

Course guide 270128 - TCI - Information Transmission and Encoding

Last modified: 13/07/2023

Academic year: 2023	ECTS Credits: 6.0	Languages: Catalan	
Degree:	BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Optional subject).		
Unit in charge: Teaching unit:	Barcelona School of Informatics 749 - MAT - Department of Mathematics.		

LECTURER

Coordinating lecturer:	RAFAEL FARRÉ CIRERA	
Others:	Primer quadrimestre: RAFAEL FARRÉ CIRERA - 10	

PRIOR SKILLS

The student should:

(a) know the logarithm function and its properties,

(b) basic properties of finite probability distributions and random variables,

(c) know the ring of modular integers and perform calculations;

(d) know the basics of vector spaces: systems of linear equation, linear dependence and independence, basis and dimension, matrix operations (sums, products) and compute inverse;

(d) know the basic properties of polynomials and know how to operate with them.

REQUIREMENTS

- Prerequisite FM
- Prerequisite M1
- Prerequisite M2

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

CTI1.4. To select, design, deploy, integrate, evaluate, build, manage, exploit and maintain the hardware, software and network technologies, according to the adequate cost and quality parameters.

CTI3.3. To design, establish and configure networks and services.

Generical:

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

TEACHING METHODOLOGY

In theoretical sessions the professor explains the theoretical issues giving examples and solving problems. It combines both the master methodology, in which the professor presents, explains and illustrates the concepts of the subject, and the interaction with students.

In the lab sessions, and during the hours of personal study, students should try to solve problems from a collection. The teacher supports the student with the difficulties that may raise. It is intended that students take the initiative in solving problems, evaluating solutions and learn from their mistakes.



LEARNING OBJECTIVES OF THE SUBJECT

1.To learn the concepts of information of an event and the entropy of a probability distribution. To learn the concepts of information source and communication channel. To learn the concepts of source coding (data compression) and channel coding (error-detection and error-correction) and Shannon's theorems.

2.To learn the basic concepts of block codes: their parameters and their relationship to the error-detecting and error-correcting abilities. To learn the main applications of modular arithmetic to the construction of block codes. To learn the protocols of error-detection and error-correction used in communication networks.

3.To learn the basic structure of finite fields, mainly those of characteristic 2. To learn the finite dimensional vector spaces over a finite field. To learn the ways of defining a linear code, determining its parameters and decoding using the algorithm based on syndromes. To learn the particularities of some specific linear codes (specially the perfect codes) and their corresponding error-correction algorithms.

4.To learn the general structure of cyclic codes and Meggit"s algorithm. To learn CRC technique: cyclic codes used for detection purposes in communication networks. To learn the binary BCH codes and their error-correction algorithms. To learn Reed-Solomon codes and their application to compact disks.

STUDY LOAD

Туре	Hours	Percentage
Hours small group	15,0	10.00
Hours large group	45,0	30.00
Guided activities	6,0	4.00
Self study	84,0	56.00

Total learning time: 150 h

CONTENTS

Information and entropy.

Description:

Mathematical definition of the amount of information. Entropy of a probability distribution and mutual information of two random variables.

Source coding and channel coding

Description:

Variable-length codes. Kraft's inequality. Huffman's codes. Extensions of a source. First Shannon's theorem. Channel capacity . Decision schemes. Second Shannon's theorem: channel coding with noise. The binary symmetric channel. Decoding by maximum likelihood.

Error-detection and error-correction with block codes.

Description:

Hamming distance. Tangency radius and covering radius. Error-detecting and error-correcting. Error-detecting protocols. The fundamental problem of coding theory.

Finite fields

Description:

Construction of finite fields, specially those of characteristic 2. Elementary properties and efective computations in finite fields.



Linear codes

Description:

Vector spaces over finite fields. Linear codes. Generating and parity-check matrices. Standard array and syndrome correction. Operations with linear codes. Perfect codes. Hamming codes, binary Golay codes and ternary Golay codes.

Cyclic codes and CRC

Description:

Polynomials over finite fields. Polynimals codes. Generating and parity-check polynomials. Systematic encoding. Meggitt's correction algorithm. Cyclic codes used for detection purposes: CRC. Ethernet CRC.

