APPLIED MATHEMATICS IN ARCHITECTURE 1

Bachelor in Architectural Studies BAS SEP-2023 M1-AS.1.S.A

Area Architecture and Design

Number of sessions: 35

Academic year: 23-24

Degree course: FIRST

Number of credits: 6.0

Semester: 1º

Category: BASIC

Language: English

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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, Applied Physics in Architecture 1 since 2018 and Applied Physics in Architecture 2.

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.

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SUBJECT DESCRIPTION

In this subject, the mathematical principles that provide the student with sufficient training to continue their studies are stablished; 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, structural analysis, 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, using a computer.

Linear algebra is a basic tool for architects, since linear algebra gives the mathematical background for vectors and matrices, the tools used for working 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 make optimal decisions.

LEARNING OBJECTIVES

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

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.

TEACHING METHODOLOGY

IE University teaching method is defined by its collaborative, active and applied nature. Students actively participate in the whole process to build their knowledge and sharpen their skills. Professor's main role is to lead and guide students to achieve the learning objectives of the course. This is done by engaging in a diverse range of teaching techniques and different types of learning activities such as the following:

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.

Learning Activity	**Weighting**	**Estimated time a student should dedicate to prepare for and participate in**
Lectures	28.0 %	42.0 hours
Discussions	3.33 %	5.0 hours
Exercises in class, Asynchronous sessions, Field Work	30.0 %	45.0 hours
Group work	0.0 %	0.0 hours
Individual studying	38.67 %	58.0 hours
TOTAL	100.0 %	150.0 hours

PROGRAM

SESSIONS 1 - 2 (LIVE IN-PERSON)

Presentation of the subject

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)

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 CALCULUS AND NUMERICAL CALCULUS

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.

SESSIONS 3 - 4 (LIVE IN-PERSON)

Introduction to functions

Limit of a function.

Book Chapters: Schaum's outline of Calculus (Functions. Pp 49-55) (See Bibliography)

Book Chapters: Schaum's outline of Calculus ("Limits" and "Continuity". Pp 56-72) (See Bibliography)

Concept of function. Different ways to express a function.

Concept of limit. Exercises.

SESSIONS 5 - 6 (LIVE IN-PERSON)

Limit of a function. Continuity

Derivatives

Book Chapters: Schaum's outline of Calculus ("The derivative" and "Rules for differentiating functions". Pp 73-89) (See Bibliography)

Exercises of limits

Concept of continuity and discontinuity.

Concept of derivative and its geometrical interpretation. Calculation of derivatives.

SESSIONS 7 - 8 (LIVE IN-PERSON)

Derivatives

Book Chapters : Schaum's outline of Calculus ("The derivative" and "Rules for differentiating functions". Pp 73-89) (See Bibliography)

Calculation of derivatives.

SESSIONS 9 - 10 (LIVE IN-PERSON)

Numerical Calculus

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

Book Chapters: Schaum's outline of Calculus (Curve Sketching. Concavity. Symmetry. Pp 119-129) (See Bibliography)

Concept. Errors. Applications.

SESSIONS 11 - 12 (LIVE IN-PERSON)

Curve sketching

Book Chapters: Schaum's outline of Calculus (Curve Sketching. Concavity. Symmetry. Pp 119-129) (See Bibliography)

Graphic representation of functions and optimization. Analysis of the graph of several functions.

SESSIONS 13 - 14 (LIVE IN-PERSON)

Graph of a function

Numerical Calculus applied to functions

Book Chapters: A Guide to Microsoft® Excel 2013 for Scientists and Engineers ("Chapter 13 - Numerical Integration" and "Chapter 14 - Differential Equations". Pp. 247-29) (See Bibliography)

Graphic representation of functions and optimization. Analysis of the graph of several functions.

Derivatives in numerical calculus.

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.

SESSIONS 15 - 16 (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.

Concept of definite integral of a function and its geometric interpretation. Applications of the definite integral.

SESSIONS 17 - 18 (LIVE IN-PERSON)

Double Integrals

Exercises of functions

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

Exercises of functions 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.

SESSIONS 19 - 20 (LIVE IN-PERSON)

Introduction to vectors and coordinate system

Basic operations with vectors

Book Chapters: Schaum's outline of Calculus ("Vectors in the plane" Pp. 321-322 and "Vectors in the space" Pp. 426-428) (See Bibliography)

Book Chapters: Schaum's outline of Calculus (Rectangular Coordinate Systems. Pp. 9-13) (See Bibliography)

Concept of vectors. General properties of vectors.

