ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

93000940 - Time series analysis

DEGREE PROGRAMME

09AT - Master Universitario En Teoria De La Señal Y Comunicaciones

ACADEMIC YEAR & SEMESTER

2018/19 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	93000940 - Time series analysis
No of credits	4.5 ECTS
Type	Optional
Academic year ot the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	09AT - Master universitario en teoria de la señal y comunicaciones
Centre	09 - Escuela Tecnica Superior de Ingenieros de Telecomunicacion
Academic year	2018-19

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Mariano Garcia Otero (Subject coordinator)	C-327	mariano.garciao@upm.es	Sin horario. Appointment arranged by 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

3.1. Recommended (passed) subjects

El plan de estudios Master Universitario en Teoria de la Señal y Comunicaciones no tiene definidas asignaturas previas recomendadas para esta asignatura.

3.2. Other recommended learning outcomes

- Probability, Random Variables, and Stochastic Processes for Engineers

- Working knowledge of MATLAB or R

- Deterministic Signals and Systems Theory

4. Skills and learning outcomes *

4.1. Skills to be learned

CB06 - 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

CB07 - 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

CB10 - 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

CE01 - Analizar y aplicar técnicas para el diseño y desarrollo avanzado de equipos y sistemas, basándose en la teoría de la señal y las comunicaciones, en un entorno internacional

CE03 - Valorar y contrastar la utilización de las diferentes técnicas disponibles para la resolución de problemas reales dentro del área de teoría de la señal y comunicaciones.

CT01 - Capacidad para comprender los contenidos de clases magistrales, conferencias y seminarios en lengua inglesa

CT03 - Capacidad para adoptar soluciones creativas que satisfagan adecuadamente las diferentes necesidades planteadas

CT04 - Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo

CT05 - Capacidad para gestionar la información, identificando las fuentes necesarias, los principales tipos de documentos técnicos y científicos, de una manera adecuada y eficiente

4.2. Learning outcomes

RA17 - Capacidad para aplicar conocimientos de modelado estadístico, técnicas de optimización y modelos de series temporales en el análisis de datos y como base para el desarrollo de algoritmos de aprendizaje automático

RA18 - Knowledge of tools for description, analysis and modeling of discrete-time random processes

RA20 - Capability to choose the appropriate modeling and filtering tools in order to extract useful information from a time series

RA19 - Knowledge of tools to design optimal filtering and signal processing structures

* 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 is an introduction to the theory and practice of time series analysis, providing statistical tools to analyze random data that are ordered in time. It begins with a review of the theory of stochastic processes, which are the underlying mathematical description of time-varying random phenomena. Then, some classical parametric models for time series are presented, along with techniques to estimate their parameters. Time series are often analyzed in the frequency domain, so the course also covers topics on spectral estimation. Finally, the theory of optimal filtering and prediction is also presented, developed under the general framework of Bayesian estimation.

5.2. Syllabus

1. Random processes and sequences
   1.1. Basic definitions. Classification.
   1.2. Probabilistic descriptions.
   1.3. Special classes of processes.
   1.4. Stationarity. Power spectra.
   1.5. Linear systems.
   1.6. Ergodicity.
2. Time series modeling
   2.1. Linear stationary models: AR, MA, ARMA.
   2.2. Linear nonstationary models: ARIMA.
   2.3. Nonlinear models.
   2.4. Parameter estimation.
3. Spectral estimation
   3.1. Autocorrelation estimation.
   3.2. Classic spectral estimation.
   3.3. Parametric methods.
4. Optimal filtering
   4.1. Bayesian estimation.
   4.2. Wiener filter.
   4.3. Linear prediction.
   4.4. Recursive estimation.

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Other face-to-face activities	Assessment activities
1				
2				
3				
4	**Topic 1: Random processes and sequences** Duration: 02:00 Lecture			
5	**Topic 1: Random processes and sequences** Duration: 03:00 Lecture **Topic 1: Random processes and sequences** Duration: 01:00 Problem-solving class			
6	**Topic 1: Random processes and sequences** Duration: 03:00 Lecture **Topic 1: Random processes and sequences** Duration: 01:00 Problem-solving class			
7	**Topic 2: Time series modeling** Duration: 03:00 Lecture **Topic 2: Time series modeling** Duration: 01:00 Problem-solving class			
8	**Topic 2: Time series modeling** Duration: 03:00 Lecture **Topic 2: Time series modeling** Duration: 01:00 Problem-solving class			
9	**Topic 2: Time series modeling** Duration: 03:00 Lecture **Topic 2: Time series modeling** Duration: 01:00 Problem-solving class			

10	**Topic 2: Time series modeling** Duration: 03:00 Lecture **Topic 2: Time series modeling** Duration: 01:00 Problem-solving class			
11	**Topic 3: Spectral estimation** Duration: 03:00 Lecture **Topic 3: Spectral estimation** Duration: 01:00 Problem-solving class			
12	**Topic 3: Spectral estimation** Duration: 03:00 Lecture **Topic 3: Spectral estimation** Duration: 01:00 Problem-solving class			
13	**Topic 4: Optimal filtering** Duration: 03:00 Lecture **Topic 4: Optimal filtering** Duration: 01:00 Problem-solving class			
14	**Topic 4: Optimal filtering** Duration: 03:00 Lecture **Topic 4: Optimal filtering** Duration: 01:00 Problem-solving class			**Homework exercises** Individual work Continuous assessment Duration: 00:00 **Computer assignments** Individual work Continuous assessment Duration: 00:00
15				
16				
17				**Final examination** Written test Continuous assessment Duration: 02:00 **Final examination** Written test Final examination Duration: 02:00 **Computer assignment** Individual work Final examination Duration: 00:00

The independent study hours are training activities during which students should spend time on individual study or individual assignments.

