FUNDAMENTALS OF PROBABILITY AND STATISTICS

Grado en Computación e Inteligencia Artificial / Bachelor in Computer Science and Artificial Intelligence BCSAI SEP-2025 FPS-CSAI.1.M.A

Area Mathematics

Number of sessions: 30

Academic year: 25-26

Degree course: FIRST

Number of credits: 6.0

Semester: 1º

Category: BASIC

Language: English

Professor: **GUILLERMO CORREDOR**

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Professor Guillermo Corredor

Guillermo Corredor holds an MSc in Banking and Quantitative Finance (with honors) from Universidad Complutense de Madrid and he is working towards a PhD in Quantitative Finance and Economics. His research interests include interest rate modeling, valuation of fixed income derivatives, and machine learning applications in finance. His professional experience involves several data analyst roles in advisory firms (Newbers Advanced Analytics) and financial institutions (BBVA, European Central Bank). While carrying out his PhD research, he has been delivering lectures in the field of statistics at IE University and in the quantitative track of the Master in Finance at Advantere School of Management.

Office Hours

Office hours will be on request. Please contact at:

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SUBJECT DESCRIPTION

In today's data-driven world, the ability to analyze, interpret, and make decisions based on data is a critical skill. Whether you are training a Machine Learning model or making predictions using AI systems, a solid understanding of Probability and Statistics is key. This course lays the groundwork for these applications by introducing the fundamental concepts and techniques that will serve as the backbone of further courses in the Bachelor of Computer Science and Artificial Intelligence, such as Fundamentals of Data Analysis, Algorithms and Data Structures and Probability for Computer Science, among others. These skills will not only help you excel in upcoming courses but also empower you to think critically about data-driven problems and design innovative solutions.

Statistics is the science of data, a discipline grounded in mathematics that converts raw data into actionable information. It uses mathematical tools to construct models, summarize and process data, and handle uncertainty in different environments. This course begins with descriptive statistics, where you will learn how to summarize data effectively. From there, we will dive into the study of probability, exploring how uncertainty can be quantified and modeled. After these foundations have been established, we will begin the study of probability distributions of both discrete and continuous random variables, gaining insights into their behavior and applications. To bridge theory with practice, an introduction to Python for scientific computing will allow students to gain hands-on experience with the implementation of statistical methods.

LEARNING OBJECTIVES

The objective of this course is to provide students with the tools to delve into data sets and to make use of this information at a theoretical and applied level. At the end of the course students should be able to:

- Analyze and synthetize the main information content in a set of univariate and multivariate data
- Understand patterns of randomness and relate them to known probability distributions to model real phenomena
- Identify the appropriate probability models
- Carry out statistical analysis using statistical software

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

- The ability to think analytically
- The ability to think critically
- The ability to solve problems in groups
- The ability to use statistical software

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	6.7 %	10.0 hours
Exercises in class, Asynchronous sessions, Field Work	13.3 %	20.0 hours
Group work	30.0 %	45.0 hours
Individual studying	30.0 %	45.0 hours
TOTAL	100.0 %	150.0 hours

AI POLICY

The course is aimed at providing students with the core skills in probability to prepare them for the coming challenges in the Bachelor in Computer Science & Artificial Intelligence. For this reason, Midterm Exam and Final Exam are closed-book evaluation items and students will not be able to access any GenAI tools as they take these exams. Therefore, students should focus on fully understanding the fundamental ideas of the course, without relying on Generative AI to provide a solution to the exercises discussed throughout the sessions.

However, given the current technological trends and the ubiquitous presence of AI tools (in particular, the Gemini assistant in Google Colab), the use of GenAI will be allowed in open-book evaluation items (Computer Exam and Problem Sets). Note that the use GenAI will not be required to get the maximum grade on the Computer Exam and that its use won't necessarily lead to better academic results.

PROGRAM

MODULE 1: DESCRIPTIVE STATISTICS

SESSION 1 (LIVE IN-PERSON)

Introduction to the Course.

Topic 1. Descriptive Statistics.

Graphical methods: Stem-and-leaf displays, dotplots, histograms, boxplots, scatterplots, contingency tables and bar plots.

Numerical summary measures: Mean, median, other measures of location, sample proportions, variance.