Addition and subtraction of vectors, multiplication of a vector and a scalar.

SESSIONS 21 - 22 (LIVE IN-PERSON)

Mid term-exam

This exam will include exercises of Functions.

SESSIONS 23 - 25 (LIVE IN-PERSON)

Scalar product or dot product

Vector product of two vector

Triple scalar product of three vectors

Book Chapters: Schaum's outline of Calculus (Scalar product (or dot product). Pp. 323-324) (See Bibliography)

Book Chapters: Schaum's outline of Calculus (Determinants. Vector Perpendicular to Two Vectors. Vector Product of Two Vectors. Pp 428-42) (See Bibliography)

Book Chapters: Schaum's outline of Calculus (Triple scalar product. Pp 430) (See Bibliography)

Geometrical interpretation of the scalar product and calculus of the angle between two vectors.

Geometrical interpretation of the vector product and calculus of areas.

Geometrical interpretation of the triple scalar product and calculus of volumen.

SESSIONS 26 - 27 (LIVE IN-PERSON)

Exercises of vectors

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

SESSIONS 28 - 29 (LIVE IN-PERSON)

Introduction to statistics

Discrete probability distribution

Book Chapters: Applied Statistics and Probability for Engineers ("Chapter 1. The Role of Statistics in Engineering" and "Chapter 2 Probability". Pp. 1-58) (See Bibliography)

Book Chapters: Applied Statistics and Probability for Engineers (Chapter 3. Discrete Random Variables and Probability Distributions. Pp. 59-89) (See Bibliography)

Descriptive statistics. Probability.

Concept of discrete probability distribution. Binomial Distribution.

SESSIONS 30 - 31 (LIVE IN-PERSON)

Continuos probability distribution

Regression. Exercises

Book Chapters: Applied Statistics and Probability for Engineers (Chapter 4. Contiunuous Random Variables and Probability Distributions. Pp. 97-121) (See Bibliography)

Book Chapters: Applied Statistics and Probability for Engineers (Chapter 11. Simple Linear Regression and Correlation. Pp. 372-400) (See Bibliography)

Concept of continuos probability distribution. Normal Distribution.

Exercises of statistics, both in a spreadsheet and by hand.

SESSIONS 32 - 33 (LIVE IN-PERSON)

Overview of the subject

Exercises of all the subject.

SESSIONS 34 - 35 (LIVE IN-PERSON)

Overview of the subject

Final Exam

Exercises of all the subjec.

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. A minimum grade of 50% in the average of these exercises is necessary to pass the subject on the first enrollment.

Appart from that, several mini tests will be done during the course. The time of these tests and the content of them will be known by the students with enough time. 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.

criteria	percentage	Learning Objectives	Comments
Final Exam	40 %		Domain of the theory and the practice of the subject.
MId-Term Exam	20 %		Domain of the theory and the practice of the subject.
Individual Work	30 %		Correct solution of problems. There will be class mini-tests and homework assignments
Class Participation	10 %		Resolution of exercises in class

RE-SIT / RE-TAKE POLICY

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.

BIBLIOGRAPHY

Compulsory

- Frank. Ayres, Elliott. Mendelson. (2021). *Schaum's outline of Calculus.* 7th edition. McGraw Hill. ISBN 9781264258338 (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

- Douglas C. Montgomery; George C. Runger. (2006). *Applied Statistics and Probability for Engineers.* 3. John Wiley & Sons, Inc. ISBN 0471204544 (Digital)

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

- Bernard V. Liengme. (2016). *A Guide to Microsoft® Excel 2013 for Scientists and Engineers.* Elsevier. ISBN 9780128028179 (Digital)

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.

- S. Lipschutz. (2001). *Schaum's outline of theory and problems of linear algebra.*

3. McGraw Hill. ISBN 0071362002 (Printed)

BEHAVIOR RULES

Please, check the University's Code of Conduct here. The Program Director may provide further indications.

ATTENDANCE POLICY

Please, check the University's Attendance Policy here. The Program Director may provide further indications.

ETHICAL POLICY

Please, check the University's Ethics Code here. The Program Director may provide further indications.