INSTITUTO POLITÉCNICO DE BRAGANÇA

Course Unit	Statistic			Field of study	Mathematics		
Bachelor in	Mechanical Engineering			School	School of Technology and Management		
Academic Year	2023/2024	Year of study	2	Level	1-2	ECTS credits	6.0
Type	Semestral	Semester	1	Code	9123-759-2101-00-23		

Workload (hours)	162	Contact hours	T -	TP 60	PL -	TC -	S -	E -	OT -	O -

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s): António Augusto Nogueira Prada

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. Understand the probability concept and its axioms and compute simple probability using the basic probability and combinatorics laws;
2. Understand the basic concepts related to random variables and perform simple calculations based on them;
3. Know and to manipulate, at a basic level, the most common random variables and use them to model simple situations;
4. Apply and to interpret the most common ways of representing and synthesize the information in a dataset;
5. Compute point and interval estimates for the most common population parameters;
6. Understand and to apply the hypothesis test methodology on the most common population parameters.

Prerequisites

Before the course unit the learner is expected to be able to:
1. Manipulate basic mathematical concepts
2. Use a spreadsheet

Course contents

Introduction. Basic Probability Theory. Random Variables and Probability Distributions. Joint Probability Distributions. Characterization of Some Discrete Distributions. Characterization of Some Continuous Distributions. Descriptive Statistics. Random Sampling and Sampling Distributions. Point Estimation. Interval Estimation. Hypothesis Tests.

Course contents (extended version)

1. Introduction
   - The statistical object
   - Descriptive statistics and statistical inference
   - Populations and samples
2. Basic Probability Theory
   - Random experiments, sampling spaces and events
   - Combinatorics
   - The probability concept
   - Conditional probability
   - Independent events
   - Bayes theorem
3. Random Variables and Probability Distributions
   - Definition of random variable
   - Discrete variables: probability function and cumulative probability function
   - Continuous variables: probability density function and cumulative density function
   - Distribution parameters
   - Variable transformations: linear and non linear transformations
4. Joint Probability Distributions
   - Definition of joint distributions
   - Marginal distributions
   - Conditional distributions
   - Independence
   - Covariance and correlation
   - Variable combinations
   - Calculation of a combination expected value and variance: linear and non linear combinations
5. Characterization of Some Discrete Distributions
   - Binomial distribution
   - Negative Binomial distribution
   - Hypergeometric distribution
   - Relations between the Binomial and the Hypergeometric distributions
   - Poisson distribution
   - Relations between the Poisson and the Binomial and Hypergeometric distributions
6. Characterization of Some Continuous Distributions
   - Uniform distribution
   - Exponential distribution
   - Relations between the Poisson and Exponential distributions
   - Normal distribution
   - Standard Normal distribution
   - Linear combination of independent Normal variables
   - Relations between the Normal and Binomial distributions
   - Chi-squared, Student's t and F distributions
7. Descriptive Statistics
   - Data classification
   - Qualitative and quantitative data
   - Univariate samples characterization
   - Location statistics (average, median and mode) e dispersion (variance)
   - Skew and Kurtosis coefficients
   - Bivariate samples characterization
   - Calculation of a linear relation coefficients using least squares
   - Correlation and determination coefficients
8. Random Sampling and Sampling Distributions
   - Distribution of sample mean
   - Expected value and variance for sample mean
   - Sample mean distribution shape for Normal populations
   - Central limit theorem

Course contents (extended version)

- Implications on sampling distributions
- Random sample generations using Monte Carlo method
- Generation of random U(0, 1) samples
- Generation of random samples for discrete and for continuous populations

9. Point Estimation
   - Estimators and estimates
   - Desirable estimator properties: unbiased, efficient and consistent
   - Estimation methods: maximum likelihood and least squares
   - Estimator selection
10. Interval Estimation
   - Confidence interval concept
   - Confidence interval specification
   - Confidence intervals for the continuous populations mean
   - Confidence intervals for the Binomial proportion: small and large samples
   - Confidence intervals for a Normal population variance
   - Confidence intervals for the mean difference between two continuous populations
   - Confidence intervals for the proportion difference with large samples
   - Confidence intervals for the variance ratio of Normal populations
   - Sample size determination
11. Hypothesis Tests
   - Basic hypothesis test procedure
   - Hypothesis definition
   - Test statistic characterization
   - Decision rule definition
   - Type I error and significance
   - Calculation of test statistics and decision making
   - P-value
   - Type II error and statistical power
   - Relations between hypothesis tests and confidence intervals
   - Reference to the most common tests

Recommended reading

1. Guimarães R. C. , & Cabral J. S. (2010). Estatística (2ª ed.). Verlag Dashöfer Portugal.
2. Iman, R. , & Conover W. (1990). Modern business statistics (2nd ed.). John Wiley & Sons.
3. Pedrosa, A. C. , & Gama S. M. (2018). Introdução computacional à probabilidade e estatística (3ª ed.). Porto Editora.
4. Wonnacott, T. H. , Wonnacott, R. J. , & Golub, A. L. (1998). Introductory statistics & decision analysis: an integrated approach (5th ed.). John Wiley & Sons.

Teaching and learning methods

In the lectures, there will be content presentations and analysis of small practical examples. In the tutorials students will solve, under supervision, practical exercises. Non contact hours should be spent reviewing the lectured contents and solving practical exercises from the worksheets.

Assessment methods

1. Alternative 1 - (Regular, Student Worker) (Final, Supplementary, Special)
   - Final Written Exam - 100%
2. Alternative 2 - (Regular, Student Worker) (Final)
   - Intermediate Written Test - 50%
   - Final Written Exam - 50%

Language of instruction

Portuguese, with additional English support for foreign students.

Electronic validation

António Augusto Nogueira Prada	Carla Alexandra Soares Geraldes	João da Rocha e Silva	José Carlos Rufino Amaro
03-11-2023	06-11-2023	06-11-2023	06-11-2023