310405 - Prediction Models in Building Construction

Coordinating unit: 310 - EPSEB - Barcelona School of Building Construction
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2018
Degree: MASTER’S DEGREE IN ADVANCED BUILDING CONSTRUCTION (Syllabus 2014). (Teaching unit Compulsory)
ECTS credits: 5
Teaching languages: Catalan, Spanish, English

Coordinator: Pantazi, Chara
Others: Serrat i Pie, Carles
Guillamon, Antoni

Prior skills
It is important that students have prior knowledge of a basic university course both linear algebra and differential calculus in one and several variables. It is also advisable to have a basic knowledge of programming.

Degree competences to which the subject contributes

Basic:
2. Possess and understand knowledge which provide a basis or opportunity to be original in the development and/or application of ideas, usually in a context of research.
3. The students must be able to apply the acquired knowledges and their ability of resolution of problems in new or little known environments inside more wide environments (or multidisciplinary) related with their study field.
4. The students must be able to integrate knowledges and front to the complexity to formulate opinions from an information which, being incomplete or limited, includes reflections about the social and ethical responsabilities linked to the application of their knowledges and opinions.
5. The students must be able to communicate their conclusions and the knowledges and ultimate reasons which support to specialised and non-specialised audiences in a clear mode and without ambiguities.
1. The students must possess the learning abilities which allow them to continue studying in a way which should be to a large extent self-directed and autonomous.

Specific:
6. Use the physic principles in the thermic, luminic and acoustic scope.

General:
9. Prepare to communicate with efficiency, orally but also in written.
10. Prepare the student in the using of tools that are common in the investigation activities, like the analysis and treatment of data, just like methodology and investigation techniques.
11. Develope and/or apply ideas with originality in a context of investigation, identifying and formulating hypothesis or innovative ideas and submit them to a objectivity, coherence, and viability test.

Transversal:
7. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in
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with the future needs of the graduates of each course.

8. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

Teaching methodology

The hours of directed learning are organized in lectures, problem classes and practical sessions with a computer.

The lectures introduce the learning objectives and the general basics of each of the course topics and they are illustrated by the resolution of practical examples to motivate the active participation of the student learning.

Laboratory sessions can be done in the classroom with laptop having the student or in the laboratory . Maple software (or any other that might be useful like Matlab) for solving data analysis problems could be used. The statistical program Minitab and the LINGO Optimization program will also be used. At the laboratory sessions we develop the practical part of the course and the concepts and methods related to the content being studied.

The basic documentation for both the theoretical descriptions and practical problems can be find in Athena.

We must also consider other hours of independent learning by students such as those devoted to the study different course topics, extension literature, resolution of problems and the proposed monitoring practices in the laboratory.

Learning objectives of the subject

Passed the course the student will be able to implement the processing of data (with the most appropriate computing resources) A mathematical prediction model using tools of differential equations, statistics and optimization.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 17h 30m 14.00%</th>
<th>Hours medium group: 5h 4.00%</th>
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<tbody>
<tr>
<td></td>
<td>Hours small group: 5h 4.00%</td>
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<tr>
<td></td>
<td>Guided activities: 7h 30m 6.00%</td>
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<td>Self study: 90h 72.00%</td>
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### B1 Multivariate analysis

**Learning time:** 52h
- Theory classes: 14h
- Guided activities: 5h
- Self study: 33h

**Description:**

1.1 Descriptive Statistics and the Normal distribution

1.2 Statistical Inference.
Confidence intervals and contrasts of hypotheses. Type I error and Type II error.

1.3 Multiple linear regression model.
Definition of linear adjustment. Estimate and prediction. Qualitative predictors. Residual analysis Autocorrelation

1.4 General linear model.
Modeling of nonlinear relationships. Interaction between predictors. Transformations of the answer. Determination of the model

1.5 ANOVA-MANOVA
The main objective of the analysis of variance (ANOVA) is to show significant differences between different averages. This is achieved by dividing the total variance into a component that is due to certain random error (within the group) and other components that are due to the differences between the averages (inter-group). The multivariate analysis of MANOVA variance, is an extension of ANOVA methods to cover cases in which there is more than one dependent variable.
B2. Optimization Modelling

**Learning time:** 26h  
- Theory classes: 6h  
- Guided activities: 3h  
- Self study: 17h

**Description:**
2.1. General formulation of mathematical programs. 
Definition of mathematical program. Geometry of mathematical programs. Types of feasible and optimal solutions. Classification of mathematical programs.

2.2. Mathematical models of optimization problems. Applications to the building construction. 

2.3. An overview of available software for solving optimization problems. 
MAPLE, LINGO

**Related activities:**
The sessions consist of a theoretical part and a practical part which will be carried out in the computer room. The completion of these proposals is the basic qualification element with a rating of 100% of the block.

**Specific objectives:**
In this block presents the definitions and the necessary mathematical language to describe the basic concepts of mathematical programming. These concepts are used to represent real optimization problems as mathematical models. Having described the model then it will be solved using existing software. The aim, on the one hand, is that the students acquire a minimum skill in describing and in solving mathematical models and optimization, on the other hand, we want that the students aware of the amount of optimization problems that have been formulated, the complexity of the modelling and the variety of resources available to address their resolution.
**B3. Differential equations and dinamical systemas**

**Learning time:** 47h  
Theory classes: 10h  
Guided activities: 5h  
Self study : 32h

**Description:**  
Partial and directional scalar fields; functions operators (gradient, divergence and Laplace) and their physical meaning; models of ordinary differential equations and partial differential equations in building construction.

3.2. Methods of analysis and solution of ordinary differential equations (ODEs).  
Linear stability analysis of stationary solutions. Methods of numerical integration of ODEs. Applications to the resolution of models depending on parameters (bifurcation diagrams).

3.3. Numerical solution of partial differential equations (PDEs).  

**Related activities:**  
The sessions consist of a theoretical part and a practical part which will be carried out to the computer room. The completion of these proposals is the basic qualification element with a rating of the 70% of the block. The evaluation is completed with a conceptual test at the end of the block (30%).

**Specific objectives:**  
In this block we work concepts and mathematical techniques needed to address several problems in building enclosures as thermal behavior, fire spread or leaks in water distribution networks, among other subjects that will be studied in the Master. The mathematical treatment of these problems involves modeling using ordinary differential equations and partial, often coupled with each other, the linear stability analysis and computation of solutions to the problem using numerical methods. It aims to provide students with the basic cultural understanding these models and tools, and enable them to numerical simulation and its representation through existing programs.

**Qualification system**

The evaluation of the course is designed so that each block is evaluated separately. For the blocks, B1 and B3, there will be a single punctuation obtained from a theoretical and a practical proposal carried out in the computer room during the laboratory classes. The completion of these proposals is the basic qualification element with a rating of the 70% of the block. The evaluation is completed with a conceptual test at the end of the block (30%).

The punctuation of block B2 is obtained from a practical proposal carried out in the computer room during the laboratory classes (100%).

The final score, Nf is Nf=(45 B1+20 B2+35 B3)/100.

All marks are calculated on 10 points.

**Regulations for carrying out activities**

Not attending in any of the tests will be graded with a zero. The final mark will be effective only if the student has been evaluated for at least two blocks.
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Bibliography

Basic:


Others resources:

Hyperlink

- página web de Matlab
  https://es.mathworks.com/products/matlab

- página web MAPLE
  https://maplesoft.com/products/Maple/

- página web LINGO
  https://www.lindo.com/index /products/lingo-and-optimization-modeling

Computer material

- Minitab
  Resource

- MAPLE
  Resource

- MATLAB
  Resource
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LINGO
Resource