270206 - PIE1 - Probability and Statistics 1

Coordinating unit: 270 - FIB - Barcelona School of Informatics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2018
Degree: BACHELOR'S DEGREE IN DATA SCIENCE AND ENGINEERING (Syllabus 2017). (Teaching unit Compulsory)
ECTS credits: 7,5  Teaching languages: Catalan, Spanish

Prior skills

The contents of the previous subjects in the Degree.

Degree competences to which the subject contributes

Specific:
CE3. Analyze complex phenomena through probability and statistics, and propose models of these types in specific situations. Formulate and solve mathematical optimization problems.

General:
CG1. To design computer systems that integrate data of provenances and very diverse forms, create with them mathematical models, reason on these models and act accordingly, learning from experience.
CG2. Choose and apply the most appropriate methods and techniques to a problem defined by data that represents a challenge for its volume, speed, variety or heterogeneity, including computer, mathematical, statistical and signal processing methods.

Transversal:
CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.

Teaching methodology

Theory:
Lectures develop the theory and include illustrative examples.

Problems:
The students have in advance the list of problems relevant to the topic being developed in theory. They had the opportunity to try to solve problems before the problems class. They require the teacher's help in the points where they have encountered difficulties. The teacher solves these questions in the blackboard and develops the full solution of some problems that he or she considers that are especially challenging.

Laboratory:
The teacher introduces the R language during the course, with special emphasis on random variables simulation tools, descriptive statistics and univariate statistical inference.

Learning objectives of the subject

1. At the end of the course, students will know the definition of probability and their properties, and will apply them to solve probability calculation problems.
2. At the end of the course students will know how to use the concept of random variable to formalize and solve probability calculation problems.
3. At the end of the course students will know how to simulate complex random phenomena with the computer and deduce approximate values of amounts of interest (probabilities, characteristics of random variables) that are difficult to calculate analytically.
4. At the end of the course students will know the most common probabilistic distributions and will be able to recognize situations where they are used to model real phenomena.
5. At the end of the course, students will know how to calculate distributions and expected expectations and use them in prediction.
6. At the end of the course, students will know whether two random variables are independent, and if they are not, they will be able to measure the linear correlation coefficient.
7. At the end of the course, students will know the Law of the Great Names and the Central Limit Theorem.
8. At the end of the course students will know the concepts of population, sample, parameter and estimator, and know the basic properties.
9. At the end of the course students will know the basic tools of descriptive statistics and will know how to apply them.
10. At the end of the course, students will know the basics of statistical inference (timely estimation, confidence intervals and hypothesis tests) and will know how to calculate them in real situations.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 187h 30m</th>
<th>Hours large group:</th>
<th>45h</th>
<th>24.00%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hours small group:</td>
<td>30h</td>
<td>16.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities:</td>
<td>7h 30m</td>
<td>4.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>105h</td>
<td>56.00%</td>
</tr>
</tbody>
</table>
# Probability and Statistics 1

## Content

### Probability spaces and random variables

**Degree competences to which the content contributes:**

- Random experiences.
- Algebra of events.
- Probability space.
- Conditional probability.
- Independence of events.
- Bayes' Theorem.
- Simulation of random experiments.

**Description:**


### Random variables

**Degree competences to which the content contributes:**

- Definition of random variable.
- Probability distribution function.
- Discrete random variables (probability function) and continuous variables (probability density function).
- Expectation and moments.
- Models of usual distributions.
- Simulation of random variables.

**Description:**


### Random vectors

**Degree competences to which the content contributes:**

- Multidimensional distributions.
- Independence.
- Conditioned distributions.
- Covariance and correlation.
- Expectation and covariance matrix.
- Conditioned expectation.
- Multinomial distribution.
- Multivariate normal distribution.

**Description:**


### Sum of random variables

**Degree competences to which the content contributes:**

- Distribution of the sum.
- Markov's, Chebyshev's and Chernoff's Inequalities.
- Law of Large Numbers.
- Central Limit Theorem.

**Description:**


### Population and sample

**Degree competences to which the content contributes:**

- Random sample.
- Empirical distribution function.
- Parametric statistical models.
- Parameters and estimators.
- Descriptive statistics.

**Description:**


### Point estimation

**Degree competences to which the content contributes:**
Confidence Intervals

Description:

Hypothesis testing

Description:
Type I and Type II Errors. Power. Relation with confidence intervals. The likelihood ratio test.
## Planning of activities

