Comp 230: *Logic and Computability*

Fall 2020

Dirk Schlimm

Sessions: Tuesdays and Thursdays, 11:35–12:55pm

Instructor:	Dirk Schlimm	Office hours:	tba
Email:	dirk.schlimm@mcgill.ca		
TA:	Moritz Bodner	Office hours:	tba
TA:	Clara Lacroce	Office hours:	tba
TA:	Albert Orozco Camacho	Office hours:	tba
TA:	Julien Ouellette-Michaud	Office hours:	tba
TA:	Johanna Schwartzentruber	Office hours:	tba

For any questions related to the course, please use the myCourses **discussion board**. In this way, everybody else in the course can also profit from your question. Before asking a question, it is advised to look at previous postings to see whether that questions was posted before and answered.

Course Description

Summary. The aim of this course is to introduce students to the theoretical foundations of computer science. Since students are not expected to have taken a logic course before, the course will include an introduction to propositional and predicate calculus. Other topics are proof systems, computability, Turing machines, Church-Turing thesis, unsolvable problems, completeness, incompleteness, Tarski semantics, uses and misuses of Gödel's theorem.

Prerequisites. High-school level mathematics. Not open to students who have done PHIL 310 or MATH 498.

Textbook. The following textbook is required for this course; available at The Word Bookstore, 469 Milton St. (5 mins. from the University Street Gates; no credit cards). You can order it also online at: https://www.wordbookstore.ca/comp-230/godel-escher-bach

- Douglas R. Hofstadter, *Gödel, Escher, Bach*, 20th Anniversary Edition, Basic Books, 1999.

Additional reading materials will be made available online on myCourses.

Course format. Due to the Covid-19 pandemic, this course will be offered in an online-only format. The course will be taught through a combination of pre-recorded lectures and online discussion sessions with the instructor and the TAs. McGill's move to remote teaching in the form of asynchronous video lectures puts more responsibility on the students regarding their time management. To alleviate this, the syllabus for this course provides more structure than for previous semesters. A more detailed schedule is available on myCourses.

- *Pre-recorded lectures.* Over the course of the semester pre-recorded lectures will be made available on myCourses.
- *Readings.* The lectures complement the assigned readings that students are expected to study carefully.
- *Synchronous sessions (Zoom).* During the scheduled class time, we will offer online Zoom sessions. These will be held on Tuesdays with the instructor and on Thursdays in smaller groups with the TAs. They will provide students the opportunity to discuss in more detail open questions from the lectures and the readings. The first 30 minutes of the Tuesday sessions will be recorded (and the recordings be made available on myCourses) to make the discussion available for students who cannot attend the meeting; the remainder of the meeting will not be recorded to respect the privacy of those who do not want to be recorded.
  Student can post questions on the myCourses discussion board that they would like to see discussed in the Zoom meeting.

Requirements & grading. Students are expected to watch the pre-recorded lectures, do the assigned readings, and complete homework assignments. The Zoom sessions are optional, but highly recommended to get a better understanding of the course material.

- *Assignments.* Usually a set of problems will be assigned every two weeks. The assignments will be posted on myCourses. These give the students the opportunity to engage with problems related to the class material at their own pace and without the pressure of receiving a grade for their efforts. Assignments will receive only a participation grade (pass/fail). Detailed sample solutions will be provided. These assignments will contribute to 10% of the final grade.
- *Weekly quizzes.* Each Friday, an online quiz covering the material discussed

in the course up to that point will be made available for 24 hours. The quiz will be designed to be completed within 30 minutes, but students will have 90 minutes to complete it after beginning. According to the Faculty of Science guidelines, This provision accounts for both internet connectivity issues or other technical difficulties (following the recommendation from TLS to add 30 minutes to assessments) and barriers to learning (following the recommendations from OSD to double the duration of the assessment). The first quiz, on Friday, September 11, is for practice and will not be counted towards your final grade. Thus, there will be 9 short quizzes during the semester. Of these, the one with the lowest grade will be dropped and each of the others will contribute with a weight of 7.5% of the final grade.

Depending on availability, some quizzes might be replaced by exercises using an online tool for logical proofs.

- *Midterm and final quizzes.* Towards the end of October and the end of November there will be two longer online quizzes that will cover all material discussed up to then. These will be designed for 60 minutes and will have to be completed within 150 minutes. Each of these quizzes will have a weight of 15% of the final grade.

To summarize, the final grade depends on:

6 Homework assignments (participation only)	10%
9 Short quizzes (one dropped, others 7.5% each)	60%
Midterm and final quiz (15% each)	30%

Plagiarism and other university regulations. McGill University values academic integrity. Therefore all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures (see http://www.mcgill.ca/students/srr/honest for more information).

Instructor generated course materials (e.g., handouts, notes, summaries, exam questions, etc.) are protected by law and may not be copied or distributed in any form or in any medium without explicit permission of the instructor. Note that infringements of copyright can be subject to follow up by the University under the Code of Student Conduct and Disciplinary Procedures.

In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.

In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.

Course Overview

- **Part I: Fundamentals and Formal Systems**
  1. Introduction to the course. Types of proofs.
  2. Definition by recursion. Mathematical induction
  3. Sets: Relations, functions, cardinality
  4. Denumerable and non-denumerable sets: Diagonalization
  5. Syntax. A simple formal system. The MIU system
  6. Semantics. Interpretations. Infinitude of primes (Euclid)
  7. R.e. sets vs. recursive sets
  8. Multiple interpretations, non-Euclidean geometry, consistency, completeness
- **Part II: Logic and Formal Arithmetic**
  1. Propositional logic: Semantics
  2. Propositional logic: Natural deduction
  3. Propositional logic: Soundness and completeness
  4. First-order logic: Expressions
  5. First-order logic: Semantics
  6. First-order logic: Substitutions, completeness
  7. First-order arithmetic
  8. Gödel numbering. Solution to MU puzzle
- **Part III: Computability and Incompleteness**
  1. Primitive recursive functions (BlooP)
  2. Recursive functions (FlooP)
  3. Turing machines. Halting problem
  4. Gödel's First Incompleteness Theorem
  5. Gödel's Second Incompleteness Theorem
  6. Church-Turing thesis. Tarski's Theorem