Introduction to Stochastic Processes (ISP)
— LMAC/MMAC/MEDC, 2^{nd} Sem. 2024/25

General info

- **Faculty**

  Manuel Cabral Morais

- **Contacts**

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  Floor 5 – Room 5.49 – Mathematics Building

- **General objectives**

  To develop skills to model stochastic systems and to identify and use the most common types of stochastic processes. The students should know how to solve basic problems associated to the Poisson process and derived processes, renewal processes, discrete and continuous time Markov chains [...].

- **Website**

- **Faculty website**

Detailed program

Due to time constraints, we only focus on mathematically tractable counting processes and discrete- and continuous-time Markov chains.[1]

Moreover, the program of the ISP course below has several sections followed by a: dagger (†), meaning that the section is very unlikely to be taught; double dagger ($\ddagger$), that is, we have to eventually shorten the presentation of the section.

0. Introduction to stochastic processes

0.1 Stochastic processes and their characterization

0.2 A pivotal characteristic of some stochastic processes

0.3 A few examples of stochastic processes

1. Poisson processes

1.1 Properties of the exponential distribution‡

1.2 Poisson process: three definitions

1.3 Event times in Poisson processes

1.4 Merging and splitting Poisson processes

1.5 Non-homogeneous Poisson process

1.6 Conditional Poisson process

1.7 Compound Poisson process

2. Renewal processes

2.1 Introduction

[1] Since *Brownian motion* is included in the syllabus of the course on *Introduction to Mathematical Finance* and the IMF course is taught in the first semester from the academic year 2021/22 onwards, it seemed appropriate to exclude this topic from the program of ISP.

Recommended bibliography

- Morais, M.C. (2024). *Stochastic Processes: Theory, Examples & Exercises*. IST Press, Lisboa — *Yellow Series (or Science & Technology Series)*, Volume 1.[2]
- Kulkarni, V.G. (1995). *Modeling and Analysis of Stochastic Systems*. Chapman & Hall, London. (QA274.12-.76.KUL.59065, QA274.12-.76.KUL.45259)
- Ross, S.M. (1983). *Stochastic Processes*. John Wiley & Sons, New York. (QA274.12-.76.ROS.36921, QA274.12-.76.ROS.37578)

[2]The most expedient way to purchase this book is online at *IST Press*, with an immediate 10% discount and free postage and handling. Alternatively, this book can be bought on-site at FNAC–IST (with a 10% discount with the FNAC card) or other on-site or online bookshops (Almedina, Bertrand, Wook, etc.). Moreover, to reduce the price of this book and promote the dissemination of knowledge at reasonable prices, the author does not receive any fees from its sale.

Optional bibliography

- Resnick, S. (1992). *Adventures in Stochastic Processes* Birkhauser, Boston.
  (QA274.12-.76.RES.43493)
- Ross, S.M. (2003). *Introduction to Probability Models* (8th. edition). Academic Press, San Diego, California.
  (QA273.ROS.62694)

Teaching material

- **Hyperlinks**
  - The hyperlinks on pages 473–475 of the IST Press can be found here.
  - Each hyperlink found in here leads to the detailed solution of the exercise in a test on Introduction to Stochastic Processes.
- **Mathematica notebooks**

  Mathematica functions are used throughout this book because they offer *flexibility in creating graphs and performing computations* regarding most of the topics the book covers, for instance, *Bernoulli processes*, *Poisson processes*, *renewal processes*, *discrete-time Markov chains*, *continuous-time Markov chains*, and *queueing systems*.

  We organized the *Mathematica* notebooks with the programs used in some *Examples*, *Exercises*, *Challenges*, and *Computational Exercises* by chapter/section. These notebooks are online.
- **Formulae**

  We added a list of relevant formulae at the end of the book and organized it chapter/section.
- **Tests**

  Detailed solutions of the tests from 2012/13, 2013/14, 2018/19, 2019/20, 2020/21 are available at https://fenix.tecnico.ulisboa.pt/homepage/ist13114/detailed-solutions-of-the-tests
- **Tables**

  Available at https://fenix.tecnico.ulisboa.pt/homepage/ist13114/formulae-and-tables

Classes and schedule

- **Classes**

  In English, in case there are any students who do not speak Portuguese, and with the following structure: motivation, result, example, exercise. The exercises are chosen and assigned to students in advance, and are solved by the students on the blackboard for *Mathematics is better learned actively than passively* (Karr, 1993, p. ix).
- **Schedule (classrooms)**

  Mon., 08:00–10:00 (weeks 1–7, P12, Mathematics Building; weeks 11-17, V1.15, Civil Engineering Building)

  Tue., 08:30–10:00 (weeks 1-2, 4-7, 11-16, VA4, Civil Engineering Building)
- **Office hours**

  Proposed: Mon., 14:00–15:45, zoom (https://videoconf-colibri.zoom.us/j/99576910983)

  The professor will eventually leave the zoom room if the students are more than 30 minutes late.
- **Extra office hours**

  By appointment preferably by sms (927941249), tel. (218417047 or Ext. 1047) or e-mail (maj@math.ist.utl.pt), at least 24 hours in advance.

Assessment method

- The assessment method comprises:
  - four 30 minute tests (*MAP30*).
- The two hour (recovery) exam will cover all chapters/sections taught and its date is announced here:
  - July 8, 2025 (Tue.), 8:00–10:00.
- To pass the course:
  - the sum of the scores of the 30 minute tests has to exceed 9.4 points (out of $4 \times 5 = 20$) points;
  - or the mark of the two hour exam has to be exceed 9.4 (out of 20) points.

  Whenever a student takes the exam, the mark obtained in it is considered for the final mark if and only if it exceeds the sum of the scores of the four 30 minute tests.
- Permitted material

  The only material allowed during 30 minute tests and the two hour exam is:
  - test/exam sheet and scrap paper (WITHOUT any written COMMENTS or ADDITIONS);
  - IST Press book;
  - tables (WITHOUT any written COMMENTS or ADDITIONS);
  - calculator.

  The use of any other material is punishable and can lead to the annulment of the test or exam.

  The use of mobile phones is also forbidden during the four 30 minute tests and the two hour exam.
- Personal identification

  The student (or identity card) should be taken to the four 30 minute tests and the exam.