APPLIED MATHEMATICS IN ARCHITECTURE 1

IE University
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Academic year: 22-23
Degree course: FIRST
Semester: 1º
Category: BASIC
Number of credits: 6.0
Language: English

PREREQUISITES

SUBJECT DESCRIPTION
In this subject, the mathematical principles that provide the student with sufficient training to continue their studies are established; the student will learn calculus and algebra tools aimed at the subsequent study of other subjects such as physics, and, on the other hand, the capacity of abstraction that will allow the student to understand, synthesize and solve professional problems.

Mathematical principles are linked to their possible applications, so that the student can perceive from the beginning of their studies the fundamental link between mathematics and the work of the architect.

During the semester, the student will learn the basis of:

- Infinitesimal calculus.
- Numerical Calculus.
- Linear algebra.
- Statistics.

Infinitesimal calculus is the branch of mathematics that deals with functions. In this part of the subject, the student will learn to deal with functions of one variable. This knowledge has a direct application in the work of an architect, as it is used to calculate thermal and acoustic insulation, calculous of structures, etc.

Numerical Calculus deals with the interaction between computers and mathematics. In this part of the subject, the student will learn how to perform complex mathematical operations, by using a computer.

Linear algebra is a basic tool for architects, since linear algebra give the mathematical background for vectors and matrices, the tool used to work with forces. Vectors are also of application in other branches of science related to the architectural work, such as spatial geometry and topography.

Statistics is a branch of mathematics that deals with the collection, analysis and interpretation of data. This branch of maths is used, in architecture, in order to take optimal decisions.

OBJECTIVES AND SKILLS
Per Ministerial Decree EDU/2075/2010, 29 of July; and the official accreditation request for the Bachelor in Architectural Studies, July 2015.

Edited by Documentation
21th June 2022
BASIC AND GENERAL OBJECTIVES

- CB1: Students have demonstrated knowledge and an understanding of a given area of study, building upon the foundation of secondary education, supported by advanced texts, and including aspects that engage the latest advances in their area of study.
- CB2: Students know how to apply their knowledge professionally to their work or vocation and possess the competencies that are often demonstrated through elaboration and defense of arguments and the resolution of problems within their area of study.
- CB3: Students can gather and interpret relevant facts (usually within their area of study) in order to make judgments that include reflection on relevant social, scientific, and ethical topics.
- CB4: Students can transmit information, ideas, problems, and solutions to both specialized and non-specialized audiences.
- CB5: Students have developed the necessary learning skills to continue their studies with a high degree of autonomy.

SPECIFIC COMPETENCIES

- CE11: Applied knowledge of numerical calculus, analytic and differential geometry, and algebraic methods.

TRANSVERSE COMPETENCIES OF THE UNIVERSITY

- CT4: Use disciplinary knowledge to analyze and evaluate current situations.

METHODOLOGY

3.1. TEACHING METHOD

The sessions will be face to face. In class, the professor will explain the lecture including a general overview, resolution of some problems and will solve possible questions of the students. Some topics or problems can be explained by the students after previous work. Furthermore, the professor will propose other problems to solve and hand in individually with increasing difficulty and in group. The aim of these assignments is that the students analyzes and understands the mathematical concepts involved in the lectures providing a valuable tool for self-learning.

3.2. STUDENT LEARNING METHOD/DISTRIBUTION OF ECTS LOAD

The lessons will be divided in a theoretical part, where the teacher will explain the content of the subject and in a practical part, when the students will solve basic problems related to the lesson. The students will have to solve more advanced problems individually and there are assignments to be handed individually. In the tutorials, the students can ask their doubts about the theory or problems.

<table>
<thead>
<tr>
<th>Teaching methodology</th>
<th>Weighting</th>
<th>Estimated time a student should dedicate to prepare for and participate in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures</td>
<td>33.33 %</td>
<td>50 hours</td>
</tr>
<tr>
<td>Discussions</td>
<td>3.33 %</td>
<td>5 hours</td>
</tr>
<tr>
<td>Exercises</td>
<td>46.67 %</td>
<td>70 hours</td>
</tr>
<tr>
<td>Group work</td>
<td>6.67 %</td>
<td>10 hours</td>
</tr>
<tr>
<td>Other individual studying</td>
<td>10.0 %</td>
<td>15 hours</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100.0 %</td>
<td>150 hours</td>
</tr>
</tbody>
</table>

PROGRAM

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SESSION 1 (LIVE IN-PERSON)
Presentation of the subject
In this session, the students will be informed of the program of the subject and the teacher will collect information about the previous math knowledge of the students.

