LISBON
SCHOOL OF
ECONOMICS &
MANAGEMENT
UNIVERSIDADE DE LISBOA

MASTERS IN ACTUARIAL SCIENCE

2018-19 DETAILED PROGRAMMES

LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

TABLE OF CONTENTS

LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

MASTERS PROGRAMME STRUCTURE

1st SEMESTER			
Curricular Unit	**ECTS**	**Type**	Contact Hours
Computation Tools for Actuaries	4	Obligatory	39
Financial Markets and Investments	6	Obligatory	39
Financial Mathematics	6	Obligatory	45.5
Probability and Stochastic Processes	8	Obligatory	58.5
Risk Models	6	Obligatory	45.5

2nd SEMESTER			
Curricular Unit	**ECTS**	**Type**	**Contact Hours**
Generalized Linear Models	4	Obligatory	26
Loss Reserving	4	Obligatory	26
Risk Theory	8	Obligatory	52
Survival Models and Life Contingencies	8	Obligatory	52
Time Series	6	Obligatory	39

3rd SEMESTER			
Curricular Unit	**ECTS**	**Type**	**Contact Hours**
Actuarial Topics	6	Elective (1)	39
Asset-Liability Management	4	Elective (2)	19.5
Finance and Financial Reporting	6	Elective (2)	52
Models in Finance	8	Obligatory	39
Pension Funds	4	Elective (1)	26
Ratemaking and Experience Rating	4	Elective (1)	26
Solvency Models	4	Obligatory	26

4th SEMESTER			
Internship / Dissertation / Project	30	Obligatory	

To conclude the Masters students must pass at least 18 ECTS in elective units, with a minimum of 8 ECTS in elcetive (1) and 4 ECTS in elective (2).

CORRESPONDENCE BETWEEN IFoA SYLLABUS and ISEG SYLLABUS

IFoA	ISEG	Percentage
CS1 – Actuarial Statistics 1	Computational Tools for Actuaries	10%
	Probability and Stochastic Processes	15%
	Risk Models	35%
	Generalized Linear Models	30%
	Ratemaking and Experience Rating	10%
	Risk Theory	0%
CS2 – Actuarial Statistics 2	Probability and Stochastic Processes	30%
	Risk Models	0%
	Risk Theory	15%
	Time Series	20%
	Actuarial Topics	25%
	Generalized Linear Models	10%
	Survival Models and Life Contingencies	0%
CM1 – Actuarial Mathematics 1	Financial Mathematics	45%
	Survival Models and Life Contingencies	55%
	Asset Liability Management	0%
CM2 – Actuarial Mathematics 2	Financial Markets and Investments	40%
	Models in Finance	40%
	Risk Theory	10%
	Loss Reserving	10%
CB1 – Business Finance	Finance and Financial Reporting	100%
CB2 – Business Economics	Economics I (BSc Degrees)	50%
	Economics II (BSc Degrees)	50%

CORRESPONDENCE BETWEEN ISEG MASTER SYLLABUS and IFoA SYLLABUS

ISEG	IFoA	Percentage
Computational Tools for Actuaries	CS1 – Actuarial Statistics 1	10%
Probability and Stochastic Processes	CS1 – Actuarial Statistics 1	15%
	CS2 – Actuarial Statistics 2	30%
Generalized Linear Models	CS1 – Actuarial Statistics 1	30%
	CS2 – Actuarial Statistics 2	10%
Ratemaking and Experience Rating	CS1 – Actuarial Statistics 1	10%
Risk Models	CS1 – Actuarial Statistics 1	35%
	CS2 – Actuarial Statistics 2	0%
Time Series	CS2 – Actuarial Statistics 2	20%
Actuarial Topics	CS2 – Actuarial Statistics 2	25%
Financial Mathematics	CM1 – Actuarial Mathematics 1	45%
Survival Models and Life Contingencies	CM1 – Actuarial Mathematics 1	55%
	CS2 – Actuarial Statistics 2	0%
Financial Markets and Investments	CM2 – Actuarial Mathematics 2	40%
Loss Reserving	CM2 – Actuarial Mathematics 2	10%
Models in Finance	CM2 – Actuarial Mathematics 2	40%
Risk Theory	CS1 - Actuarial Statistics 1	0%
	CS2 – Actuarial Statistics 2	15%
	CM2 – Actuarial Mathematics 2	10%
Finance and Financial Reporting	CB1 – Business Finance	100%

1st SEMESTER

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	CTA	Course name:	Computation Tools for Actuaries		ECTS credits:	4	
Scientific field:	Statistics and Actuarial Science			Department:	Mathematics		
Curricular year:	1st	Semester	1st	X	Type	Obligatory	X
			2nd			Elective	
Lecturer:	José Pedro Gaivão						

Contact hours	Total workload
39	112

Aims and scope

Information systems are important tools for actuaries, as they make it possible to automatically perform complex calculations on large data sets. In this context, an essential skill lies in the ability to express solutions to actuarial problems using appropriate computational tools. This course aims providing actuaries with a set of conceptual and practical computational tools, ranging from simple formulas computed in a spreadsheet (typically Excel) to programs written in R.

Summary

- EXCEL ESSENTIALS
- STATISTICAL ANALYSIS WITH EXCEL
- USING THE EXCEL SOLVER
- WORKING WITH LARGE DATA
- INTRODUCTION TO VBA
- INTRODUCTION TO R

Main bibliography

- Akaiwa, F., Nordquist, K. and Gross,D. (2013) Succeeding in Business with Microsoft Excel 2013: A Problem-Solving Approach (New Perspectives) 1st Edition, Cengae Learning
- Maindonald, J. and Braum, W.J. (2011) Data Analysis and Graphics Using R – an example-based approach, 3rd edition, Cambridge University Press.
- Seref, M.M.H., Ahuja, R.K. and Winston W.L. (2007) Developing Spreadsheet-based Decision Support Systems using Excel and VBA for Excel Dynamic Ideas, Belmont, Massachusetts.
- Venables, W.N., Smith, D.M. and the R Core Team (2012) An Introduction to R Notes on R: A Programming Environment for Data Analysis and Graphics Version 2.15.2.

Teaching and assessment methodologies

The curricular unit will be taught by means of theoretical-practical lectures using slides to underline the main points. An intensive use of the computer by all students will be required.
The final grade, on a 0-20 scale, is assigned on the basis of an exam to be answered using the computer.

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COURSE CONTENTS

1. EXCEL ESSENTIALS
2. STATISTICAL ANALYSIS WITH EXCEL
- 2.1 Introduction
- 2.2 Understanding data
- 2.3 Distributions
- 2.4 Data analysis module

3. USING THE EXCEL SOLVER
- 3.1 Introduction
- 3.2 The Excel Solver
- 3.3 Applications

4. WORKING WITH LARGE DATA
- 4.1 Importing data
- 4.2 Exporting data
- 4.3 Creating Pivot Tables from external data

5. INTRODUCTION TO VBA
- 5.1 Introduction - The VBA editor
- 5.2 Macros
- 5.3 Referencing and names in VBA
- 5.4 Formulas in VBA
- 5.5 Variables
- 5.6 VBA math functions
- 5.7 Sub Procedures and Function Procedure
- 5.8 Programming Structures
- 5.9 Arrays
- 5.10 User Interface
- 5.11 Working with large Data using VBA

6. INTRODUCTION TO R
- 6.1 Introduction (The R language and Environment)
- 6.2 Getting started
- 6.3 Expressions and assignments
- 6.4 Built-in functions
- 6.5 Logical operators
- 6.6 One dimensional arrays – vectors
- 6.7 Two dimensional arrays – matrices. Matrix operators
- 6.8 Using libraries
- 6.9 Reading data
- 6.10 Lists and data frames
- 6.11 Loops and conditional execution
- 6.12 Simple graphs
- 6.13 User written functions

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Degree:	2nd	**Field of Study:**	Actuarial Sciences				
Code:	MIF-FI	**Course name:**	Financial Markets and Investments		**Credits ECTS:**	6	
Scientific field:	Finance			**Department:**	Management		
Curricular year:	1st	**Semester:**	1st	X	**Type:**	Compulsory	X
			2nd			Elective	
Responsible lecturer:	Raquel Medeiros Gaspar						

Contact hours:

Lectures	Practicals	Lecture/Practicals	Total	Total workload
		39	39	168

Aims and scope

This course starts with an overview on financial markets and their instruments, and then goes towards combinations of alternative investments and portfolio theory. On what concerns portfolio theory, it covers the standard Modern Portfolio Theory (MPT), at a relatively high mathematical level.
Investor profiling and choice of optimal portfolios are analysed under the classical expected utility theory (EUT) setup. Stochastic dominance and alternative risk measures are presented. The role of factor models is discussed and the two main types of equilibrium models – CAPM and APT – are derived and analysed.
The course finishes discussing the limitations of the classical EUT setup and with a brief introduction into behavioural issues and prospect theory.

Summary

1. Financial markets and their instruments
2. Definitions of risk and return
3. Two asset portfolios
4. The notion of efficient portfolios
5. Various market conditions: existence (or not) of a risk-free asset, possibility (or not) of (un)constrained short selling
6. Finding the efficient frontier
7. Factor models: single and multi-factor models
8. Utility theory and deriving investor's utility function
9. Expected utility theory (EUT) and optimal portfolios
10. Stochastic Dominance
11. Risk Measures
12. Equilibrium models: capital asset pricing model (CAPM), arbitrage pricing theory (APT)
13. Market efficiency and rationality
14. Behavioural issues and alternatives to EUT

Main Bibliography

- Joshi, M. S., & Paterson, J. M. (2013). *Introduction to Mathematical Portfolio Theory*. Cambridge University Press.
- Elton, E. J., Gruber, M. J., Brown, S. J., & Goetzmann, W. N. (2014). *Modern portfolio theory and investment analysis*. John Wiley & Sons, 9th edition.

