Study Plan

School: School of Sciences and Technology
Degree: Master
Course: Statistical Modeling and Data Analysis (cód. 617)

Specialization * TRANSLATE ME: Aplicações em Ciências Biológicas, da Saúde e do Ambiente ***

1st Year - 1st Semester
Specialization * TRANSLATE ME: Aplicações em Ciências Biológicas, da Saúde e do Ambiente ***

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10210M	Biomedical Statistics	Mathematics	6	Semester	156
SOC10211M	Demography	Sociology	6	Semester	156

***** TRANSLATE ME:Optativas-Quadro 2.1.1 *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10213M	Survey Sampling	Mathematics	9	Semester	234
MAT10214M	Data Analysis with Statistical Software	Mathematics	9	Semester	234
MAT10167M	Experimental Design	Mathematics	6	Semester	156
MAT10169M	Statistical Inference	Mathematics	9	Semester	234
MAT10152M	Numerical Optimization	Mathematics	6	Semester	156
MAT10170M	Stochastic Processes	Mathematics	6	Semester	156

1st Year - 2nd Semester
Specialization * TRANSLATE ME: Aplicações em Ciências Biológicas, da Saúde e do Ambiente ***

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10172M	SStochastic Differential Equations and Biological Applications	Mathematics	6	Semester	156
PAO10212M	Ecological Modelling - Advanced	Environment and Ecology Sciences	6	Semester	156

***** TRANSLATE ME:Optativas-Quadro 3.1.1 *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10171M	Categorical Data Analysis	Mathematics	9	Semester	234
MAT10168M	Computational Statistics	Mathematics	9	Semester	234
MAT10173M	Multivariate Data Statistics	Mathematics	9	Semester	234
MAT10174M	Time Series	Mathematics	6	Semester	156
MAT10158M	Dynamical Systems	Mathematics	6	Semester	156

2nd Year - 3rd Semester
Specialization * TRANSLATE ME: Aplicações em Ciências Biológicas, da Saúde e do Ambiente *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10175M	Sampling Biological Populations	Mathematics	6	Semester	156
MAT10178M	Mathematical Models in Biology	Mathematics	6	Semester	156
Dissertation					
Report					

2nd Year - 4th Semester
Specialization * TRANSLATE ME: Aplicações em Ciências Biológicas, da Saúde e do Ambiente *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					
Report					

Specialization *** TRANSLATE ME: Aplicações em Ciências Económicas e Empresariais ***

1st Year - 1st Semester
Specialization * TRANSLATE ME: Aplicações em Ciências Económicas e Empresariais *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10213M	Survey Sampling	Mathematics	9	Semester	234
ECN10216M	Applied Econometrics	Economy	6	Semester	156

***** TRANSLATE ME:Optativas-Quadro 2.2.1 *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10214M	Data Analysis with Statistical Software	Mathematics	9	Semester	234
MAT10167M	Experimental Design	Mathematics	6	Semester	156
SOC10211M	Demography	Sociology	6	Semester	156
MAT10169M	Statistical Inference	Mathematics	9	Semester	234
MAT10152M	Numerical Optimization	Mathematics	6	Semester	156
MAT10170M	Stochastic Processes	Mathematics	6	Semester	156

1st Year - 2nd Semester
Specialization * TRANSLATE ME: Aplicações em Ciências Económicas e Empresariais *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10217M	Advanced Financial Calculus	Mathematics	6	Semester	156
GES10961M	Marketing Research	Management	6	Semester	156

1st Year - 2nd Semester
Specialization * TRANSLATE ME: Aplicações em Ciências Económicas e Empresariais *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
*** TRANSLATE ME:Optativas-Quadro 3.2.1 ***					

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10171M	Categorical Data Analysis	Mathematics	9	Semester	234
ECN10219M	Financial Derivatives and Risk Management	Economy	6	Semester	156
MAT10168M	Computational Statistics	Mathematics	9	Semester	234
MAT10173M	Multivariate Data Statistics	Mathematics	9	Semester	234
MAT10174M	Time Series	Mathematics	6	Semester	156
MAT10158M	Dynamical Systems	Mathematics	6	Semester	156

2nd Year - 3rd Semester
Specialization * TRANSLATE ME: Aplicações em Ciências Económicas e Empresariais *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10176M	Quality Control and Reliability	Mathematics	6	Semester	156
MAT10177M	Operational Research	Mathematics	6	Semester	156
Dissertation					
Report					

