COMPUTATIONAL THINKING FOR DATA MANAGEMENT AND ANALYSIS

Bachelor in Data and Business Analytics BDBA SEP-2023
CTDM-DBA.1.M.A

Area Others

Number of sessions: 30

Academic year: 23-24

Degree course: FIRST

Number of credits: 6.0

Semester: 2º

Category: BASIC

Language: English

Professor: **RAFIF SROUR DAHER**

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RAFIF SROUR DAHER

Experience in teaching, analytical and empirical research, and data analysis. Demonstrated ability to work in international/multicultural environments (Lebanon, USA, Spain). Life-long learner; both academically and personally. Advocate of women in STEM empowerment - Breaking stereotypes one at time. Multiple times winner of Best Professor award and strong advocate of using coaching and mentoring to help students improve their academic performance and overall college experience. Lately, nominated among the top 183 Leading Data Academics of 2021 by CDO magazine. Also nominated among 55 leading women in the #technology sector in Spain, under the category of "Yo, Jefa", 2021. Driven by a passion to use technology as a disrupter in higher education, constantly working on innovating curricula and teaching methodologies.

Experience

Executive Vice Dean, IE School of Science and Technology, May 23 - Present.
Vice Dean of Undergraduate Programs, IE School of Science and Technology, Jun 2022 - Present.
Acting Dean, IE School of Science and Technology.

Academic Director of BSc in Data and Business Analytics, School of Science and Technology, Dec 2017 - May 2022.
Adjunct Faculty, IE university, Sep 2014 - Present.

Office Hours

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rsrour@faculty.ie.edu before or after class or by appointment.

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SUBJECT DESCRIPTION

Have you ever wondered why math puzzles are often used for interviews? Did you know that linear algebra is at the heart of Google´s famous PageRank Algorithm? Have you ever wondered what a paradox is and how it can contradicts all the basics of mathematical logic? Did you know that multivariate optimization is at the heart of many statistical and machine learning concepts? Answers to these questions and a lot more are provided in this course on computational thinking for data management and analysis.

Students often argue that thanks to the machine learning community, it is possible to apply many powerful machine learning and artificial intelligence methods without a thorough understanding of the underpinning mathematics. This is great, but what happens when things go wrong or an algorithms fails to perform the task it was developed for? If you learn the language and the meaning of the underlying math, you can work out what´s gone wrong and possibly find a way to fix it.

In this context, this course is developed for first year data and business analytics students. It focuses on teaching students the fundamentals of mathematical concepts needed to master topics in data science and artificial intelligence focusing not only on theoretical concepts and applications, but also on building student's intuition and critical thinking.

Students following this course will be trained to see mathematical structures in the object you work with, and understand their properties. They will study a particular set of mathematical facts such as basic and discrete structures, functions, recursive and inductive relations. This will teach them how to apply logic and mathematical reasoning to problem-solving in real-life situations. In addition, they will learn the basics of multivariate functions and optimization, including simple linear programming.

LEARNING OBJECTIVES

The main objective of this course is to demonstrate through exercises and assignments that the techniques developed throughout the course are not an end unto themselves but tools that can be used to assist data scientists and analysts in becoming more effective decision-makers.

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

- Gain the pre-requisite mathematical knowledge to continue their journey and lean more advanced courses in computer science and artificial intelligence.
- Learn the importance of mathematics, particularly discrete math in solving artificial intelligence challenges;
- Master the concepts of propositional logic and proof;
- Understand basic structures mainly sets, sequences, and sums;
- Study the properties of multivariable functions,
- Learn how to derive multivariate functions using basic and more advanced rules (Chain rule and implicit differentiation)
- Study optimization, both constrained and unconstrained and understand the main difference;

- Apply the concepts of optimization to understand complex machine learning algorithms.

Additionally, the course will focus on the acquisition or reinforcement of generic skills:

- The ability to summarize and present information in a meaningful way;
- The ability to build an abstract model to address any real-life problem;
- The ability to quickly identify the tools that need to be used in a particular problem.

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:

Learning Activity	**Weighting**	**Estimated time a student should dedicate to prepare for and participate in**
Lectures	20.0 %	30.0 hours
Discussions	10.0 %	15.0 hours
Exercises in class, Asynchronous sessions, Field Work	20.0 %	30.0 hours
Group work	30.0 %	45.0 hours
Individual studying	20.0 %	30.0 hours
TOTAL	100.0 %	150.0 hours

METHODOLOGY

The methodology that will be adopted in this course will follow liquid learning with a hybrid format. Liquid learning is a transformational and interactive educational experience that transcends single methodologies and platforms to blend physical, digital and natural environments so that students obtain a world-class education irrespective of their location and/or situation.