Binary BCH codes

Description:

Roots of a cyclic code: description of a cyclic code by its roots. BCH codes over a finite field. Binary primitive and stric BCH codes. The key equation. Euclid's algorithm for decoding. Berlekamp-Massey decoding.

Reed-Solomon codes

Description:

Reed-solomon codes as cyclic codes. The finite Fourier transform. Algorithm for error-correction. Application: coding of the audio compact disc.

ACTIVITIES

Information and entropy

Description:

Developing the subject "Information and entropy"

Specific objectives:

1

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 9h 30m Theory classes: 3h Laboratory classes: 1h Self study: 5h 30m



Developing the subject "Source coding and channel coding"

Description:

Developing the subject "Source coding and channel coding"

Specific objectives:

1

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 18h Theory classes: 3h Laboratory classes: 1h Self study: 14h

Partial exam

Description:

Partial exam on subjects 1, 2 and 3

Specific objectives:

1,2

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 9h

Guided activities: 2h Self study: 7h

Developing the subject "Error-detection and error-correction with block codes".

Description:

Developing the subject "Error-detection and error-correction with block codes".

Specific objectives:

2

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 9h Theory classes: 4h Laboratory classes: 1h Self study: 4h



Solving problems 1

Description:

Troughout the course the student has to work on at least two problems.

Specific objectives:

1,2

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 2h 42m Guided activities: 0h 30m Self study: 2h 12m

Developing the subject "Finite fields"

Description:

Developing the subject "Finite fields"

Specific objectives:

3

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 13h

Theory classes: 6h Laboratory classes: 2h Self study: 5h

Developing the subject "Linear codes"

Description: Developing the subject "Linear codes"

Specific objectives: 3

С

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 13h Theory classes: 5h Laboratory classes: 2h Self study: 6h



Developing the subject "Cyclic codes and CRC"

Description:

Developing the subject "Cyclic codes and CRC"

Specific objectives:

4

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 15h Theory classes: 6h Laboratory classes: 3h Self study: 6h

Developing the subject "Binary BCH codes"

Description:

Developing the subject "Binary BCH codes"

Specific objectives:

4

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 16h

Theory classes: 6h Laboratory classes: 3h Self study: 7h

Developing the subject "Reed-Solomon codes"

Description:

Developing the subject "Reed-Solomon codes"

Specific objectives:

4

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 11h Theory classes: 6h Laboratory classes: 1h Self study: 4h



Solving problems 2

Description:

Troughout the course the student has to work on at least two problems.

Specific objectives:

3,4

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 2h 48m Guided activities: 0h 30m Self study: 2h 18m

Report on a subject related to the course

Description:

Report on a subject related to the course where both the contents and the use of reliable information resources will be assessed.

Specific objectives:

1, 2, 3, 4

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 11h

Guided activities: 1h Self study: 10h

Final exam

Description: Final exam on subjects from 4 to 8

Specific objectives:

3,4

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 20h Guided activities: 3h Self study: 17h

GRADING SYSTEM

There will be two partial exams.

The final mark is obtaining averaging the gradings of the partial exams.



BIBLIOGRAPHY

Basic:

- Farré, Rafel. Apunts de Teoria de la Informació i Codificació. 2003.
- Brunat Blay, Josep M; Ventura Capell, Enric. Informació i codis [on line]. Barcelona: Edicions UPC, 2001 [Consultation: 21/09/2023]. Available on: https://upcommons.upc.edu/handle/2099.3/36184. ISBN 8483015285.
- Ball, Simeon. A Course in algebraic error-correcting codes. Cham: Birkhäuser, [2020]. ISBN 9783030411527.
- Bierbrauer, Jürgen. Introduction to coding theory. 2nd ed. Boca Raton: CRC Press, 2017.

Complementary:

- Hill, R. A first course in coding theory. Repr. with corr. Clarendon Press, 1988. ISBN 0198538030.

- Wicker, Stephen B.; Bhargava, Vijay K. (editores). Reed-Solomon codes and their applications. IEEE Press, 1994. ISBN 078031025X.

- Adámek, J. Foundations of coding: theory and applications of error-correcting codes, with an introduction to cryptography and information theory. Wiley, 1991. ISBN 0471621870.

RESOURCES

Hyperlink:

- http://www.sagemath.org