Assessment

- Final exam (80% = written exam 50% + computer exam 30%) + Group Assignment (20%)

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COURSE CONTENTS

PART I – FINANCIAL MARKET STRUCTURE AND INSTRUMENTS

1. **Market Organization and Structure**
   - 1.1. Functions of the financial system
   - 1.2. Market Classification
2. **Financial Instruments**
   - 2.1. Equity Securities
   - 2.2. Debt Instruments
   - 2.3. Derivatives
   - 2.4. Pooled Investments
3. **Trading in financial markets**
4. **The role of Information**
5. **An overview on portfolio management**

PART II – THEORY OF PORTFOLIO MANAGEMENT

1. **Definitions of risk and return**
2. **Mean – Variance Theory (MVT)**
   - 2.1. Efficient Portfolios: the two-asset case
   - 2.2. Portfolios with a risk-free asset
   - 2.3. Finding the efficient Frontier
   - 2.4. Safety restrictions
   - 2.5. Internationally diversified portfolios
3. **Return Generating Models**
   - 3.1. Single-factor models
   - 3.2. Multi-factor Models
   - 3.3. Estimation risk versus model risk

PART III – SELECTING OF OPTIMAL PORTFOLIOS

1. **Expected Utility Theory (EUT)**
   - 1.1. Introducing utility
   - 1.2. Utility and risk aversion
   - 1.3. Foundations of EUT
   - 1.4. Risk Tolerance functions
   - 1.5. Optimal Portfolios
   - 1.6. Basics on prospect theory
2. **Alternatives to Utility**
   - 2.1. Maximizing long-term growth
   - 2.2. Stochastic Dominance
   - 2.3. Safety Criteria
   - 2.4. Value-at-Risk
   - 2.5. Conditional expected shortfall
   - 2.6. Other risk issues

PART IV – MODELS OF EQUILIBRUM IN CAPITAL MARKETS

1. **The Capital Asset Pricing Model (CAPM)**
   - 1.1. Assumptions of standard CAPM
   - 1.2. Using CAPM
   - 1.3. Empirically testing CAPM
2. **The Arbitrage Pricing Theory (APT)**
   - 2.1. Assumptions of APT
   - 2.2. Estimating and testing APT
   - 2.3. APT versus CAPM
3. **Market Efficiency**
   - 3.1. Forms of efficiency
   - 3.2. Testing market's efficiency
   - 3.3. Week versus strong arbitrage
4. **Behavioral Finance**
   - 4.1. Anomalies in financial markets
   - 4.2. Behavioral issues and APT
   - 4.3. Anomalies in financial markets

LISBON SCHOOL OF ECONOMICS & MANAGEMENT
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Degree:	2nd	Field of Study:	Actuarial Science

Degree:	2nd	**Field of Study:**	Master in Actuarial Sciences

Code:	MAFI-CA	**Course name:**	Financial Mathematics	**Credits ECTS:**	6

Scientific field:	Mathematical Analysis and Mathematical Finance	**Department:**	Mathematics

Curricular year:	1st	**Semester:**	1st	X	**Type:**	Compulsory	X
			2nd			Elective	

Responsible lecturer:	Onofre Alves Simões

Contact hours:	Lectures	Practicals	Lectures/Practicals	Total	Total workload
			45.5	45.5	168

Aims and scope
– To provide a grounding in Financial Mathematics, including an introduction to equity and fixed income investments and to financial derivatives. – To instill the ability to take into account the time value of money, and to understand the term structure of interest rates and simple stochastic interest rate models. – To learn how to solve paradigmatic problems in the insurance business.

Summary
• Data and basics of modelling • Interest rate measurement • Valuation of annuities • Loan repayment • Measuring the rate of return of an investment • The term structure of interest rates • Investments

Main bibliography
• Broverman, S. A. (2015), *Mathematics of investment and credit*, 6th ed., Actex Publications, Winstead. (required textbook) • Matias, R. (2004), *Cálculo Financeiro – Teoria e Prática*, Escolar Editora, Lisboa. • McCutcheon & W. Scott (1986), *An Introduction to the Mathematics of Finance*, Heinemann, London.

Teaching and assessment methodologies
Lectures will be theoretical and practical, focused on the models used to carry out financial assessments in various situations. As these situations replicate very often real life problems, of which students are in some way aware, it is possible to use a mix of verbal, active, and even intuitive methods. The final grade, on the scale 0 to 20, is assigned based on written exam (70%) and a computer based Excel exam (30%).

COURSE CONTENTS

1. DATA AND BASICS OF MODELLING

1.1 Data analysis

1.2 Principles of actuarial modelling

1.3 Generalized cashflow models

2 INTEREST RATE MEASUREMENT

2.1 Financial transactions. Time, money and interest

2.2 Simple and compound interest

2.3 Present value and equations of value

2.4 Effective and nominal rates of interest

2.5 Simple and compound discount

2.6 The force of interest

2.7 Inflation and the "real" rate of interest

3 VALUATION OF ANNUITIES

3.1 Annuities: definition and types of annuities

3.2 Level payment annuities in discrete and continuous time

3.3 Annuities with non-constant payments in discrete and continuous time

4 LOAN REPAYMENT

4.1 Loan repayment methods

4.2 Deferral periods; variable interest rates; sinking funds; Makeham's formula

4.3 Bond valuation: determination of bond prices; amortization of a bond; callable bonds; serial bonds

5 MEASURING THE RATE OF RETURN OF AN INVESTMENT

5.1 Internal rate of return and net present value

5.2 Profitability index; payback period; discounted payback period; modified internal rate of return

5.3 Money weighted and time weighted rates of return

5.4 Yield in continuous time

5.5 Interest preference rates for borrowing and lending

6 THE TERM STRUCTURE OF INTEREST RATES

6.1 Spot rates of interest

6.2 Forward rates of interest

6.3 At-par yield

6.4 Interest rate swaps

7 INVESTMENTS

7.1 Stocks and short sale

7.2 Fixed Income Investments. Inflation protected securities; bond default and risk premium

7.3 Forward and futures contracts

7.4 Options

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UNIVERSIDADE DE LISBOA

Degree:	2nd	**Field of Study:**	Master in Actuarial Sciences				
Code:	PPE	**Course name:**	Probability and Stochastic Processes			**Credits ECTS:**	8
Scientific field:	Statistics and Actuarial Science			**Department:**	Mathematics		
Curricular year:	1st	**Semester:**	1st: X / 2nd:	**Type:**	Obligatory: X / Elective:		
Responsible lecturer:	Alexandra Bugalho Moura						

Contact hours:	Lectures	Practicals	Lectures/Practicals	Total	Total workload
			58.5	58.5	224

Aims and scope

- It is our aim with this Curricular Unit that students acquire the necessary background to precede to the study of other more advanced stochastic phenomena that arise in insurance business, in more advanced Curricular Units.
- The first part of the Curricular Unit is intended to introduce important concepts of probability distributions and their characteristics. In addition to a more advanced study of topics already taught in the first cycle, new concepts are introduced, with actuarial science applications, as is the case of measures for evaluating the tails of the distributions.
- In the second part some of the most relevant stochastic processes used for modelling actuarial phenomena are introduced.

Summary

- Distributions and basic distributional quantities: random variable, distribution and survival functions, multivariate random variables, moments, quantiles, generating functions, sums of random variables, residual life, censored random variables, limited random variables, tails of distributions
- Characteristics of actuarial models: the role of the parameters, the exponential and the linear exponential family
- Continuous models: creating new distributions; identification of some distributions; extreme value distributions
- Introduction to copulas
- General notions of stochastic processes and their classification
- Discrete time Markov chains
- Continuous time homogeneous Markov chains
- Time Inhomogeneous Markov Chains
- Actuarial Applications

Main bibliography

- Klugman, S.A.; Panjer, H.H. & Willmot, G.E. (2008), *Loss Models, From Data to Decisions*, (3rd edition), John Wiley & Sons.
- Core Reading 2011, CT4 Models, The Actuarial Profession.
- Dickson, D., Hardy, M., and Waters, H., (2009) Actuarial Mathematics for Life Contingent Risks, Cambridge University Press.
- Ross. S. M. (2010), *Introduction to Probability Models*, (Tenth Edition), Academic Press, New York.
- Ross. S. M. (1996), *Stochastic Processes*, 2nd ed. John Wiley & Sons, New York.
- Taylor, H. M. & Karlin, S. (1998), *An Introduction to Stochastic Modelling*, (3rd edition), Academic Press, New York.

Teaching and assessment methodologies

Sessions are of a theoretical-practical nature, based on oral presentations, accompanied by the projection of slides containing the main results, which will be derived, explained and exemplified.

Students must solve the recommended exercises, as assigned homework, so that proposed solutions may be discussed in the class. The final grade, on the scale of 0 to 20, is assigned on the basis of a written exam.

COURSE CONTENTS

1. DISTRIBUTIONS AND BASIC DISTRIBUTIONAL QUANTITIES

1.1. Overview of some concepts: Random variable; distribution function; continuous, discrete and mixed random variables; decomposition of a distribution function.
1.2. Some well-known discrete random variables: uniform on a finite set, Bernoulli, binomial, Poisson, geometric, negative binomial and hypergeometric.
1.3. Some well-known continuous random variables: uniform, normal, lognormal, Pareto, exponential, gamma, chi-square, t, F and beta.
1.4. Multivariate random variables; independent random variables.
1.5. Moments and related quantities.
1.6. Residual life; left censored and shifted random variable; limit loss variable.
1.7. Moment generating function, probability generating function and cumulant generating function.
1.8. Sum of independent random variables; central limit theorem.
1.9. Tails of distributions: comparison of the tail based on moments, on the limiting tail behaviour, on the hazard rate function and on the mean excess loss function; the equilibrium distribution and the tail behaviour.