INFINITESIMAL CALCULOUS AND NUMERICAL CALCULOUS
Infinitesimal calculus is the branch of mathematics that deals with functions. In this part of the subject, the student will learn to deal with functions of one variable. This knowledge has a direct application in the work of an architect, as it is used to calculate thermal and acoustic insulation, calculus of structures, etc.
Numerical Calculus deals with the interaction between computers and mathematics. In this part of the subject, the student will learn how to perform complex mathematical operations, by using a computer.

SESSION 2 (LIVE IN-PERSON)
Coordinate system and Trigonometry
Book Chapters: *Schaum's outline of Calculus* (Rectangular Coordinate Systems. Pp. 9-13) (See Bibliography)
Book Chapters: *Schaum's outline of Calculus* (Review of Trigonometry. Pp 130-138) (See Bibliography)

SESSION 3 (LIVE IN-PERSON)
Introduction to functions
Book Chapters: *Schaum's outline of Calculus* (Functions. Pp 49-55) (See Bibliography)
Concept of function. Different ways to express a function.

SESSION 4 (LIVE IN-PERSON)
Limit of a function. Continuity
Book Chapters: *Schaum's outline of Calculus* ("Limits" and "Continuity". Pp 56-72) (See Bibliography)
Concept of limit. Concept of continuity and discontinuity.

SESSION 5 (LIVE IN-PERSON)
Limit of a function. Continuity
Concept of limit. Concept of continuity and discontinuity.

SESSION 6 (LIVE IN-PERSON)
Derivatives
Book Chapters: *Schaum's outline of Calculus* ("The derivative" and "Rules for differentiating functions". Pp 73-89) (See Bibliography)
SESSION 7 (LIVE IN-PERSON)

Derivatives

SESSION 8 (LIVE IN-PERSON)

Numerical Calculus
Book Chapters: Schaum's outline of Calculus (Newton's Method. Pp 173-180) (See Bibliography)
Concept. Errors. Applications.

SESSION 9 (LIVE IN-PERSON)

L'Hôpital's Rule
Book Chapters: Schaum's outline of Calculus (L'Hôpital's Rule. Pp 222-229) (See Bibliography)

SESSION 10 (LIVE IN-PERSON)

Graph of a function
(See Bibliography)
Graphic representation of functions.

SESSION 11 (LIVE IN-PERSON)

Graph of a function
(See Bibliography)
Graphic representation of functions and optimization. Analysis of the graph of several functions.

SESSION 12 (LIVE IN-PERSON)

Graph of a function
Graphic representation of functions and optimization. Analysis of the graph of several functions.

SESSION 13 (LIVE IN-PERSON)

Numerical Calculus applied to functions
Derivatives in numerical calculous.

SESSION 14 (LIVE IN-PERSON)

Introduction to Integrals
Book Chapters: Schaum's outline of Calculus (“Antiderivatives” and “The Definite Integral. Area Under a Curve”. Pp. 181-197) (See Bibliography)
Concept of primitive and indefinite integral of a function. Calculation of primitives.
SESSION 15 (LIVE IN-PERSON)

Introduction to Integrals
Concept of primitive and indefinite integral of a function. Calculation of primitives.

SESSION 16 (LIVE IN-PERSON)

Integrals
Book Chapters: Schaum's outline of Calculus ("Antiderivatives" and "The Definite Integral. Area Under a Curve". Pp. 181-197) (See Bibliography)
Concept of definite integral of a function and its geometric interpretation. Applications of the definite integral.

SESSION 17 (LIVE IN-PERSON)

Double Integrals
Book Chapters: Schaum's outline of Calculus (Double and Iterated Integrals. Pp. 474-480) (See Bibliography)

SESSION 18 (LIVE IN-PERSON)

Exercises of functions
Exercises of functions and revision of all this part of the subject.

