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
2020/21 - Semester 1
Index

Learning guide

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1. Description

1.1. Subject details

<table>
<thead>
<tr>
<th>Name of the subject</th>
<th>93000940 - Time Series Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of credits</td>
<td>4.5 ECTS</td>
</tr>
<tr>
<td>Type</td>
<td>Optional</td>
</tr>
<tr>
<td>Academic year of the programme</td>
<td>First year</td>
</tr>
<tr>
<td>Semester of tuition</td>
<td>Semester 1</td>
</tr>
<tr>
<td>Tuition period</td>
<td>September-January</td>
</tr>
<tr>
<td>Tuition languages</td>
<td>English</td>
</tr>
<tr>
<td>Degree programme</td>
<td>09AT - Master Universitario en Teoría de la Señal y Comunicaciones</td>
</tr>
<tr>
<td>Centre</td>
<td>09 - Escuela Tecnica Superior de Ingenieros de Telecomunicacion</td>
</tr>
<tr>
<td>Academic year</td>
<td>2020-21</td>
</tr>
</tbody>
</table>

2. Faculty

2.1. Faculty members with subject teaching role

<table>
<thead>
<tr>
<th>Name and surname</th>
<th>Office/Room</th>
<th>Email</th>
<th>Tutoring hours *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mariano Garcia Otero</td>
<td>C-327</td>
<td><a href="mailto:mariano.garciao@upm.es">mariano.garciao@upm.es</a></td>
<td>Sin horario. Appointment arranged by email</td>
</tr>
</tbody>
</table>

* 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

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

3.2. Other recommended learning outcomes

- Deterministic Signals and Systems Theory
- Probability, Random Variables, and Stochastic Processes for Engineers
- Working knowledge of MATLAB or R

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*

<table>
<thead>
<tr>
<th>Week</th>
<th>Face-to-face classroom activities</th>
<th>Face-to-face laboratory activities</th>
<th>Distant / On-line</th>
<th>Assessment activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Topic 1: Random processes and sequences</td>
<td>Duration: 03:00</td>
<td>Lecture</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Topic 1: Random processes and sequences</td>
<td>Duration: 01:00</td>
<td>Problem-solving class</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Topic 2: Time series modeling</td>
<td>Duration: 03:00</td>
<td>Lecture</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Topic 2: Time series modeling</td>
<td>Duration: 01:00</td>
<td>Problem-solving class</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Topic 2: Time series modeling</td>
<td>Duration: 03:00</td>
<td>Lecture</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Topic 3: Spectral estimation</td>
<td>Duration: 03:00</td>
<td>Lecture</td>
<td></td>
</tr>
</tbody>
</table>

*GA_09AT_93000940 1S_2020-21  Time Series Analysis  Master Universitario en Teoría de la Señal y Comunicaciones*
| 10 | Topic 3: Spectral estimation  
Duration: 03:00  
Lecture |  
| 11 | Topic 4: Optimal filtering  
Duration: 03:00  
Lecture |  
| 12 | Topic 4: Optimal filtering  
Duration: 03:00  
Lecture |  
| 13 | Topic 4: Optimal filtering  
Duration: 03:00  
Lecture | Homework exercises  
Individual work  
Continuous assessment  
Not Presental  
Duration: 00:00  
Computer assignments  
Individual work  
Continuous assessment  
Not Presental  
Duration: 00:00 |  
| 14 |  
| 15 |  
| 16 |  
| 17 | Final examination  
Written test  
Continuous assessment  
Presental  
Duration: 02:00  
Final examination  
Written test  
Final examination  
Presental  
Duration: 02:00  
Computer assignment  
Individual work  
Final examination  
Not Presental  
Duration: 00:00 |  

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.

* 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

<table>
<thead>
<tr>
<th>Week</th>
<th>Description</th>
<th>Modality</th>
<th>Type</th>
<th>Duration</th>
<th>Weight</th>
<th>Minimum grade</th>
<th>Evaluated skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Homework exercises</td>
<td>Individual work</td>
<td>No Presential</td>
<td>00:00</td>
<td>25%</td>
<td>3.5 / 10</td>
<td>CT01, CB07, CT03, CB06, CT04, CE01, CE03, CT05, CB10</td>
</tr>
<tr>
<td>13</td>
<td>Computer assignments</td>
<td>Individual work</td>
<td>No Presential</td>
<td>00:00</td>
<td>25%</td>
<td>3.5 / 10</td>
<td>CT01, CB07, CT03, CB06, CT04, CE01, CE03, CT05, CB10</td>
</tr>
<tr>
<td>17</td>
<td>Final examination</td>
<td>Written test</td>
<td>Face-to-face</td>
<td>02:00</td>
<td>50%</td>
<td>3.5 / 10</td>
<td>CT01, CB07, CT03, CB06, CT04, CE01, CE03, CT05, CB10</td>
</tr>
</tbody>
</table>

### 7.1.2. Final examination

<table>
<thead>
<tr>
<th>Week</th>
<th>Description</th>
<th>Modality</th>
<th>Type</th>
<th>Duration</th>
<th>Weight</th>
<th>Minimum grade</th>
<th>Evaluated skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Final examination</td>
<td>Written test</td>
<td>Face-to-face</td>
<td>02:00</td>
<td>75%</td>
<td>5 / 10</td>
<td>CT01, CB07, CT03, CB06, CT04, CE01, CE03, CT05</td>
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</tbody>
</table>
## 7.1.3. Referred (re-sit) examination

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

Continuous 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 every item (final examination, homework exercises and computer assignments) 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

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture slides and exercises.</td>
<td>Bibliography</td>
<td>Course material available on Moodle</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Title</td>
<td>Source</td>
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<tr>
<td>-----------</td>
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