APPLIED MATHEMATICS IN ARCHITECTURE 2

Bachelor in Architectural Studies BAS SEP-2023 M2-AS.2.S.A

Area Operations and Business Analytics

Number of sessions: 17

Academic year: 23-24

Degree course: SECOND

Number of credits: 3.0

Semester: 1º

Category: BASIC

Language: English

Professor: **ALESSANDRO MATTOCCIA**

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Alessandro is a co-founder of 50SuperReal studio, where he focuses on applying coding to the automatisation of design and technical processes, as well as playing the role of BIM Manager and computational expert.

He is currently an adjunct professor at IE School of Architecture and Design where he teaches Mathematics and Computational Geometry, Co-Director at Structuralia in the Master “BIM and Smart Buildings” as well as professor in the “Programming applied to BIM” Master programe.

Alessandro spends a lot of his time in educational processes, giving lectures, workshops and corporate training programs. Previously, he has been teaching in ETSAM as part of the Masters in Advanced Infographics, and you can find his online classes on several different educational and profesional platforms. He has also been a researcher in the Institute of Advanced Architecture of Catalonia, focusing on urban scale projects, and part of MargenLab team designing and building architectural prototypes based on energy modelling and sustainable strategies.

Currently he is focusing his career in pushing the boundaries of the Building Information Modelling methodology. Processes as advanced modelling, automatisation and data informed geometry are his main topics of research, mixing programming and drafting to explore the digital capabilities of architecture and design.

Alessandro graduated cum laude in 2015 from the Faculty of Engineer in Pisa with a master degree in “Building Engineering and Architecture”, presenting a project that studied the intersection between vernacular architecture and information technologies, which can be found in several publications. Trough exchange programs, he has also studied at the Technical University of Riga and the Institute of Advanced Architecture of Catalonia (IAAC). In 2016 he enrolled the International Master BIM Manager from Zigurat, Global Institute of Technology.

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SUBJECT DESCRIPTION

Contemporary architecture is designed predominately with digital software, different digital tools encourage distinct workflows, which have critical impact over design outcomes. This course explores three-dimensional geometric transformations, while simultaneously providing an introduction in traditional differential geometry. The focus is on understanding the relevance of form as a product of exploring the reciprocity between math and computation. This dual perspective enriches understanding on both sides, and leads to the development of practical algorithms for working with real-world geometric data.

LEARNING OBJECTIVES

Along the course concepts of linear algebra, transformations, curves and surfaces classifications and multivariable calculus will be revisited, putting a strong emphasis on intuitive, visual understanding that complements the more traditional formal treatment.

In each session students will learn the fundamental mathematical concepts that they will after apply in a coding environment, visualising these abstract systems. Students will be introduced to the visual programming language Grasshopper within the software Rhinoceros 3D.

Students will learn how to describe the topology of shapes through matrix representation, translating geometric transformations and differential geometry into a language suitable for computation.

(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

Each session has a distinct theme, an exploration of a distinct aspect of transformations and differential geometry The sessions begin with a theory lecture or demonstration, but the bulk of our time is spent actively working through a series of exercises/tutorials. Students will utilize both digital and physical media. Teaching throughout the course will be based on learning through exploration and experimentation, from numbers to form. The course provides essential mathematical knowledge applied to a large array of real-world examples and applications.

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:

Learning Activity	**Weighting**	**Estimated time a student should dedicate to prepare for and participate in**
Lectures	20.0 %	15.0 hours
Discussions	13.33 %	10.0 hours
Exercises in class, Asynchronous sessions, Field Work	20.0 %	15.0 hours
Group work	0.0 %	0.0 hours
Individual studying	46.67 %	35.0 hours
TOTAL	100.0 %	75.0 hours

PROGRAM

SESSIONS 1 - 2 (LIVE IN-PERSON)

Affine Transformations 01

Matrices. Operations with Matrices. Homogeneous Coordinates.

Affine Transformation (Translation, Rotation). Transformation Matrices. Composing Transformations.

Application of the concepts previously learned through visual programming.

SESSIONS 3 - 4 (LIVE IN-PERSON)

Affine Transformations 02

Affine Transformation (Dilatation, Shear, Reflection, Symmetry Groups). Transformation Matrices. Composing Transformations.

Application of the concepts previously learned through visual programming.

SESSIONS 5 - 6 (LIVE IN-PERSON)

More Transformations

Inversion in a Circle. Projective Transformations (Parallel and Central Projection).

Application of the concepts previously learned through visual programming.

Assignment 01 OUT (20% of the grade).

SESSIONS 7 - 8 (LIVE IN-PERSON)

Parametric Curves

Parametric Representation of Curves. Curve Domain. Manipulating Curves.