This course is divided into 5 modules, each module comprises five sessions. All sessions are face to face and involve two kind of lectures: Conceptual and practical.

Conceptual sessions are delivered using Power Point presentations and short explanatory videos (whenever possible) and focus on discussing mathematical theorems, with each new theorem being accompanied by a number of exercises, to be solved in class (test your understanding, worked examples, and challenging problems). The practical sessions are designed to give the students, grouped in small size teams (2 or 3 members) hands-on exercises, datasets, puzzles and/or specific problems.

In addition, the course will include the following:

Forum Discussions (a total of 2 forums per semester) form an integral part of this course; where students are encouraged to interact with their classmates and share opinions/comments/ideas regarding an important and sometimes challenging topic covered (or not) in class. Videos, articles and sometimes puzzles will be posted for students on their Campus Online webpage and accompanied with a list of questions to direct the discussion between students. Participation to these forums is mandatory.

Problem sets (a total of 5 problem sets, one set per unit) are in-depth problems that will be uploaded to campus online. I strongly recommend that you do the exercises given as homework during the course and not leave them for a date close to the exam. Though you are strongly encouraged to work with others on understanding the lecture material and attempting the regular assignments, the intention is that you work alone on the Problem Sets, which are designed to give you feedback on how you are progressing.

Blog (a total of 3 blogs): Students are required to blog on their learning journey throughout the semester. Different themes will be suggested to the students for each blog and the participation and attendance will be evaluated. However, students should also feel to blog at their own rhythm and share with is any experience they think could help us understand better their educational evolution.

Peer-graded assignments (total 2 per semester): These assignments introduce challenging topics to the students: The Big game and the Gradient Descent. Detailed rubrics will be given to the students to help them review and grade each other works. Emphasis will be placed on giving constructive feedback to each other's.

Brief quizzes (total 4 per semester): These quizzes are online and are usually given at the end of each module. These quizzes are meant to test your overall understanding of the material and will help the professor assess the overall performance and evolution of the class.

Prior to all live sessions, you should read assigned textbook sections. Reading the textbook in advance will allow you to get the most out of each lecture. When reading the textbook sections prior to each lecture, you must look at the examples but you do not need to solve them.

PROGRAM

The course kicks off with an introduction to mathematical thinking, covering basics of logic and proof theories, set and graph theory, in addition to functions and induction and recursive relations. Then, we will move to calculus and focus on functions of more than one variables and optimization. The course ends with constrained optimization and simple linear programming. Special emphasis is placed on the applications of each of these concepts to data science and machine learning.

In this context, the course is divided in 5 modules, each module consists of 5 sessions. The rest of the sessions are dedicated to exams and review sessions.

- Module 1: INTRODUCTION TO MATHEMATICAL THINKING
- Module 2: SET THEORY, INDUCTION AND RECURSION RELATIONSHIPS
- Module 3: FUNCTIONS OF MORE THAN TWO VARIABLES
- Module 4: MULTIVARIABLE OPTIMIZATION
- Module 5: CONSTRAINED OPTIMIZATION

All the required readings are from the two recommend textbooks "Discrete Mathematics and Its Applications", Kenneth Rosen; 8th edition; McGraw-Hill and "Essential Mathematics for Economic Analysis" Knut Sydsæter, Peter Hammond, Arne Strøm and Andrés Carvajal; 5th edition, Person Education Limited. Reading a section means reading the text AND doing the examples. Extra handouts will be provided to students to cover specific topics.

Disclaimer: The following description of the material covered is tentative. An attempt will be made to cover all listed topics. However; the pace in the classes will depend on the group performance.

Important: In the next section, "Discrete Mathematics and Its Applications" is referred to as DMIA and "Essential Mathematics for Economic Analysis" is referred to by the acronym EMEA.

MODULE ZERO: GETTING TO KNOW EACH OTHER

Activity: Forum Discussion 0 (optional): < 10 min

Description of the activity: log in to your student account and access the course webpage on Campus Online. On the left-hand menu, click on Discussion Board and double-click on the forum entitled: Getting to know each other. Introduce yourself, your background, where you are from and what do you expect to learn from this course.

