ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

593000601 - Advanced Information Theory

DEGREE PROGRAMME

59AI - Master Universitario En Comunicaciones Inalámbricas

ACADEMIC YEAR & SEMESTER

2024/25 - Semester 1

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Learning guide

1. Description

1.1. Subject details

Name of the subject	593000601 - Advanced Information Theory
No of credits	6 ECTS
Type	Compulsory
Academic year ot the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	59AI - Master Universitario en Comunicaciones Inalámbricas
Centre	59 - Escuela Tecnica Superior De Ingenieria Y Sistemas De Telecomunicacion
Academic year	2024-25

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Cesar Diaz Martin (Subject coordinator)	8210	cesar.diazm@upm.es	Sin horario.
Jose Enrique Gonzalez Garcia	8415	joseenrique.gonzalez@upm.es	Sin horario.
Jose Luis Rodriguez Vazquez	8305	jl.rodriguez.vazquez@upm.es	Sin horario.

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- Digital modulations, basic source coding and line coding.

4. Skills and learning outcomes *

4.1. Skills to be learned

CB6 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

CB7 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio

CB8 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios

CEM02 - Utilizar adecuadamente los cÃ³digos fuente, cÃ³digos de canal y cÃ³digos de encriptado que se necesiten en un sistema de comunicaciones inalÃ¡mbrico.

CGI02 - Comprender el procedimiento, valor y límites del método científico, siendo capaz de identificar, localizar y obtener datos requeridos en un trabajo de investigación, de diseñar y guiar investigaciones analíticas, de modelado y experimentales, así como de evaluar datos de una manera crítica y extraer conclusiones.

CGI03 - Valorar la importancia de las fuentes documentales, manejarlas y buscar la información para el desarrollo de cualquier trabajo de investigación.

CGI04 - Leer y comprender publicaciones dentro de su ámbito de estudio/investigación, así como su catalogación y valor científico.

UPM1 - Uso de la lengua inglesa

UPM4 - OrganizaciÃ³n y planificaciÃ³n /

4.2. Learning outcomes

RA17 - RA02.- Apply the knowledge acquired to the understanding of qualitative and quantitative problems related to source coding and channel coding.

RA18 - RA03.- Choose the mathematical methods and tools necessary to tackle a problem and finds the solution.

RA16 - RA01.- Distinguish between channel codes, source codes and encryption models and their practical application.

RA20 - RA05.- Interpret data derived from empirical observations and measurements in terms of their importance and relate them to the appropriate theory.

RA19 - RA04.- Anticipate the behavior of a source code, channel code or encryption model and its influence on a telecommunication system.

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

This course aims to provide students with knowledge of the principles of information processing and transmission. To this end, it presents in detail the modern techniques of source coding, channel coding and encryption. Thus, the course is divided into the following four main parts:

- The first part reviews the basic concepts of information theory, which are fundamental for understanding the rest of the course syllabus.
- After that, there is the part dedicated to source coding, which covers both lossless and lossy source coding. As an essential appendix of this part, we present the coding techniques for two of the most relevant types of signals: audio and video, including a historical overview of the strategies used in different types of communication systems and the most advanced ones used today.
- The part on channel coding reviews the basic concepts of this type of codes, as well as its difference with other types of error correction strategies, and then goes on to present the definition and operation of the block and convolutional codes in today's transmission systems.
- Finally, the most important types of cryptographic techniques and their use in modern communication systems are shown.

