310001 - Mathematical Fundamentals of Engineering for Building Construction

Coordinating unit: 310 - EPSEB - Barcelona School of Building Construction
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2018
Degree: BACHELOR’S DEGREE IN ARCHITECTURAL TECHNOLOGY AND BUILDING CONSTRUCTION (Syllabus 2015). (Teaching unit Compulsory)
BACHELOR’S DEGREE IN BUILDING CONSTRUCTION SCIENCE AND TECHNOLOGY (Syllabus 2009). (Teaching unit Compulsory)
ECTS credits: 6
Teaching languages: Catalan, Spanish, English

Teaching staff

Coordinator: Maria Montserrat Bruguera Padró
Others: Delshams I Valdes, Amadeu López, Pere Roca Lacostena, Jordi Pantazi, Chara Rodríguez Jordana, Juanjo

Opening hours

Timetable: to be fixed

Degree competences to which the subject contributes

Specific:
1. FB-1 Aptitude to use the applied knowledges related with the numerical and infinitesimal calculus, linear algebra, analytic and differential geometry, and the probabilistic and statistical analysis techniques and methods.

Transversal:
2. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
3. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

Teaching methodology

The learning hours consist on the one hand in theoretical classes (big group) where the faculty does a brief exposition to introduce the general learning goals related with the basic knowledge of the subject. Later through practical exercises, the faculty tries to motivate and involve the students so that they can be part of their own apprenticeship. It will be used support material through ATENEA: Learning objectives by contents, concepts, examples, schedule of evaluation and learning activities and bibliography. On the other hand there also will be practical classes (medium group) through the resolution of numerical exercises related with the learning objectives of each one of the subject contents. In these practical sessions the intention is to incorporate some generic competences, like team work. The last learning hours consist on doing lab practices (small group) which allows to develop basic skills in symbolic computation software. It also must be considered that there are other autonomous learning hours like related readings, the resolution of the proposed exercises or the self-learning questionnaires of the different contents through virtual campus ATENEA or aCTeX software.

Learning objectives of the subject

1. FB-1 Aptitude to use the applied knowledges related with the numerical and infinitesimal calculus, linear algebra, analytic and differential geometry, and the probabilistic and statistical analysis techniques and methods.
2. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
3. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
At the end of the course, students should be able to:

- Classify and solve determinate, indeterminate and overdetermine equation systems.
- Use reference systems changes.
- Do matrix calculations.
- Calculate and interpret the matrix's diagonal form of a lineal transformation.
- Be competent using an algebraic manipulator system.
- Define the concept of functions with single or multiple variables.
- Calculate, interpret and apply partial derivatives, directional derivatives and differential matrix.
- Numerically solve elemental mathematic problems: interpolation, approximation to functions and Taylor.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 30h</th>
<th>20.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 15h</td>
<td>10.00%</td>
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<tr>
<td></td>
<td>Hours small group: 15h</td>
<td>10.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Self study: 90h</td>
<td>60.00%</td>
</tr>
</tbody>
</table>
## Content

| **C1: Linear algebra, vectors, matrixes and lineal transformations.** |
| Learning time: 84h |
| Theory classes: 18h |
| Practical classes: 8h |
| Laboratory classes: 8h |
| Guided activities: 0h |
| Self study : 50h |

### Description:
Content of the lesson:
- Determinate, indeterminate and overdeterminate linear system equation resolution.
- Scalar, vector and matrix calculations.
- Recognize if a function is a linear transformation.
- Geometric interpretation of linear transformations of 2 and 3 variables.
- Linear subspace and basis
- Dot product. Orthogonal basis. Orthonormal basis. Projections.
- Formulation and geometric interpretation of reference systems changes.
- Invariant directions and matrix's diagonal form of a lineal transformation. Implementations.

### Related activities:
Activities carried out:
- Lab practice L1.
- Individual test (Activity 5) during the continuous assessment sessions.
- TGF (Global Final Test) with questions of C1 and C2 contents.

In case that the student needs to do a reappraisal:
At the end of the course there will be the Activity 9 with problems of the C1 and C2 contents.
C2: Single and multiple variables calculation.