2. CHARACTERISTICS OF ACTUARIAL MODELS

2.1. Parametric and scale distributions: scale distribution and scale parameter; location and shape parameters; the exponential family and the linear exponential family and the overdispersed linear exponential family.
2.2. Mixed distributions: discrete and continuous mixtures.

3. SEVERITY MODELS (CONTINUOUS MODELS)

3.1. Creating new distributions: sums of distributions; transformation of random variables; mixing of distributions; frailty models; spliced distributions.
3.2. Recognition of families of distributions and their relations.
3.3. Extreme value distributions: distribution of the maximum; stability of the maximum of the extreme value distribution; generalised Pareto distribution.

4. INTRODUCTION TO COPULAS

4.1. Introduction
4.2. Skalar's theorem and copulas
4.3. Measures of dependency
4.4. Tail dependence
4.5. Archimedean copulas
4.6. Elliptical copulas
4.7. Extreme value copulas

5. GENERAL NOTIONS OF STOCHASTIC PROCESSES

5.1. Some definitions.
5.2. Specification of a stochastic process.
5.3. Classification of a stochastic process.

6. DISCRETE TIME MARKOV CHAINS

6.1. Definitions.
6.2. Transition probability matrices.
6.3. First step analysis.
6.4. Classification of states.
6.5. Limit behaviour.
6.6. Applications to no claim discount and *bonus-malus* systems.

7. CONTINUOUS TIME HOMOGENEOUS MARKOV CHAINS

7.1. Introduction: time homogeneous Markov process; Chapman-Kolmogorov equations.
7.2. The transition probability matrix.
7.3. The forward and backward differential equations.
7.4. The embedded Markov chain.
7.5. Stationary and limiting distributions.

8. TIME INHOMOGENEOUS MARKOV CHAINS

8.1. Introduction; Chapman-Kolmogorov equations.
8.2. Kolmogorov's forward differential equations.
8.3. Probabilities of remaining in states for given time periods.
8.4. Kolmogorov's backward differential equations.
8.5. Applications in insurance.

Degree:	2nd	**Field of Study:**	Master in Actuarial Sciences				
Code:	MR-CA	**Course name:**	Risk Models			**Credits ECTS:**	6
Scientific field:	Statistics and Actuarial Science			**Department:**	Mathematics		
Curricular year:	1st	**Semester:**	1st: X / 2nd:	**Type:**	Obligatory: X / Elective:		
Responsible lecturer:	João Manuel de Sousa Andrade e Silva						

Contact hours:

Lectures	Practicals	Lectures/Practicals	Total	Total workload
		45.5	45.5	168

Aims and scope

The student is expected:

- To use statistical methods to define and estimate models adequate to model claims behaviour or other relevant aspects of the actuarial work.
- To understand the assumptions implicit in each statistical technique.
- To recognize which assumptions and statistical technique are appropriate to solve a given problem.

Summary

- Review of Basic statistical concepts
- Non-parametric estimation
- Frequentist estimation
- Bayesian estimation
- Model Selection
- Simulation and Bootstrap

Main bibliography

- Klugman, S.A., Panjer, H.H. and Willmot, G.E. (2012), *Loss Models – From data to decisions*, 4th Edition, John Wiley & Sons, Inc., New-Jersey.
- Hesterberg, T., Monaghan, S., Moore, D.S., Clipson, A., Epstein, R. (2003), *Bootstrap Methods and Permutation Tests* (http://bcs.whfreeman.com/pbs/cat_160/PBS18.pdf), companion chapter 18 to The practice of Business Statistics by David S. Moore, MCCabe, Duckworth and Sclove.
- Casella, G. and Berger, R. (2002), *Statistical Inference* (Second Edition). Duxbury Press.
- Efron, B. and Tibshirami, R.J. (1993), *An Introduction to the Bootstrap*, Chapman & Hall, New-York.
- Ross, S.M. (2002) *Simulation*, 3rd Edition, Academic Press.
- Seila, A., Ceric,V. and Tadikamalla,P. (2003), *Applied Simulation Modeling,* Duxbury Applied Series.
- Sharma, S. (1996) *Applied Multivariate Techniques,*John Wiley & Sons Inc., New-York.
- Wasserman, L. (2004), *All of Statistics: A Concise Course in Statistical Inference*, New York, Springer.

Teaching and assessment methodologies

The curricular unit will be taught by mean of theoretical-practical lectures using slides to underline the main points and using a computer to solve some examples. Student's autonomous work is a main point of teaching methodologies. Students must also solve a set of exercises. The final grade, on the scale of 0 to 20, is assigned on the basis of a written exam (70%) and an exam using the computer (30%) based on EXCEL and R.

COURSE CONTENTS

1. Review of basic statistical concepts

1.1. Introduction – Population versus sample
1.2. Summarizing information
1.2.1. Location, variability and other characteristics of a data collection
1.2.2. Measures of relationship between variables
1.2.3. Basics of Principal Components Analysis (PCA)
1.3. Sampling and sampling distribution
1.4. Point estimation with emphasis on measures of quality
1.5. Interval estimation
1.6. Tests of hypothesis

2. Non-parametric estimation

2.1. The empirical distribution for complete individual data
2.2. The empirical distribution for grouped data
2.3. Kernel density models

3. Frequentist estimation

3.1. Methods of moments and percentile matching
3.2. Maximum likelihood estimation (individual, grouped, censored and truncated data)
3.3. Variance and interval estimation
3.4. Non-normal confidence intervals

4. Bayesian estimation

4.1. Bayesian Estimation
4.2. Definitions and Bayes' theorem
4.3. Inference and prediction
4.4. Conjugate prior distributions

5. Model selection

5.1. Introduction
5.2. Representation of the data and model
5.3. Graphical comparison of the density and distribution functions
5.4. Hypothesis tests
5.5. Selecting a model

6. Simulation

6.1. Basics of simulation
6.2. Examples of simulation in actuarial modeling and finance

7. An introduction to the bootstrap

7.1. Introduction to bootstrapping
7.2. Bootstrap distributions and standards errors
7.3. Bootstrap confidence intervals
7.4. Significance testing using permutation tests

2nd SEMESTER

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	MLG	Course name:	Generalized Linear Models			Credits ECTS:	4
Scientific field:	Statistics and Actuarial Science			Department:	Mathematics		
Curricular year:	1st	Semester	1st		Type	Obligatory	X
			2nd	X		Elective	
Lecturer:	Rui Paulo						

Contact hours:

Lectures	Praticals	Lectures/Praticals	Total	Total workload
		26	26	112

Aims and scope

To introduce the foundations of Generalized Linear Models (GLM) and its applications. Provide skills for real-data estimation of GLM. Additionally, to introduce the main concepts of machine learning and some key algorithms. Provide skills to use appropriate software to apply machine learning techniques to simple real-data problems.

Summary

Generalized Linear Models:

- Review of linear regression models
- Generalized linear models: general overview
- Inference
- Examples of generalized linear models for continuous and discrete response
- Quasi-likelihood and overdispersion

Machine Learning:

- What is machine learning
- Branches of machine learning
- Applications

Main bibliography

- Faraway, J., *Extending the Linear Model With R*, Chapman and Hall, 2006.
- James, J., Witten, D., Hastie,T. and Tibshirani, R., An Introduction to Statistical Learning, Springer, 2013.
- Kleiber, C. and Zeileis, A., *Applied Econometrics with , Springer, 2008.*
- Lantz, B., Machine Learning with R, 2nd Edition, Packt Publishing, 2015.
- Lindsey, J., *Applying Generalized Linear Models*, Springer, 1997.
- McCullagh P. And Nelder, J.A., *Generalized Linear Models*, 2nd Edition, Chapman and Hall, London, 1989.
- Venables W. N. and Ripley B. D., *Modern Applied Statistics with S*, 4th Edition, Spinger, 2002.

Teaching and assessment methodologies

Lectures will alternate theoretical presentations of statistical models with data analysis performed with suitable software.

The final grade, on a 0-20 scale, is awarded on the basis of a written exam and of a practical exam done on a computer using R. The mark on the written exam will be worth 70% of the final grade.

COURSE CONTENTS

Part I: Generalized Linear Models

1. **Review of linear regression models**
   - 1.1. Basic hypotheses of the model
   - 1.2. Estimation via least squares
   - 1.3. Coefficient of determination
   - 1.4. The normal linear regression model: inference and model checking
2. **Generalized linear models**
   - 2.1. Exponential family of distributions
   - 2.2. Link functions, canonical link function, linear predictor
   - 2.3. Variables, factors, interactions. Parametrisation.
   - 2.4. Deviance and scaled deviance
   - 2.5. Pearson and deviance residuals
   - 2.6. Statistical inference for generalised linear models
   - 2.7. Point and interval estimation
   - 2.8. Test of hypotheses on individual parameters
   - 2.9. Test of linear restrictions
   - 2.10. Model fit and model comparison
   - 2.11. Estimation of dispersion parameter
   - 2.12. Continuous response models
     a) The normal model
     b) The exponential and gamma models
   - 2.13. Discrete response models
     a) Binomial model
     b) Poisson model
3. **Quasi-likelihood and over-dispersion**
   - 3.1. Likelihood equations for the general model
   - 3.2. Choice of mean value and variance functions
   - 3.3. Estimation of the dispersion parameter

Part II: Machine Learning

1. **What is Machine Learning**
2. **Supervised and unsupervised machine learning techniques**
3. **Applications:**
   - 3.1. Penalized Regression
   - 3.2. Naive Bayes classification
   - 3.3. K-means clustering

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	PRVS	Course name:	Loss Reserving			Credits ECTS:	4
Scientific field:	Statistics and Actuarial Science			Department:	Mathematics		
Curricular year:	1st	Semester	1st		Type	Obligatory	X
			2nd	X		Elective	
Lecturer:	Walther Adolf Hermann Neuhaus						

Contact hours:

Lectures	Practicals	Lectures/Practicals	Total	Total workload
		26	26	112

Aims and scope

To give students:

- A good understanding of outstanding claims in general insurance
- Models and methods for estimating the cost of outstanding claims
- Practical exercise with the analysis of several realistic data sets

Summary

- Introduction
- Standard methods
- Modelling claim counts
- Tail extension
- Modelling claim amounts
- Generalized linear models
- Diagnostics and data
- Reinsurance recoveries
- Accounting for outstanding claims
- Towards better estimates

Main bibliography

- Neuhaus, Walther (2009-2016). Lecture notes.
- Taylor, G.C. (2000). Loss reserving: an actuarial perspective, Kluwer Academic, Boston.

