

# ANX-PR/CL/001-01

## LEARNING GUIDE

### SUBJECT

**593000608 - Wireless Channel Modelling**

### DEGREE PROGRAMME

**59AJ - Master Universitario En Comunicaciones Inalámbricas**

### ACADEMIC YEAR & SEMESTER

**2024/25 - Semester 2**

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### Learning guide

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## 1. Description

### 1.1. Subject details

|                                       |                                                                            |
|---------------------------------------|----------------------------------------------------------------------------|
| <b>Name of the subject</b>            | 593000608 - Wireless Channel Modelling                                     |
| <b>No of credits</b>                  | 4.5 ECTS                                                                   |
| <b>Type</b>                           | Optional                                                                   |
| <b>Academic year of the programme</b> | First year                                                                 |
| <b>Semester of tuition</b>            | Semester 2                                                                 |
| <b>Tuition period</b>                 | February-June                                                              |
| <b>Tuition languages</b>              | English                                                                    |
| <b>Degree programme</b>               | 59AJ - Master Universitario en Comunicaciones Inalámbricas                 |
| <b>Centre</b>                         | 59 - Escuela Técnica Superior De Ingeniería Y Sistemas De Telecomunicación |
| <b>Academic year</b>                  | 2024-25                                                                    |

## 2. Faculty

### 2.1. Faculty members with subject teaching role

| <b>Name and surname</b>                  | <b>Office/Room</b> | <b>Email</b>    | <b>Tutoring hours *</b> |
|------------------------------------------|--------------------|-----------------|-------------------------|
| Ruben Fraile Muñoz (Subject coordinator) |                    | r.fraile@upm.es | - -                     |

\* 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

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#### 3.1. Recommended (passed) subjects

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

#### 3.2. Other recommended learning outcomes

- Operation of RF instrumentation
- Management of technical information
- Programming in MATLAB and SIMULINK

### 4. Skills and learning outcomes \*

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#### 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/ Students have demonstrated knowledge and understanding providing the groundwork or opportunity for innovation in developing and/or applying ideas, often within a research context

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/Students are capable of applying their knowledge, understanding, and problem-solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study

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/Students are capable of integrating knowledge and making complex decisions, which, although based on incomplete or limited information, require reflection on social and ethical responsibilities linked to the application of their knowledge and opinions

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. / Understand the procedure, value, and limits of the scientific method, being able to identify, locate and obtain data required in a research work, to design and guide analytical, modeling, and experimental investigations, as well as to critically evaluate data and extract conclusions.

CGI03 - Valorar la importancia de las fuentes documentales, manejarlas y buscar la información para el desarrollo de cualquier trabajo de investigación. / Assess the importance of documentary sources, manage them and search for information for the development of any research work.

CGI04 - Leer y comprender publicaciones dentro de su ámbito de estudio/investigación, así como su catalogación y valor científico. / Read and understand publications within their field of study / research, as well as their cataloging and scientific value.

## 4.2. Learning outcomes

RA5 - Interpretar los datos derivados de observaciones empíricas y mediciones en términos de su importancia y relacionarlos con la teoría apropiada/ Interpret data derived from empirical observations and measurements in terms of their importance and relate them to the appropriate theory

RA24 - Reunir la información precisa para poder evaluar el impacto del canal móvil radioeléctrico sobre la propagación de una señal/ Collect the precise information to be able to evaluate the impact of the mobile radioelectric channel on the propagation of a signal

RA29 - Elegir los métodos y herramientas de programación necesarios para abordar la solución de un problema/ Choose the programming methods and tools necessary to tackle the solution of a problem

RA25 - Aplicar el conocimiento adquirido a la solución de problemas cualitativos y cuantitativos relacionados con el modelado del canal móvil radioeléctrico/ Apply the acquired knowledge to the solution of qualitative and quantitative problems related to the modeling of the mobile radioelectric channel

RA3 - Elegir los métodos y herramientas matemáticas necesarios para abordar la solución de un problema/ Choose the mathematical methods and tools necessary to tackle the solution of a problem

\* 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

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### 5.1. Brief description of the subject

This course is aimed to give a comprehensive view of the wireless channel characteristics. This includes an understanding of the underlying physical propagation mechanisms and measurements of the channel properties.