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 subject schedule is based on a previous theorical planning of the subject plan and might go to through experience some unexpected changes along throughout the academic year.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
14	Homework exercises	Individual work	No Presential	00:00	25%	/ 10	CT01 CB07 CT03 CB06 CT04 CE01 CE03 CT05 CB10
14	Computer assignments	Individual work	No Presential	00:00	25%	/ 10	CT01 CB07 CT03 CB06 CT04 CE01 CE03 CT05 CB10
17	Final examination	Written test	Face-to-face	02:00	50%	3.5 / 10	CT01 CB07 CT03 CB06 CT04 CE01 CE03 CT05 CB10

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Final examination	Written test	Face-to-face	02:00	75%	5 / 10	CT01 CB07 CT03 CB06 CT04 CE01 CE03 CT05

							CB10
17	Computer assignment	Individual work	No Presential	00:00	25%	5 / 10	CT01 CB07 CT03 CB06 CT04 CE01 CE03 CT05 CB10

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Final examination	Written test	Face-to-face	02:00	75%	5 / 10	CT01 CB07 CT03 CB06 CT04 CE01 CE03 CT05 CB10
Computer assignment	Individual work	No Presential	00:00	25%	5 / 10	CT01 CB07 CT03 CB06 CT04 CE01 CE03 CT05 CB10

7.2. Assessment criteria

Students will be qualified through continuous evaluation by default. According to the Normativa de Evaluación del Aprendizaje de la Universidad Politécnica de Madrid, students willing to renounce to continuous evaluation must complete the Moodle task entitled "Renounce to continuous evaluation" within 8 weeks from the start date of the course (deadline will be announced in Moodle).

Evaluation will assess if students have acquired all the competences of the subject. Thus, evaluation through final assessment will be carried out considering all the evaluation techniques used in continuous evaluation (EX, ET, TG, etc.), and will be celebrated in the exam period approved by Junta de Escuela for the current academic semester and year. Evaluation activities that assess learning outcomes that cannot be evaluated through a single exam can be carried out along the semester.

Extraordinary examination will be carried out exclusively by the final assessment method.

Continous assessment

Several homework assignments will be proposed to be delivered throughout the semester. Some of them will be exercises to be solved by the students (25% of final grade). Others will require the students to develop computer code (in Matlab or R) to analyze more complex problems (25% of final grade).

There is also a final examination at the end of the semester (50% of final grade).

A minimum grade of 3.5 (in a 0 to 10 scale) on the final examination and a global average of 5.0 (in a 0 to 10 scale) will be required to pass the course.

Final assessment

Those students who waive continuous evaluation should take the final examination (75% of final grade) and also submit the computer assignments (25% of final grade).

A minimum grade of 5.0 (in a 0 to 10 scale) both on the final examination and on the computer assignments will be required to pass the course.

Extraordinary examination

Students taking the extraordinary examination (75% of final grade) should also submit the computer assignments (25% of final grade).

A minimum grade of 5.0 (in a 0 to 10 scale) both on the extraordinary examination and on the computer assignments will be required to pass the course.

Those students who had previously submitted the computer assignments throughout the semester and obtained the minimum grade of 5.0 are not required to resubmit them.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Lecture slides and exercises.	Bibliography	Course material available on Moodle
M. García Otero. Notes on Probability and Random Variables. SSR-ETSIT-UPM, 2016.	Bibliography	Background material available on Moodle
C. W. Therrien. Discrete Random Signals and Statistical Signal Processing. Prentice-Hall, 1992.	Bibliography	
H. Kobayashi et al. Probability, Random Processes, and Statistical Analysis. Cambridge University Press, 2011.	Bibliography	
M. H. Hayes. Statistical Digital Signal Processing and Modeling. Wiley, 1996.	Bibliography	

K. Sam Shanmugan, A. M. Breipohl. Random Signals: Detection, Estimation and Data Analysis. Wiley, 1988.	Bibliography	
R. H. Shumway, D. S. Stoffer. Time Series Analysis and Its Applications: With R Examples. Springer, 2010. (http://www.stat.pitt.edu/stoffer/tsa3/)	Bibliography	
M. Falk et al. A First Course on Time Series Analysis: Examples with SAS. University of Würzburg, 2012. (http://www.statistik-mathematik.uni-wuerzburg.de/wissenschaftforschung/time_series/the_book/)	Bibliography	
P. J. Brockwell, R. A. Davis. Introduction to Time Series and Forecasting. Springer, 2002.	Bibliography	
D.C. Cryer, K. Chan. Time Series Analysis with Application in R. Springer, 2008.	Bibliography	
G. E. P. Box, G. M. Jenkins, G. C. Reinsel, G. M. Ljung. Time Series Analysis: Forecasting and Control. Wiley, 2015.	Bibliography	