



INTERNATIONAL  
CAMPUS OF  
EXCELLENCE

COORDINATION PROCESS OF  
LEARNING ACTIVITIES  
PR/CL/001

Esc. Politéc. Enseñanza  
Superior (Epes)

# ANX-PR/CL/001-01

## LEARNING GUIDE

### SUBJECT

**303000092 - Análisis Avanzado**

### DEGREE PROGRAMME

30AH - Máster Universitario En Matemáticas Avanzadas

### ACADEMIC YEAR & SEMESTER

2025/26 - Semester 1

## Index

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### Learning guide

1. Description.....	1
2. Faculty.....	1
3. Prior knowledge recommended to take the subject.....	2
4. Skills and learning outcomes .....	2
5. Brief description of the subject and syllabus.....	4
6. Schedule.....	6
7. Activities and assessment criteria.....	8
8. Teaching resources.....	11
9. Other information.....	12

## 1. Description

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### 1.1. Subject details

<b>Name of the subject</b>	303000092 - Análisis Avanzado
<b>No of credits</b>	6 ECTS
<b>Type</b>	Optional/elective
<b>Academic year of the programme</b>	First year
<b>Semester of tuition</b>	Semester 1
<b>Tuition period</b>	September-January
<b>Tuition languages</b>	English
<b>Degree programme</b>	30AH - Máster Universitario en Matemáticas Avanzadas
<b>Centre</b>	30 - Esc. Politéc. Enseñanza Superior (epes)
<b>Academic year</b>	2025-26

## 2. Faculty

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### 2.1. Faculty members with subject teaching role

<b>Name and surname</b>	<b>Office/Room</b>	<b>Email</b>	<b>Tutoring hours *</b>
M. Elena Dominguez Jimenez (Subject coordinator)		elena.dominguez@upm.es	Sin horario. Contact with the teacher via email

\* 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

- Fourier series
- Integration of elemental functions
- Complex numbers
- Basic programming in Matlab or Python

### 4. Skills and learning outcomes \*

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#### 4.1. Skills to be learned

CO1 - Conocer los principales métodos y teorías matemáticas, próximos a la frontera del conocimiento, que permitan tener una amplia perspectiva en al menos tres de las siguientes áreas: Análisis Matemático, Métodos Numéricos, Ecuaciones Diferenciales, Estadística y Ciencia de Datos, Álgebra, Geometría y Topología. TIPO: Conocimientos o contenidos.

CO2 - Conocer demostraciones matemáticas avanzadas que permitan relacionar de una manera rigurosa las hipótesis con las conclusiones en al menos tres de las áreas relacionadas en el CO1. TIPO: Conocimientos o contenidos.

CO3 - Conocer diversas aplicaciones de las teorías matemáticas y su modelización en otros entornos o disciplinas que permitan adaptar los conocimientos matemáticos a nuevos problemas. TIPO: Conocimientos o contenidos.

CP1 - Utilizar programas informáticos especializados como laboratorio para diseñar, construir o validar hipótesis científicas en alguno de los ámbitos de las matemáticas. TIPO: Competencias.

CP2 - Ser capaz de trabajar en equipos multidisciplinares que involucren conocimientos matemáticos avanzados en áreas teóricas o aplicadas. TIPO: Competencias.

CP3 - Seleccionar y comprender la bibliografía científica sobre un tema concreto, extrayendo la información relevante. TIPO: Competencias.

CP4 - Comunicar de forma oral y escrita conocimientos y conclusiones científicas, valorando diferentes interpretaciones en públicos especializados y no especializados de una manera clara y rigurosa. TIPO: Competencias

CP5 - Complementar la formación matemática de manera autónoma en avances específicos de las Matemáticas, seleccionando la bibliografía adecuada y planteando cuestiones de interés. TIPO: Competencias

CP6 - Reflexionar sobre la relevancia social y ética de la aplicación de los conocimientos adquiridos a determinados problemas. TIPO: Competencias

HA1 - Aplicar los conocimientos matemáticos adquiridos a la resolución de problemas nuevos de una manera crítica, generando hipótesis de trabajo claras, definiciones precisas, nuevos enfoques con fundamento matemático y soluciones originales. TIPO: Habilidades o destrezas

HA2 - Ser capaz de abstraer y detectar las dificultades relevantes ante problemas complejos para poder plantearlos correctamente y resolverlos con técnicas matemáticas avanzadas. TIPO: Habilidades o destrezas

HA3 - Dominar el rigor matemático en las técnicas de demostración aprendidas para su posterior uso en el enunciado y demostraciones de nuevos teoremas. TIPO: Habilidades o destrezas

