UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Fondamenti dell'Informatica

2526-1-E3102Q101

Aims

The course provides the theoretical and formal foundations of computer science, with particular emphasis on discrete mathematics, logic, and automata theory.
Its objective is to develop students’ ability to model and analyze computational problems using rigorous tools, fostering appropriate levels of abstraction, formalization, and deductive reasoning. Exercises on both theoretical and applied problems will play a central role.
By the end of the course, students will have acquired essential theoretical, methodological, and practical tools to rigorously tackle the conceptual complexities typical of the computer science curriculum.

1. Knowledge and understanding
By the end of the course, the student will:

- know the theoretical and computational foundations of computer science, including discrete mathematics, set theory, logic, and automata;
- understand the role of abstract structures in modeling computational problems;
- have internalized the distinction between syntax and semantics.

2. Applying knowledge and understanding
The student will be able to:

- understand a text or a computational problem defined in formal terms
- model complex problems using sets, relations, functions, graphs, and formal logic;
- apply recursion, construct proofs, use deductive systems, and design finite-state automata;
- use formal languages to analyze computational structures and systems.

3. Making judgements
The student will develop the ability to:

- understand the formal language used in theoretical and applied computer science;

- evaluate the correctness and adequacy of models and proofs;
- choose appropriate formal tools for the problem at hand.

4. Communication skills
The student will be able to:

- clearly and precisely communicate formal concepts and models;
- use appropriate technical language in computer science contexts.

5. Learning skills
The student will be able to:

- approach theoretical and practical content with increasing autonomy;
- apply acquired knowledge in advanced courses and interdisciplinary contexts.

Contents

The course introduces the fundamental mathematical and formal tools essential for understanding computer science, including the acquisition of a basic formal language (sets, functions, relations), the study of abstract structures for conceptualization (graphs, trees, orderings, lattices, and algebraic structures), mathematical tools such as recursion and induction, the essential principles of mathematical logic, both propositional and predicate logic, and an introduction to automata theory.

Detailed program

Section 1 | "Sets, Relations, and Functions"
Topics: Discrete mathematics; numbers; sets; subsets; power set; extensional and intensional representations; set operations; families of sets; partitions; ordered pairs/tuples; Cartesian product; relations; domain and codomain; operations on relations; properties of relations; representations of relations (arrow/graph), Cartesian diagram, table); properties of relations; bipartite graphs; Boolean matrices; operations on Boolean matrices: join, meet, Boolean product (composition of relations); equivalence relations; equivalence classes; quotient set; functions; properties of functions; arity; fixed point; operations; inverse image; function composition; inverse function; characteristic function; multisets; cardinality and functions; Cantor's theorem.

Section 2 | "Graphs, Trees, Orderings, and Boolean Algebra"
Topics: Graphs, degree, (semi)paths, cycles, distance, DAGs, induced subgraphs, labeled graphs, complete and connected graphs, graph isomorphism; trees; depth and height; binary trees; properties of binary trees (full, complete, balanced); orderings; posets; coverings, extremal elements, join and meet; Hasse diagrams, lattices, types of lattices; complement; complemented lattices; algebraic structures; Boolean lattices; Boolean algebra; logical operations.

Section 3 | "Induction and Recursion"
Topics: Difference between recursion and induction; definitions; axioms, hypotheses, and theorems; recursion: base case and recursive function; well-founded sets; recursive code; recursive functions on strings and complex structures; proofs by induction: base case, inductive hypothesis, inductive step; strong induction.

Section 4 | "Propositional Logic"
Topics: Atomic propositions; operators and precedence; well-formed formulas; syntax tree; semantics; Boolean assignments; Boolean evaluations; truth tables; compositionality; equivalences; completeness; models and

countermodels; types of formulas: tautologies, contradictions, satisfiable but non-tautological formulas; logical systems; logical consequence relation ?; satisfiability; deductive systems; inference rules; axioms; proofs and theorems; derivability ?; deductive closure; properties of deductive systems (inclusiveness, monotonicity, compactness, premise cutting, deduction); connection between logical and deductive systems; soundness and completeness; decidability; propositional tableaux.

Section 5 | “Predicate Logic”
Topics: Syntax of predicate logic: variables, constants, functions, predicates, operators, logical constructors, quantifiers; arity of functions and predicates; focus on universal and existential quantifiers; terms, atoms, and well-formed formulas; free and bound variables; statements; semantics of predicate logic; first-order interpretation or structure: domain, interpretation function; assignments; atomic satisfiability; substitutions; models and tautologies; semantic equivalences; first-order theories; knowledge representation; from formulas to natural language and vice versa; logical systems vs. deductive systems; predicate tableaux.

Section 6 | “Introduction to Formal Languages: Finite-State Automata”

Prerequisites

High school-level mathematical skills.

Teaching form

The planned activities are:

- 48 hours of **frontal lessons** in lecture mode
- 20 hours of **exercise** in interactive mode.

Usage of the e-learning platform.
Course language: **Italian**.

Textbook and teaching resource

Luigia Carlucci Aiello, Fiora Pirri, “Strutture, logica, linguaggi” (Pearson, 2005).

The textbook is in Italian. Alternative books in English can be suggested upon request.

Semester

1st Semester

Assessment method

Final exam (without intermediate tests) that consists of two separate tests: written test and oral test.

The **written test** includes ten questions on all the topics addressed in the course and is evaluated with a mark ranging from 0 to 30. Each question includes three sub-questions, each belonging to one of the following types of exercises: open questions on a topic, questions that require reasoning and deduction, resolution of exercises requiring calculation or development of a solution to an assigned problem, with prevalence of exercises of the third type .

The **oral test** consists in the evaluation of the knowledge acquired about the course topics through open questions, possibly related to the mistakes made during the written test.

Those who have taken a sufficient mark, that is, greater than or equal to 18/30, are admitted to the oral test (optional) or can register their mark.

Office hours

On demand.

Sustainable Development Goals

QUALITY EDUCATION