Professor will be logging in at various times in Week zero to great and get to know the students.

MODULE 1/5: INTRODUCTION TO MATHEMATICAL THINKING

Sessions 1 – 5

SESSION 1 (LIVE IN-PERSON)

Topics: Introduction and presentation of the course syllabus, objectives and pedagogy. Computational thinking for data management and analysis: what? Why? How?

Problem set 1.

SESSION 2 (LIVE IN-PERSON)

Topics: Propositional logic: theory and applications (DMIA; Chapter 1; pp 1 – 25). Propositional equivalences (DMIA; Chapter 1; pp 25 – 36).

SESSION 3 (LIVE IN-PERSON)

Topics: Propositional equivalences (DMIA; Chapter 1; pp 25 – 36).

Activity Blog 1: My Math Journey; Approximate time of completion: < 10 min

Description of the activity: This activity is designed to map your math learning journey throughout this course.

Requirements: For this week, you are asked to describe how do you feel about math? Did you have a good or bad experience with math courses in your high school? What are your expectations from this course?

You can decide on the frequency of blogging in your journey (daily, alternate days, weekly etc.).

Please limit your blogs to a maximum of 500 words.

Evaluation: Attendance + Participation

Over the period of one week (beginning and end dates will be specified in class during session 2), the professor will be logging in to your blog, checking your input and providing feedback. Attendance will be evaluated based on whether or not your blogged. Your participation grade will be based on the quality (as opposed to the quantity, i.e. the number of line) of your blog. Details regarding your evaluation criteria will be provided in due time.

SESSION 4 (LIVE IN-PERSON)

Topics: Predicates and quantifiers (DMIA; Chapter 1; pp 36 – 57). Introduction to proofs (DMIA; Chapter 1; pp 80 – 92). Presenting asynchronous activities for session 5.

Peer-graded assignment 1: The Big Game. Introducing the assignment and setting objectives deadlines.

SESSION 5 (LIVE IN-PERSON)

Practical session. Solving excercices and Review of module 1 < 20 min

Quiz 1

MODULE 2/5: SET THEORY, INDUCTION AND RECURSION RELATIONSHIPS

Sessions 6 – 10

SESSION 6 (LIVE IN-PERSON)

Topics: Introducing module 2, topics, assignments, deliverables and asynchronous activities. Sets: theory and operations (DMIA; Chapter 2; pp 115 – 138). Functions (DMIA; Chapter 2; pp 138 – 156).

Problem set 2.

SESSION 7 (LIVE IN-PERSON)

Topics: Sequences and Sums (DMIA; Chapter 2; pp 156 – 170). Cardinality of sets (DMIA; Chapter 2; pp 170 – 177). Introducing asynchronous activities for session 8.

SESSION 8 (LIVE IN-PERSON)

Topics: Mathematical induction. Strong induction and well-ordering. Recursive relations and structural induction.

Quiz 2

SESSION 9 (LIVE IN-PERSON)

Activity: Discussion + review + hands-on exercises. Re-enforcement learning. Flipping the classroom approach.

SESSION 10 (LIVE IN-PERSON)

Topics: Russell´s paradox in class group activity.

Activity: Blog 2: My Math Journey; Approximate time of completion: < 40 min

Description of the activity: For this week, you are asked to think about one of the mathematical concepts you have learned in this module. Which one is your most and/or least favorite and why? Why one you think is the hardest and if you were to explain this concept, how would you do it.

Please limit your blog to a maximum of 500 words.

MODULE 3/5: FUNCTIONS OF MORE THAN TWO VARIABLES

Sessions 11 – 15

SESSION 11 (LIVE IN-PERSON)

Topics: Functions of two variables. Domain & Range. Partial derivatives with two variables. Higher order partial derivatives, graph of a function of two variables, level curves. (EMEA; chapter 11; pp 407 – 416). Problem set 3.

SESSION 12 (LIVE IN-PERSON)

Topics: Functions of two variables. Domain & Range. Partial derivatives with two variables. Higher order partial derivatives, graph of a function of two variables, level curves. (EMEA; chapter 11; pp 407 – 416). Problem set 3.

SESSION 13 (LIVE IN-PERSON)

Topics:

1. Geometric interpretation of partial derivatives
2. Surfaces and distance.

Optional Reading: EMEA; Chapter 11: Sections 11.3 & 11.4.