Teaching and assessment methodologies

The curricular unit will be taught by mean of theoretical-practical lectures using slides to underline the main points and using the computer to solve some examples.

The assessment is based on

1. a written examination (1.5 hours, 50% of overall mark),
2. a computer examination in Excel (1 hour, 50% of overall mark).

COURSE CONTENTS

1. **INTRODUCTION**
   a. General insurance contracts: lines of insurance, claim attachment
   b. Stages in the life of a claim: notification, assessment, handling, payment, settlement, reopening, recoveries
   c. Purpose of valuation: accounting, pricing, portfolio transfer, commutation
   d. Case estimates
   e. Time dimensions (events): underwriting, loss event, claim reporting, payments, settlement
   f. Four-letter words: CBNI, IBNR, RBNS
2. **STANDARD METHODS**
   a. Development triangles
   b. Bornhuetter-Ferguson's method
   c. Chain ladder method
   d. Benktander method
   e. Average cost per claim method
   f. Generalised linear models
3. **MODELLING CLAIM COUNTS**
   a. MLE derivation of Bornhuetter-Ferguson method
   b. MLE derivation of chain ladder method
4. **TAIL EXTENSION**
5. **MODELLING CLAIM AMOUNTS**
   a. Additive model
   b. Multiplicative model
   c. Bühlmann-Straub model
   d. Hesselager-Witting model
   e. Mack model
6. **GENERALISED LINEAR MODELS**
   a. Link functions, covariates and probability distributions
   b. Modelling examples
   c. Estimation and prediction
   d. Bootstrapping
7. **DIAGNOSTICS AND DATA**
8. **REINSURANCE RECOVERIES**
   a. Contract type and form of recovery
   b. Duration of contracts (clean-cut vs run-off)
   c. Limitations and exclusions
   d. Accounting considerations
9. **ACCOUNTING FOR OUTSTANDING CLAIMS**
   a. Balance sheet items
   b. Premium provision
   c. Claim provision
   d. Risk margin
   e. Recoveries
10. **TOWARDS BETTER ESTIMATES**
    a. Stages in the life of a claim: CBNI, IBNR, RBNS
    b. Making the most of scarce information
    c. Separating the analysis of RBNS, IBNR and CBNI

Degree:	2nd	**Field of Study:**	Master in Actuarial Sciences				
Code:	TR	**Course name:**	Risk Theory	**Credits ECTS:**	8		
Scientific field:	Statistics and Actuarial Science	**Department:**	Mathematics				
Curricular year:	1st	**Semester:**	1st		**Type:**	Obligatory	X
			2nd	x		Elective	

Responsible lecturer: Maria de Lourdes Caraças Centeno

Contact hours:

Lectures	Practicals	Lectures/Practicals	Total	Total workload
		52	52	224

Aims and scope

Students that have successfully completed this course should be able of understanding how:
- stochastic models are used in insurance, namely in general insurance
- calculating the aggregate claim distribution
- calculating the ruin probability or an approximation
- analysing the effect of reinsurance on the retained claim process.

Summary

- The number of claims: the (a,b,0) class of distributions;the homogeneous Poisson process; the class (a,b,1) of distributions - truncation and modification at zero; compound frequency models; mixed frequency models; the mixed Poisson process; effect of exposure on frequency
- Impact of coverage modifications in the frequency and severity, including deductible, inflation effects, policy limits
- Aggregate models: collective risk model versus individual risk model; the compound model; special cases; the aggregate claim distribution; the impact of individual policy modifications on the aggregate claim distribution; the individual model; approximated methods
- Premium principles; Risk Measures
- Reinsurance: Quota-share, Surplus, Excess of Loss and Stop Loss
- Ruin Theory: continuous time model; discrete time model; the impact of reinsurance on the ruin probability

Main bibliography

- Klugman, S., Panjer, H. and Willmot, G. (2008) *Loss Models, Third Edition*. John Wiley & Sons.
- Kaas, R., Goovaerts, M., Dhaene, J. and Denuit, M. (2008), *Modern Actuarial Risk Theory*, Using R. , Springer.
- Centeno, M.L. (2003), *Teoria do Risco na Actividade Seguradora*, Celta Editora, Oeiras, Portugal.

Teaching and assessment methodologies

Sessions are of a theoretical-practical nature, based on oral presentations, accompanied by the projection of slides containing the main results, which will be derived, explained and exemplified. Students must solve the recommended exercises, as assigned homework, so that proposed solutions may be discussed in the class. The final grade, on the scale of 0 to 20, is assigned on the basis of a written exam (70%) and of a computer exam using R (30%).

COURSE CONTENTS

1. RISK AND INSURANCE COMPANIES

2. THE NUMBER OF CLAIMS

2.1 The (a,b,0) class of distributions

2.2 The homogeneous Poisson process: its genesis, discussion of the postulates, some related distributions –the exponential, the gamma, the binomial and the uniform

2.3 The class (a,b,1) of distributions: Truncation and modification at zero

2.4 Compound frequency models

2.5 Mixed frequency distributions

2.6 Mixed Poisson Process. The Polya process.

2.7 Effect of exposure on frequency

3. IMPACT OF COVERAGE MODIFICATIONS IN THE FREQUENCY AND SEVERITY

3.1 Deductible

3.2 Inflation effects

3.3 Policy limits

3.4 Coinsurance, deductibles and limits

3.5 The impact of deductibles on the claim frequency

4. AGGREGATE LOSS MODELS

4.1 Collective risk model *versus* individual risk model

4.2 Assumptions and characteristics of the compound model

4.3 Special cases

4.4 The aggregate claim distribution

- 4.4.1 Introduction
- 4.4.2 Recursive method
- 4.4.3 Constructing arithmetic distributions

4.5 The impact of individual policy modifications on the aggregate claim distribution

4.6 The individual model

4.7 Approximated methods

- 4.7.1 The Normal Power approximation
- 4.7.2 The translated Gamma approximation

5. PREMIUM PRINCIPLES

5.1 Some premium calculation principles

5.2 Properties

6. RISK MEASURES

6.1 Coherent risk measures

6.2 Value at Risk (VaR)

6.3 Tail Value at Risk (TVaR)

6.4 Conditional Tail Expectation (CTE)

6.5 Expected Shortfall (ES)

7. REINSURANCE

7.1 Introduction

7.2 Quota share reinsurance

7.3 Surplus reinsurance

7.4 Excess of loss reinsurance, per risk and per event covers, working and clash covers

7.5 Stop loss reinsurance

8. RUIN THEORY

8.1 Continuous time model *versus* discrete time model

8.2 Continuous time model

8.2.1 The adjustment coefficient

8.2.2 Lundberg's inequality

8.3 Discrete time model

8.3.1 The adjustment coefficient

8.3.2 The impact of reinsurance on the adjustment coefficient

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Degree:	2nd	Field of Study:	Actuarial Science				
Code:	MASV	Course name:	Survival Models and Life Contingencies			Credits	8
Scientific field:	Statistics and Actuarial Science			Department:	Mathematics		
Curricular year:	1st	Semester	1st		Type	Obligatory	X
			2nd	X		Elective	
Lecturer:	Onofre Alves Simões						

Contact hours:

Lectures	Practicals	Lectures/Practicals	Total	Total
		52	52	224

Aims and scope

The aim of this subject is to provide students with the skills necessary to apply and develop actuarial mathematics concepts and techniques, in the area of life contingent risks. In a particular way, those skills must be used to model and evaluate cash-flows dependent on death, survival, disability and other risks present in life insurance and pensions.

Summary

- Life Insurance Products
- Mortality and Life Tables
- The Evaluation of Assurances and Annuities
- Premiums and Reserves Calculation
- Multi-state Policies
- Discounted Emerging Cost Techniques
- Single Figure Indices to Summarise and Compare Mortality Levels

Main bibliography

- Dickson, D., Hardy, M. and Waters, H. (2013), *Actuarial Mathematics for Life Contingent Risks*, 2nd ed., Cambridge University Press.
- Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997), *Actuarial Mathematics* , 2nd ed, The Society of Actuaries, Schaumburg, IL.
- The Actuarial Profession, Subject CT5 - Contingencies - Core Reading for the 2017 exams (2016), The Actuarial Profession.

Teaching and assessment methodologies

The sessions of theoretical and practical content will consist of oral presentations accompanied by the projection of slides containing the main formulae and results, which will be explained, demonstrated and exemplified using suitable techniques. A significant part of the sessions will be devoted to drafting exercises and practical applications.

The final grade, on a 0-20 scale, is awarded on the basis written exam (70%) and a computer solved exam (30%).