This course deals with the main propagation mechanisms in wireless communications channel. In this sense, some of the goals are to know the main characteristics of wireless radio channels, and to understand how they can impact on communication performance as well.

In a second stage, specific wireless radio channels using appropriate models will be described using suitable models

Besides, some practical experiences will be driven in order to measure the main characteristics of some wireless channels.

## 5.2. Syllabus

### 1. Introduction

- 1.1. Radio spectrum: band names and allocations
- 1.2. Basic radio propagation principles
- 1.3. Channel modelling approaches: deterministic vs stochastic

### 2. Generic channel models

- 2.1. SISO Time-variant channels
  - 2.1.1. Narrowband
  - 2.1.2. Wideband
- 2.2. SISO Time-invariant channels
  - 2.2.1. Frequency dispersion
  - 2.2.2. Stationarity
  - 2.2.3. Coherence functions
- 2.3. MIMO channels
- 2.4. Lab Activity

### 3. Models for specific radio channels

- 3.1. Outdoor: rural, urban, microcellular
- 3.2. Indoor
- 3.3. Vehicle-to-vehicle
- 3.4. Body-Area
- 3.5. Millimeter-wave
- 3.6. Lab activity

### 4. Channel sounding

- 4.1. Basic principles
- 4.2. Channel sounding approaches: waveforms and processing
- 4.3. Parameters of a channel sounder
- 4.4. Lab activity

## 6. Schedule

### 6.1. Subject schedule\*

| Week | Type 1 activities                                                                                 | Type 2 activities                                               | Distant / On-line | Assessment activities                                                                                                                                  |
|------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | <b>Introduction</b><br>Duration: 04:00                                                            |                                                                 |                   |                                                                                                                                                        |
| 2    | <b>Introduction</b><br>Duration: 02:00<br><br><b>2. Generic channel models</b><br>Duration: 02:00 |                                                                 |                   | <b>Dissertation about Channel modelling approaches: deterministic vs stochastic</b><br><br>Progressive assessment<br>Not Presential<br>Duration: 02:00 |
| 3    | <b>2. Generic channel models</b><br>Duration: 04:00                                               |                                                                 |                   | <b>Problems-exercises about generic channel models</b><br><br>Progressive assessment<br>Not Presential<br>Duration: 02:00                              |
| 4    | <b>2. Generic channel models</b><br>Duration: 02:00                                               | <b>2. Generic Channel Model</b><br>Duration: 02:00              |                   | <b>Quizz: Generic channel models</b><br><br>Progressive assessment<br>Presential<br>Duration: 00:20                                                    |
| 5    | <b>3. Models for specific radio channels</b><br>Duration: 04:00                                   |                                                                 |                   | <b>Lab Report (unit 2)</b><br><br>Progressive assessment<br>Not Presential<br>Duration: 04:00                                                          |
| 6    |                                                                                                   | <b>3. Models for specific radio channels</b><br>Duration: 04:00 |                   |                                                                                                                                                        |
| 7    | <b>3. Models for specific radio channels</b><br>Duration: 04:00                                   |                                                                 |                   |                                                                                                                                                        |
| 8    |                                                                                                   | <b>3. Models for specific radio channels</b><br>Duration: 02:00 |                   | <b>Problems about specific channel models</b><br><br>Progressive assessment<br>Not Presential<br>Duration: 02:00                                       |
| 9    |                                                                                                   | <b>3. Models for specific radio channels</b><br>Duration: 02:00 |                   | <b>Quizz: Models for specific radio channels</b><br><br>Progressive assessment<br>Presential<br>Duration: 00:20                                        |

