



POLITÉCNICA

INTERNATIONAL
CAMPUS OF
EXCELLENCE

COORDINATION PROCESS OF
LEARNING ACTIVITIES
PR/CL/001



E.T.S. de Ingenieros
Industriales

ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

53000687 - Computational Statistics And Stochastic Modelling

DEGREE PROGRAMME

05BD - Master Universitario En Ingenieria De La Organizacion

ACADEMIC YEAR & SEMESTER

2021/22 - Semester 1

Index

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.....	5
6. Schedule.....	8
7. Activities and assessment criteria.....	10
8. Teaching resources.....	11

1. Description

1.1. Subject details

Name of the subject	53000687 - Computational Statistics And Stochastic Modelling
No of credits	3 ECTS
Type	Optional
Academic year of the programme	Second year
Semester of tuition	Semester 3
Tuition period	September-January
Tuition languages	English
Degree programme	05BD - Master Universitario en Ingenieria de la Organizacion
Centre	05 - Escuela Tecnica Superior De Ingenieros Industriales
Academic year	2021-22

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Carolina Silvia Garcia Martos (Subject coordinator)		garcia.martos@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

3.1. Recommended (passed) subjects

- Bigdata: De Los Datos A Las Decisiones

3.2. Other recommended learning outcomes

The subject - other recommended learning outcomes, are not defined.

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

CB08 - 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

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 - Conocer y aplicar técnicas y herramientas para el manejo y análisis de grandes masas de datos

CG01 - Utilizar los conocimientos científicos y tecnológicos adquiridos en sus estudios de Grado en Ingeniería como recurso a integrar en la generación de soluciones a problemas de las organizaciones, sean éstos de funcionamiento o de diseño

CG02 - Analizar situaciones estructuradas y poco estructuradas de empresas y otras organizaciones, estableciendo diagnósticos apropiados, en particular, de carácter estratégico

CG05 - Conocer las tendencias predominantes en el entorno actual de las distintas políticas funcionales (marketing, producción, logística, finanzas, recursos humanos, liderazgo...)

CG06 - Conocer y aplicar las principales tramas conceptuales (frameworks) para el desarrollo de la estrategia de una organización y la gestión de los procesos de diseño, de gestión de la información y cambio de dicha organización

CT01 - Aplica. Habilidad para aplicar conocimientos científicos, matemáticos y tecnológicos en sistemas relacionados con la práctica de la ingeniería

CT02 - Experimenta. Habilidad para diseñar y realizar experimentos así como analizar e interpretar datos

CT03 - Diseña. Habilidad para diseñar un sistema, componente o proceso que alcance los requisitos deseados teniendo en cuenta restricciones realistas tales como las económicas, medioambientales, sociales, políticas, éticas, de salud y seguridad, de fabricación y de sostenibilidad

CT04 - Trabaja en equipo. Habilidad para trabajar en equipos multidisciplinares

CT05 - Resuelve. Habilidad para identificar, formular y resolver problemas de ingeniería

CT08 - Entiende los impactos. Educación amplia necesaria para entender el impacto de las soluciones ingenieriles en un contexto social global

CT09 - Se actualiza. Reconocimiento de la necesidad y la habilidad para comprometerse al aprendizaje continuo

CT10 - Conoce. Conocimiento de los temas contemporáneos

CT11 - Usa herramientas. Habilidad para usar las técnicas, destrezas y herramientas ingenieriles modernas necesarias para la práctica de la ingeniería

CT12 - Es bilingüe. Capacidad de trabajar en un entorno bilingüe (inglés/español)

4.2. Learning outcomes

RA1 - Elegir y aplicar técnicas de análisis exploratorios de grandes bases de datos

RA3 - Elegir y aplicar técnicas de predicción para variables cuantitativas y cualitativas

RA47 - Enumerar, seleccionar y aplicar herramientas y metodologías para la explotación de datos mediante modelos

RA48 - Identificar y aplicar modelos estadísticos de predicción en el funcionamiento diario de una empresa eléctrica

RA71 - RA1 - Elegir y aplicar técnicas de análisis exploratorios de grandes bases de datos

RA73 - RA3 - Elegir y aplicar técnicas de predicción para variables cuantitativas y cualitativas

RA2 - Elegir y aplicar técnicas de modelado de grandes bases de datos

RA74 - RA47 - Enumerar, seleccionar y aplicar herramientas y metodologías para la explotación de datos mediante modelos

RA75 - RA48 - Identificar y aplicar modelos estadísticos de predicción en el funcionamiento diario de una empresa eléctrica

RA76 - RA6 - Formalizar, implementar y explotar modelos no deterministas

RA6 - Formalizar, implementar y explotar modelos no deterministas

RA72 - RA2 - Elegir y aplicar técnicas de modelado de grandes bases de datos

* 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 mainly focused on the analysis, modelling and forecasting of time-dependent data. There are many examples of time series: electricity prices in liberalized markets, Industrial Production Indexes in the EU countries, CO2 emission prices or unemployment rates, among many others. We will firstly review main concepts of univariate time series (Autocorrelation and Partial Autocorrelation Function, ACF and PACF, respectively, stationary processes such that AR, MA and ARMAs) and then revise nonstationary processes (ARIMAs) and go deeply into Seasonal ARIMA models. This is all focused on modelling and forecasting the conditional mean (i.e., modelling and forecasting the same variable for which we have the historical data) in the univariate framework (a single variable evolving over time, or several ones but not accounting for their multivariate relationship).

