Course guides
310701 - 310701 - Mathematical Fundamentals

Unit in charge: Barcelona School of Building Construction
Teaching unit: 749 - MAT - Department of Mathematics.
Degree: BACHELOR’S DEGREE IN ARCHITECTURAL TECHNOLOGY AND BUILDING CONSTRUCTION (Syllabus 2019). (Compulsory subject).
Academic year: 2021  ECTS Credits: 6.0  Languages: Catalan, Spanish, English

LECTURER
Coordinating lecturer: Maria Montserrat Bruguera Padró
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Rivas Guijarro, Xavier

REQUIREMENTS
It is necessary to have a laptop to carry out the continuous assessment questionnaires in the classroom.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTE
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 clases (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 leaning 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

At the end of the course, students should be able to:

· Classify and solve determinate, indeterminate and overdeterminate 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>Type</th>
<th>Hours</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Hours small group</td>
<td>21,0</td>
<td>14.00</td>
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<tr>
<td>Hours medium group</td>
<td>9,0</td>
<td>6.00</td>
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<tr>
<td>Self study</td>
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<tr>
<td>Hours large group</td>
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<td>20.00</td>
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Total learning time: 150 h

CONTENTS

C1: Linear algebra, vectors, matrixes, vectorial spaces, and lineal transformations.

Description:
Content of the lesson:
· Determinate, indeterminate and overdetermine 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: 1 to 6.
In case that the student needs to do a reappraisal: 1/2 activity 13.

Full-or-part-time: 84h
Theory classes: 18h
Practical classes: 8h
Laboratory classes: 8h
Self study : 50h
# C2: Single and multiple variables calculation.

**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.

**Full-or-part-time:** 66h

- Theory classes: 12h
- Practical classes: 7h
- Laboratory classes: 7h
- Self study: 40h
## ACTIVITIES

### A1 A1: CLASSES OF PROBLEMS and INDIVIDUAL QUESTIONNAIRE (Matrices and Systems)

**Description:**
Problem solving class, by hand and using Matlab, of Matrix calculation and systems of linear equations.
The last 60 minutes of class, resolution of an individual questionnaire at Atenea (It will be done in person, in a classroom supervised by teachers or, if not possible, via Meet).

**Specific objectives:**
At the end of the activity, students should be able to do basic matrix operations, discuss ans solve linear system equations by different methods and do Gaussian eliminations.
Reaffirm and demonstrate the learning, conceptual and practical.

**Material:**
- Laptop with access to Atenea and Matlab.
- Questionnaire in Atenea for the test realization.
- Symbolic manipulator, Matlab, as a calculus support.
- Maple file and basic formulas form.

**Delivery:**
Realización del cuestionario en Atenea.
Representa una parte de la evaluación continua (5% de la nota final de la asignatura).

**Related competencies:**
- FB-01. FB-1 Aptitude to use the applied knowledge related with the numerical and infinitesimal calculus, linear algebra, analytic and differential geometry, and the probabilistic and statistical analysis techniques and methods.
- 07 AAT. 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.

**Full-or-part-time:** 6h
Practical classes: 3h
Self study: 3h
A1 A1: CLASSES OF PROBLEMS and INDIVIDUAL QUESTIONNAIRE (VECTORIAL SPACES)

Description:
Problem solving class, by hand and using Matlab, about vectorial spaces.
The last 60 minutes of class, resolution of an individual questionnaire at Atenea (It will be done in person, in a classroom
supervised by teachers or, if not possible, via Meet).

Specific objectives:
Reaffirm and demonstrate the learning, conceptual and practical, related to vectorial spaces.

Material:
Laptop with access to Atenea and Matlab.
Questionnaire in Atenea for the test realization.
Symbolic manipulator, Matlab, as a calculus support.
Maple file and basic formulas form.

Delivery:
Delivery through Atenea
It represents a 5% on the final grade and of the continuous assessment.

Related competencies:
FB-01. 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.
07 AAT. 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.

Full-or-part-time: 6h
Practical classes: 3h
Self study: 3h

A3 A3: CLASSES OF PROBLEMS and INDIVIDUAL QUESTIONNAIRE (LINEAL FORMS)

Description:
Problem solving class, by hand and using Matlab, about linear forms.
The last 60 minutes of class, resolution of an individual questionnaire at Atenea (It will be done in person, in a classroom
supervised by teachers or, if not possible, via Meet).

Specific objectives:
Reaffirm and demonstrate the learning, conceptual and practical, related to linear forms.

