Press 2003.
2. Ling, S., Xing, C., *Coding Theory. A First Course, Cambridge University Press,* 2004.
3. Volf, A. C, *Introducere în teoria codurilor,* Editura Al. Myller, Iaşi, 2013.
4. Zaragoza, R.M, *The art of Error-Correcting Coding*, John Wiley, 2002.

9. Coordination of the contents with the expectations of the community representatives, professional associations and relevant employers in the corresponding domain

Error correcting codes are ubiquitous and indispensable in all devices and technologies used in storing and transmitting digital data: optical media storage (CD, DVD, Blu-Ray), hard disks, RAM memories, SSD, deep space data transmissions, wireless, QR codes etc. Knowledge of the principles and methods that form the basis of error correcting coding is useful and often essential to future IT specialists, and it marks a strong point in any CV of IT-related professional.

10. Assessment and examination

Activity	**10.1 Criteria**	**10.2 Modes**	**10.3 Weight in the final grade (%)**
10.4 Course	Knowing and using the theoretical notions and results, appying to problems	Written paper Oral examination	50
10.5 Seminary / Laboratory	Identifying methods for solving exercises and problems, computation abilities, abilities to understand a text related to the topics, abilities to present a report or a project	Written paper Oral examination Report or project presentation	50
10.6 Minimal requirements			
- Knowledge of the fundamental notions, understanding of main results - Solving some basic exercises and problems - writing and presenting a project or report of minimal difficulty			

Date,
03.10.24

Course coordinator,
Conf. dr. Aurelian Claudiu VOLF

Seminary coordinator,
Conf. dr. Aurelian Claudiu VOLF

Aproval date in the department,

Head of the departament,
Prof. univ. dr. Ionel-Dumitrel GHIBA