Then we will move to volatility models (conditionally heteroskedastic models) where the main issue is to model and forecast the volatility and to use that for improving the computation of forecasting intervals.

Finally we will move to the multivariate framework: VARIMA models will be studied.

The approach will be practical, with extensive use of the R an open-source package for the analysis of real-data examples.

Significant attention will be devoted to, by means of statistical inference, quantification of uncertainty, which is an essential added value of Statistics for decision-making processes under uncertainty.

OUTLINE:

1) Introduction to Time series.

1a. ACF and PACF

1b. Stationary time series (AR, MA and ARMA models)

1c. ARIMA models.

1d. Seasonal ARIMA models.

2. Conditional Heteroskedasticity and volatility

2a. GARCH models

2b. SV models

3. Multivariate time series models

5.2. Syllabus

1. Introduction to Time Series
 - 1.1. ACF and PACF
 - 1.2. AR, MA and ARMA models
 - 1.3. ARIMA models
 - 1.4. Seasonal ARIMA models
2. Conditional Heteroskedasticity and volatility
 - 2.1. ARCH and GARCH models
 - 2.2. SV models
3. Multivariate Time Series Models
 - 3.1. VARIMA models
 - 3.2. Introduction to dimensionality reduction techniques

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Distant / On-line	Assessment activities
1				
2	Introduction to univariate time series models. ACF and PACF. Stationary models (AR, MA, ARMA). Duration: 04:00 Lecture			
3	ARIMA models Duration: 01:00 Lecture	ARIMA models Duration: 01:00 Cooperative activities		
4	Seasonal ARIMA models Duration: 02:00 Lecture			
5		Seasonal ARIMA models and review on univariate models Duration: 02:00 Problem-solving class		
6				Presentations on Seasonal ARIMA models (groups of 2 or 3 students depending on the total number of students enrolled) Group presentation Continuous assessment Presential Duration: 02:00
7	Volatility modelling and ARCH models Duration: 02:00 Lecture			
8	Volatility and conditional heteroskedasticity Duration: 01:00 Lecture ARCH models Duration: 01:00 Lecture			
9	GARCH models Duration: 01:00 Lecture	ARCH and GARCH models Duration: 01:00 Problem-solving class		
10	Stochastic Volatility models Duration: 02:00 Lecture			

11				Practical exam on volatility models (using RStudio and analyzing real datasets). Written test Continuous assessment Presential Duration: 02:00
12	Multivariate models. Introduction and VARIMA models Duration: 02:00 Lecture			
13		VARIMA models with the package MTS in R Duration: 02:00 Problem-solving class		
14	An Introduction to dimensionality reduction techniques in the context of multivariate time series Duration: 02:00 Lecture			
15				Group presentations. Modelling real datasets using multivariate times series models Group presentation Continuous assessment Presential Duration: 02:00
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. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
6	Presentations on Seasonal ARIMA models (groups of 2 or 3 students depending on the total number of students enrolled)	Group presentation	Face-to-face	02:00	33%	5 / 10	CB07 CB08 CB10 CT09 CG05 CT11 CT10 CT12 CG02 CT03 CT05 CT01 CT02 CG06 CE01 CG01 CT08 CT04 CB06
11	Practical exam on volatility models (using RStudio and analyzing real datasets).	Written test	Face-to-face	02:00	33%	4 / 10	CT11 CB07 CB08 CT12 CT05 CT01 CT02 CE01 CG01
15	Group presentations. Modelling real datasets using multivariate times series models	Group presentation	Face-to-face	02:00	33%	5 / 10	CG05 CT11 CB07 CB08 CB10 CT09 CT10 CT12 CG02 CT03 CT05 CT01

							CT02
							CG06
							CE01
							CG01
							CT08
							CT04
							CB06

7.1.2. Final 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 group projects are mandatory to be able to pass the course. If any student fails the exam on volatility models with a grade smaller than 4, then he/she will take it again in the extraordinary exam. A minimum grade of 4 in this part is again needed. The average between the 3 parts must equal or larger than 5.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
"Time Series Analysis and Its Applications with R Examples" by Robert H. Shumway and David S. Stoffer.	Bibliography	
"Analysis of Financial Time Series", by Ruey Tsay.	Bibliography	
Statistical Learning for Big Dependent Data, by Daniel Peña and Ruey Tsay.	Bibliography	
Material developed by Carolina García-Martos, slides and R code	Others	