Next is included the **syllabus** of the course:

1. Information theory

- Measure of information
- Entropy
- Channel model
- Mutual information
- Channel capacity
- Shannon's theorem

2. Source coding: introduction

- Coding parameters
- Source coding theorem
- Classification of codes
- Kraft inequality
- Rate-distortion theory

3. Source coding: advanced audio coding

- Audio perceptual and statistic characteristics
- Audio standards

4. Source coding: advanced video coding

- Video perceptual and statistic characteristics
- Video standards

5. Channel coding: introduction

- Code rate
- Types of codes: block, convolution
- Error control strategies: ARQ, FEC
- Generator matrices and polynomials

6. Channel coding: Simple codes

- BCH, Reed-Muller, Reed-Solomon
- Cyclic Redundancy Check (CRC)
- Low Density Parity Check Codes (LDPC)
- Hybrid Automatic Repeat Request (HARQ)

7. Channel coding: Concatenated codes

- Simple Concatenated Codes (SCC)
- Parallel Concatenated Convolutional Codes (PCCC): Turbo codes
- Serial Concatenated Convolutional Codes (SCCC)

8. Cryptography applied to wireless systems

- Plain text, cipher text, and key
- Symmetric-key cryptography
- Asymmetric-key cryptography
- RSA Algorithm

The course also includes the following five lab sessions embedded within the theory classes:

1. P1: Basic algorithm design for source coding
2. P2: Algorithm design for advanced audio coding
3. P3: Algorithm design for advanced video coding
4. P4: Algorithm design for channel coding, block and convolution codes
5. P5: Algorithm design for cryptography applied to wireless systems

5.2. Syllabus

1. Information theory

2. Source coding: introduction

3. Source coding: advanced audio coding

4. Source coding: advanced video coding

5. Channel coding: introduction

6. Channel coding: Simple codes

7. Channel coding: Concatenated codes

8. Cryptography applied to wireless systems

6. Schedule

6.1. Subject schedule*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	**Lesson 1** Duration: 02:00 Lecture **Lesson 1** Duration: 02:00 Lecture **Lesson 2** Duration: 02:00 Lecture **Lab session Lesson 2** Duration: 02:00 Laboratory assignments			**Submission Results Lab Session Lesson 2** Problem-solving test Progressive assessment Presential Duration: 00:00
2	**Lesson 2** Duration: 02:00 Lecture **Lesson 2** Duration: 02:00 Lecture **Lesson 2** Duration: 02:00 Lecture **Lesson 5** Duration: 02:00 Lecture			**Task Lesson 2** Written test Progressive assessment Not Presential Duration: 00:00
3	**Lesson 3** Duration: 02:00 Lecture **Lesson 3** Duration: 02:00 Lecture **Lesson 5** Duration: 02:00 Lecture **Lesson 6** Duration: 02:00 Lecture			

4	**Lesson 3** Duration: 02:00 Lecture **Lab session Lesson 3** Duration: 02:00 Laboratory assignments **Lesson 6** Duration: 02:00 Lecture **Lesson 7** Duration: 02:00 Lecture			**Submission Results Lab Session Lesson 6** Problem-solving test Progressive assessment Presential Duration: 00:00 **Submission Results Lab Session Lesson 3** Problem-solving test Progressive assessment Presential Duration: 00:00 **Task Lesson 3** Written test Progressive assessment Not Presential Duration: 00:00
5	**Lesson 4** Duration: 02:00 Lecture **Lesson 4** Duration: 02:00 Lecture **Lesson 7** Duration: 02:00 Lecture **Lab session Lessons 6 and 7** Duration: 02:00 Laboratory assignments			**Task Lesson 4 (I)** Written test Progressive assessment Not Presential Duration: 00:00
6	**Lab session Lesson 4** Duration: 02:00 Laboratory assignments **Lesson 4** Duration: 02:00 Lecture **Lab session Lessons 6 and 7** Duration: 02:00 Laboratory assignments **Lab session Lessons 6 and 7** Duration: 02:00 Laboratory assignments			**Submission Results Lab Session Lesson 4** Problem-solving test Progressive assessment Presential Duration: 00:00 **Task Lesson 4 (II)** Written test Progressive assessment Not Presential Duration: 00:00 **Submission Results Lab session Lessons 6 and 7** Problem-solving test Progressive assessment Presential Duration: 00:00
7	**Lesson 8** Duration: 02:00 Lecture **Lesson 8** Duration: 02:00 Lecture **Lesson 8**			**Submission Results Lab Session Lesson 8** Problem-solving test Progressive assessment Presential Duration: 00:00