<table>
<thead>
<tr>
<th>Learning time: 66h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 12h</td>
</tr>
<tr>
<td>Practical classes: 7h</td>
</tr>
<tr>
<td>Laboratory classes: 7h</td>
</tr>
<tr>
<td>Self study: 40h</td>
</tr>
</tbody>
</table>

Description:
Content of the lesson:
- Real functions with single real variable, limits, continuity and derivatives.
- Derivatives calculations.
- Development of Taylor series of a function in a dot range.
- Function interpolations using plan dots.
- Real function of multiple variables.
- Concept, geometric description and calculus of contour lines, partial derivatives and directional derivatives.
- Differential concept. Jacobian matrix calculus.
- Gradient concept and geometric interpretation.
- Concept and geometric interpretation of Hessian matrix.

Related activities:
Activities carried out:
- Activity 3 that belongs to the directed learning laboratory (in English).
- L2 Individual laboratory test (Activity 6) during the continuous assessment sessions.
- P2 Written problem (Activity 7) about the second content.
- TFG (Final Global Test) with questions of the C1 and C2 contents.

In case that the student needs to do a reappraisal:
At the end of the course there will be the Activity 8 (TFG) and the Activity 9 which has problems of the C1 and C2 contents.
## Planning of activities

| **A1 PRACTICE 0. INTRODUCTION TO MANIPULATORS** | **Hours:** 3h  
Practical classes: 2h  
Self study: 1h |
<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Group practice carried out at the computer room and with a duration of an hour. Students should make the exercises of the support activities.</td>
</tr>
<tr>
<td><strong>Support materials:</strong></td>
<td>Example document, algebraic manipulator manual, practice formulation, exercise list to resolve and solution available in ATENEA.</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>At the end of the activity, students should be able to do basic function and polynomial operations, elemental graphic representation and numeric representation of manipulators.</td>
</tr>
</tbody>
</table>

| **A2 PRACTICE 1. SYMBOLIC MATRIX CALCULUS FOUNDATIONS** | **Hours:** 3h  
Practical classes: 2h  
Self study: 1h |
<table>
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<tr>
<td><strong>Support materials:</strong></td>
<td>Example document, algebraic manipulator manual, practice formulation, exercise list to resolve and solution available in ATENEA.</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>At the end of the activity, students should be able to do basic matrix operations, discuss and solve linear system equations by different methods and do Gaussian eliminations. Furthermore, students should be able to solve matrix diagonalization and calculate coordinates and endomorphism basis change.</td>
</tr>
</tbody>
</table>

| **A3 PRACTICE 2. SYMBOLIC CALCULUS FOUNDATIONS WITH SINGLE AND MULTIPLE VARIABLES.** | **Hours:** 6h  
Practical classes: 2h  
Self study: 4h |
<table>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Group practice carried out at the computer room and with a duration of two hours (In English). Students should make the exercises of the support activities.</td>
</tr>
<tr>
<td><strong>Support materials:</strong></td>
<td>Example document, algebraic manipulator manual, practice formulation, exercise list to resolve and solution available in ATENEA.</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>At the end of the activity, students must be able to represent functions graphically, solve derivatives, to find zeros and functions and to adequately simplify all the results. He must also be able to calculate Taylor’s developments. Calculate interpolated polynomials and determine the error. Calculate the gradient of a function on several variables as well as its Hessian matrix. Represent the contour lines.</td>
</tr>
</tbody>
</table>
### A4 P1: INDIVIDUAL TEST PROBLEMS OF THE CONTENT 1

<table>
<thead>
<tr>
<th>Description:</th>
<th>Students will solve an exercise with different parts of the lessons of content 1.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support materials:</td>
<td>Students can bring calculator.</td>
</tr>
<tr>
<td>Descriptions of the assignments due and their relation to the assessment:</td>
<td>In paper. Partial exam. The test is worth 30% of the final grade.</td>
</tr>
<tr>
<td>Specific objectives:</td>
<td>Student must know how to solve the exercises of content 1.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours:</th>
<th>5h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>1h</td>
</tr>
<tr>
<td>Self study:</td>
<td>4h</td>
</tr>
</tbody>
</table>

