# Mathematics for Management

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***COURSE AIMS AND INTENDED LEARNING OUTCOMES***

The course has the objective of introducing quantitative and numerical instruments for the formalization and the study of dynamic problems in a wide range of fields: Industrial Organization, Finance, Research & Development Decision Making, Supply Chains and, more in particular, Management.

At the end of the course, students will be able to:

* develop the knowledge and understanding of the dynamical systems theory (knowledge);
* understand theoretical and conceptual mathematical models which incorporate issues related to the social responsibility of firms (knowledge);
* apply dynamical systems theory to solve exercises (intellectual skills);
* effectively translate a real management situation into a mathematical model by using a rigorous and essential language (intellectual skills);
* apply a mathematical model of a complex system in order to critically develop and analyze viable solutions for the business problem under investigation and choose among them (transferable skills);
* operate effectively within an international multicultural team engaged in complex business and managerial problems involving both qualitive and quantitative perspectives (transferable skills).

***COURSE CONTENT***

The course is organized in two parts.

First part: *Continuous-time models*

– Basic Definitions of Dynamical Systems Theory (fixed point, local stability, global stability).

– One-Dimensional Systems (from linear to nonlinear differential equations).

– Local Bifurcations in One-Dimensional Systems: Transcritical, Pitchfork, Flip.

– Two-Dimensional Systems (from linear to nonlinear systems of differential equations).

– Local Bifurcations in Two-Dimensional Systems: Saddle-Node, Andronov-Hopf.

– N-dimensional systems (from linear to nonlinear systems of differential equations).

– Deterministic Chaos and the Butterfly Effect.

– Applications to Industrial Organization, Environmental Management, Natural Resource Management, R&D Management, Evolutionary Games and other fields (for instance, Epidemic Models & Covid-19).

Second part: *Discrete-time models*

– Differences between continuous-time and discrete-time formulation of dynamic models.

– One-Dimensional Maps (from linear to nonlinear difference equations).

– The Logistic Map and Deterministic Chaos in discrete time.

– Local Bifurcations in One-Dimensional Maps: Transcritical, Pitchfork, Flip.

– Two-Dimensional Maps (from linear to nonlinear systems of difference equations).

– Local Bifurcations in Two-Dimensional Maps: Saddle-Node and Neimark-Sacker bifurcation.

– Piecewise-Linear Maps and Border-Collision Bifurcations.

*–* Applications to Industrial Organization, Corporate-Social Responsibility, Finance, and other fields.

***READING LIST***

*Required readings*

G.I. Bischi, F.Lamantia, D.Radi, *Lecture Notes on Dynamical systems in Economics and Finance*. 2014. Avilable on the e-leanring platform *Blackboard.*

Exercise Sets and additional materials available on *Blackboard*.

The material on Blackboard is self-contained and covers all the topics of the course.

***TEACHING METHOD***

To stimulate the active intervention of students, teacher lectures will be alternated with exercise sessions, practical sessions with a software for numerical simulations and case studies. Instructional materials is published on the *Blackboard* Platform.

***ASSESSMENT METHOD AND CRITERIA***

Students can choose between a multiple assessment route and a single assessment route.

*Multiple assessment route*

Students are evaluated through an interim teamwork and a final written test.

For the teamwork, students will be subdivided into groups made up by 3 or 4 students. Groups are expected to deliver a final report including the application of mathematical tools to real-case situations and present it in class. Detailed information regarding the extepcted output will be published in Blackboard. All the members of a group will receive the same evaluation.

 The written test includes a part of exercises and a part of theoretical open questions (weights: 50% for the exercises and 50% for the theoretical questions). The part of exercises is made up by 2 or 3 exercises. The points associated to each exercise will be clearly indicated. The part of theoretical questions is made up by two main questions (one for each part of the program) and several sub-questions. The amount of points achievable is specified for each sub-question.

In the evaluation half points are admitted. The final mark is obtained by calculating the weighted average (the teamwork provides 1/3 of the final evaluation while the written test the remaining 2/3). If this mark is not an integer number it will be approximated by excess. If the final mark is 30 without any approximation, it will be considered a 30 *cum laude*.

Even though attendance is not mandatory for a PASS in the multiple assessment route, it is strongly recommended.

A student can take the final written test of the multiple assessment tool only in the first exams’ session (i.e. two dates) following the term where the lessons are given. After that, all the students will have to take the single assesment route.

*Single assessment route*

Students are evaluated through a final written exam.

The written test includes a part of exercises, a part of theoretical open questions, and a part of open questions about business cases and the software for numerical simulations (weights: 35% for the exercises, 35% for the theoretical questions, 15% for the question about business cases and 15% for the software).

The part of exercises is made up by 2 or 3 exercises. The points associated to each exercise will be clearly indicated. The part of theoretical questions is made up by two main questions (one for each part of the program) and several sub-questions. To each sub-question will be clearly indicated the amount of point they permit to achieve.

In the evaluation half points are admitted. The final mark is obtained by calculating the weighted average (see weights above). If this mark is not an integer number it will be approximated by excess. If the final mark is 30 without any approximation, it will be considered a 30 *cum laude*.

Even though attendance is not mandatory for a PASS in the single assessment route, it is strongly recommended.

*Assessment criteria*

The student's preparation is evaluated according to grading scales which are published in Blackboard.

***NOTES AND PREREQUISITES***

*N. ECTS* - 8

*Enrollment requirements* - It is required to have a basic knowledge of the typical topics of an undergraduate course in Mathematics for Economics, such as the study of a real-valued functions, derivatives, partial derivatives and linear algebra. Suggested book which covers these topics: G. Bosi, C. Corsato, M.E. Zuanon, Essential Mathematics for Economics, Apogeo Education – Maggioli Editore, 2018.

*Language of instruction* - English

*Time* – I term; 7.5 hours per lecture week (7.5 x 8 weeks = 60 hours in total).

*Attendance* – Even though attendance is not mandatory for a PASS, it is strongly recommended.

*Associated courses* – Statistics for big data, Supply chain management

*International dimension* – International teaching materials are used throughout the course.

*Business connection* - The course makes extensive use of contemporary business cases and examples.

*Professional context* - In professional life, the proper usage of quantitative tools of dynamical systems theory is helpful to support a comprehensive decision making in a wide range of business fields.

*Further information* – Additional information regarding the course schedule and delivery, learning assessment, expectation and policies, general announcements, and additional course materials will be posted on Blackboard.