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DISI — University of Trento
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Computability and Computational Complexity

Introduction to the course

Organization

- 6-credit course,
- 48 mandated hours of frontal lectures.
- 4 hours per week:
  - Mondays: 10:30—12:30
    Suspended on December 7 (Immaculate conception bridge holiday);
  - Tuesdays: 13:30—15:30
    Suspended on December 8 (Immaculate conception national holiday).

In total:

$$15\,\text{weeks} \times 4\,\frac{\text{hours}}{\text{week}} = 60\,\text{hours},$$

time for discussions, exercises, Q&A sessions.

Course material

Find all material at `https://comp3.eu/`:

- These slides
- Lecture notes
- Up to date program
- Videos of lectures
- Exams from previous years
- Book references, papers, etc.

Moodle / Didattica Online

We won't use Moodle apart from the following exceptions:

- urgent notifications (e.g., lecture cancellation or time changes);
- forum: if you have anything to discuss publicly, you are more than welcome to use it.

Hence, *please register!*

Special educational needs (BES) and Specific Learning Disorders (DSA)

If you have any particular learning or educational need, please write me an email to discuss possible compensatory measures (for the exam, but also for lectures).

Exam

- The exam is written (pen and paper):
  - Two or three exercises (theory and/or practical questions)
  - Plenty of examples on the webpage and in the lecture notes
  - Three hours time (no hurry)
  - Aimed at assessing learning outcomes.

Prerequisites

- Mathematical logic
  - logical connectors, quantifiers, basic propositional calculus;
  - being able to follow the proof of simple theorems.
- Mathematics
  - polynomials, logarithms, exponentials;
  - positional representation of integers in different bases.
- Programming, algorithms and data structures
  - knowledge of a specific programming language is not required,
  - **but** being able to describe algorithms and data structures is essential!
  - We will often resort to informal pseudo-code.

Syllabus (outline)

- Computability
  - Turing machines.
  - Decidable languages and computable functions.
  - The Halting Problem.
  - Turing reductions. Other undecidable languages and non-computable functions.
  - Rice's Theorem.
- Computational Complexity
  - Problem instance size, measures of complexity, classification of problems.
  - Time complexity classes: **P**, **NP**, **EXP**.
  - Polynomial reductions. **NP**-completeness. Cook-Levin Theorem. Study of **NP**-complete problems.
  - Randomized complexity classes: **RP**, **PP**, **BPP**.
  - Advanced topics, depending on available time (space complexity classes, polynomial hierarchy, counting classes, interactive proofs, approximations...)

Books

Not required, but useful.

- Sanjeev Arora and Boaz Barak.
  Computational Complexity: A Modern Approach.
  Cambridge University Press, 2009.
  ISBN 9780521424264
  Draft of the book available at `http://theory.cs.princeton.edu/complexity/`
- Christos H. Papadimitriou.
  Computational complexity.
  Addison Wesley (Pearson College Div.), 1994.
  ISBN 9780020153085
- John E. Hopcroft, Rajeev Motwani, and Jeffrey D. Ullman.
  Introduction to Automata Theory, Languages and Computation.
  Pearson new International Edition, 2013.
  ISBN: 9781292039053

This would be a great time to ask questions.