UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Matematica e Informatica

2021-1-E1301Q085

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 know the basic definitions and their meaning, and will gain knowledge about “computational thinking”, in order to critically use concepts and tools of computer science (algorithms, computational methods, software) for the solution of any given problem.

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, 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 definitions, and choosing the proper 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 the adequate language in oral/written reports.

5. Learning ability.

At the end of the course the student will have acquired the necessary competences 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 computational methods for biological data analysis.

Contents

Mathematics

Vector calculus, matrix algebra, eigenvalues and eigenvectors, asymptotic behaviour and study of function, derivation, expansion in power series of elementary functions, integration of elementary functions, integration of elementary ordinary differential equations.

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), 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).

Informatics

1) Introduction to computer science. Principles of computer operations (von Neumann architecture, fetch-execute cycle). Data representation.

2) Computational thinking and basics of structured programming. Definition of algorithm. From problems to algorithms, from algorithms to programs. Programming languages. Structured programming and pseudo-code. Notions of computational complexity. DNA computing: Adleman’s experiment.

3) Fundamentals of bioinformatics, computational biology and systems biology. Biological databases.

Sequence alignment: algorithms and heuristics.

Protein folding, molecular docking. Computational approaches for complex biological systems.

4) From biology to computer science: bio-inspired computational methods, and their applications in bioinformatics.

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.

Informatics

Basic notions of biology.

Teaching form

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.

Informatics

Classroom lectures supported by PowerPoint slides.

All lectures will be videorecorded and published on 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.

Informatics

All the educational material – slides and videorecordings - will be available on Moodle platform.

Textbooks:

M. Helmer Citterich, F. Ferrè, G. Pavesi, C. Romualdi, G. Pesole. Fondamenti di Bioinformatica. Zanichelli, 2018

S. Pascarella, A. Paiardini. Bioinformatica. Dalla sequenza alla struttura delle protein. Zanichelli, 2011

Semester

Annuals

Mathematics: first semester

Informatics: second semester

Assessment method

Mathematics

The written exam paper consists of solving 4 assigned questions, each regarding a particular topic presented during the course. The trial consists of an individual exposition of the solution to each of the 4 assigned questions (complete with all necessary computations) done without any auxiliary equipment, such as textbooks, pocket computers or personal notes. Questions reproduce similar exercises proposed during the course.

The written exam paper must show operational capability to tackle and solve the proposed questions by using the acquired knowledge and the necessary competence to reproduce the topics presented during the course.

First-year students regularly enrolled can take partial trials on portions of the programme, following the same methodology proposed for the official examination.

There is no oral examination.

Informatics

Written exam (2 hours), consisting in multiple-choice questions and open questions about the topics presented during the classroom lectures. No "in itinere" tests will be done.

Office hours

On demand by e-email to the lecturer.

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