	Duration: 02:00 Lecture **Lab session Lesson 8** Duration: 02:00 Laboratory assignments			
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				**Final exam** Written test Global examination Not Presential Duration: 02:00

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
1	Submission Results Lab Session Lesson 2	Problem-solving test	Face-to-face	00:00	10%	5 / 10	CGI02 CGI04 CB6 CB7 CB8 UPM5 CEM02 CGI03 UPM1 UPM4
2	Task Lesson 2	Written test	No Presential	00:00	10%	4 / 10	CGI02 CGI04 CB6 CB7 CB8 UPM5 CEM02 CGI03 UPM1 UPM4
4	Submission Results Lab Session Lesson 3	Problem-solving test	Face-to-face	00:00	10%	5 / 10	CGI02 CGI04 CB6 CB7 CB8 UPM5 CEM02 CGI03 UPM1 UPM4
4	Submission Results Lab Session Lesson 6	Problem-solving test	Face-to-face	00:00	10%	5 / 10	CGI02 CGI04 CB6 CB7 CB8 UPM5 CEM02 CGI03 UPM1

							UPM4
4	Task Lesson 3	Written test	No Presential	00:00	10%	4 / 10	CGI02 CGI04 CB6 CB7 CB8 UPM5 CEM02 CGI03 UPM1 UPM4
5	Task Lesson 4 (I)	Written test	No Presential	00:00	10%	4 / 10	CGI04 CB6 CB7 CB8 UPM5 CEM02 CGI03 UPM1 UPM4 CGI02
6	Submission Results Lab Session Lesson 4	Problem-solving test	Face-to-face	00:00	10%	5 / 10	CGI04 CB6 CB7 CB8 UPM5 CEM02 CGI02 CGI03 UPM1 UPM4
6	Task Lesson 4 (II)	Written test	No Presential	00:00	10%	4 / 10	CGI02 CGI04 CB6 CB7 CB8 UPM5 CEM02 CGI03 UPM1 UPM4
6	Submission Results Lab session Lessons 6 and 7	Problem-solving test	Face-to-face	00:00	10%	5 / 10	CB6 CB7 CB8 UPM5 CEM02 CGI03 UPM1 UPM4 CGI02 CGI04

7	Submission Results Lab Session Lesson 8	Problem-solving test	Face-to-face	00:00	10%	5 / 10	CGI02 CGI04 CB6 CB7 CB8 UPM5 CEM02 CGI03 UPM1 UPM4

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Final exam	Written test	No Presential	02:00	100%	5 / 10	CGI02 CGI04 CB6 CB7 CB8 UPM5 CEM02 CGI03 UPM1 UPM4

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Final exam	Written test	Face-to-face	02:00	100%	5 / 10	CGI02 CGI04 CB6 CB7 CB8 UPM5 CEM02 CGI03 UPM1 UPM4

7.2. Assessment criteria

Professors will ask students to complete individual or group theoretical and practical assignments (as shown in the table Assessment activities above), which will be graded. The obtained scores will be combined to obtain the final grade of the course.

A score of 5/10 is required to pass the course. If any student obtains a grade lower than the mimum required in a given part, they can recover said part in an exceptional call in January and finally in July.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Moodle	Web resource	Files with theory, practice scripts, notes, etc.
PC + Matlab	Equipment	Necessary for the realization of laboratory practices and simulations.
Classroom with digital screen	Equipment	Necessary for the teaching of theory. How the laboratory is embedded, the classroom must have PCs with Matlab for the students.

9. Other information

9.1. Other information about the subject

As can be seen in the schedule, the course will cover seven weeks. Please note that several non-interdependent lessons of the course will be taught in parallel.