2nd Year - 4th Semester
Specialization * TRANSLATE ME: Aplicações em Ciências Económicas e Empresariais *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					
Report					

Specialization Statistical Modeling and Data Analysis

1st Year - 1st Semester

Specialization Statistical Modeling and Data Analysis

Component code	Name	Scientific Area Field	ECTS	Duration	Hours

***** TRANSLATE ME:Optativas-Quadro 2.3.1 *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10213M	Survey Sampling	Mathematics	9	Semester	234
MAT10214M	Data Analysis with Statistical Software	Mathematics	9	Semester	234
MAT10167M	Experimental Design	Mathematics	6	Semester	156
SOC10211M	Demography	Sociology	6	Semester	156
ECN10216M	Applied Econometrics	Economy	6	Semester	156
MAT10210M	Biomedical Statistics	Mathematics	6	Semester	156
MAT10169M	Statistical Inference	Mathematics	9	Semester	234
MAT10152M	Numerical Optimization	Mathematics	6	Semester	156
MAT10170M	Stochastic Processes	Mathematics	6	Semester	156

1st Year - 2nd Semester

Specialization Statistical Modeling and Data Analysis

Component code	Name	Scientific Area Field	ECTS	Duration	Hours

***** TRANSLATE ME:Optativas-Quadro 3.3.1 *****

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10171M	Categorical Data Analysis	Mathematics	9	Semester	234
MAT10217M	Advanced Financial Calculus	Mathematics	6	Semester	156
ECN10219M	Financial Derivatives and Risk Management	Economy	6	Semester	156
MAT10172M	SStochastic Differential Equations and Biological Applications	Mathematics	6	Semester	156
MAT10168M	Computational Statistics	Mathematics	9	Semester	234
MAT10173M	Multivariate Data Statistics	Mathematics	9	Semester	234
PAO10212M	Ecological Modelling - Advanced	Environment and Ecology Sciences	6	Semester	156
GES10961M	Marketing Research	Management	6	Semester	156
MAT10174M	Time Series	Mathematics	6	Semester	156
MAT10158M	Dynamical Systems	Mathematics	6	Semester	156

2nd Year - 3rd Semester
Specialization Statistical Modeling and Data Analysis

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
*** TRANSLATE ME:Optativas-Quadro 4.3.1 ***					

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT10175M	Sampling Biological Populations	Mathematics	6	Semester	156
MAT10176M	Quality Control and Reliability	Mathematics	6	Semester	156
MAT10177M	Operational Research	Mathematics	6	Semester	156
MAT10178M	Mathematical Models in Biology	Mathematics	6	Semester	156

Dissertation
Report

2nd Year - 4th Semester
Specialization Statistical Modeling and Data Analysis

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					
Report					

Conditions for obtaining the Degree:

*** TRANSLATE ME: Para conclusão do curso é necessário a aprovação (através de avaliação ou creditação) das seguintes unidades curriculares:

Aplicações em Ciências Biológicas, da Saúde e do Ambiente

1.º Ano

1.º Semestre:

2 UC obrigatórias num total de 12 Ects

2 a 3 UC optativa do quadro de optativas 2.1.1 num total de 18 Ects

2.º Semestre:

2 UC obrigatórias num total de 12 Ects

2 a 3 UC optativa do quadro de optativas 3.1.1 num total de 18 Ects

2.º Ano

3.º Semeste

2 UC obrigatórias num total de 12 Ects

Aplicações em Ciências Económicas e Empresariais

1.º Ano

1.º Semestre:

2 UC obrigatórias num total de 12 Ects

2 a 3 UC optativa do quadro de optativas 2.2.1 num total de 18 Ects

2.º Semestre:

2 UC obrigatórias num total de 12 Ects

2 a 3 UC optativa do quadro de optativas 3.2.1 num total de 18 Ects

2.º Ano

3.º Semeste

2 UC obrigatórias num total de 12 Ects

Modelação Estatistica e Análise de Dados

1.º Ano

1.º Semestre:

4 a 5 UC optativa do quadro de optativas 2.3.1 num total de 30 Ects

2.º Semestre:

4 a 5 UC optativa do quadro de optativas 3.3.1 num total de 30 Ects

2.º Ano

3.º Semeste

2 UC optativa do quadro de optativas 4.3.1 num total de 12 Ects

Para obtenção do grau, é necessário também a aprovação na Dissertação, Relatório de Estágio, com um total de 48 ECTS, no 3.º e 4.º Semestre. ***

Program Contents

Back

Biomedical Statistics (MAT10210M)

1. Introduction to clinical trials.
2. Planning the clinical trials.
3. Statistics considerations in the analysis of Clinical tests.
4. Cross-over Trials.
5. Sequential Designs.
6. Introduction to Survival Analysis.
7. Some non-parametric procedures.
8. Cox proportional hazards models.
9. Parametric regression models.
10. Introduction to frailty models and to recurrent event models.

