# THEORETICAL COMPUTER SCIENCE
# WS 2018

VERA FISCHER

This is a master level course in theoretical computer science. We will cover central topics in recursion theory and computational complexity. **The lectures are taking place Fridays from 16:00 to 18:20 at the Seminar room of the KGRC (room 101).** The final exam will be oral.

Detailed information on the material covered during the semester, including relevant references to the literature, will be regularly given here. Our two main textbooks are listed below. Both of those textbooks are available for **free download** via the **University of Vienna Library**. The book of Herbert Enderton, *Computability theory. An introduction to recursion theory*, gives a detailed introduction to the subject of recursion theory and will be used in the beginning of the course. The book of Sanjeev Arora and Boaz Barak, *Computational complexity. A Modern Approach*, gives a comprehensive account of many interesting topics in computational complexity. Another excellent source is [3].

**Dates for the final exam are 28.01.2019 and 28.02.2019. If you would like to take the final exam in one of those two dates, please send me an E-mail a couple of days in advance.**

**Lecture 1, 12.10.:** We defined the classes of primitive recursive and general recursive functions. The notions of register machine, as well as function computable by a register machine were defined. Most of the material can be found in Sections 1.2 and 2.1 of [1].

**Lecture 2, 19.10.:** We proved that every register machine computable function is general recursive, and considered a universal register machine which simulates every register machine computation. The material can be found in Sections 3.1 and 3.2 of [1].

**Lecture 3, 09.11.:** In the lecture, we introduced the notion of recursive enumerability, proved the Theorem of Kleene and showed that a partial function is computable if and only if its graph is a recursively enumerable relation.

**lecture 4, 16.11.:** There were two main theorems proved in the lecture: the Parameter Theorem and the Theorem of Rice. The material can be found in Chapter 4 of [1].

**Lecture 5, 23.11.:** Turing degrees and the jump operation. The material corresponds to Chapter 6 of [1].

**Lecture 6, 30.11.:** Turing machines; configuration graph; time complexity classes;

**Lecture 7, 07.12.:** Time hierarchy theorem; non-deterministic Turing machines; space complexity classes;

**Lecture 8, 14.12.:** We looked at relations between complexity classes, proved the theorem of Savitch and concluded that the classes of polynomial space and non-deterministic polynomial space coincide; For a given complexity class $\mathfrak{C}$ we introduced the notion of $\mathfrak{C}$-completeness.

**Lecture 9, 11.01.:** We proved the Space Hierarchy Theorem, we showed that CIRCUIT SAT is reducible to SAT, CIRCUIT VALUE is reducible to CIRCUIT SAT and that HAMILTON PATH is reducible to SAT. We proved that CIRCUIT VALUE is $\mathbb{P}$-complete.

**Lecture 10, 18.01.:** We showed that REACHABILITY is reducible to CIRCUIT VALUE and proved Cook's theorem. We proved the Theorem of Immerman-Szelepscényi and discussed the notion of co-Classes showing that for certain functions $f$, non-deterministic-f-space classes are closed with respect to comlpements.

**Lecture 11, 25.01.:** The lecture will be given by Prof. Dr. Benjamin Miller and will cover chapter 5 of [1].

## References

[1] H. Enderton *Computability theory. An introduction to recursion theory.* Elsevier/Academic Press, Amsterdam, 2011. xii+174 pp. ISBN: 978-0-12-384958-8.
[2] S. Arora, B. Barak *Computational complexity. A Modern Approach.* Cambridge University Press, Cambridge, 2009. xxiv+579 pp. ISBN: 978-0-521-42426-4.
[3] C. H. Papadimitriou *Computational complexity.* Addison-Wesley Publishing Company, Reading, MA, 1994. xvi+523 pp. ISBN: 0-201-53082-1
[4] M. Ziegler *Mathematische Logik.* Mathematik Kompakt. Birkhuser Verlag, Basel, 2010. viii+116 pp. ISBN: 978-3-7643-9973-3

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