<table>
<thead>
<tr>
<th>Developing the Topic &quot;Probability and random variables&quot;</th>
<th>Hours: 17h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> Developing the Topic &quot;Probability and random variables&quot;</td>
<td><strong>Theory classes:</strong> 6h</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong> 1, 3</td>
<td><strong>Practical classes:</strong> 2h</td>
</tr>
<tr>
<td></td>
<td><strong>Laboratory classes:</strong> 2h</td>
</tr>
<tr>
<td></td>
<td><strong>Guided activities:</strong> 0h</td>
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<tr>
<td></td>
<td><strong>Self study:</strong> 7h</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Developing the Chapter &quot;Random variables&quot;</th>
<th>Hours: 17h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> Developing the Chapter &quot;Random variables&quot;</td>
<td><strong>Theory classes:</strong> 6h</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong> 2, 3, 4, 9</td>
<td><strong>Practical classes:</strong> 2h</td>
</tr>
<tr>
<td></td>
<td><strong>Laboratory classes:</strong> 2h</td>
</tr>
<tr>
<td></td>
<td><strong>Guided activities:</strong> 0h</td>
</tr>
<tr>
<td></td>
<td><strong>Self study:</strong> 7h</td>
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<table>
<thead>
<tr>
<th>Developing the Chapter &quot;Random vectors&quot;</th>
<th>Hours: 18h 48m</th>
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</thead>
<tbody>
<tr>
<td><strong>Description:</strong> Developing the Chapter &quot;Random vectors&quot;</td>
<td><strong>Theory classes:</strong> 7h 30m</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong> 3, 5, 6, 9</td>
<td><strong>Practical classes:</strong> 3h</td>
</tr>
<tr>
<td></td>
<td><strong>Laboratory classes:</strong> 2h</td>
</tr>
<tr>
<td></td>
<td><strong>Guided activities:</strong> 0h</td>
</tr>
<tr>
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<td><strong>Self study:</strong> 6h 18m</td>
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<table>
<thead>
<tr>
<th>Developing the Chapter &quot;Sum of random variables&quot;</th>
<th>Hours: 12h 48m</th>
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</thead>
<tbody>
<tr>
<td></td>
<td><strong>Theory classes:</strong> 4h 30m</td>
</tr>
<tr>
<td></td>
<td><strong>Practical classes:</strong> 1h 30m</td>
</tr>
<tr>
<td></td>
<td><strong>Laboratory classes:</strong> 1h 30m</td>
</tr>
<tr>
<td></td>
<td><strong>Guided activities:</strong> 0h</td>
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<tr>
<td></td>
<td><strong>Self study:</strong> 5h 18m</td>
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### 270206 - PIE1 - Probability and Statistics 1

#### Description:
Developing the Chapter "Sum of random variables"

#### Specific objectives:
3, 5, 7

#### Developing the Chapter "Population and sample"

<table>
<thead>
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<th>Developing the Chapter &quot;Population and sample&quot;</th>
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</thead>
<tbody>
<tr>
<td>Specific objectives:</td>
<td>3, 8, 9</td>
</tr>
</tbody>
</table>

#### Hours:
12h 42m
- Theory classes: 4h 30m
- Practical classes: 1h 30m
- Laboratory classes: 1h 30m
- Guided activities: 0h
- Self study: 5h 12m

#### Developing the Chapter "Point estimation"

<table>
<thead>
<tr>
<th>Description:</th>
<th>Developing the Chapter &quot;Point estimation&quot;</th>
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</thead>
<tbody>
<tr>
<td>Specific objectives:</td>
<td>10</td>
</tr>
</tbody>
</table>

#### Hours:
18h 42m
- Theory classes: 7h 30m
- Practical classes: 2h
- Laboratory classes: 3h
- Guided activities: 0h
- Self study: 6h 12m

#### Developing the Chapter "Confidence intervals"

<table>
<thead>
<tr>
<th>Description:</th>
<th>Developing the Chapter &quot;Confidence intervals&quot;</th>
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</thead>
<tbody>
<tr>
<td>Specific objectives:</td>
<td>10</td>
</tr>
</tbody>
</table>

#### Hours:
7h 30m
- Theory classes: 3h
- Practical classes: 1h
- Laboratory classes: 1h
- Guided activities: 0h
- Self study: 2h 30m
## Developing the Chapter "Hypothesis testing"

**Description:**
Developing the Chapter "Hypothesis testing"

**Hours:** 15h 30m
- Theory classes: 6h
- Practical classes: 2h
- Laboratory classes: 2h
- Guided activities: 0h
- Self study: 5h 30m

## Final examination

**Description:**
Final examination

**Specific objectives:**
1, 2, 4, 5, 6, 7, 8, 10

**Hours:** 33h
- Guided activities: 3h
- Self study: 30h

## Mid-term examination

**Description:**
Mid-term examination

**Specific objectives:**
1, 2, 4, 5, 6

**Hours:** 12h
- Guided activities: 2h
- Self study: 10h

## Mid-term lab examination

**Description:**
Mid-term lab examination

**Specific objectives:**
3, 9

**Hours:** 11h
- Guided activities: 1h
- Self study: 10h

## Final lab examination

**Description:**
Final lab examination

**Hours:** 11h 30m
- Guided activities: 1h 30m
- Self study: 10h
Specific objectives:
3, 9, 10

Qualification system
A partial exam (EP) and a final exam (EF). Each of them has a part of theory and problems, and another part of laboratory.
During the course (approximately biweekly), short activities (ACT) will be proposed (a problem to solve analytically or with the computer).
The final grade (NF) is computed as
\[ NF = 0.65 \times EF + 0.25 \times \max(EP,EF) + 0.10 \times \max(ACT,EF) \]
The re-evaluation exam grade (ER) replaces the 100% of the final exam grade. So the final grade after re-evaluation (NFreav) will be
\[ NFreav = 0.65 \times ER + 0.25 \times \max(EP,ER) + 0.10 \times \max(ACT,ER) \]

Bibliography

Basic:

Complementary:

Others resources:
Hyperlink
https://www.math.dartmouth.edu/~prob/prob/prob.pdf