# 200614 - MCI - Computational Intensive Methods

**Coordinating unit:** 200 - FME - School of Mathematics and Statistics  
**Teaching unit:** 715 - EIO - Department of Statistics and Operations Research  
1004 - UB - (ENG)Universitat de Barcelona  
**Academic year:** 2016  
**Degree:** MASTER'S DEGREE IN STATISTICS AND OPERATIONS RESEARCH (Syllabus 2013). (Teaching unit Optional)  
**ECTS credits:** 5  
**Teaching languages:** Spanish

## Teaching staff

**Coordinator:** JORDI OCAÑA REBULL  
**Others:** Segon quadrimestre:  
PEDRO FRANCISCO DELICADO USEROS - A  
JORDI OCAÑA REBULL - A

## Opening hours

**Timetable:** Monday, from 5pm to 7pm

## Prior skills

Familiarity with the foundations of calculus in one and more variables. Intermediate studies in probability and inference. Skills using the R environment for statistical computing and programming. Any good online R course may help, like http://www.ub.edu/stat/docencia/EADB/Curso%20basico%20de%20R.htm.

## Requirements

"Fundamentos de Inferencia Estadística" o "Inferencia Estadística Avanzada"  
"Computación en Estadística y en Optimización"

## Degree competences to which the subject contributes

**Specific:**  
MESIO-CE2. CE-2. Ability to master the proper terminology in a field that is necessary to apply statistical or operations research models and methods to solve real problems.  
MESIO-CE3. CE-3. Ability to formulate, analyze and validate models applicable to practical problems. Ability to select the method and / or statistical or operations research technique more appropriate to apply this model to the situation or problem.  
MESIO-CE6. CE-6. Ability to use appropriate software to perform the necessary calculations in solving a problem.  
MESIO-CE8. CE-8. Ability to discuss the validity, scope and relevance of these solutions and be able to present and defend their conclusions.  
MESIO-CE4. CE-4. Ability to use different inference procedures to answer questions, identifying the properties of different estimation methods and their advantages and disadvantages, tailored to a specific situation and a specific context.

**Transversal:**
CT1a. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

### Teaching methodology

#### On-Site Learning

On-site learning is organized into theoretical-practical sessions. It is anticipated that 50% of the sessions will be held in the theory class with computer-applied aids and projections, while the other 50% will be in the nature of guided practice or in workshops and will take place in the computer lab.

In the theoretical aspect of the sessions, the theoretical aspects are presented and discussed, accompanied by practical examples using transparencies that will be provided previously to the student.

The fundamental work environment of the practical sessions will be R, of which an intermediate knowledge is presumed (use of the environment and basic programming). Logical support will also be introduced when deemed necessary.

Hours present for the subject: The contents of the diverse subjects will be attempted to be balanced, with an investment of 12 hours (6 in classroom theory + 6 in the computer lab) for each topic.

#### Off-Site Learning

Off-site learning will consist of the study and resolution of theoretical and practical problems that the student should turn in throughout the course.

Concretely, the planned activities will be:

- Study of the learning materials, before and/or after each on-site session.
- Detailed analysis of diverse data sets, (personalized, specific to each student). It will be attempted that each data set serves as a basis for a case study in diverse methods (i.e. calculation of diverse bootstrap confidence intervals and the execution of permutation tests).
- The completion of theoretical and practical exercises on the studied methods. The practical exercises will require completion of programming tasks in R.

### Learning objectives of the subject

#### Abilities to Acquire:

- Acquisition of the ability to study through simulation all classes of inferential situations and statistical modeling.
- To understand the fundamentals of the Bootstrap Method and know how to apply it to the resolution of diverse statistical problems.
- To know the principal methods for constructing bootstrap confidence intervals.
- To understand the fundamentals of permutation tests and to acquire the necessary abilities for applying these concepts in diverse situations with a practical interest.
- To understand the fundamentals of the Montecarlo Method based in Markov Chains, and to acquire the necessary abilities to apply them, especially in determining prior distributions under a Bayesian focus.

Fundamental Transversal Goal: to adequately internalize and know how to apply two fundamental ideas: a) the Monte Carlo Method as a tool for studying the properties of statistical methods; b) the Monte Carlo Method as a basis for some
statistical methods.

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 30h</th>
<th>24.00%</th>
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<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Hours small group: 15h</td>
<td>12.00%</td>
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<tr>
<td></td>
<td>Guided activities: 0h</td>
<td>0.00%</td>
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<td></td>
<td>Self study: 80h</td>
<td>64.00%</td>
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## Content

<table>
<thead>
<tr>
<th>-Topic 1. Bootstrap Method</th>
<th>Learning time: 11h 15m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 7h 30m</td>
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<tr>
<td></td>
<td>Practical classes: 3h 45m</td>
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</tbody>
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**Description:**

**Related activities:**
Theoretical and practical classroom activities to introduce the main concepts, combined with practical exercises with real data, as face-to-face classwork and homework.

**Specific objectives:**
Given a dataset coming from an experimental or observational design, to acquire the abilities in order to perform an inferential analysis based on the bootstrap methodology.

<table>
<thead>
<tr>
<th>-Topic 2. Permutation and Randomization Tests</th>
<th>Learning time: 11h 15m</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 7h 30m</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 3h 45m</td>
</tr>
</tbody>
</table>

**Description:**
Sufficiency of ordinal statistics. Exact conditional tests. Monte Carlo approximation. Determining the number of random permutations. Some important practical permutation tests. Mantel test. Permutation tests and bootstrap tests. Distance-based permutation tests. PERMANOVA

**Related activities:**
Classroom activities to introduce the main concepts, in conjunction with practical exercises, to be performed at class and also as homework.

**Specific objectives:**
Given a null hypothesis, to acquire the capacity of identifying invariance with respect to permutations and to know how the corresponding permutation test is implemented.
The student evaluation will be based on:
- Exercises that are completed and turned in throughout the course (50%)
- A practical examination with questions on the theoretical concepts studied throughout the course (50%)

**Qualification system**

In order to be evaluated, the student must attend at least 80% of the classes.
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Bibliography

Basic:


Complementary:


Others resources:

Campus virtual