LEARNING GUIDE

SIGNAL ANALYSIS FOR COMMUNICATIONS

TELECOMMUNICATION ENGINEERING (MS)

ACADEMIC YEAR	CODE	COURSE	CREDITS	TYPE	SEMESTER
2026-27	93000792	1	6 ECTS	COMPULSORY	FIRST SEMESTER

LANGUAGE	ASSIGNED CENTER
SPANISH	E.T.S. DE INGENIEROS DE TELECOMUNICACION

ASSIGNED DEPARTMENT
SEÑALES, SISTEMAS Y RADIOCOMUNICACIONES

COORDINATOR
JUAN IGNACIO GODINO LLORENTE - ignacio.godino@upm.es

REQUIRED PREREQUISITES

REQUIRED COURSES

—

RECOMMENDED PRIOR KNOWLEDGE

RECOMMENDED COURSES

—

OTHER RECOMMENDATIONS

Degree-level knowledge of linear algebra, infinitesimal calculus, linear systems, and random signals.

Firmado Por	Firma Automatizada	02/07/2026	Página 1/13

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RESULTS

RD-1393/2007

Competences

CG2 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.

CE1 Capacidad para aplicar métodos de la teoría de la información, la modulación adaptativa y codificación de canal, así como técnicas avanzadas de procesado digital de señal a los sistemas de comunicaciones y audiovisuales.

CT5 Capacidad para gestionar la información, identificando las fuentes necesarias, los principales tipos de documentos técnicos y científicos, de una manera adecuada y eficiente.

CG1 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.

CG5 Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

CT4 Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo.

CT3 Capacidad para adoptar soluciones creativas que satisfagan adecuadamente las diferentes necesidades planteadas.

Learning Outcomes

RA134 Manejar con soltura las bases de álgebra lineal y cálculo infinitesimal necesarias para formular problemas de optimización.

RA135 Conocer y dominar herramientas para la resolución de problemas fundamentales de optimización.

RA137 Conocer y dominar herramientas para la resolución de problemas de estimación y detección.

RA136 Manejar con soltura las bases del modelado matemático de señales aleatorias.

DESCRIPTION

Firmado Por	Firma Automatizada	02/07/2026	Página 2/13

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This course provides advanced tools for signal processing, with applications in digital communications systems. Its content is structured in two main parts:

Optimization: In this part, convex optimization techniques, optimization algorithms with and without restrictions and least squares problems.

Statistical Signal Processing: A review of the random processes and sequences is carried out to then expose basic elements of estimation theory and statistical hypothesis tests, with applications in spectral estimation, adaptive filtering and detection of signals in noise.

TOPICS

1. Optimization

1.1. Introduction

1.1.1. Short review of linear algebra

1.1.2. Short review of multivariate calculus

1.1.3. The general optimization problem

1.2. Convex optimization

1.2.1. Convex sets and functions

1.2.2. Some special types of convex optimization problems. Linear programming, quadratic programming

1.2.3. Duality. The Lagrange dual problem

1.3. Algorithms

1.3.1. Unconstrained optimization

1.3.2. Optimization with equality constraints

1.3.3. Optimization with inequality constraints

1.4. Least-squares problems

1.4.1. General problem

1.4.2. Euclidean norm aproximation

Firmado Por	Firma Automatizada	02/07/2026	Página 3/13

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1.4.3. Non-Euclidean norms aproximation