Evaluating Curves

Tangent, Normal and Binormal Vector (Frenet Frame). Curvature and Torsion. Osculating Circle. Differential of a Curve.

Application of the concepts learned through visual programming.

SESSIONS 9 - 10 (LIVE IN-PERSON)

Parametric Surfaces

Parametric Representation of Surfaces. Surface Domain.

Evaluating Surfaces

Tangent Plane and Normal Vector. Principal, Gauss and Mean Curvature. Osculating Sphere. Differential of a Surface.

Application of the concepts learned through visual programming.

SESSIONS 11 - 12 (LIVE IN-PERSON)

Motion Surfaces

A Surface as the locus of a moving deforming Curve.

Extrusions. Translational Surfaces. Surface of Revolution. Swept Surfaces. Ruled Surfaces

Application of the concepts learned through visual programming.

Assignment 01 DUE (20% of the grade)

Assignment 02 OUT (20% of the grade)

SESSIONS 13 - 15 (LIVE IN-PERSON)

Assignment Review

Students are expected to explain the concept they want to develop, bringing drawings and diagrams. References and guidance will be given based on the needs and directions of each proposal. Peer-reviews will take place at the end of the session.

SESSIONS 16 - 17 (LIVE IN-PERSON)

Final Exam

(50% of the grade)

It will contain exercises on:

- Matrices Operations and Transformations.
- Parametrized Curves and Surfaces.
- Curves and Surfaces Evaluation.
- Surface Creation: Extrusion, Translational, Revolution, Swept, Ruled Surfaces.

Assignment 02 DUE (20% of the grade)

EVALUATION CRITERIA

A. FINAL EXAM

The final exam consists of the following: based on what was discussed in the course (through lectures, exercises and assignments) the students will have to successfully complete a series of exercises. Details of how to correctly approach the exercises will be given during the course. For better results, students are asked to pay attention and take notes during class.

B. ASSIGNMENTS

The course relies on two assignments that requires the student to work outside the class. The details of what these submissions imply will be discussed in class and are mention above in the course program. The final grade is based on continuous evaluation throughout the course.

C. FINAL GRADE

The final grade breakdown:

- Sobresaliente/Outstanding: 9.0-10.0 (A to A+). Consistently produces work of the highest quality and craft; exhibits notable progress and development over the course of the semester; meets all course objectives at highest level; attendance is near-perfect, and contributions to course discussions are extremely valuable.
- Notable: 7.0-8.9 (B to B+). Completes all assignments with work of above-average quality and craft; exhibits significant progress and development; meets most course objectives; attendance and participation are very good.
- Aprobado: 6.0-7.0 (C to C+). Completes all assignments with work of acceptable quality and craft; exhibits some progress and development; meets a majority of course objectives. Attendance and participation are acceptable.
- Aprobado: 5.0-6.0 (D). Assignments are delivered but are incomplete and/or of low quality and craft; exhibits little progress and development; meets few course objectives. Attendance and participation are poor, but absences do not total more than 30%
- Suspenso: 0-4.9 (F). Work is incomplete, missing, or does not meet course objectives. Attendance and participation are poor.
- Automatic Failure/Suspenso: 0 (F). Please note that a student who misses 30% or more of the scheduled sessions receives an automatic 0.0, and loses his or her right to the second "convocatoria.

criteria	**percentage**	**Learning Objectives**	**Comments**
Final Exam	40 %		
Assignments	50 %		
Class Participation	10 %		

RE-SIT / RE-TAKE POLICY

Each student has 4 chances to pass any given course distributed in two consecutive academic years (regular period and July period).

Students who do not comply with the 70% attendance rule will lose their 1st and 2nd chance, and go directly to the 3rd one (they will need to enrol again in this course next academic year).

Grading for retakes will be subject to the following rules: Students failing the course in the first regular period will have to do a retake in June (except those not complying with the attendance rules, which are banned from this possibility). Dates and location of the June retakes will be posted in advance and will not be changed. Please take this into consideration when planning your summer. The maximum grade that a student may obtain in any type of retake will be 8 out of 10.The retakes will consist on a comprehensive exam. The grade will depend on the performance in this exam and on the assignments submission; continuous evaluation over the semester will not be taken into account.

BIBLIOGRAPHY

Recommended

- Arturi Tedeschi. *AAD Algorithms-Aided Design: Parametric Strategies using Grasshopper.* ISBN 9788895315300 (Printed)
- Michael E Mortenson. *Geometric Transformations for 3D Modeling.* ISBN 978083113338 (Printed)
- Erwin Kreyszig. *Differential Geometry.* ISBN 978048666721 (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.