|    |                                        |                                        |  |                                                                                                              |
|----|----------------------------------------|----------------------------------------|--|--------------------------------------------------------------------------------------------------------------|
| 10 | 4. Channel sounding<br>Duration: 02:00 |                                        |  | Lab Report (unit 3)<br><br>Progressive assessment<br>Not Presential<br>Duration: 06:00                       |
| 11 | 4. Channel sounding<br>Duration: 02:00 |                                        |  |                                                                                                              |
| 12 | 4. Channel sounding<br>Duration: 02:00 |                                        |  |                                                                                                              |
| 13 |                                        | 4. Channel sounding<br>Duration: 02:00 |  | Problems/exercises about channel sounding<br><br>Progressive assessment<br>Not Presential<br>Duration: 02:00 |
| 14 |                                        | 4. Channel sounding<br>Duration: 02:00 |  | Quizz: Channel Sounding<br><br>Progressive assessment<br>Presential<br>Duration: 00:20                       |
| 15 |                                        |                                        |  | Lab Report (unit 4)<br><br>Progressive assessment<br>Not Presential<br>Duration: 06:00                       |
| 16 |                                        |                                        |  |                                                                                                              |
| 17 |                                        |                                        |  |                                                                                                              |

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 |
|------|------------------------------------------------------------------------------|----------|---------------|----------|--------|---------------|------------------|
| 2    | Dissertation about Channel modelling approaches: deterministic vs stochastic |          | No Presential | 02:00    | 5%     | / 10          | CGI04<br>CGI03   |
| 3    | Problems-exercises about generic channel models                              |          | No Presential | 02:00    | 10%    | / 10          | CB7              |
| 4    | Quizz: Generic channel models                                                |          | Face-to-face  | 00:20    | 10%    | 4 / 10        | CB6<br>CB8       |
| 5    | Lab Report (unit 2)                                                          |          | No Presential | 04:00    | 10%    | / 10          | CGI02            |
| 8    | Problems about specific channel models                                       |          | No Presential | 02:00    | 10%    | / 10          | CB7              |
| 9    | Quizz: Models for specific radio channels                                    |          | Face-to-face  | 00:20    | 10%    | 4 / 10        | CB6<br>CB8       |
| 10   | Lab Report (unit 3)                                                          |          | No Presential | 06:00    | 10%    | / 10          | CGI02            |
| 13   | Problems/exercises about channel sounding                                    |          | No Presential | 02:00    | 15%    | / 10          | CB7              |
| 14   | Quizz: Channel Sounding                                                      |          | Face-to-face  | 00:20    | 10%    | 4 / 10        | CB6<br>CB8       |
| 15   | Lab Report (unit 4)                                                          |          | No Presential | 06:00    | 10%    | / 10          | CGI02            |

#### 7.1.2. Global examination

No se ha definido la evaluación sólo por prueba final.

#### 7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

## 7.2. Assessment criteria

The type of course and the approach described above make more convenient to select an assessment mechanism different to the traditional final exam. A continuous evaluation methodology is here proposed for this course, based on a set of short quizzes and exercises (problems) resolution .

The assessment of lab practices is based on the realization of a report (in pairs) will be also considered

If some quizzes are failed will be retrieved in a final exam at the end of the course

## 8. Teaching resources

### 8.1. Teaching resources for the subject

| Name                                                                                                                                           | Type         | Notes  |
|------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------|
| - LTE-advanced and next generation wireless networks: channel modelling and propagation. G. de la Roche et al, John Wiley & Sons, 2012.        | Bibliography |        |
| - Radio propagation measurement and channel modelling, S. Salous, John Wiley & Sons, 2013.                                                     | Bibliography |        |
| - Propagation channel characterization, parameter estimation, and modeling for wireless communications, X. Yin et al, John Wiley & Sons, 2016. | Bibliography |        |
| Slides                                                                                                                                         | Web resource | Moodle |
| Lab guides                                                                                                                                     | Web resource | Moodle |
| - The Mobile Radio Propagation Channel, J.D. Parsons, John Wiley & Sons, 2000.                                                                 | Bibliography |        |