Back

Demography (SOC10211M)

1. Basic concepts, methods and techniques of demographic analysis: Models of population growth; period and cohort analysis; ages specific rates and probabilities; Life Tables, Fertility and Reproduction.
2. Population projections and population models: Projections and Forecasts, Demographic Projections Methodology, cohort and components method; Projection matrices, probabilistic forecasts.
3. Planning and Forecasting: Structural models; demo-economic models; derived projections (Practical Examples: participation in labor market, school attendance, health and health care); contribution to planning and decision-making processes.

Back

Survey Sampling (MAT10213M)

1. Basic notions on sampling and estimation.
2. Main steps about planning a sampling design and selection of sampling units.
3. Simple random sampling.
4. Estimation of totals, means, proportions and ratios.
5. Systematic random sampling, stratified random sampling and post-stratification.
6. Unequal probability sampling and sub-sampling designs.
7. Clusters and multi-step sampling designs.
8. Methods for data collection in survey sampling.
9. Treatment of non-responses and measurement errors.
10. Sampling elusive populations.

Back

Data Analysis with Statistical Software (MAT10214M)

- Descriptive Statistics.
- Contingency tables and statistics of association.
- Point Estimation.
- Interval Estimation.
- Parametric Hypotheses Testing.
- Nonparametric Hypothesis Testing.
- Simple linear regression.
- Introduction to multiple linear regression.

Note: The subjects taught involve the use of appropriate statistical software, including SPSS, R and Excel.

Back

Experimental Design (MAT10167M)

Scientific method and experimental design.
Analysis of variance models: fixed effects (single and multiple factor), random effects (single and multiple factor) and mixed effects.
Split-plot and nested designs.
Multiple comparisons.
Complete and incomplete block designs. Latin square designs.
Non-parametric approaches.
Simple linear regression model and multiple regression model (estimation, inference, prediction, model adequacy and validation).
Diagnostics for influence points, outliers,
multicollinearity and autocorrelation. Model selection.
Analysis of Covariance.
Nonlinear Regression.

Back

Statistical Inference (MAT10169M)

Fundamental concepts of probability (measure and probability, random vectors, marginal and conditional distributions, expected values, generating and characteristics functions, functions of random vectors and transformations).
Review of discrete and continuous distributions properties. Exponential families.
Multinormal and multinomial distributions.
Stochastic convergences and limit theorems.
Sampling and the most used sampling distributions.
Point estimation. Estimation methods (moments, maximum likelihood, least squares and bayes estimators). Properties of estimators. Crámer-Rao lower bound. Asymptotic behaviour. Robustness.
Interval estimation. Methods for finding interval estimators. Properties. Classical and bayesian approach.
Hypotheses testing. Type I and Type II probability errors. Duality. Methods for finding testes. Likelihood ratio tests. Properties of tests. Neyman-Pearson theorem, most powerful tests. Asymptotic behaviour. Robustness. Classical and bayesian approach.

Back

Numerical Optimization (MAT10152M)

1. Elements of Convex Analysis. Necessary and sufficient conditions of optimality.
2. Nonlinear Optimization. One-dimensional optimization. Unconstrained optimization with and without derivatives.
3. Constrained Optimization. Penalty functions. Interior point method.
4. Multiobjective Optimization. Global Optimization. Evolutionary and Genetic Algorithms.
5. Dynamic Programming. Applications to the Optimal Control problems. Automatic Differentiation.

Back

Stochastic Processes (MAT10170M)

1. General concepts of Stochastic Processes.
2. Martingale and applications.
3. Markov chains in discrete time.
4. General concepts of time series.
5. Poisson process of homogeneous and inhomogeneous.
6. Compound Poisson process.
7. Processes of birth and death.
8. Introduction to queues.
9. Renewal processes.
10. Methods of Monte Carlo simulation.