COURSE CONTENTS

1. LIFE INSURANCE PRODUCTS

1.1. Life Insurance contracts

1.2. Annuity contracts

1.3. Pension benefits

2. MORTALITY AND LIFE TABLES

2.1. Survival functions and force of mortality

2.2. The future life time and curtate future lifetime

2.3. Life tables

2.4. Select survival models

2.5. Select life tables

3. THE EVALUATION OF ASSURANCES AND ANNUITIES

3.1. Valuation of insurance benefits (level and variable, in continuous and discrete time)

3.2. Valuation of life annuities (level and variable, in continuous and discrete time)

4. CALCULATION OF PREMIUMS AND RESERVES

4.1. Net and gross premiums

4.2. The principle of equivalence

4.3. The portfolio percentile principle

4.4. Extra mortality risk

4.5. Reserving for a policy with discrete cash flows (annual and other)

4.6. Reserving for a policy with continuous cash flows

4.7. Policy alterations

5. MULTI-STATE POLICIES

5.1. Multiple state models

5.2. Assumptions and notation

5.3. Transition intensities and probabilities

5.4. Numerical evaluation of probabilities

5.5. Premiums

5.6. Thiele's differential equation generalisations

5.7. Multiple decrement models (competing risks)

5.8. Joint life status and last survivor status

5.9. Multiple decrement models (competing risks) revisited

6. DISCOUNTED EMERGING COST TECHNIQUES

6.1 Evaluating expected cash flows

6.2 Deterministic profit testing for traditional life insurance

6.3 Deterministic profit testing for equity-linked insurance

6.4. Stochastic profit testing

7. SINGLE FIGURE INDICES TO SUMMARISE AND COMPARE MORTALITY LEVELS

7.1. Mortality, selection and standardisation

7.2. Crude mortality rate

7.3. Directly standardised mortality rate

7.4. Indirectly standardised mortality rate and area comparability factor

7.5. Standardised mortality ratio

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Degree:	2nd	Field of Study:	Actuarial Science				
Code:	MP-CA	Course name:	Time Series			Credits ECTS:	6
Scientific field:	Econometrics			Department:	Mathematics		
Curricular year:	1st	Semester	1st		Type	Obligatory	X
			2nd	X		Elective	
Lecturer:	Nuno Sobreira						

Contact hours:

Lectures	Practicals	Lectures/Practicals	Total	Total workload
		39	39	168

Aims and scope

On completion of this course, the student should be able to:

- Recognize and understand the main econometric models used in the analysis of time series.
- Understand the theoretical reasoning which led to the development of the most important univariate and multivariate models.
- Be familiar with the use of econometric software to carry out time series analysis.
- Develop critical thinking about empirical work with time series data.
- Be able to develop a forecasting study of different sets of variables and formulate statistical hypotheses of interest. Understand the limitations of the econometric methodology applied in the study.

Summary

- Introduction to time series analysis. Fundamental concepts
- Models for stationary time series. Autoregressive Moving Average (ARMA) models
- Box-Jenkins methodology: model identification, estimation and diagnostic checking
- Models for nonstationary time series. Autoregressive Integrated Moving Average (ARIMA) models and unit root testing
- Forecasting using ARIMA models
- Seasonality and Seasonal ARIMA (SARIMA) models
- Conditional Heteroskedasticity time series models. ARCH/GARCH models
- Forecasting with exponential smoothing methods
- Multivariate Time Series Models

Main bibliography

- Hamilton, J. (1994). *Time Series Analysis*, Princeton University Press.
- Sobreira, N. (2014). Lecture notes.
- Tsay, R. S. (2010). *Analysis of Financial Time Series*, Wiley.
- Wei, W. W. S. (2005). *Time series analysis: univariate and multivariate methods*, Pearson.

Teaching and assessment methodologies

Lectures will be theoretical and practical, starting on main empirical patterns found in time series as a basis to present statistical methods and models used to represent it. Core mathematical models for time series will be presented in a constructive way, but practical relevance of different models in terms of time series behavioural patterns and on the nature of implied forecast functions will also be strengthened. Using available software, models and modelling strategies will be applied on real time series data with emphasis in critical analysis as a function of purposes.

Students will be assessed based on a final exam (60%) and a practical computational test (40%) using R.

COURSE CONTENTS

1. INTRODUCTION TO TIME SERIES ANALYSIS. FUNDAMENTAL CONCEPTS

1.1. Definition and examples of time series observations

1.2. Objectives of time series analysis

1.3. Examples of time series patterns and the time series modelling strategy

1.4. Time series processes and the importance of stationarity for time series analysis

1.5. Definition of strict and weak stationarity. Examples of (weak) stationarity processes. Stationarity in practice: time series plot and correlogram

2. MODELS FOR STATIONARY TIME SERIES. ARMA MODELS

2.1. Introduction to ARMA models

2.2. Fundamental concepts: Lag/Backshift Operator, Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). Sample ACF and Sample PACF

2.3. Properties of MA processes: Expected Value, Variance, Autocovariance Function (ACVF), ACF and PACF. Stationarity of MA processes

2.4. Properties of AR processes: Stationarity conditions, Expected Value, Variance, ACVF, ACF and PACF. Yule-Walker equations

2.5. Duality between AR and MA processes. Invertibility conditions of MA processes

2.6. ARMA models: stationarity and invertibility conditions. Properties of the ARMA(1,1) process

3. BOX-JENKINS METHODOLOGY: MODEL IDENTIFICATION, ESTIMATION AND DIAGNOSTIC CHECKING

3.1. Model tentative identification

3.1.1. *Stationarizing* a time series. Variance stabilizing transformations, seasonal adjustments and the first-difference operator

3.1.2. Using the sample ACF and PACF to choose candidate models

3.2. Model estimation. Method of moments and maximum likelihood estimators

3.3. Model diagnostic checking: statistical testing procedures on the residuals

3.4. Model selection criteria and the principle of parsimony

4. MODELS FOR NON-STATIONARY TIME SERIES. ARIMA MODELS AND UNIT ROOT TESTING

4.1. A note on spurious time series regression and cointegration

4.2. Difference-Stationary (DS) and Trend-Stationary processes (TS): definitions and appropriate transformations

4.3. Examples of DS and TS processes: random walk, random walk with drift, ARIMA and deterministic trend models

4.4. Unit root (Dickey-Fuller) statistical tests

5. FORECASTING WITH ARIMA MODELS

5.1. Minimum Mean Square Error (MSE) forecasts for ARIMA models. Point and Interval forecasts

5.2. The Markov property

5.3. Forecast function profiles for ARIMA models

5.4. Forecasting accuracy measures

6. SEASONALITY AND SARIMA MODELS

6.1. Deterministic and stochastic seasonality time series models.

6.2. Pure seasonal time series models (SMA, SAR, SARMA, SARIMA) and the general multiplicative model (SARIMA$(p,d,q)(P,D,Q)_s$)

6.3. Forecasting with the SARIMA class of models

7. CONDITIONAL HETEROSKEDASTICITY TIME SERIES MODELS. ARCH/GARCH MODELS

7.1. Financial time series patterns

7.2. ARCH and GARCH volatility models

8. FORECASTING WITH EXPONENTIAL SMOOTHING METHODS

8.1. (S)ARIMA versus exponential smoothing based approach to forecasting. The simple exponential smoothing method

8.2. Other exponential smoothing methods: trend and seasonal models

9. MULTIVARIATE TIME SERIES MODELS

9.1. Vector Autoregressions (VAR)

9.2. Cointegration and the Vector Error Correction Model (VECM)

3rd SEMESTER

Degree:	2nd	**Field of Study:**	Actuarial Sciences				
Code:	TOA-CA	**Course name:**	Actuarial Topics		**Credits ECTS:**	6	
Scientific field:	Statistics and Actuarial Science		**Department:**	Mathematics			
Curricular year:	2nd	**Semester:**	1st	X	**Type:**	Obligatory	
			2nd			Elective	x

Responsible lecturer: Agnieszka Bergel

Contact hours:	Lectures	Practicals	Lectures/Practicals	Total	Total workload
			39	39	168

Aims and scope

The aim of this unit is to provide an understanding in survival models and their applications.

Summary

- Estimating lifetime distributions – The Kaplan-Meier, Nelson-Aalen and Cox estimates.
- Maximum likelihood estimators for transition intensities in models of transfers between states.
- Transition intensities based on age.
- Testing crude estimate for consistency based on different methods. The graduation process.
- Mortality projection. Forecasting future mortality rates. Regression models.

Main bibliography

- Bowers, Newton, Hans Gerber, James Hickman, Donald Jones e Cecil Nesbit; *Actuarial Mathematics,* The Society of Actuaries, Illinois, 2nd edition, 1997.
- Dickson, D., Hardy, M., and Waters, H. *Actuarial Mathematics for Life Contingent Risks*, Cambridge University Press, 2009.
- Klugman, S.A. ;Panjer H.H.; Willmott, G.E.; *Loss Models from Data to Decision,* Third Edition, Wiley.
- Wolthuis, H.; *Life Insurance Mathematics*, Caire Education Series 2, Brussels, 1994.
- Core Reading 2013, CT4 Models, The Actuarial Profession.
- A.S. Macdonald, An actuarial survey of statistical models for decrement and transition data, British Actuarial Journal 2, 1996.

Teaching and assessment methodologies

The curricular unit will be taught by mean of theoretical-practical lectures using slides to underline the main points.

The assessment is based on an examination 70% and computer project in R 30%.