Readings:

Book Chapters: Chapter 1. Section 1.1, 1.2, 1.3, 1.4 (DEV) (See Bibliography)

SESSION 2 (LIVE IN-PERSON)

(Continues from previous Session)

Introduction to the Course.

Topic 1. Descriptive Statistics.

Graphical methods: Stem-and-leaf displays, dotplots, histograms, boxplots, scatterplots, contingency tables and bar plots.

Numerical summary measures: Mean, median, other measures of location, sample proportions, variance.

Readings:

Book Chapters: Chapter 1. Section 1.1, 1.2, 1.3, 1.4 (DEV) (See Bibliography)

SESSION 3 (LIVE IN-PERSON)

(Continues from previous Session)

Introduction to the Course.

Topic 1. Descriptive Statistics.

Graphical methods: Stem-and-leaf displays, dotplots, histograms, boxplots, scatterplots, contingency tables and bar plots.

Numerical summary measures: Mean, median, other measures of location, sample proportions, variance.

Readings:

Book Chapters: Chapter 1. Section 1.1, 1.2, 1.3, 1.4 (DEV) (See Bibliography)

SESSION 4 (LIVE IN-PERSON)

Introduction to Python for Scientific Computing. Jupyter Notebooks and Google Colaboratory.

Jupyter Notebooks and Google Colab

Introduction to Python

Technical note: Introduction to Python Notebooks and Colaboratory (Google Colab)

Book Chapters: Introduction to Scientific Programming with Python

SESSION 5 (LIVE IN-PERSON)

Python Topic 1. Descriptive Statistics with Python

NumPy

Descriptive Statistics with Python

Book Chapters: Introduction to Scientific Programming with Python

MODULE 2: PROBABILITY

SESSION 6 (LIVE IN-PERSON)

Topic 2. Probability

Probability provides a mathematical framework to study randomness and uncertainty. In any situation in which one of several possible outcomes may occur, the discipline of probability provides methods for quantifying the chances, or likelihoods, associated with the different outcomes.

Sample Spaces and Events. Properties of Probability. Counting Techniques. Conditional probability. Independence.

Readings:

Book Chapters: Chapter 2. All Sections (DEV) (See Bibliography)

SESSION 7 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 2. Probability

Probability provides a mathematical framework to study randomness and uncertainty. In any situation in which one of several possible outcomes may occur, the discipline of probability provides methods for quantifying the chances, or likelihoods, associated with the different outcomes.

Sample Spaces and Events. Properties of Probability. Counting Techniques. Conditional probability. Independence.

Readings:

Book Chapters: Chapter 2. All Sections (DEV) (See Bibliography)

SESSION 8 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 2. Probability

Probability provides a mathematical framework to study randomness and uncertainty. In any situation in which one of several possible outcomes may occur, the discipline of probability provides methods for quantifying the chances, or likelihoods, associated with the different outcomes.

Sample Spaces and Events. Properties of Probability. Counting Techniques. Conditional probability. Independence.

Readings:

Book Chapters: Chapter 2. All Sections (DEV) (See Bibliography)

MODULE 3: RANDOM VARIABLES AND PROBABILITY DISTRIBUTIONS

SESSION 9 (LIVE IN-PERSON)

Topic 3. Discrete Random Variables. Discrete Probability Distributions.

There are two fundamentally different types of random variables -discrete random variables and continuous random variables. In this topic, we examine the basic properties and discuss the most important examples of discrete variables.

Definition of random variable. Probability mass function. Expectation and Variance. Probability distributions for discrete random variables: Bernoulli, Binomial, Hypergeometric, Negative Binomial, Poisson.

Readings:

Book Chapters: Chapter 3. All Sections (DEV) (See Bibliography)

SESSION 10 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 3. Discrete Random Variables. Discrete Probability Distributions.

There are two fundamentally different types of random variables -discrete random variables and continuous random variables. In this topic, we examine the basic properties and discuss the most important examples of discrete variables.

Definition of random variable. Probability mass function. Expectation and Variance. Probability distributions for discrete random variables: Bernoulli, Binomial, Hypergeometric, Negative Binomial, Poisson.

Readings:

Book Chapters: Chapter 3. All Sections (DEV) (See Bibliography)

SESSION 11 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 3. Discrete Random Variables. Discrete Probability Distributions.