Back

SStochastic Differential Equations and Biological Applications (MAT10172M)

Introduction to Stochastic Differential Equations and Applications:
Wiener process and diffusion processes. Stochastic integrals. Outline of construction of the Itô integral. Using Itô's theorem. Reference to the Stratonovich integral. Existence and uniqueness theorems for stochastic differential equations (SDEs). Strong and weak solutions. Dynkin and Feynman-Kac formulas. Classification of bounderies in one-dimensional diffusion processes. First passage times. Stationary solutions of one-dimensional SDEs. Ergodicity. Monte Carlo Simulation of SDEs.

Biological Applications of Stochastic Differential Equations:
The Stratonovich integral, relations with the Itô integral and their use in applications. Biological applications in population dynamics and growth of living organisms or biological tissues in a random environment. Study of extinction and extinction times. Existence of stationary densities. Qualitative and quantitative study of solutions (by simulation if required). Optimization problems in the management of renewable natural resources. Comparison with models based on birth and death processes (demographic randomness) and approximation of these models by SDEs. Applications to population genetics. Statistical issues in SDEs, with emphasis on estimation and prediction.

Back

Ecological Modelling - Advanced (PAO10212M)

Topics:
What is ecological modeling? Mathematical tools for modeling. The components of the ecological models. Steps in ecological modeling. Conceptual models and their languages. Population dynamics models. Plant growth models. Algal growth models. Wetland models. Biogeochemistry models. Individual growth models.

Back

Categorical Data Analysis (MAT10171M)

Contingency Tables.
Generalized linear models: characterization, link functions, statistical modelling, assumptions, residual analysis, validation and inference.
Discrete and continuous models: Logistic (Binomial, Ordinal and Multinomial), Poisson, Negative Binomial, Inverse-Gaussian, Gama, Lognormal.
Generalized Estimating Equations (GEE).
Other topics in statistical modeling of categorical data.

Back

Computational Statistics (MAT10168M)

1. Statistical modelling. Common Statistical models. Adjustment non-parametric tests. Independence tests and uniformity tests. Graphics methods.
2. Maximum Likelihood estimation and the EM algorithm (with resource to numerical methods).
3. Uniform pseudorandom numbers generaton.
4. Pseudorandom numbers generation with a specified distribution.
5. Resampling methods.
6. Monte Carlo Method.
7. Bootstrap and Jackknife.
8. Markov Chains Monte Carlo Methods (MCMC), Gibbs algorithm and Metroplolis-Hasting algorithm.
9. Applications and use of statistical software.

Back

Multivariate Data Statistics (MAT10173M)

1. Overview of Multivariate Statistical Methods. Introduction. Dependence Techniques and Interdependence Techniques. Extentions.
2. Preliminary and exploratory multivariate data analysis
3. Principal Component Analysis
4. Exploratory Factorial Analysis versus Confirmatory Factorial Analysis
5. Cluster Analysis
6. Discriminant Analysis
7. Structural Equation Modeling: an introduction

Back

Time Series (MAT10174M)

1. Introduction to time series analysis and to stochastic processes
2. Linear processes: ARMA, ARIMA and SARIMA processes
3. Non linear processes: ARCH and GARCH processes
4. Temporal dynamic regression
5. Modeling in R of different types of temporal phenomena. Application to real data.

Back

Dynamical Systems (MAT10158M)

Functions of the interval in the interval and the circle in the circle: hiperbolicity, symbolic dynamics, topological conjugation, theorem of Sharkovsky, structural stability, topological bifurcation, invariants, renormalization, chaos, theory of the kneading of Milnor and Thurston.
Iteration of complex functions: normal families, periodic, Julia joint points, sets of Mandelbrot. Applications.

Back

Sampling Biological Populations (MAT10175M)

1. Elements of Statistical Inference and finite population sampling.
2. Estimation of wildlife population abundance.
3. Distance sampling, capture-recapture and combined models.
4. Estimation of demographic parameters (survival, recruitment, transition probabilities, migration rates).
5. Parameter estimation in Community Dynamics.

Back

Mathematical Models in Biology (MAT10178M)

1. Introduction to population and ecosystem modelling.
2. Deterministic and stochastic mathematical population growth models.
3. Introduction to population genetic modelling.
4. Natural resources modelling.
5. Structured population modelling.
6. Demographic models.
7. Spatial dispersion models.
8. Ecosystem modelling (competition, predation, etc.)
9. Deterministic epidemic modelling.

