COURSE PROGRAMME

1. Information about the programme

1.1 University	**University "Alexandru Ioan Cuza" of Iasi**
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			Theory of codes				
2.2 Course taught by			Assoc. Prof. PhD. AURELIAN CLAUDIU VOLF				
2.3 Seminary / laboratory taught by			Assoc. Prof. PhD. AURELIAN CLAUDIU VOLF				
2.4 Year	I	**2.5** Semester	II	**2.6** Type of evaluation*	E	**2.7** Course type**	Op

E – Exam / C – Colloquium / V – Verification
***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.	45
Supplimentary study (library, on-line platforms, etc.)	27
Individual study for seminary/laboratory, homeworks, projects, etc.	45
Tutoring	0
Examination	2
Other activities	0
3.7 Total hours of individual activity*	119
3.8 Total hours per semester	175
3.9 Credit points	7

4. Pre-requisites - Curriculum (if necessary)

Linear Algebra, Fundamental algebraic structures, Logic and set theory, Arithmetic and combinatorics

5. Conditions (if necessary)

5.1 Course	Classroom/lecture theater
5.2 Seminary / Laboratory	Classroom/lecture theater

6. Objectives

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. Specific competencies/Learning outcomes

• communicates scientific findings
• promotes knowledge transfer
• applies scientific methods

8. Contents

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

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

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

10.1 Continuous assessment		Percentage (min. 30%)		30
Course	Assessment type			
	Percentage			0
	Failure to pass the continuous assessment results in failure to pass the final assessment			
	Assessment methods	Details	Percentage	with reexamination

Seminary / Laboratory	Assessment type			Mixed assessment
	Percentage			100
	Failure to pass the continuous assessment results in failure to pass the final assessment			No
	Assessment methods	Details	Percentage	with reexamination
		Essay	50	No
		Continuous oral assessment	50	No

10.2 Final assessment	Percentage (max. 70%)	70
	Assessment type	Final mixed assessment

10.3 Special notes (special situations is assessment)	

10.4 Minimum performance standard	
- 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, **Course coordinator,**
Assoc. Prof. PhD. AURELIAN CLAUDIU VOLF

Seminary coordinator,
Assoc. Prof. PhD. AURELIAN CLAUDIU VOLF

Aproval date in the department,

Head of the departament,
Prof. PhD. IONEL DUMITREL GHIBA