There are two fundamentally different types of random variables -discrete random variables and continuous random variables. In this topic, we examine the basic properties and discuss the most important examples of discrete variables.

Definition of random variable. Probability mass function. Expectation and Variance. Probability distributions for discrete random variables: Bernoulli, Binomial, Hypergeometric, Negative Binomial, Poisson.

Readings:

Book Chapters: Chapter 3. All Sections (DEV) (See Bibliography)

SESSION 12 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 3. Discrete Random Variables. Discrete Probability Distributions.

There are two fundamentally different types of random variables -discrete random variables and continuous random variables. In this topic, we examine the basic properties and discuss the most important examples of discrete variables.

Definition of random variable. Probability mass function. Expectation and Variance. Probability distributions for discrete random variables: Bernoulli, Binomial, Hypergeometric, Negative Binomial, Poisson.

Readings:

Book Chapters: Chapter 3. All Sections (DEV) (See Bibliography)

SESSION 13 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 3. Discrete Random Variables. Discrete Probability Distributions.

There are two fundamentally different types of random variables -discrete random variables and continuous random variables. In this topic, we examine the basic properties and discuss the most important examples of discrete variables.

Definition of random variable. Probability mass function. Expectation and Variance. Probability distributions for discrete random variables: Bernoulli, Binomial, Hypergeometric, Negative Binomial, Poisson.

Readings:

Book Chapters: Chapter 3. All Sections (DEV) (See Bibliography)

SESSION 14 (LIVE IN-PERSON)

Review Session. Topics 1, 2 and 3.

SESSION 15 (LIVE IN-PERSON)

Midterm Exam

The Midterm Exam covers the following topics:

Topic 1. Descriptive Statistics

Topic 2. Probability

Topic 3. Discrete Random Variables. Discrete Probability Distributions.

It does not include Python topics. The Midterm Exam is a closed-book exam. Students are required to bring a laptop with the appropriate proctoring software and a simple handheld calculator to take the exam.

Please note that this date is tentative. Depending on the pace of the sessions, the Midterm Exam could take place either in Session 16 or in Session 17.

SESSION 16 (LIVE IN-PERSON)

Topic 4. Continuous Random Variables. Continuous Probability Distributions

There are two fundamentally different types of random variables -discrete random variables and continuous random variables. In this topic, we examine the basic properties and discuss the most important examples of continuous variables.

Probability Density Functions. Cumulative Distribution Functions. Expectation and Variance. Uniform, Standard Normal, Normal, Lognormal, Exponential and Gamma distributions.

Readings:

Book Chapters: Chapter 4. All Sections (DEV) (See Bibliography)

SESSION 17 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 4. Continuous Random Variables. Continuous Probability Distributions

There are two fundamentally different types of random variables -discrete random variables and continuous random variables. In this topic, we examine the basic properties and discuss the most important examples of continuous variables.

Probability Density Functions. Cumulative Distribution Functions. Expectation and Variance. Uniform, Standard Normal, Normal, Lognormal, Exponential and Gamma distributions.

Readings:

Book Chapters: Chapter 4. All Sections (DEV) (See Bibliography)

SESSION 18 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 4. Continuous Random Variables. Continuous Probability Distributions

There are two fundamentally different types of random variables -discrete random variables and continuous random variables. In this topic, we examine the basic properties and discuss the most important examples of continuous variables.

Probability Density Functions. Cumulative Distribution Functions. Expectation and Variance. Uniform, Standard Normal, Normal, Lognormal, Exponential and Gamma distributions.

Readings:

Book Chapters: Chapter 4. All Sections (DEV) (See Bibliography)

SESSION 19 (LIVE IN-PERSON)

Python Topic 2. Computing probabilities using SciPy

Probability mass function/Probability density function
Cumulative distribution functions
Inverse cumulative distribution functions

Book Chapters: Introduction to Scientific Programming with Python

SESSION 20 (LIVE IN-PERSON)

Topic 4. Continuous Random Variables. Continuous Probability Distributions

There are two fundamentally different types of random variables -discrete random variables and continuous random variables. In this topic, we examine the basic properties and discuss the most important examples of continuous variables.

