UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Mathematics, Statistics and Informatics

2425-1-E1301Q088

Aims

The course Mathematics and Informatics gives the background to acquire the basic knowledge about the fundamental definitions and results of calculus, together with the main concepts of informatics, with a particular focus on the relationships between computer science and biology (e.g. biological databases and problems in bioinformatics).

1. Knowledge and understanding.

At the end of the course the student will gain knowledge about:
- the basic mathematical definitions and their meaning;
- “computational thinking”, in order to critically use concepts and tools of computer science (algorithms, computational methods, software) for the solution of a given problem;
- the choice of the proper sampling and statistical methods, and the interpretation of outcomes in the analysis of biological data.

2. Ability to apply knowledge and understanding.

At the end of the course, the student will be able to apply the knowledge listed in item 1 to solve the proposed exercises in mathematics, to solve and analyze problems in statistics, and to apply the computational tools for the solution of problems in biological applications.

3. Making judgment.

The student will be able to process the acquired knowledge by identifying the appropriateness of the applications of the mathematical definitions, and choosing the proper statistical and computational methods for different applications.

4. Communication skills.

At the end of the course the student will be able to use an appropriate scientific vocabulary, and to communicate with adequate language in oral/written reports.

5. Learning ability.

At the end of the course, the students will have acquired the necessary competencies to tackle in autonomy the mathematical problems that they will encounter during the course of studies, and will be able to apply the learned skills in those courses that have these as prerequisites. The student will also gain skills in the elaboration, analysis, and application of the acquired knowledge in other courses related to the application of statistical and computational methods for biological data analysis.

Contents

Mathematics

Vector calculus, matrix algebra, eigenvalues and eigenvectors, asymptotic behaviour and study of function of one variable, derivation, functions of two or more variables, differential operators, expansion in power series of elementary functions, integration of elementary functions, integration of elementary ordinary differential equations.

Statistics
Fundamentals of descriptive (population and sample, measures of centre/dispersion/position, graphical representations) and inferential statistics (probability distributions, hypothesis testing) for the analysis of biological data.

Informatics

Introduction to computer science. Algorithms, computational thinking, and basics of structured programming. Notions of computational complexity. DNA computing. Fundamentals of bioinformatics, computational biology, systems biology. Bio-inspired meta-heuristics.

Detailed program

Mathematics

Vector calculus (scalar and vector product, equation of a straight line in vector form), matrix algebra (basic definitions, algebra of matrices, determinant, inverse, transpose, eigenvalues and eigenvectors), asymptotic behaviour and study of function (basic definitions, elementary functions, trigonometric functions, power laws, exponential functions, logarithmic functions, limits , asymptotes, rules of differentiation, stationary points, maxima and minima of function), functions of two or more variables, gradient, divergence, curl, expansion in power series of elementary functions (power series, Taylor's expansion of a function, expansion of exponential, expansion of elementary trigonometric functions), integration of elementary functions (basic definitions, rules of integration, integration by change of variable, integration by parts), integration of elementary ordinary differential equations (integration by separation of variables, general solution, particular solution, application to population dynamics).

Statistics

1) Descriptive statistics. Introduction to statistics (types of data, collecting sample data). Summarizing and graphing data (frequency distributions, histograms, boxplots). Statistics for describing, exploring and comparing data (measures of center, measures of variation, measures of relative standing).

2) Inferential statistics. Basic concepts of probability. Probability distributions (uniform, binomial, normal, t distribution). Sampling distributions and estimators. Hypothesis testing. Correlation and regression.

Computer Science

1) Introduction to Computer Science. What informatics deals with, what algorithms are, what a computer is and what it can do, what software is.
2) Computational Thinking. From problems to algorithms. Search and sorting algorithms.
3) Algorithms and Programs: Properties of algorithms, representation of algorithms, from algorithms to programs.
4) Computational Complexity, Heuristic Algorithms, how biology ban help Informatics (to help biology). Do all problems have a solution? Decision and optimization problems. Efficiency of algorithms and computational complexity. DNA computing and bio-inspired algorithms.
5) Introduction to Bioinformatics. What bioinformatics deals with, biological databases, alignment of DNA or amino acid sequences.
6) Introduction to Machine Learning. Difference between supervised and unsupervised machine learning. Regression and classification problems. Training and testing. Evaluation of machine learning models' performance.