SESSION 19 (LIVE IN-PERSON)

Numerical Calculous applied to functions
Book Chapters: A Guide to Microsoft® Excel 2013 for Scientists and Engineers (Chapter 13 - Numerical Integration. Pp. 247-29) (See Bibliography)
Integrals in numerical calculous.

SESSION 20 (LIVE IN-PERSON)

Mid term-exam
This exam will include exercises of: Functions introduction.

LINEAR ALGEBRA

Linear algebra is a basic tool for architects, since linear algebra give the mathematical background for vectors and matrices, the tool used to work with forces. Vectors are also of application in other branches of science related to the architectural work, such as spatial geometry and topography.

SESSION 21 (LIVE IN-PERSON)

Introduction to vectors and coordinate system.
Book Chapters: Schaum's outline of Calculus ("Vectors in the plane" Pp. 321-322 and "Vectors in the space" Pp. 426-428) (See Bibliography)
Concept of vectors. General properties of vectors.
SESSION 22 (LIVE IN-PERSON)

Basic operations with vectors
Book Chapters: Schaum's outline of Calculus (Rectangular Coordinate Systems. Pp. 9-13) (See Bibliography)
Addition and subtraction of vectors, multiplication of a vector and a scalar.

SESSION 23 (LIVE IN-PERSON)

Scalar product or dot product
Book Chapters: Schaum's outline of Calculus (Scalar product (or dot product). Pp. 323-324) (See Bibliography)
Geometrical interpretation of the scalar product and calculus of the angle between two vectors.

SESSION 24 (LIVE IN-PERSON)

Vector product of two vector
Book Chapters: Schaum's outline of Calculus (Determinants. Vector Perpendicular to Two Vectors. Vector Product of Two Vectors. Pp 428-42) (See Bibliography)
Geometrical interpretation of the vector product and calculus of areas.

SESSION 25 (LIVE IN-PERSON)

Triple scalar product of three vectors
Book Chapters: Schaum's outline of Calculus (Triple scalar product. Pp 430) (See Bibliography)
Geometrical interpretation of the triple scalar product and calculus of volumen.

SESSION 26 (LIVE IN-PERSON)

Exercises of vectors
Exercises of vectors and revision of all this part of the subject.

SESSION 27 (LIVE IN-PERSON)

Exercises of vectors
Exercises of vectors and revision of all this part of the subject.

STATISTICS

Statistics is a branch of mathematics that deals with the collection, analysis and interpretation of data. This branch of maths is used, in architecture, in order to take optimal decisions.

SESSION 28 (LIVE IN-PERSON)

Introduction to statistics
Descriptive statistics. Probability.

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SESSION 29 (LIVE IN-PERSON)
Discrete probability distribution
Concept of discrete probability distribution. Binomial Distribution.

SESSION 30 (LIVE IN-PERSON)
Continuous probability distribution
Book Chapters: Applied Statistics and Probability for Engineers (Chapter 4. Continuous Random Variables and Probability Distributions. Pp. 97-121) (See Bibliography)
Concept of continuous probability distribution. Normal Distribution.

SESSION 31 (LIVE IN-PERSON)
Regression. Exercises
Book Chapters: Applied Statistics and Probability for Engineers (Chapter 11. Simple Linear Regression and Correlation. Pp. 372-400) (See Bibliography)
Exercises of statistics, both in a spreadsheet and by hand.

SESSION 32 (LIVE IN-PERSON)
Overview of the subject
Exercises of all the subject.

SESSION 33 (LIVE IN-PERSON)
Overview of the subject
Exercises of all the subject.

SESSION 34 (LIVE IN-PERSON)
Overview of the subject
Exercises of all the subject.

SESSION 35 (LIVE IN-PERSON)
Final Exam

BIBLIOGRAPHY
Compulsory
McGraw Hill. ISBN 9780071795531 (Printed)
Students can gain a thorough understanding of differential and integral calculus with this powerful study tool. They’ll also find the related analytic geometry much easier. The clear review of algebra and geometry in this edition will make calculus
easier for students who wish to strengthen their knowledge in these areas. Updated to meet the emphasis in current courses, this new edition of a popular guide - includes problems and examples using graphing calculators.