COURSE CONTENTS

1. ESTIMATING LIFETIME DISTRIBUTIONS

1.1. Estimating the survival function in the absence of censoring
1.2. Life time data censoring and its consequences in the estimation process
1.3. The Kaplan- Meier estimate
1.4. The Nelson-Aalen estimate
1.5. The Cox model for proportional hazards, partial likelihood estimate in the absence of ties and its asymptotic distribution

2. MAXIMUM LIKELIHOOD ESTIMATORS FOR TRANSITION INTENSITIES IN MODELS OF TRANSFERS BETWEEN STATES

2.1. Define an observational plan and derive the resulting statistics, including waiting times
2.2. Likelihood function for constant intensities in a Markov model, using the results of 2.1.
2.3. Maximum likelihood estimators for transition intensities in 2.2. and their asymptotic joint distribution
2.4. Poisson approximation to the estimator in 2.3.

3. TRANSITION INTENSITIES BASED ON AGE

3.1. Importance of dividing data into homogeneous classes
3.2. The importance of the principle of correspondence
3.3. Data requirements for an exact calculation of a central exposed to risk depending on age and sex
3.4. Calculate a central exposed to risk given data in 3.3
3.5. Estimates of transition probabilities
3.6. Assumptions underlying census approximation of waiting times
3.7. Rate interval
3.8. Census formulae given age at birthday
3.9. Age to which estimates of transition intensities or probabilities in 3.8

4. TESTING CRUDE ESTIMATE FOR CONSITENCY BASED ON DIFFERENT METHODS. THE GRADUATION PROCESS

4.1. Statistical tests of crude estimates, for comparison with a standard table: chi-square test, standardised deviations test, sign test, cumulative deviation test, grouping of signs test, serial correlations test.
4.1.1. For each test: formulation of the hypothesis, the test statistic and its distribution.
4.2. Reasons for graduating crude estimates of transition intensities or probabilities
4.3. Test for smoothness of a set of graduated estimates
4.4. Graduation by the following methods:
4.4.1. parametric formula
4.4.2. standard table
4.4.3. spline functions
4.5. Amend tests in 4.1. to compare crude and graduates sets of estimates and to allow for the presence of duplicate policies
4.6. Comparison of crude estimates and a standard table, or between crude estimates and graduate estimates

5. MORTALITY PROJECTION

5.1. Approaches to the forecasting of future mortality rates based on extrapolation, explanation and expectation. Advantages and disadvantages.
5.2. The Lee-Carter, age-period-cohort and p-spline regression models.
5.3. Computer packages to apply the models in 5.2. to a suitable mortality dataset.
5.4. Main sources of error in mortality forecast.

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Degree:	2nd	**Field of Study:**	Master in Actuarial Sciences				
Code:	GAP-CA	**Course name:**	Asset Liability Management	**Credits ECTS:**	4		
Scientific field:	Finance			**Department:**	Management		
Curricular year:	2nd	**Semester:**	1st: X / 2nd:	**Type:**	Obligatory: / Elective: x		
Responsible lecturer:	Walther Adolf Hermann Neuhaus						

Contact hours:

Lectures	Practicals	Lectures/Practicals	Total	Total workload
		19.5	19.5	112

Aims and scope

To give students:
- a broad understanding of the financial risks of an insurance company
- measures of risk
- models for asset risk and liability risks
- methods to analyse and manage the overall risk

Summary

- Interest rates
- Term structure
- Risk measures
- Reinsurance
- Insurance linked securities
- Dynamic financial analysis
- Mean-variance analysis

Main bibliography

- Neuhaus, Walther. Lecture notes.

Teaching and assessment methodologies

The curricular unit will be taught by mean of theoretical-practical lectures using slides to underline the main points and using the computer to solve some examples.

The assessment is based on

1. a project (two weeks to deliver, 50% of overall mark),
2. a computer examination in Excel (1 hour, 50% of overall mark).

COURSE CONTENT

1. INTEREST RATES

Basic theory
Yield curve estimation
Present value, duration, convexity
Sensitivity
Matching
Immunisation

2. TERM STRUCTURE

2.1. Stochastic term structure models
2.2. Vasicek, CIR
2.3. Simulation of the term structure

3. RISK MEASURES

3.1. VaR and TailVaR
3.2. Coherent risk measures
3.3. Spectral risk measures

4. REINSURANCE

4.1. Contract types
4.2. Recovery forms
4.3. Premium calculation
4.4. Duration and commutation
4.5. Alternative risk transfer
4.6. Risks to be aware of

5. INSURANCE LINKED SECURITIES

5.1. Catastrophe futures
5.2. Catastrophe bonds
5.3. Industry loss warranties
5.4. Collateralised reinsurance
5.5. Sidecars
5.6. Contingent capital

6. DYNAMIC FINANCIAL ANALYSIS

6.1. The overall structure of a DFA
6.2. Assumptions (underwriting, reinsurance, asset management)
6.3. Simulations (assets, claims, economic drivers)
6.4. Compilation (insurance results, investment results, company results)
6.5. Evaluation of results

7. MEAN-VARIANCE ANALYSIS

7.1. Optimum asset allocation for one period
7.2. Optimum asset allocation to fund a stochastic liability
7.3. Discussion of the mean-variance framework

Degree:	2nd	Field of Study:	Actuarial Science		
Code:	FFR	Course name:	Finance and Financial Reporting	ECTS credits:	6
Scientific field:	Finance	Department:	Management		

Curricular year:	2nd	Semester	1st	X	Type	Obligatory	
			2nd			Elective	X

Lecturer: Pedro Rino Vieira

Contact hours:

Lectures	Practicals	Lectures/Practicals	Total	Total workload
		52	52	168

Aims and scope

During the semester students will be introduced to corporate finance and the interpretation of company account, such that at the end of the course they will be able to: understand the economic context in which the business operates, namely the shareholder-manager relationship; discuss the role of Corporate Governance in business finance; demonstrate an understanding of accounting and financial reporting principles; state the importance of auditing; interpret an auditing report; construct simple balance sheets, profit and loss accounts and cash flow statements; interpret financial statements; to make investment decisions that create shareholder value; explain the different debt and equity financial instruments; discuss the capital structure of a firm and its relationship with the firm's value; understand and explain the main impact of taxation in a firm.

Summary

- Introduction to corporate finance and corporate governance
- Financial Accounting
- Financial Statement Analysis
- Working Capital
- Budgeting
- Cost of Capital
- Investment Appraisal
- Capital Structure
- Payout Policy
- Financing

Main bibliography

- Subject CB1 - Business Finance - Core Reading, IFoA
- Corporate Finance, Berk, J.; DeMarzo, P. 4rd ed., Pearson, 2017. 1168 pages. ISBN: 978-0134083278 (main textbook)
- Finance for Executives - Managing Value Creation, Hawawini, G.; Viallet, Claude, 4rd ed., Cengage Learning, 2015. 736 pages. ISBN: 9781408093801
- Financial Accounting and Reporting, Stolowy, H;. Lebas, Michel J.; Ding, Yuan. 4th Edition. Cengage Learning, 2014. 666 pages. ISBN: 978-1-4080-6662-1
- International Financial Statement Analysis. Robinson, T. R.; Henry, E.; Pirie, W. L.; Broihahn, M. A.; Cope, A. T. 3th ed. Wiley, 2015. 1072 pages. ISBN: 978-1118999479
- A Risk Based-Approach to Conducting a Quality Audit, Johnstone, K.; Gramling. A.; Rittenberg, L. E., 10th ed., Cengage Learning, 2016. 960 pages. ISBN: 978-1305080577
- Accounting and finance for non-specialists. Atrill, P.; McLaney, E. 9th ed. Pearson, 2015. 600 pages. ISBN: 978-1292062716
- Fundamentals of financial management (concise edition). Brigham, E. F.; Houston, J. F. 8th ed. Cengage Learning, 2015. 688 pages. ISBN: 9781285065137
- How to understand the financial pages. Davidson, A. 2nd ed. Kogan Page, 2008. 384 pages. ISBN: 978-0749451448
- Interpreting company reports and accounts. Holmes, G.; Sugden, A.; Gee, P. 10th ed. 336 pages. FT Prentice Hall, 2008. ISBN: 978-0273711414.

Teaching and assessment methodologies

The teaching approach combines the presentation and discussion of the theory and examples of the main concepts with practical problems. The final note, on the scale of 0 to 20, is assigned on the basis of a written exam.

COURSE CONTENTS

1. **Introduction to corporate finance and corporate governance**
   - 1.1. What is a firm?
   - 1.2. Diverse Types of Firms
   - 1.3. Value Creation and the Theory of Agency
   - 1.4. The role of Corporate Governance
   - 1.5. Institutional Context
2. **Financial Accounting**
   - 2.1. Accounting: the Language of Business
   - 2.2. International Standards: IFRS and U.S. GAAP
   - 2.3. Accounting Mechanics
   - 2.4. Income Statement
   - 2.5. Balance Sheet
   - 2.6. Cash Flow Statement
   - 2.7. Intercorporate Investments and Consolidations
   - 2.8. Insurance Companies Accounts
3. **Financial Statement Analysis**
   - 3.1. The Financial Analysis Process
   - 3.2. Analysis Tools and Techniques
   - 3.3. Common Ratios Used in Financial Analysis
   - 3.4. Equity Analysis
   - 3.5. Credit Analysis
   - 3.6. Earnings Quality and Auditing
4. **Working Capital**
   - 4.1. Estimation
   - 4.2. Management
   - 4.3. Financing strategies
   - 4.4. Working Capital and Cash
5. **Budgeting**
   - 5.1. Types of Budgets
   - 5.2. Budgeting Process
   - 5.3. Constructing Forecast Financial Statements
6. **Cost of Capital**
   - 6.1. Cost of Equity
   - 6.2. Cost of Debt
   - 6.3. WACC