2. Statistical Signal Processing

2.1. Random processes and sequences

2.1.1. Introduction

2.1.2. Statistical properties

2.1.3. Special types of processes

2.1.4. Stationarity

2.1.5. Power spectra

2.1.6. Linear systems

2.2. Parameter estimation

2.2.1. Introduction

2.2.2. Fisher information and Cramér-Rao bound

2.2.3. Maximum likelihood estimation

2.2.4. Linear parameter estimator

2.2.5. Estimation of the statistical properties of a stochastic process

2.3. Bayesian estimation

2.3.1. Introduction

2.3.2. Random variable estimation

2.3.3. LMMSE estimation of a sequence. Wiener Filter

2.3.4. Applications

2.4. Hypothesis testing

2.4.1. Introduction

2.4.2. Classical aproach: Likelihood ratio test

Firmado Por	Firma Automatizada	02/07/2026	Página 4/13

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2.4.3. Bayesian decision

2.4.4. Applications

ACTIVITIES

Assessment activity   Learning activity

WEEKS	FORMAT	TOTAL DURATION	LOCATION	GROUP	METHODOLOGY
1	In person	04h 00m	Classroom (scheduled)	Normal	Lecture
2	In person	04h 00m	Classroom (scheduled)	Normal	Lecture
3	In person	04h 00m	Classroom (scheduled)	Normal	Lecture
4	In person	04h 00m	Classroom (scheduled)	Normal	Lecture

Firmado Por	Firma Automatizada	02/07/2026	Página 5/13

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WEEKS 1 2 3 4 **5** 6 7 8 9 10 11 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	04h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

WEEKS 1 2 3 4 5 **6** 7 8 9 10 11 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	04h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

WEEKS 1 2 3 4 5 6 **7** 8 9 10 11 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	02h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

WEEKS 1 2 3 4 5 6 **7** 8 9 10 11 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	02h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

WEEKS 1 2 3 4 5 6 7 **8** 9 10 11 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	04h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

Firmado Por	Firma Automatizada	02/07/2026	Página 6/13

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WEEKS 1 2 3 4 5 6 7 8 **9** 10 11 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	04h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

WEEKS 1 2 3 4 5 6 7 8 9 **10** 11 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	02h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

WEEKS 1 2 3 4 5 6 7 8 9 **10** 11 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	02h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

WEEKS 1 2 3 4 5 6 7 8 9 10 **11** 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	ASSESSMENT	WEIGHT	MINIMUM GRADE
In person	01h 30m	Other	Progressive	50%	3.5

METHODOLOGY
Written exam

ASSESSED OUTCOMES
CG1 CG2 CG5 CT3 CT4 CT5 CE1

WEEKS 1 2 3 4 5 6 7 8 9 10 **11** 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	04h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

Firmado Por	Firma Automatizada	02/07/2026	Página 7/13

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WEEKS 1 2 3 4 5 6 7 8 9 10 **11** 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	02h 00m	Classroom (scheduled)	Normal

TOPICS
T1

METHODOLOGY
Other activities

WEEKS 1 2 3 4 5 6 7 8 9 10 11 **12** 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	02h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

WEEKS 1 2 3 4 5 6 7 8 9 10 11 **12** 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	02h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

WEEKS 1 2 3 4 5 6 7 8 9 10 11 12 **13** 14 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	04h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

WEEKS 1 2 3 4 5 6 7 8 9 10 11 12 13 **14** 15 E

FORMAT	TOTAL DURATION	LOCATION	GROUP
In person	04h 00m	Classroom (scheduled)	Normal

METHODOLOGY
Lecture

Firmado Por	Firma Automatizada	02/07/2026	Página 8/13

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WEEKS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	ASSESSMENT	WEIGHT	MINIMUM GRADE
In person	04h 00m	Other	Retake (Extraordinary)	100%	5

TOPICS
T1 T2

METHODOLOGY
Written exam

ASSESSED OUTCOMES
CG1 CG2 CG5 CT3 CT4 CT5 CE1

WEEKS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	ASSESSMENT	WEIGHT	MINIMUM GRADE
In person	02h 00m	Other	Progressive	50%	3.5

TOPICS
T2

METHODOLOGY
Written exam

ASSESSED OUTCOMES
CG1 CG2 CG5 CT3 CT4 CT5 CE1

WEEKS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 E

FORMAT	TOTAL DURATION	LOCATION	ASSESSMENT	WEIGHT	MINIMUM GRADE
In person	04h 00m	Other	Global	100%	5