Probability Density Functions. Cumulative Distribution Functions. Expectation and Variance. Uniform, Standard Normal, Normal, Lognormal, Exponential and Gamma distributions.

Book Chapters: Chapter 4 (DEV) (See Bibliography)

SESSION 21 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 4. Continuous Random Variables. Continuous Probability Distributions

There are two fundamentally different types of random variables -discrete random variables and continuous random variables. In this topic, we examine the basic properties and discuss the most important examples of continuous variables.

Probability Density Functions. Cumulative Distribution Functions. Expectation and Variance. Uniform, Standard Normal, Normal, Lognormal, Exponential and Gamma distributions.

Readings:

Book Chapters: Chapter 4 (DEV) (See Bibliography)

MODULE 4. JOINT PROBABILITY DISTRIBUTIONS. STATISTICS AND THEIR DISTRIBUTIONS

SESSION 22 (LIVE IN-PERSON)

Topic 5. Joint Probability Distributions

Many problems in probability and statistics involve working simultaneously with two or more random variables. This topic addresses the concept of joint probability distributions.

Jointly Distributed Random Variables. Expected Values, Covariance, and Correlation.

Readings:

Book Chapters: Chapter 5. Section 5.1, Section 5.2 (DEV) (See Bibliography)

SESSION 23 (LIVE IN-PERSON)

Topic 6. Statistics and their Distributions

Statistics and Their Distributions. The Distribution of the Sample Mean. The Distribution of a Linear Combination

Readings:

Book Chapters: Chapter 5. Section 5.3, Section 5.4, Section 5.5 (DEV) (See Bibliography)

SESSION 24 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 6. Statistics and their Distributions

Statistics and Their Distributions. The Distribution of the Sample Mean. The Distribution of a Linear Combination

Readings:

Book Chapters: Chapter 5. Section 5.3, Section 5.4, Section 5.5 (DEV) (See Bibliography)

SESSION 25 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 6. Statistics and their Distributions

Statistics and Their Distributions. The Distribution of the Sample Mean. The Distribution of a Linear Combination

Readings:

Book Chapters: Chapter 5. Section 5.3, Section 5.4, Section 5.5 (DEV) (See Bibliography)

SESSION 26 (LIVE IN-PERSON)

(Continues from previous Session)

Topic 6. Statistics and their Distributions

Statistics and Their Distributions. The Distribution of the Sample Mean. The Distribution of a Linear Combination

Readings:

Book Chapters: Chapter 5. Section 5.3, Section 5.4, Section 5.5 (DEV) (See Bibliography)

SESSION 27 (LIVE IN-PERSON)

Python Topic 3. Introduction to Monte Carlo simulation

Random number generation

Approximating probabilities

SESSION 28 (LIVE IN-PERSON)

Review Session. Topics 1,2,3,4,5 and 6

SESSION 29 (LIVE IN-PERSON)

Computer Exam

The Computer Exam involves solving and discussing several exercises regarding Python topics 1,2 and 3. It is an open-book exam.

SESSION 30 (LIVE IN-PERSON)

Final Exam

The Final Exam covers the following topics:

Topic 1. Descriptive Statistics

Topic 2. Probability

Topic 3. Discrete Random Variables. Discrete Probability Distributions.

Topic 4. Continuous Random Variables. Continuous Probability Distributions.

Topic 5. Joint Probability Distributions.

Topic 6. Statistics and their Distributions.

It does not include Python topics. The Final Exam is a closed-book exam. Students are required to bring a laptop with the appropriate proctoring software and a simple handheld calculator to take the exam.

EVALUATION CRITERIA

Your final grade in the course will be determined by your performance on the following evaluation items:

criteria	percentage	Learning Objectives	Comments
Final Exam	30 %		
Computer exam	20 %		
Midterm exam	20 %		
Class Participation	10 %		
Problem Sets	20 %		

RE-SIT / RE-TAKE POLICY

Class participation

Active participation: participation in class will be evaluated positively if students: (1) attain a threshold quantity of contributions that is sufficient for making a reliable assessment of comment quality. Additionally, (2) participation will be evaluated in quality terms. A high-quality comment reveals a depth of insight, rigorous use of case evidence, consistency of argument, and realism. A high-quality presentation of ideas must consider the relevance and timing of comments and the flow and content of the ensuing class discussion. It demands comments that are concise and clear, and that are conveyed with a spirit of involvement in the discussion at hand.