HA4 - Poseer destreza para proponer, validar e interpretar modelos matemáticos de diferente dificultad en situaciones reales complejas, utilizando las herramientas matemáticas más adecuadas a los fines que se persigan, y valorando las hipótesis y conclusiones asociadas a cada nivel de dificultad del modelo. TIPO: Habilidades o destrezas

HA5 - Adaptar teorías y técnicas matemáticas avanzadas al estudio de problemas en otros ámbitos con criterio científico para valorar su repercusión y formular las hipótesis adecuadas. TIPO: Habilidades o destrezas

HA6 - Interpretar adecuadamente la relevancia de nuevos resultados en Matemáticas, su aplicabilidad en situaciones particulares donde pudieran suponer nuevos avances y su relación con los resultados existentes. TIPO: Habilidades o destrezas

## 4.2. Learning outcomes

RA6 - To understand Fourier Theory and its applications

RA7 - To understand Wavelet Theory and its applications

\* 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 studies advanced analysis concepts such as Fourier series, Fourier Transform and the Wavelet Transform, both in functional spaces and in their discrete versions. Their theoretical study is complemented by numerous practical applications, including spectral analysis, signal compression, signal denoising, image compression and image processing, among others.

### 5.2. Syllabus

#### 1. Fourier series

- 1.1. Trigonometric approximation of periodic functions. Fourier coefficients. Fourier series.
- 1.2. Gibbs phenomenon.

#### 2. Fourier Transform

- 2.1. Definition and properties. Uncertainty principle.
- 2.2. Shannon sampling theorem: reconstruction of band limited functions.
- 2.3. Fourier Analysis applications: filter design and spectral analysis.

#### 3. Discrete Fourier Transform (DFT)

- 3.1. Definition of the DFT of a vector. Motivation from Fourier coefficients.
- 3.2. Fourier matrix and DFT. Properties of DFT. FFT algorithm.
- 3.3. Trigonometric interpolation via DFT.
- 3.4. Applications of DFT: data compression, filtering of digital signals.

#### 4. Continuous Wavelet Transform (CWT)

- 4.1. Definition of Wavelet. Continuous Wavelet Transform.
- 4.2. Multiresolution Analysis
- 4.3. Wavelet families: Haar wavelet and Daubechies wavelet
- 5. Discrete Wavelet Transform (DWT)
  - 5.1. Definition of DWT. Mallat's algorithm.
  - 5.2. Discrete Wavelet Transform of images.
  - 5.3. Applications: signal approximation, compression, denoising, singularities detection.

## 6. Schedule

### 6.1. Subject schedule\*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	<b>Fourier series</b> Duration: 04:00 Lecture			
2	<b>Fourier series</b> Duration: 02:00 Lecture  <b>Fourier. series</b> Duration: 02:00 Problem-solving class			
3	<b>Fourier Transform</b> Duration: 04:00 Lecture			
4	<b>Fourier Transform</b> Duration: 02:00 Lecture  <b>Fourier Transform</b> Duration: 02:00 Problem-solving class			
5	<b>Discrete Fourier Transform (DFT)</b> Duration: 04:00 Lecture			
6	<b>Discrete Fourier Transform (DFT)</b> Duration: 02:00 Lecture  <b>Discrete Fourier Transform (DFT)</b> Duration: 02:00 Problem-solving class			
7	<b>Discrete Fourier Transform (DFT)</b> Duration: 02:00 Problem-solving class  <b>Written Test 1</b> Duration: 02:00 Additional activities			<b>Written test 1</b> Written test Progressive assessment Presential Duration: 02:00
8	<b>Applications of DFT</b> Duration: 02:00 Problem-solving class  <b>Computer Practice</b> Duration: 02:00 Laboratory assignments			<b>Computer Practice</b> Problem-solving test Progressive assessment Presential Duration: 02:00

9	<b>Wavelet Transform</b> Duration: 04:00 Lecture			
10	<b>Wavelet Transform</b> Duration: 04:00 Lecture			
11	<b>Discrete Wavelet Transform (DWT)</b> Duration: 04:00 Lecture			
12	<b>Discrete Wavelet Transform (DWT)</b> Duration: 02:00 Lecture  <b>Discrete Wavelet Transform (DWT)</b> Duration: 02:00 Problem-solving class			
13	<b>Written Test 2</b> Duration: 02:00 Additional activities  <b>Applications of Wavelet Transform</b> Duration: 02:00 Lecture			<b>Written test 2</b> Written test Progressive assessment Presential Duration: 02:00
14	<b>Applications of Wavelet Transform</b> Duration: 04:00 Lecture			
15	<b>Applications of Wavelet Transform</b> Duration: 02:00 Problem-solving class  <b>Work on Applications of Fourier/Wavelet Transform</b> Duration: 02:00 Additional activities			<b>Work on applications of Fourier/Wavelet transforms</b> Other assessment Progressive assessment Presential Duration: 02:00
16				
17				<b>Global Exam</b> Individual work Global examination Presential Duration: 03:00

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.