### A5 L2: INDIVIDUAL TEST OF CONTINUOUS ASSESSMENT ON THE LABORATORY (CONTENT 1)

<table>
<thead>
<tr>
<th>Description:</th>
<th>Solve problems of the CONTENT 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support materials:</td>
<td>Wording for the test realization. Symbolic manipulator as a calculus support. Maple form and document.</td>
</tr>
<tr>
<td>Descriptions of the assignments due and their relation to the assessment:</td>
<td>Delivery through Atena. It represents a 10% on the final grade and of the continuous assessment.</td>
</tr>
<tr>
<td>Specific objectives:</td>
<td>Show that the students has learnt the contents of content 1.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours:</th>
<th>5h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical classes:</td>
<td>1h</td>
</tr>
<tr>
<td>Self study:</td>
<td>4h</td>
</tr>
</tbody>
</table>

### A6 P2 INDIVIDUAL TEST OF EXERCISES ABOUT CONTENT 2

<table>
<thead>
<tr>
<th>Description:</th>
<th>Students will solve an exercise with different parts about the aspects studied in content 2. Final exam.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support materials:</td>
<td>Calculator can be used.</td>
</tr>
<tr>
<td>Descriptions of the assignments due and their relation to the assessment:</td>
<td>On paper. The test represents a 30% of the subject.</td>
</tr>
<tr>
<td>Specific objectives:</td>
<td>Students must solve an exercise about content 2.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours:</th>
<th>5h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>1h</td>
</tr>
<tr>
<td>Self study:</td>
<td>4h</td>
</tr>
</tbody>
</table>
### A7 L2: LABORATORY INDIVIDUAL TEST OF CONTINUOUS ASSESSMENT (CONTENT 2)

**Description:**
Solve problems of the CONTENT 2

**Support materials:**
- Wording for the test solving.
- Symbolic manipulator as a calculus support.
- Maple form and document.

**Description of the assignments due and their relation to the assessment:**
- ATENEA
  - The test is worth a 10% of the final grade.

**Specific objectives:**
- Show that the students has learnt the contents of content 2.

**Hours:** 5h
- Theory classes: 1h
- Self study: 4h

### A8 GLOBAL SUBJECT TEST

**Description:**
Multiple-choice test relative to all the lessons of the course (content 1 and 2)

**Support materials:**
- The test and a calculator. It can be done on the lab room.

**Description of the assignments due and their relation to the assessment:**
- The test can be done on the lab room.
  - It represents the 20% of the final grade.

**Specific objectives:**
- Students must be able to answer the test.

**Hours:** 13h
- Practical classes: 2h
- Self study: 11h

### A9 Re-evaluation

**Description:**
Exam of problems concerning contents 1 and 2. According to the regulations of the school the students can do the re-evaluation if his mark is between 3.5 and 4.9

**Hours:** 11h 40m
- Theory classes: 2h
- Self study: 9h 40m
Qualification system

The grading system consists of two lab practices L1 and L2, a midterm exam (which has a P1 problems part) and a final exam (which has a P2 problems part and a TGF test part). The First Contents Block (Algebra) has two evaluating exercises: L1 (lab test) and the midterm exam P1 (resolution of a problem). The Second Contents Block (Calculus) has also two evaluating exercises: L2 (lab test) and the final exam which contains a P2 problem (resolution of a problem) and a final global test where there can be considered theoretical and practical aspects of the subject (Final Global Test) and the First and Second Contents Blocks will be evaluated.

Calculation of the Final Grade
\[ N_f = \frac{L1 \times 10 + P1 \times 30 + L2 \times 10 + P2 \times 30 + TGF \times 20}{100} \]

Midterm exam = P1
Final exam = P2 + TGF
Nf: Final Grade.

P1: Notes of the Problems
P1: Problem resolution [Activity 5 (Week after the midterm)]
P2: Problem resolution about the content 2 [Activity 7 (day after the Final exam)]
L1: Laboratory notes.
L1 [Activity 5; the week after the midterms]
L2 [Activity 6; last class week]
TGF: Final Global Exam [Activity 8: the day of the final exam]

All grades are based on 10.

The re-evaluation test will consist of a unique problems test and questions about the contents 1 and 2.

Regulations for carrying out activities

- If some of the lab practices or exam tests is not done, it will be considered as not rated.
- In calculus lab practices it can be used limited teaching material (specific files and formularies).
- In the midterm and final exams it only can be brought a calculator.

Bibliography

Basic:

Others resources:

Material Available in ATENEA