Back

Applied Econometrics (ECN10216M)

I.Topics on Linear Regression analysis
1.1. Estimation Methods and Inference
1.2. Specification Analysis
1.3. Asymptotic theory
1.4. Endogeneity and Instrumental Variables Estimation.
II-Econometric analysis with Cross-sectional data and Panel Data:
2.1.Discrete and limited variable models (Discrete choice models, Introduction to count data models, Tobit models)
2.2.Panel Data Models: Fixed effects model and Random effects model; Specification Analysis.
III-Frontier Models and Efficiency Analysis:
3.1. Parametric and non-parametric approaches
3.2. Stochastic frontier models with cross-sectional data and panel data.
3.3. Models with Time-varying efficiency and with time-invariant efficiency
3.4. Models with technical inefficiency effects

Back

Advanced Financial Calculus (MAT10217M)

1. Introduction to Stochastic Differential Equations and applications:
1.1 Wiener Process and diffusions.
1.2 Martingales, adapted processes.
1.3 Stochastic integrals.
1.4 Sketch of the construction of the Itô integral, and use of Itô's Theorem.
1.5 Existence and Uniqueness theorem for Stochastic Differential Equations.
1.6 Strong and weak solutions
1.7Formula of Feynman-Kac.
2. Financial Applications of Stochastic Differential Equations
2.1 Model of Cox-Ross-Rubinstein.
2.2 European e american options of buying and selling. Generalization of the methodology to other financial assets.
2.3 Statement and interpretation of Girsanov's theorem, transition to the risk-neutral probability.
2.4 Derivation of the Black-Scholes formulas.
2.5 The model of Black-Scholes at the stock exchange, implicit volatility.

Back

Marketing Research (GES10961M)

(I. - Introduction
II - Methodology for Data Collection

Decision about the type of information to collect.
Methods to collect primary data.
Measure and Scale Methods.
Construction of the instrument to sample data.
Sampling method
Work Field
III - Methodology for data analysis.
Steps of the process preparation data
Statistic techniques
Some specific methods useful in Marketing
- Clusters analysis
- Factorial analysis
- Multidimensional Scaling (MDS)
- Correspondence analysis
- Conjoint analysis
- Preferences analysis

Back

Financial Derivatives and Risk Management (ECN10219M)

-Introduction to Derivative Markets
- Future contracts: Interest rate and FX forward contracts; Future contracts: concept, market organization, underlying, market valuation: cost-of-carry model, hedging, arbitrage and speculation strategies
-Option contracts: concept, market organization, basic payoffs, fundamental properties of the price of options, intrinsic value vs time value, put-call parity, simple and complex hedging strategies
-Pricing options in Discrete time: Binomial model, Replicating portfolio; Equivalent martingale measure; Risk neutral valuation
-Pricing options in Continuous time: introduction to stochastic calculus, Random Walk, Brownian Motion, Itô's Lemma, fundamental PDE, Feynman-Kac theorem; Black-Scholes model: Risk-Neutral Valuation, Girsanov's Theorem, Change of numeraire, Black's approximation: American options, Merton's model: dividend yield, hedging parameters (Greeks), Delta-Gamma hedging, exótic options
-Swap markets: types of swaps; IRS and FX swaps

Back

Quality Control and Reliability (MAT10176M)

Control charts for variables and attributes.
Process capability analysis. 6-sigma processes.
Capacity of the measuring system. Accuracy and Precision. Repeatability and reproducibility.
Acceptance sampling. Different sampling plans. MIL STD tables.
Sampling methods in quality control.
Reliability and survival.
Series and parallel systems.
Parametric and non-parametric hazard models.
Inspection systems policies.

Back

Operational Research (MAT10177M)

1. Linear and Nonlinear Programming: Applications, Revised Simplex; Interior Point methods. Integer and Mixed Linear Programming: Applications, Branch and Bound Method. Nonlinear Programming: Applications, Karush-KuhnTucker Conditions (KKT), Evolutionary and Genetic Methods.
2. Optimization over Networks and Graphs; Inventory theory and Project management: graphs: applications, definitions, Matrix representation. Trees. Facility location and maximum flux problems. Project Management (PERT/CPM). Basics of Inventory Theory.
3. Decision Support Systems: Decision Trees. Utility Functions. Multi-Criteria Analysis: Multi-Attribute, Multi-Objective. Game theory.