Prerequisites

Mathematics

Basic concepts of algebra and geometry, concept of number, elementary and periodic function, calculus on power laws, concept of equation and inequality, fundamental equation of straight line, circle and parabola.

Statistics

None.

Informatics

Basic notions of biology.

Teaching form

The course is entirely delivered in Italian.

Mathematics

The teaching of the course includes both lectures and exercises. Lectures are theoretical lessons in which the knowledge of definitions, results and relevant examples is given. The exercises involve the resolution of exercises and the analysis of mathematical problems, allowing the student to verify his/her ability to apply the theoretical notions acquired during the lectures. For this modules, there will be tutorials aimed at improving the capabilities of students.
A hybrid teaching approach is used, that combines lecture-based teaching (DE) and interactive teaching (DI). DE involves detailed presentation and explanation of theoretical content. DI includes active student participation through exercises and problems, short presentations, group discussions, and group or individual work. It is not possible to precisely determine in advance the number of hours dedicated to DE and DI, as these methods are dynamically intertwined to adapt to the course's needs and promote a participatory and integrated learning environment, combining theory and practice.

Statistics and Informatics

About 90% of the lessons will be delivered in-person, supported by PowerPoint presentations and Wooclap polls to encourage student participation.
Approximately 2 interactive lessons are planned, involving group work.
About 2 lessons will be conducted in a blended remote (asynchronous) mode, where students will independently prepare theoretical topics that will then be elaborated in class.
There will be 5 laboratory activities. The labs will be supported by tutoring sessions for using spreadsheets and bioinformatics tools, as well as for solving exercises assigned by the instructor.
All teaching activities will be recorded and made available through the Moodle platform.

Textbook and teaching resource

Mathematics

Material presented on the board by the lecturer.
Auxiliary recommended textbook:
- D. Benedetto, M. Degli Esposti, C. Maffei, “Matematica per le scienze della vita”, Casa Editrice Ambrosiana, or any other equivalent textbook for undergraduates in physical sciences.

Statistics

All the educational material – slides and video recordings of lectures/tutoring hours - will be available on Moodle platform.
Textbooks:
- M.M. Triola, M.F. Triola. Fondamenti di statistica per le discipline biomediche, Pearson, 2017
- M.C. Whitlock, D. Schluter. Analisi statistica dei dati biologici, Zanichelli, 2022

Informatics

All the educational material – slides and video recordings of lectures/tutoring hours - will be available on Moodle platform.
Textbooks:
- M.G. Schneider, J.L. Gersting. Informatica. Algoritmi, architetture, linguaggi, applicazioni. Maggioli Editore, Apogeo Education, 2020
- M. Helmer Citterich, F. Ferrè, G. Pavesi, C. Romualdi, G. Pesole. Fondamenti di Bioinformatica. Zanichelli, 2018

Semester

Annuals
Mathematics: first semester
Statistics and Informatics: second semester

Assessment method

Mathematics

Written exam consists of a test of 1 hour or 1 hour and 15 minutes based on multiple-choice questions on topics presented during the course and tutorials aimed at evaluating the ability of students to apply the acquired competences to solve proposed exercises in Mathematics. First-year students regularly enrolled can take a test on Mathematics at the end of the Mathematics term, following the same assessment method used for the ordinary official examination. No partial test will be set during the course, and both the Mathematics test and the complete examination test will check the competences acquired during the whole cycle of lectures. There is no oral examination.

Statistics and Informatics

Written exam consists of a test of 1 hour and 15 minutes based on multiple-choice questions and open questions about the topics presented during the lectures and tutoring hours, aimed at evaluating the ability of the student to apply the acquired competences to solve the proposed exercises and theoretical aspects on Statistics and Informatics. First-year students regularly enrolled can take a test on Statistics and Informatics at the end of the Statistics and Informatics term, following the same assessment method used for the ordinary official examination. No partial test will be set during the course, and both the Mathematics test and the complete examination test will check the competences acquired during the whole cycle of lectures. There is no oral examination.

Office hours

By appointment with the lecturer through e-email.

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Statistics and Informatics: chiara.damiani@unimib.it

Sustainable Development Goals

QUALITY EDUCATION