TOPICS
T1 T2

METHODOLOGY
Written exam

ASSESSED OUTCOMES
CG1 CG2 CG5 CT3 CT4 CT5 CE1

WEEKLY SCHEDULE

Assessment activity · Learning activity · Week with activity · E Exam period

Firmado Por	Firma Automatizada	02/07/2026	Página 9/13

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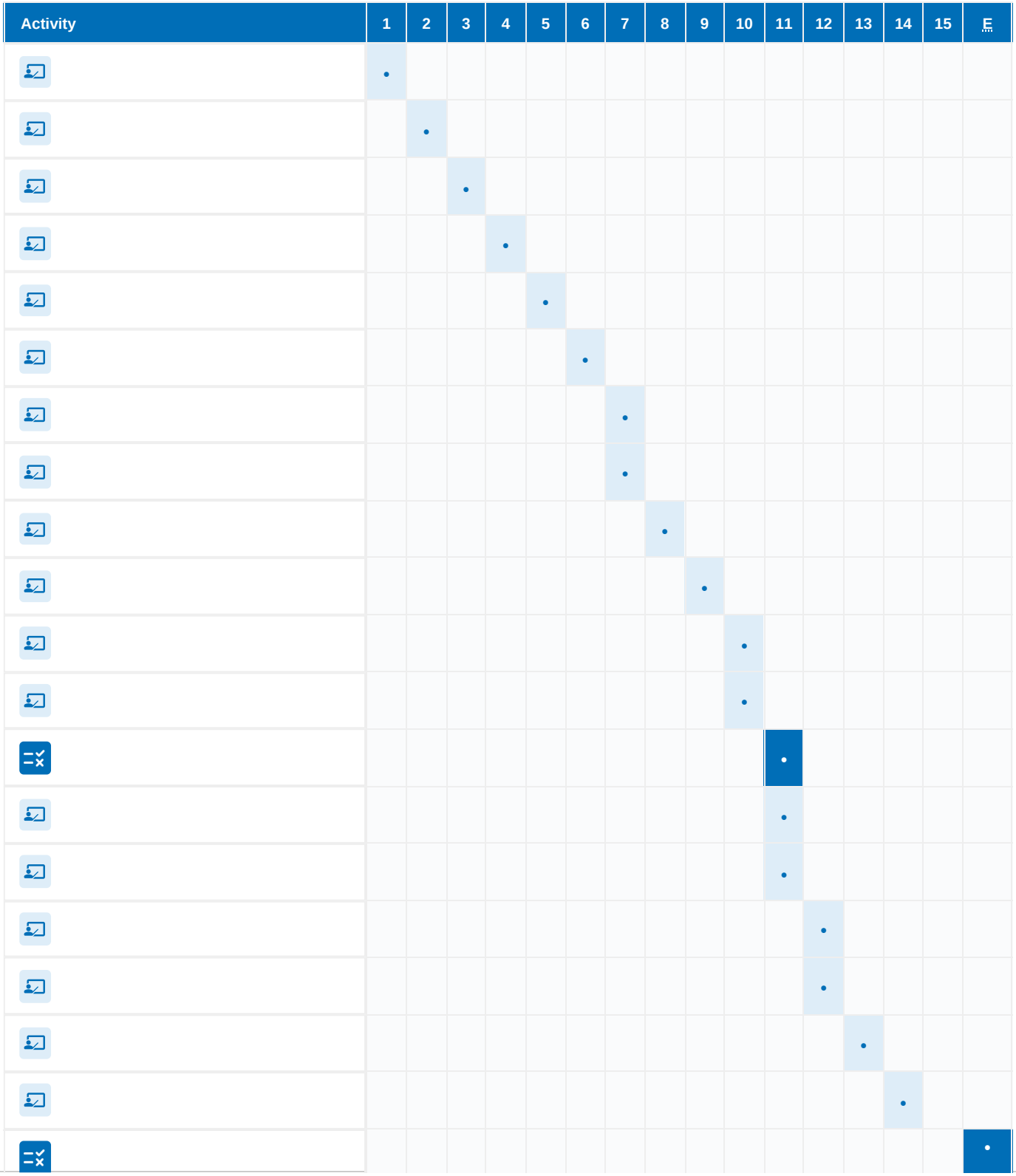

