CM30071: Logic and its applications.

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Applications

- Program verification (Hoare logic)
- Automated theorem proving, e.g. logic programming (Prolog etc.)
- Reasoning about possibility/necessity, time, moral codes, agent's, belief, knowledge (modal logic)
- Functional programming (lambda-calculus)

Logic

- Syntax (formulæ etc.), semantics (i.e. meaning), the connection between the two (soundness, completeness)
- Levels of logic: propositional logic, predicate logic (= 1st-order logic), 2nd-order logic. . .
- Flavours of logic: classical logic, program logic (e.g. Hoare logic), modal logic, intuitionistic logic
- Inference systems: natural deduction vs. sequent calculus

Reading

I will make my slides available on my homepage; I will also set reading to support the lectures.

The course book is

- **Logic in Computer Science: modelling and reasoning about systems**, M. Huth and M. Ryan, Cambridge University Press. Available at Waterstone's, in the library, everywhere; contains introduction to logic, program verification, agents and modal logic.

I recommend to buy it.

More reading

- **Logic and structure**, D. van Dalen, Springer-Verlag. Available at Amazon, in the library, and hopefully Waterstone's. Recommended for the mathematically inclined; contains introduction to natural deduction systems (classical and intuitionistic) and nice completeness proofs.
- **Proofs and Types**, J.-Y. Girard. Available online! Good for natural deduction, sequent calculus, propositions-as-types, normalization, lambda-calculus.

Yet more reading

- **Logic**, W. Hodges, Penguin Books. Available at Waterstone's, in the library, everywhere. Informal, quite philosophical; good to read in bed.
- **Computability and Logic**, Boolos/Burgess/Jeffrey. Introduction to logic, plus many advanced chapters. Available at Waterstone's, in the library, everywhere. Also used in first-year computability course; don't buy now, but have a look at it if you own it.

Reading for the very keen

- **Logic of Computer Science (Foundations of Automated Theorem Proving)**, J.H. Gallier. Available online. Introduction, sequent calculus & cut-elimination, some of the theory behind logic programming.
- **Basic Proof Theory**, Troelstra/Schwichtenberg, Cambridge University Press. Very advanced; studies various natural deduction and sequent calculi; in-depth study of cut-elimination.

Assessment

- Written exam (75%). I will occasionally present sample exam questions during the lecture.
- Coursework (25%). You will be asked to write a five-page essay on a topic from a given range.
  - I will circulate the course work options in early March (around Week 4).
  - Course work submission deadline is Thursday, 13 May at 5pm!

Outline

1. Introduction
2. Propositional logic and its semantics (revision)
3. Natural deduction systems; soundness and completeness
4. Predicate logic and its semantics (revision)
5. Natural deduction for predicate logic, and its soundness, completeness, and undecidability
6. Program verification: Hoare logic
7. Sequent calculus
8. Logic programming
9. Modal logic and its Kripke semantics
10. Intuitionistic logic and its Kripke semantics
11. Lambda-calculus and functional programming, normalization, Proposition-as-Types

Timeline

Weeks 1–6	lectures
Week 7	reading for course work; no lectures
Easter Break	
Weeks 8–11	lectures
Week 12	office hours for questions

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