## 7. Activities and assessment criteria

### 7.1. Assessment activities

#### 7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
7	Written test 1	Written test	Face-to-face	02:00	20%	0 / 10	CO1 CO2 CO3 CP4 HA1 HA2 HA3
8	Computer Practice	Problem-solving test	Face-to-face	02:00	10%	0 / 10	CO3 CP1 CP2 HA4 HA5
13	Written test 2	Written test	Face-to-face	02:00	20%	0 / 10	CO1 CO2 CO3 CP4 HA1 HA2 HA3 HA4
15	Work on applications of Fourier/Wavelet transforms	Other assessment	Face-to-face	02:00	25%	3 / 10	CO1 CO3 CP1 CP2 CP3 CP4 CP5 CP6 HA1 HA2 HA4 HA5 HA6

#### 7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Global Exam	Individual work	Face-to-face	03:00	100%	5 / 10	CO1 CO2 CO3 CP1 CP2 CP3 CP4 CP5 CP6 HA1 HA2 HA3 HA4 HA5 HA6

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

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Extraordinary call	Individual work	Face-to-face	03:00	100%	5 / 10	CO1 CO2 CO3 CP1 CP2 CP3 CP4 CP5 CP6 HA1 HA2 HA3 HA4 HA5 HA6

## 7.2. Assessment criteria

**Progressive Evaluation (PE):** The grades will be the sum of the following items:

- 2 written tests, one of the first part (Fourier theory, 20%) and one of the second part (Wavelet theory, 20%)
- Computer Practice (10%)
- Some written exercises that will be developed either in the classroom or as homework (20%)
- A final work (25%) on a practical application of Fourier/wavelet methods to real problem. It will be done individually or in pairs, and will be presented the last weeks of the course
- Participation in the classroom will also be assessed (with a maximum of 5% of the grade).

**Global Assessment:** Students who do not pass the PE are entitled to a Global Exam, which will consist of a theoretical and practical test (100% of the grade).

The extraordinary call also consists of an exam covering the entire subject.

In all the tests: correct mathematical approach, theoretical knowledge, and correct exercise solutions will be assessed, as well as analysis of results and clarity of presentation.

## 8. Teaching resources

### 8.1. Teaching resources for the subject

Name	Type	Notes
Theory notes	Bibliography	Teaching material written in English by the teacher, available in Moodle.
Exercises	Bibliography	Exercises proposed and solved by the teacher, available in Moodle.
Moodle page	Web resource	The Moodle page for this course <a href="http://moodle.upm.es/titulaciones/oficiales">http://moodle.upm.es/titulaciones/oficiales</a> will include notes, exercises and information available for the students.
MATLAB software	Equipment	Available for UPM students through UPM campus licence.
Bachman et al, "Fourier and wavelet analysis", Ed. Springer, 2000	Bibliography	Book on Fourier Theory and exercises, available at the ETSIAAB Library (signature 517.52 BAC FOU)
C. Gasquet, P. Witomski, "Fourier Analysis and Applications. Filtering, numerical computation, wavelets", Ed. Springer, 1998	Bibliography	Book on Fourier Theory and exercises. Available at at DMAII Library (ETSII), signature 06GAS3.
A. Boggess, F. J. Narcowich: "A First Course in Wavelets with Fourier Analysis", 2nd Edition, Wiley, 2009	Bibliography	Book on Fourier and Wavelet Theory and applications. Available online for UPM at <a href="https://learning.oreilly.com/library/view/a-first-course/9781118211151/">https://learning.oreilly.com/library/view/a-first-course/9781118211151/</a>
M.E. Domínguez, G. Sansigre, "Transformada wavelet básica para ingenieros" (2006), ISBN: 84-689-8331-4	Bibliography	Book which contains the Fourier and Wavelet Theory of this course, written in Spanish. Available for students in Moodle.
G. Strang and T. Nguyen, "Wavelets and filter banks", Ed. Wellesley-Cambridge, 1996.	Bibliography	Book with theory and applications of Wavelet Transform. Available at DMAII Library (ETSII), signature 06STR2.

## 9. Other information

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### 9.1. Other information about the subject

The course will be given for the first time in the academic year 25/26.. Cronogram and instructions in this guide are guidelines and may be modified during the course based on teaching needs and the requirements of each assessment test. For computer-based practical work, students may use, among other things, the Matlab program, which the University has licensed for students.

Communication with the professor, if face-to-face communication is not possible, will be by email or online platform. Only messages from institutional addresses (@alumnos.upm.es) will be read, and replied as soon as possible during working hours (Monday to Friday).

This course is related to the Sustainable Development Goal SDG12 (ODS12, in Spanish), by promoting minimal resource consumption.