**Recommended**
  It provides a practical approach designed for engineering and science majors. Students learn how the material will be relevant in their careers through the integration of unique problem sets that reflect realistic applications and situations from research as well as the authors consulting experiences. *Applied Statistics, 7e* is suitable for either a one- or two-term course in probability and statistics
  Completely updated guide for students, scientists and engineers who want to use Microsoft Excel 2013 to its full potential. Electronic spreadsheet analysis has become part of the everyday work of researchers in all areas of engineering and science. Microsoft Excel, as the industry standard spreadsheet, has a range of scientific functions that can be utilized for the modeling, analysis and presentation of quantitative data.

**EVALUATION CRITERIA**

During the semester, several exercises will be proposed to do at home. These exercises should be delivered through campus before the scheduled time.

Apart from that, several mini tests will be done during the subject. The time of these tests and the content of them will be known by the students with enough time. A minimum grade of 5 in the average of these tests is necessary to pass the subject on the first enrollment. The percentage of the final mark of these assignments is shown in the table.

Furthermore, there are two exams, a mid-term exam and a final exam. The exams will be held within the date designated by the School. The marks will range from 0 to 10. A serious mistake about the concepts will be penalized in the corresponding part. Comments, explanations, coherence and structure will be evaluated positively.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Percentage</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Final Exam</td>
<td>40 %</td>
<td>Domain of the theory and the practice of the subject.</td>
</tr>
<tr>
<td>Mid-Term Exam</td>
<td>20 %</td>
<td>Domain of the theory and the practice of the subject.</td>
</tr>
<tr>
<td>Class Participation</td>
<td>10 %</td>
<td>Resolution of exercises in class</td>
</tr>
</tbody>
</table>

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| Individual Work | 30 % | Correct solution of problems. There will be class mini-tests and homework assignments |

1. Students have access to a total of four enrollments, in two consecutive academic years.
2. Students must attend at least 70% of all class sessions. Students who do not meet this minimum percentage automatically fail both first and second enrollments, and pass directly to the third enrollment.

The final mark of the first enrollment will be the average of the different marks as shown in the table. In order to pass, it is necessary a minimum mark of 3.5 in both exams and an average grade greater than 5.

Students who have attended less than 70% of classes will not be entitled to take the final exam and hence will not pass the module neither in the 1st nor in the 2nd examination sessions.

Students that have failed the subject in first enrollment pass to the second enrollment, except those who do not meet the minimum attendance percentage, and that therefore pass directly to the third enrollment.

3. Grading of students in the second enrollment will follow the following guidelines:

There is an extra exam session for those students that do not pass the module. It consists in a retake exam weighting 60% for the final mark. The remaining 40% will be counted as class participation and individual work. The final grade will be the maximum of the retake exam or the weighting of the exam and the class participation and individual work.

The maximum mark in the 2nd extra session is 8.

4. 3rd and 4th enrollments

For those students that do not pass the module there are two more consecutive sessions. In the 3rd and 4th exam sessions the evaluation system will consist on the same criteria, taking into account the fact that they might not be able to attend regularly the sessions.

PROFESSOR BIO

Professor: LUIS ECHEVARRIA GIMENEZ
E-mail: lechevarria@faculty.ie.edu

Professor Luis Echevarría is a Civil Engineer who studied at the University of La Coruña where he graduated in 2010 with a final mark of "Matrícula de Honor". He is now following his studies in order to obtain a doctorate in Civil Engineer.

He teaches Applied Mathematics in Architecture 1 since 2015 and Applied Physics in Architecture 1 since 2018.

Echevarría began working in 2010 as a Civil Engineer at the Eduardo Torroja Institute of Construction Science, a public institution under the Spanish National Research Council, where he works as a researcher in the fields of structures and materials used in construction and structural pathology.

Email: lechevarria@faculty.ie.edu

OTHER INFORMATION

Each student will need a calculator.

Calculators are not provided at the test, and you can't share a calculator. **Bring Your Own Calculator**
If you have a calculator with characters that are one inch or higher, or if your calculator has a raised display that might be visible to other test-takers, you will be seated at the discretion of the teacher. Only battery-operated, handheld equipment can be used for testing. No power cords are allowed. No graphical calculator nor programable calculators are allowed.

You will be dismissed and your scores canceled if you use your calculator to share information during the test, or to remove test questions or answers from the test room.