Stochastic Processes

Academic Year: (2023 / 2024) **Review date: 09-02-2024**

Department assigned to the subject: Statistics Department

Coordinating teacher: JIMENEZ RECAREDO, RAUL JOSE

Type: Compulsory ECTS Credits : 6.0

Year : 4 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Probbability (Year 2 - Semester 2)

SKILLS AND LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB3. Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.
CB4. Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
CB5. Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.
CG1. Students are able to demonstrate knowledge and understanding of concepts in mathematics, statistics and computation and to apply them to solve problems in science and engineering with an ability for analysis and synthesis.
CG2. Students are able to formulate in mathematical language problems that arise in science, engineering, economy and other social sciences.
CG5. Students can synthesize conclusions obtained from analysis of mathematical models coming from real world applications and they can communicate in verbal and written form in English language, in an clear and convincing way and with a language that is accessible to the general public.
CG6. Students can search and use bibliographic resources, in physical or digital support, as they are needed to state and solve mathematically and computationally applied problems arising in new or unknown environments or with insufficient information.
CE1. Students have shown that they know and understand the mathematical language and abstract-rigorous reasoning as well as to apply them to state and prove precise results in several areas in mathematics.
CE4. Students have shown that they understand the fundamental results from the theory of ordinary differential equations as well as the theory of partial derivative and stochastic equations.
CE7. Students are able to construct mathematical models of both discrete and continuous processes that appear in real world applications emphasizing the use of deterministic and stochastic difference and differential equations.
CE22. Students have shown that they understand the concept of random phenmena, and that they can apply the basic principles of probability calculus and the statistic inference, recognizing their applicability to real problems.
CE23. Students have shown that they understand the concepts of stochastic processes and queuing theory to model real world processes as well as to simulate them in a computer.

RA1. Students must have acquired advanced cutting-edge knowledge and demonstrated indepth understanding of the theoretical and practical aspects of working methodology in the area of applied mathematics and computing.
RA2. Through sustained and well prepared argument and procedures, students will be able to apply their knowledge, their understanding and the capabilities to resolve problems in complex specialized professional and work areas requiring the use of creative and innovative ideas.
RA3. Students must have the capacity to gather and interpret data and information on which they base

their conclusions, including where relevant and necessary, reflections on matters of a social, scientific, and ethical nature in their field of study.
RA4. Students must be able to perform in complex situations that require developing novel solutions in the academic as well as in the professional realm, within their field of study.
RA5. Students must know how to communication with all types of audiences (specialized or not) their knowledge, methodology, ideas, problems and solutions in the area of their field of study in a clear and precise way.
RA7. Students must possess the professional maturity necessary to choose and evaluate their work objectives in a reflexive, creative, self-determined and responsible way, for the betterment of society.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction to Stochastic Processes.
1.1. Basic Definitions and Notations.
1.2. Examples: branching processes and queues.
1.3. Review of Conditional Expectation.
1.4. Review of Characteristic Functions and applications.

2. Discrete time Markov Chains.
2.1. Basic Definitions and Notations.
2.2 Chapman-Kolmogorov Equations and classification of states.
2.3. Asymptotic results.
2.4. First Step Analysis.
2.5. Random Walks and Success Runs.
2.6 The Geo/Geo/1 queue.

3. Renewal Theory and Poisson process.
3.1 Definition and basic notions.
3.2 The Elementary Renewal Theorem.¿
3.3 The Key Renewal Theorem.
3.4 The Delayed Renewal Theorem.
3.5 Compound Poisson Process.

4. Continuous time Markov Chains.
4.1 Definition and basic notions¿
4.2 Chapman-Kolmogorov Equations and Limit Theorems
4.3 Birth and Death Processes (M/M/m queues).

5. Continuous time Markov Processes: Brownian Motion.
5.1 Brownian Motion and Gaussian Processes.
5.2 Variations and Extensions.
5.3 Hitting times.¿
5.4 Relation with Martingales.

LEARNING ACTIVITIES AND METHODOLOGY

- Clases magistrales: Presentación de conceptos, desarrollo de la teoría y ejemplos, 2.2 ECTS
- Clases de resolución de problemas: 2.2 ECTS
- Prácticas de ordenador: 0.6 ECTS
- Sesiones de evaluación (exámenes de evaluación continua y examen final): 1 ECTS

ASSESSMENT SYSTEM

40% of the final qualification is obtained in a final exam. The remaining 60% is the result of continuous evaluation based on the acquired abilities of the student by two midterm exams (40%), carry out practical data analyses, computer labs and explain the results they have obtained (20%).
In the extraordinary examination, the final grade will be the maximum between the previous system and 100% of the final exam.

% end-of-term-examination:	40
% of continuous assessment (assigments, laboratory, practicals…):	60

BASIC BIBLIOGRAPHY

- 1. Moshe Haviv. A Course in Queueing Theory. , Springer, 2013
- Sheldon M. Ross. Stochastic Processes. , Wiley, 1995