SESSION 14 (LIVE IN-PERSON)

Topics: Functions of N variables, domain, Continuity, Euclidean n-dimensional space; partial derivatives with more variables, Young's theorem; economic applications (marginal products and partial elasticities). (EMEA; chapter 11; pp 427 – 437).

SESSION 15 (LIVE IN-PERSON)

Topics:

1. The chain rule for two and many variables.
2. Implicit differentiation along a level curve, MRS and elasticity of substitution, differentials.

Evaluation: Attendance + Pop up questions (Continuous evaluation). Total points: 10 points.

Quiz 3

SESSION 16 (LIVE IN-PERSON)

Activity: Review for the Midterm exam.

SESSION 17 (LIVE IN-PERSON)

Midterm exam.

MODULE 4/5: MULTIVARIABLE OPTIMIZATION

Sessions 18 – 22

SESSION 18 (LIVE IN-PERSON)

Topics: Midterm correction and evaluation. Introducing module 4, topics, assignments, deliverables and asynchronous activities. Optimization of a function of two variables. Necessary and sufficient conditions. Economic examples (EMEA; Chapter 13; pp 495 - 503). Local extreme points. Linear models with quadratic objectives. Economic applications (EMEA; Chapter 13; pp 504 – 520). Problem set 4.

Peer-graded assignment 2: Gradient Descent and Optimization.

SESSION 19 (LIVE IN-PERSON)

Topics: Midterm correction and evaluation. Introducing module 4, topics, assignments, deliverables and asynchronous activities. Optimization of a function of two variables. Necessary and sufficient conditions. Economic examples (EMEA; Chapter 13; pp 495 - 503). Local extreme points. Linear models with quadratic objectives. Economic applications (EMEA; Chapter 13; pp 504 – 520). Problem set 4.

Peer-graded assignment 2: Gradient Descent and Optimization.

SESSION 20 (LIVE IN-PERSON)

Topics:

1. The extreme value theorem. Finding maxima and minima.
2. Optimization of a function of three or more variables.

SESSION 21 (LIVE IN-PERSON)

Topics: Review: Q and A session. Flipping the classroom approach.

SESSION 22 (LIVE IN-PERSON)

Practical session. Applied Exercises.

Quiz 4

MODULE 5/5: CONSTRAINED OPTIMIZATION

Sessions 23 – 27

SESSION 23 (LIVE IN-PERSON)

Topics: Introducing module 5, topics, assignments, deliverables and asynchronous activities. The Lagrange multiplier method – Equality constraints. (EMEA; Chapter 14; pp 533 - 540). Problem set 5.

SESSION 24 (LIVE IN-PERSON)

Topics: The Lagrange multiplier method. Additional variables and constraints. (EMEA; Chapter 14; pp 552 – 558).

SESSION 25 (LIVE IN-PERSON)

Practical Session.

Blog 3: My Math Journey; Approximate time of completion: < 20 min

Description of the activity: This activity is designed to map your math learning journey throughout this course.

Requirements: Now that we are reaching the end of this course, reflect on what you have learned and share with us your ideas.

You can decide on the frequency of blogging in your journey (daily, alternate days, weekly etc.).

Please limit your blogs to a maximum of 500 words.

SESSION 26 (LIVE IN-PERSON)

Topics: Inequality constraints. Nonlinear programming. The Khun-Tucker method. (EMEA; Chapter 14; pp 563 – 569).

SESSION 27 (LIVE IN-PERSON)

Practice session

SESSION 28 (LIVE IN-PERSON)

REVIEW FOR FINAL EXAM

SESSIONS 29 - 30 (LIVE IN-PERSON)

FINAL EXAM

FINAL EXAM

EVALUATION CRITERIA

Your final grade in the course will be based on both individual and group work of different characteristics that will be weighted in the following way:

criteria	percentage	Learning Objectives	Comments
Class Participation	15 %		
quizzes	15 %		
Continuous evaluation	25 %		
Midterm	20 %		
Individual Work	10 %		
Final Exam	20 %		

RE-SIT / RE-TAKE POLICY

BIBLIOGRAPHY

Recommended

- Rosen, Kenneth H.. (2019). *Discrete Mathematics and its Applications.* 8th edition. McGraw Hill. ISBN 9781259676512 (Printed)

DMIA

- Sydsæter, Knut; Hammond, Peter; Strøm Arne and Carvajal Andrés.. (2021). *Essential Mathematics for Economic Analysis.* 6th. Pearson Education Ltd./. ISBN 9781292359281 (Printed)

EMEA

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.