7. Investment Appraisal

7.1. Introduction to Stock and Bond Valuation

7.2. Investment Decision Rules

7.3. Capital Budgeting

7.4. Risk Analysis

7.5. Real Options and Decision Trees

7.6. Stock Valuation Revisited

7.7. Mergers and Acquisitions

8. Capital Structure

8.1. In a Perfect Market

8.2. Taxation

8.3. Debt and Taxes (corporate and personal)

8.4. Financial Distress, Managerial Incentives and Information

9. Payout Policy

9.1. Payout: Dividends and Share Repurchases

9.2. A discussion on Dividend Relevancy

9.3. Retain or Payout?

10. Financing

10.1. Raising Equity Capital

10.2. Debt Financing

10.3. Leasing

10.4. Other Sources of Financing

10.5. Long Term and Short Term Financial Instruments

10.6. The Role of Derivatives

LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	MODFIN	Course name:	Models in Finance	Credits ECTS:	8		
Scientific field:	Mathematical Analysis and Mathematical Finance			Department:	Mathematics		
Curricular year:	2nd	Semester	1st: X / 2nd:	Type	Obligatory: X / Elective:		
Lecturer:	João Miguel Espiguinha Guerra						

Contact hours:	Lectures	Practicals	Lectures/Practicals	Total	Total workload
			39	39	168

Aims and scope

– The aim of this course is to develop the necessary skills in order to understand and apply the mathematical methods, of analytical, stochastic and numerical type, that play an important role in financial stochastic models either in discrete or continuous time. In particular, we are interested in models for the valuation of derivative securities. These skills are also important in order to communicate with other financial professionals and to critically evaluate modern financial theories.

Summary

- Brownian motion
- The Itô integral and Itô's Formula
- Stochastic Differential Equations
- Stochastic interest rates models and models of security prices
- Introduction to the valuation of derivative securities
- The Binomial model
- The Black-Scholes model
- Models for the term structure of interest rates
- Credit risk models

Main bibliography

- Institute and Faculty of Actuaries, *Subject CT8 Financial Economics Core Technical Core Reading for the 2017 exams*, Institute and Faculty of Actuaries, 2016.
- Guerra, J. (2013), *Stochastic Calculus for Models in Finance*, Lecture Notes, ISEG, 2013.
- Hull, J. (2008) *Options, futures and other derivatives*, 7th ed., Prentice Hall.
- Mikosch, T. (1998), *Elementary Stochastic Calculus with Finance in view*, World Scientific.
- Oksendal, B. (2003), *Stochastic Differential Equations: An Introduction with Applications*, 6th edition, Springer.
- Björk, Tomas (2004), *Arbitrage Theory in Continuous Time*, second edition, Oxford University Press.

Teaching and assessment methodologies

In classes, we shall discuss the syllabus topics in sequential order. However, we will point the multiple connections and relations between the topics and models. In classes, the syllabus topics will be presented and we shall stimulate critical discussion about the different models and their underlying financial theories. The students should read parts of the books of the main bibliography and selected papers will be recommended for a deeper study of a particular area.
Assessment: The final grade is awarded on the basis of a written exam (75%) and of a computer based exam - numerical methods (25%). In the computer based exam, the students should use the software Excel or R.

COURSE CONTENTS

1. STOCHASTIC CALCULUS

1.1. The Brownian motion

1.1.1. Definition

1.1.2. Main properties of the Brownian motion

1.1.3. The geometric Brownian motion

1.1.4. Martingales in discrete and in continuous time

1.2. The Itô integral

1.2.1. The Itô integral for deterministic functions

1.2.2. The Itô integral for simple processes

1.2.3. Main properties of the Itô integral

1.2.4. The Itô integral for adapted and square-integrable processes

1.3. Itô's Formula

1.3.1. The one dimensional Itô formula or Itô lemma. Examples of application.

1.3.2. The multidimensional Itô formula

1.3.3. The martingale representation theorem

1.4. Stochastic Differential Equations

1.4.1. Itô processes and diffusions

1.4.2. The existence and uniqueness theorem

1.4.3. The geometric Brownian motion and mean reverting processes

1.4.4. The Ornstein-Uhlenbeck process

2. STOCHASTIC INTEREST RATE MODELS AND MODELS OF SECURITY PRICES

2.1. Introduction to deterministic and stochastic interest rates

2.2. Probability distribution and moments of the accumulated amount of a series of annual investments (exact or generated by simulation methods)

2.2.1. Independent annual rates of return (discrete or continuous random variables)

2.2.2. Dependent annual rates of return (discrete or continuous random variables)

2.2.3. Log-normal distribution of yields

2.2.4. Probability that a simple sequence of payments will accumulate to a given amount

2.3. The properties of the lognormal distribution and the lognormal model

2.4. Empirical tests of the lognormal model

3. VALUATION OF DERIVATIVE SECURITIES

3.1. Introduction to the valuation of derivative securities

3.1.1. Arbitrage and complete markets

3.1.2. Factors that affect option prices

3.1.3. Forward and futures contracts

3.1.4. European and American options

3.1.5. Bounds for options prices

3.1.6. The Put-Call parity and arbitrage opportunities

3.2. The Binomial model
- 3.2.1 The Binomial model with one time step
- 3.2.2 The Binomial model with two time steps
- 3.2.3 The Binomial model with n time steps
- 3.2.4 The risk-neutral pricing measure for a binomial lattice and the risk-neutral pricing approach
- 3.2.5 The binomial trees recombination
- 3.2.6 How to calculate the value of European and American options using the binomial model
- 3.2.7 How to calibrate a binomial model
- 3.2.8 The state-price deflator approach to pricing

3.3. The Black-Scholes model
- 3.3.1. Application of the Girsanov theorem and of the martingale representation theorem in continuous time
- 3.3.2. The Black-Scholes model assumptions
- 3.3.3. The Black-Scholes PDE and the Black-Scholes formula
- 3.3.4. How to calculate the value of European options using the Black-Scholes option-pricing model
- 3.3.5. The Black-Scholes model for assets with dividends
- 3.3.6. The martingale method. The risk-neutral pricing and the equivalent martingale measure
- 3.3.7. How to control the risk using the Delta hedging
- 3.3.8. The Deflator approach and its equivalence to the risk-neutral pricing approach
- 3.3.9. The Greeks and their interpretation: Delta, Gamma, Vega, Rho, Lambda and Theta

3.4. Value basic benefit guarantees using option pricing techniques

4. TERM STRUCTURE AND CREDIT RISK MODELS

4.1. Models for the term structure of interest rate
- 4.1.1. Introduction
- 4.1.2. Desirable characteristics of term-structure models
- 4.1.3. The risk-neutral approach to the pricing of zero-coupon bonds and interest-rate derivatives
- 4.1.4. The state-price deflators approach to the pricing of zero-coupon bonds and interest-rate derivatives
- 4.1.5. Features of the Vasicek bond price model
- 4.1.6. Features of the Cox-Ingersoll-Ross (CIR) bond price model
- 4.1.7. The Hull-White model
- 4.1.8. Limitations of one-factor models

4.2. Credit risk models
- 4.2.1 Introduction
- 4.2.2 Credit event and recovery rate
- 4.2.3 Structural models. Reduced form models and intensity based models
- 4.2.4 The Merton model
- 4.2.5 Two-state models for credit ratings with a constant transition intensity
- 4.2.6 The Jarrow-Lando-Turnbull model
- 4.2.7 Two-state models for credit ratings with stochastic transition intensity

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	FPEN-CA	Course name:	Pension Funds			ECTS credits:	4
Scientific field:	Statistics and Actuarial Science			Department:	Mathematics		
Curricular year:	2nd	Semester	1st	X	Type	Obligatory	
			2nd			Elective	x
Lecturer:	Fátima Pires de Lima						

Contact hours:

Lectures	Practicals	Lectures/Practicals	Total	Total workload
		26	26	112

Aims and scope

The aim of this subject is to provide the master students with the skills required to apply and develop the mathematical techniques used in modelling and evaluating cash-flows dependent on retirement, disability, and other uncertain risks present in Pension Funds, group insurance and other social plans.

Summary

- Introduction to some basic concepts in pension funds.
- Evaluation of liabilities regarding age-retirement benefits.
- Individual and aggregate methods of Funding in pension funds.
- Some considerations about the best estimate for the actuarial assumptions.
- Evaluation of liabilities regarding vested rights benefits.
- Evaluation of liability for D&D, early retirement and pre-retirement benefits.
- Pensions Accounting according to IAS19-R.
- DC pension plans
- Investment policy for pension funds
- ALM for Pension Funds

Main bibliography

- Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. & Nesbitt, C.J. (1997) *Actuarial Mathematics*, 2nd ed, The Society of Actuaries, Schaumburg, IL.
- Dickson, D., Hardy, M., and Waters, H. *Actuarial Mathematics for Life Contingent Risks*, (2009), Cambridge University Press.
- Lee E M, (1986) *An Introduction to Pension Schemes*, Institute of Actuaries and Faculty of Actuaries.
- Lima, Fátima, (2013). Lecture notes.
- Mcgill, D., (1989) *Fundamentals of Private Pensions*, sixth edition, Irwin, Homewood, Illinois.

Teaching and assessment methodologies

Sessions will be of theoretical and practical content, with oral presentations, accompanied by the projection of slides containing the main formulae and results, which will be explained, derived and exemplified. A significant part of the time will be devoted to drafting exercises and practical applications.
The final grade, on a 0-20 scale, is awarded on the basis of a written exam.

COURSE CONTENTS

1. Introduction to some basic concepts in pension funds

1.1 Definition of pension fund, pension plan and the various parties involved.

1.2 Classification of Pension Funds and Pension Plans.

1.3 Presentation of the structure division of pension systems on three pillars.

1.4 Presentation of the current formula for calculating old-age pension given by Social Security in Portugal.

1.5 Transition rules, currently in force, to calculating the Portuguese Social Security pension for old age.

1.6 Identify and interpret the common states and decrements for pension plans, and the parametric and tabular models, including Markov chain models, associate with these decrements.