Material:
Laptop with access to Atenea and Matlab.
Questionnaire in Atenea for the test realization.
Symbolic manipulator, Matlab, as a calculus support.
Maple file and basic formulas form.

Delivery:
Delivery through Atenea
It represents a 5% on the final grade and of the continuous assessment.

Related competencies:
FB-01. 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.
07 AAT. 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.

Full-or-part-time: 6h
Practical classes: 3h
Self study: 3h
A4 A4: CLASSES OF PROBLEMS and INDIVIDUAL QUESTIONNAIRE (DIAGONALIZATION)

Description:
Problem solving class, by hand and using Matlab, corresponding to CONTENT 1 and mainly on diagonalization of endomorphisms. The last 60 minutes of class, resolution of an individual questionnaire at Atenea (It will be done in person, in a classroom supervised by teachers or, if not possible, via Meet).

Specific objectives:
Show that the students has learnt the contents of content 1.
Reaffirm and demonstrate the learning, conceptual and practical, related to Content 1.

Material:
Laptop with access to Atenea and Matlab.
Questionnaire in Atenea for the test realization.
Symbolic manipulator, Matlab, as a calculus support.
Maple file and basic formulas form.

Delivery:
Delivery through Atenea
It represents a 5% on the final grade and of the continuous assessment.

Related competencies:
FB-01. 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.
07 AAT. 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.

Full-or-part-time: 6h
Practical classes: 3h
Self study: 3h

A5 TA: INDIVIDUAL EXERCISE OF CONTENT PROBLEMS 1

Description:
Students will solve exercises with different parts of the lessons of content 1.

Specific objectives:
The student must know how to manually solve content problems 1.
Dede demonstrate the ability to correctly write the resolution of the problems, justifying all the steps taken.
Also explaining if it is necessary to use algebraic manipulators to verify and complement the manual calculations.
It is also an apprenticeship to take the partial exam (PA).

Material:
The student can use calculator and algebraic manipulators (Matlab) to verify and complement the calculations made manually.

Delivery:
Document, as a report, made by hand or with a word processing program.
On paper or uploading a pdf to an Athena store.
The test is worth 5% of the final grade.

Related competencies:
FB-01. 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.
07 AAT. 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.

Full-or-part-time: 4h
Self study: 4h
A6 PA: INDIVIDUAL TEST PROBLEMS OF THE CONTENT 1

Description:
Students will solve an exercise with different parts of the lessons of content 1.

Specific objectives:
Student must know how to solve the exercises of content 1.

Material:
Students can bring calculator.

Delivery:
In paper. Partial exam. The test is worth 25% of the final grade.

Related competencies:
FB-01. 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.
07 AAT. 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.

Full-or-part-time: 6h
Theory classes: 2h
Self study: 4h

A7 C1: CLASSES OF PROBLEMS and INDIVIDUAL QUESTIONNAIRE ()

Description:
Problem solving class, by hand and using Matlab.
The last 60 minutes of class, resolution of an individual questionnaire at Atenea (It will be done in person, in a classroom supervised by teachers or, if not possible, via Meet).

Specific objectives:
Reaffirm and demonstrate the learning, conceptual and practical.

Material:
Laptop with access to Atenea and Matlab.
Questionnaire in Atenea for the test realization.
Symbolic manipulator, Matlab, as a calculus support.
Maple file and basic formulas form.

Delivery:
Delivery through Atenea
It represents a 5% on the final grade and of the continuous assessment.

Related competencies:
FB-01. 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.
07 AAT. 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.

Full-or-part-time: 6h
Practical classes: 3h
Self study: 3h
A8 C2: CLASSES OF PROBLEMS and INDIVIDUAL QUESTIONNAIRE (TAYLOR AND INTERPOLATION)

Description:
Problem solving class, by hand and using Matlab, corresponding to Taylor and interpolation.
The last 60 minutes of class, resolution of an individual questionnaire at Atenea (It will be done in person, in a classroom supervised by teachers or, if not possible, via Meet).

Specific objectives:
Reaffirm and demonstrate the learning, conceptual and practical. He must also be able to calculate Taylor's developments and Calculate interpolated polynomials.

Material:
Laptop with access to Atenea and Matlab.
Questionnaire in Atenea for the test realization.
Symbolic manipulator, Matlab, as a calculus support.
Maple file and basic formulas form.

Delivery:
Delivery through Atenea
It represents a 5% on the final grade and of the continuous assessment.

Related competencies:
FB-01. 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 techiques and methods.
07 AAT. 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.