Firmado Por	Firma Automatizada	02/07/2026	Página 10/13

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Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	E
																•
																•

ASSESSMENT CRITERIA

General criteria

The assessment will verify whether students have acquired the competencies for the subject. Therefore, the assessment in the extraordinary session will use the same types of assessment techniques as those used in the assessment of the ordinary session (EX, ET, TG, etc.).

Assessment criteria for the regular exam period. Progressive assessment

Assessment criteria

The continuous evaluation consists of 2 partial examinations. The final score of the subject will be obtained in the following way:
50% from the score of the first partial examination corresponding with the optimization part
50% form the grade of the second partial examination corresponding with the statistical signal processing part.

Requirements to pass the subject:
Obtain at least 3.5 points (out of 10) in each partial examination. If this case does not happen, it will appear the minimum.
Obtain a final grade greater than or equal to 5 points (out of 10).

The first partial test will take place on week 11st.

The second partial test will be done on the subject official date for the final examination.

Activities

- Primer parcial (50%)
- Segundo parcial (50%)

Assessment criteria for the regular exam period. Global assessment

Assessment criteria

Firmado Por	Firma Automatizada	02/07/2026	Página 11/13

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The qualification is obtained as follows:
100% of the final examination score.

The final exam will have 2 parts: One for optimization and another for statistical signal processing.

Requirements to pass the subject:
Obtain at least 3.5 points (out of 10) in each of the 2 parts of the exam. If this case does not happen, it will appear the minimum.
Obtain a final grade greater than or equal to 5 points (out of 10).

Activities

- Examen final (100%)

Assessment criteria for the retake (extraordinary) exam period

Assessment criteria

The extraordinary examination will use the same evaluation procedure as the final assesment.
The score of the subject will be obtained in the following way:
100% of the final examination score.

The final exam will have 2 parts: One for optimization and another for statistical signal processing.

Requirements to pass the subject:
Obtain at least 3.5 points (out of 10) in each of the 2 parts of the exam. If this case does not happen, it will appear the minimum.
Obtain a final grade greater than or equal to 5 points (out of 10).

Activities

- Examen extraordinario (100%)

RESOURCES

Bibliography

Apuntes y ejercicios de la asignatura

Linear and Nonlinear Programming, 2nd ed. D. G. Luenberger. Addison-Wesley, 1984

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Engineering Optimization, Theory and Practice, 4th ed. S. S. Rao. John Wiley & Sons, 2009

Mathematical Methods and Algorithms for Signal Processing. T. K. Moon. Prentice-Hall, 2000

Probability, Random Variables, and Stochastic Processes, 4th ed. A. Papoulis, S. U. Pillai. McGraw-Hill, 2002

Fundamentals of Statistical Signal Processing, Volume 1: Estimation Theory. S. M. Kay. Prentice Hall, 1993

Fundamentals of Statistical Signal Processing, Volume 2: Detection Theory. S. M. Kay. Prentice Hall 1998

Adaptive Filter Theory, 5th ed. S. O. Haykin. Pearson, 2013

SUSTAINABLE DEVELOPMENT GOALS

Quality Education

Industry, Innovation and Infrastructure

OTHER INFORMATION

More generally, applied mathematics is used extensively in engineering and, in particular, will have an impact on everything related to telecommunications infrastructure (SDG 9). The course will also contribute to sub-goals 4.4: Substantially increase the number of people with the professional and technical skills needed for employment and entrepreneurship; and 4.7: Ensure that all students acquire the theoretical and practical knowledge needed to promote sustainable development.

Firmado Por	Firma Automatizada	02/07/2026	Página 13/13

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