1.7 Apply to calculations involving pension plans benefits approximation methods such as uniform distribution of deaths, constant force, Woolhouse and Euler.

1.8 Rules to constitute a closed pension fund, an open pension fund and a contract of collective membership of an open pension fund.

1.9 Classification of the type of benefits.

2. Individual methods of Funding in pension funds, contributions and normal funding for:

2.1 Pay -as-you –go

2.2 Initial Funding

2.3 Terminal Funding

2.4 Entry Age

2.5 Individual Level Premium

2.6 Unit Credit (Projected, Non-Projected and Corrected)

2.7 Individual Attained Age

3. Aggregate Methods of Funding in Pension Funds, contributions and normal funding for

3.1 Aggregate

3.2 Attained Age

4. Some considerations about actuarial assumptions

4.1 Factors affecting the choice of funding method.

4.2 Population data necessary to compute the liabilities value and demographic assumptions needed;

4.3. Description of the factors to consider in choosing the best estimate for the interest rate, salary scale, inflation, mortality table, disability rates, retirement age rates, turnover rates and population increments;

4.4. Distinction between economic assumptions.

5. Evaluation of liabilities regarding vested rights benefits
   - 5.1 Classification of pension plans in accordance with the vested rights.
   - 5.2 Some observations about the portability of acquired rights.
   - 5.3 Formulas for calculating the actual values of the vested rights benefits and of the corresponding liabilities.
   - 5.4 Normal contributions required to fund vested rights benefits.
   - 5.5 Valuation of the liabilities with the participants who had already termite their services.
   - 5.6 Value of the Minimum Fund required by the supervisory authority.
6. Evaluation of liability for D&D, early retirement and pre-retirement benefits
   - 6.1 Calculation's formula of the annual risk with disability.
   - 6.2 Methods of financing of disability liabilities.
   - 6.3 Determination of the reinsurance value in order to limit the annual risk with disability.
   - 6.4 Calculation's formula of the annual risk with death while active.
   - 6.5 Methods of financing the survival benefits.
   - 6.6 Determination of the reinsurance value in order to limit the annual risk with death.
   - 6.7 Liability with early-retirement and pre-retirement benefits and respective funding methods.
7. Pension Accounting according to IAS19R
   - 7.1 Identification of items necessary for the accounts of pension fund liabilities.
   - 7.2 Requirements in accordance with IAS19R.
   - 7.3 Special events such as Plan Terminations, Settlements, Curtailments and Termination Benefits.
   - 7.5 How to determine the financial ant the actuarial Gains and Losses.
8. DC pension plans
   - 8.1 Various types of DC Pension Plans.
   - 8.2 Expected value of the individual account, at retirement date, and the corresponding expected value.
   - 8.3 The special case of the DC Pension plan with target-benefit.
9. Investment policy for pension funds
   - 9.1 Principles for the pension's fund management.
   - 9.2 Aspects to include in the investment policy.
   - 9.3 Aspects to define the investment strategy.
   - 9.4 Measures of investment performance: IRR, TWR, Alpha, Beta, R2, Tracking Error, Sharpe Ratio and Information Ratio.
10. ALM for Pension Funds
    - 10.1 Actuarial Factors and their interrelationship in an ALM Model.
    - 10.2 Definition of Risk, Risk analysis and Risk Management.
    - 10.3 The Three main categories of ALM Models: Static Models, Dynamic Models, Stochastic Models.
    - 10.4 Macauley Duration, Convexity, stress tests and scenarios testing, and stochastic model.
    - 10.5 Model for simulate Mortality, termination, retirement and other decrements, annual salary increases, annual inflation and Investment Returns.

Degree:	2nd	Field of Study:	Actuarial Science		
Code:	TARIF-CA	Course name:	Ratemaking and Experience Rating	Credits ECTS:	4
Scientific field:	Statistics and Actuarial Science			Department:	Mathematics

Curricular year:	2nd	Semester	1st	X	Type	Obligatory	
			2nd			Elective	X

Lecturer:	Alfredo Duarte Egídio dos Reis			
Contact hours:	Lectures	Practicals	Lectures/Practicals	Total
			26	26

Total workload
112

Aims and scope
On completion of the subject the student should be able to build a tariff for some sorts of insurance, particularly those for big portfolios, like in the motor insurance line of business. To achieve that, it is necessary to bring tools that model the past experience onto the portfolio future rating. Thus, the student should get solid knowledge on Credibility Theory, Bonus-Malus Systems, as well as be able to apply his acquired knowledge on Generalized Linear Models to ratemaking.
Summary
• Introduction and concepts • Credibility theory • Bonus-malus systems • Experience rating and Generalized Linear Models. Applications
Main bibliography
• Denuit, M.; Maréchal, X.; Pitrebois, S. & Walhin, J-F. (2007), Actuarial Modelling of Claim Counts: Risk Classification, Credibility and Bonus-malus Systems, John Wiley & Sons, Chichester, England. • Klugman, S.A.; Panjer, H.H. & Willmot, G.E. (2008 or 2012), Loss Models, From Data to Decisions (3rd or 4th editions), John Wiley & Sons, Hoboken NJ. • Kaas, R., Goovaerts, M., Dhaene, J. & Denuit, M. (2008), Modern Actuarial Risk Theory: Using R (2nd edition), Springer. • Ohlsson, E. & Johansson, B. (2010). Non-Life Insurance Pricing with Generalized Linear Models, EAA series/EAA Lecture Notes, Springer.
Teaching and assessment methodologies
Lectures will be of a mixed type, theoretical and practical, where there will be a presentation of the theory and explanation, followed by practical illustration. Students will be asked to solve the given problems. Evaluation will be twofold: A final exam according to ISEG's exam regulations at the end of the semester and a project. Exam is individual and the project is a tariff build and made by group of students. Project grade has a weight of 20% in the final mark.

LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

COURSE CONTENTS

1. **Introduction and concepts**
2. **Credibility theory**
   - 2.1 The Credibility formula
   - 2.2 Classical and Bayesian methodology
   - 2.3 Bühlmann's model
   - 2.4 Bühlmann-Straub's model
   - 2.5 Exact credibility
   - 2.6 Parameter estimation
3. **Bonus-malus systems**
   - 3.1 Introduction and definitions
   - 3.2 The Credibility approach
   - 3.3 Markov Modelling
   - 3.4 Evaluation measures
4. **Ratemaking and Generalized Linear Models. Applications**

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	MSOLV	Course name:	Solvency Models			Credits ECTS:	4
Scientific field:	Finance			Department:	Management		
Curricular year:	2nd	Semester	1st: X 2nd:	Type	Compulsory: x Elective:		
Lecturer:	Hugo Borginho						

Contact hours:	Lectures	Practicals	Lectures/Practicals	Total	Total workload
			26	26	112

Aims and scope
• to introduce the objectives and specificities of the regulation of the insurance sector; • to understand the risks associated to the insurance sector and their dynamics; • to introduce the European supervisory architecture implemented in 2011; • to introduce the new European regulatory regime – Solvency II; • to gather knowledge of the Pillar I aspects of Solvency II, namely the valuation of assets and liabilities, technical provisions, own funds and capital requirements (SCR and MCR); • to gather knowledge of the Pillar II aspects of Solvency II, namely the system of governance, ORSA, capital add-ons and supervisory review process; • to gather knowledge of the Pillar III aspects of Solvency II, namely requirements on public disclosure and reporting to supervisors.
The main competences to be developed are: • the ability to identify and understand the dynamics of risks underlying insurance activities; • the ability to perceive and interpret the regulatory requirements applicable to the insurance sector.

Summary
• Insurance basics and need for regulation • European financial supervision architecture • Risk fundamentals • New European regulatory regime: Solvency II

Main bibliography
• International Actuarial Association (2004), A Global Framework for Insurer Solvency Assessment; • Directive 2009/138/EC of the European Parliament and of the Council of 25 November 2009 (on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II)); • Commission Delegated Regulation (EU) 2015/35 of 10 October 2014 supplementing Directive 2009/138/EC.

Teaching and assessment methodologies
Classes will combine Theory and Practice, with the presentation and discussion of slides. Students will be evaluated through a group work and respective presentation in class (weight of 30%) and an exam (weight of 70%). However, the grade of the exam should in no case be less than 8.0 (non-rounded mark).

COURSE CONTENTS

1. **Introduction to solvency models**
   - 1.1. Insurance basics
   - 1.2. Overview of the European insurance market
   - 1.3. Why regulate?
   - 1.4. Banks vs. insurers
2. **European financial supervision architecture**
   - 2.1. Origins of the financial crisis
   - 2.2. EU answers
   - 2.3. Recent developments
3. **Risk fundamentals**
   - 3.1. Risk definition and categories
   - 3.2. Components of risk
   - 3.3. Purpose and design of capital requirements
4. **Solvency II**
   - 4.1. Introduction to the Solvency II regime
   - 4.2. Pillar I – quantitative requirements
     - 4.2.1.Overview
     - 4.2.2.Valuation of assets and liabilities
     - 4.2.3.Own funds
     - 4.2.4.Capital requirements
     - 4.2.5.SCR standard formula
     - 4.2.6.Internal models
     - 4.2.7.Minimum capital requirement (MCR)
   - 4.3. Pillar II – qualitative requirements
     - 4.3.1.System of governance
     - 4.3.2.Own risk and solvency assessment (ORSA)
     - 4.3.3.Capital add-ons
     - 4.3.4.Supervisory review process
   - 4.4. Pillar III – transparency, reporting and disclosure of information