Full-or-part-time: 6h
Practical classes: 3h
Self study: 3h

A9 C3: CLASSES OF PROBLEMS and INDIVIDUAL QUESTIONNAIRE (FUNCTIONS OF SEVERAL VARIABLES)

Description:
Problem solving class, by hand and using Matlab, on functions of several variables and explicitly defined surfaces.
The last 60 minutes of class, resolution of an individual questionnaire at Atenea (It will be done in person, in a classroom supervised by teachers or, if not possible, via Meet).

Specific objectives:
Reaffirm and demonstrate the learning, conceptual and practical.

Material:
Laptop with access to Atenea and Matlab.
Questionnaire in Atenea for the test realization.
Symbolic manipulator, Matlab, as a calculus support.
Maple file and basic formulas form.

Delivery:
Delivery through Atenea
It represents a 5% on the final grade and of the continuous assessment.

Related competencies:
FB-01. 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 techiques and methods.
07 AAT. 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.

Full-or-part-time: 6h
Practical classes: 3h
Self study: 3h
A10 C4: CLASSES OF PROBLEMS and INDIVIDUAL QUESTIONNAIRE (Several Variables)

Description:
Problem solving class, by hand and using Matlab, corresponding to CONTENT 2. The last 60 minutes of class, resolution of an individual questionnaire at Atenea (It will be done in person, in a classroom supervised by teachers or, if not possible, via Meet).

Specific objectives:
Reaffirm and demonstrate the learning, conceptual and practical, related to Content 2.

Material:
Laptop with access to Atenea and Matlab. Questionnaire in Atenea for the test realization. Symbolic manipulator, Matlab, as a calculus support. Maple file and basic formulas form.

Delivery:
Delivery through Atenea. It represents a 5% on the final grade and of the continuous assessment.

Related competencies:
FB-01. 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 tehcniques and methods.
07 AAT. 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.

Full-or-part-time: 6h
Practical classes: 3h
Self study: 3h

A11 TC: INDIVIDUAL EXERCISE OF CONTENT PROBLEMS 2

Description:
Students will solve exercises with different parts of the lessons of content 2.

Specific objectives:
The student must know how to manually solve content problems 1. Dede demonstrate the ability to correctly write the resolution of the problems, justifying all the steps taken. Also explaining if it is necessary to use algebraic manipulators to verify and complement the manual calculations. It is also an apprenticeship to take the partial exam (PC).

Material:
The student can use calculator and algebraic manipulators (Matlab) to verify and complement the calculations made manually.

Delivery:
Document, as a report, made by hand or with a word processing program. On paper or uploading a pdf to an Athena store. The test is worth 5% of the final grade.

Related competencies:
FB-01. 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 tehcniques and methods.
07 AAT. 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.

Full-or-part-time: 4h
Self study: 4h
### A12 PC: INDIVIDUAL TEST OF EXERCISES ABOUT CONTENT 2

**Description:**
Students will solve an exercise with different parts about the aspects studied in content 2.

**Specific objectives:**
Students must solve an exercise about content 2.

**Material:**
Calculator can be used.

**Delivery:**
On paper
The test represents a 25% of the subject.

**Related competencies:**
FB-01. 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.
07 AAT. 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.

**Full-or-part-time:** 6h
Theory classes: 2h
Self study: 4h

### A13 Re-evaluation

**Description:**
Exam of problems and questionnaire about 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

**Full-or-part-time:** 13h 40m
Theory classes: 4h
Self study: 9h 40m
GRADING SYSTEM

The qualification system is of continuous evaluation. It is done in 8 questionnaires A1, A2, A3, A4, C1, C2, C3 C4, 2 TA and TC exams, a midterm exam (PA) and another final exam (PC). Half of the tests correspond to Block 1 (Algebra) and the other half to Block 2 (Calculus).

Calculation of the Final Grade

\[ \text{Nf} = \frac{(A1 + A2 + A3 + A4 + TA) \times 5 + PA \times 25 + (C1 + C2 + C3 + C4 + TC) \times 5 + PC \times 25}{100} \]

- Partial exam = PA
- Partial exam = PC

Nf: final note.

TA: problem solving on content 1 (before the PA partial)
TC: problem solving on content 2 (before PC partial)

Ai and Ci: notes from the Athena questionnaires that will be taken in class.
Ai Block 1 questionnaires [weeks 2, 3, 4 and 5] (before PA)
Ci Block 2 questionnaire [weeks 8, 9, 10 and 11] (after PA and before PC)

All grades are calculated out of 10.

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

EXAMINATION RULES.

- If some of the 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:

RESOURCES

Other resources:
Material Available in ATENEA