Problem Sets

Students will solve several Problem Sets throughout the course. These problem sets can be solved using *pen and paper* and/or using Python.

Midterm Exam

The Midterm Exam will take place in session 15. Please note that this date is tentative. Depending on the pace of the sessions, the Midterm exam could take place either in Session 16 or in Session 17. It does not include Python topics. The Midterm Exam is a closed-book exam. Students are required to bring a laptop with the appropriate proctoring software and a simple handheld calculator to take the exam. Students are also allowed to bring up one double-sided A4 sheet of paper with any notes and formulae.

Computer exam

The Computer Exam involves solving and discussing several exercises regarding Python topics 1,2 and 3. It is an open-book exam.

Final Exam

The Final Exam is scheduled in Session 30 and will cover Topics 1,2,3,4,5 and 6. It does not include Python topics. The Final Exam is a closed-book exam. Students are required to bring a laptop with the appropriate proctoring software and a simple handheld calculator to take the exam. Students are also allowed to bring up two double-sided A4 sheet of paper with any notes and formulae.

In order to pass the course, students need a minimum grade of 3.5 (out of 10) in the Final Exam. If the grade in the Final Exam does not reach the threshold value of 3.5, the student will fail the course, even if the overall grade (computed as the weighted average of the evaluation items) reaches or exceeds 5.0.

Retake Exam

Each student has four chances to pass any given course distributed over two consecutive academic years: ordinary call exams and extraordinary call exams (re-sits) in June/July.

Students who do not comply with the 80% attendance rule during the semester will fail both calls for this Academic Year (ordinary and extraordinary) and have to re-take the course (i.e., re-enroll) in the next Academic Year.

Evaluation criteria:

- Students failing the course in the ordinary call (during the semester) will have to re-sit the exam in June / July (except those not complying with the attendance rule, who will not have that opportunity and must directly re-enroll in the course on the next Academic Year).
- The extraordinary call exams in June / July (re-sits) require your physical presence at the campus you are enrolled in (Segovia or Madrid). There is no possibility to change the date, location or format of any exam, under any circumstances. Dates and location of the June / July re-sit exams will be posted in advance. Please take this into consideration when planning your summer.
- The June / July re-sit exam will consist of a comprehensive exam. Your final grade for the course will depend on the performance in this exam only; continuous evaluation over the semester will not be taken into consideration. Students will have to achieve the minimum passing grade of 5 and can obtain a maximum grade of 8.0 (out of 10.0) – i.e., “notable” in the in the re-sit exam.
- Retakers: Students who failed the subject on a previous Academic Year and are now re-enrolled as re-takers in a course will be needed to check the syllabus of the assigned professor, as well as contact the professor individually, regarding the specific evaluation criteria for them as retakers in the course during that semester (ordinary call of that Academic Year). The maximum grade that may be obtained in the retake exam (3rd call) is 10.0.

After ordinary and extraordinary call exams are graded by the professor, you will have a possibility to attend a review session for that exam and course grade. Please be available to attend the session in order to clarify any concerns you might have regarding your exam. Your professor will inform you about the time and place of the review session. Any grade appeals require that the student attended the review session prior to appealing.

- Students failing more than 18 ECTS credits in the academic year after the June-July re-sits will be asked to leave the Program. Please, make sure to prepare yourself well for the exams in order to pass your failed subjects.
- In case you decide to skip the opportunity to re-sit for an exam during the June / July extraordinary call, you will need to enroll in that course again for the next Academic Year as a re-taker and pay the corresponding extra cost. As you know, students have a total of four allowed calls to pass a given subject or course, in order to remain in the program.

BIBLIOGRAPHY

Compulsory

- Devore, Jay L.. (2016). *Probability and Statistics for Engineering and the Sciences.* 9th. Cengage Learning. ISBN 9781305251809 (Digital)

Recommended

- Sundnes, J.. (2020). *Introduction to Scientific Programming with Python.* Springer Open. ISBN 9783030503567 (Digital)
  https://link.springer.com/book/10.1007/978-3-030-50356-7

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.