

CAS 760
Logic for Practical Use
Fall 2021

Course Outline

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McMaster University

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Note: This course outline contains important information that may affect your grade. You should retain it and refer to it throughout the semester, as you will be assumed to be familiar with the rules specified in this document.

Instructor

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Mission

Simple type theory is a classical version of higher-order logic that extends first-order logic. It is far better than first-order logic for reasoning about mathematics and, in particular, mathematical structures. Alonzo Church introduced in 1940 a very practical form of simple type theory, known as *Church's type theory*, that is tailored for reasoning with functions. This course will study a version of simple type theory named *Alonzo* based on Church's type theory that admits, unlike traditional predicate logic, undefined expressions (resulting from partial functions and definite descriptions). The course is intended as an introduction to the use of logic as a practical tool for reasoning about mathematical ideas. It is also intended to be a foundation for the study of higher-order logic and type theory and the use of programming languages, proof assistants, and other mathematical software systems based on higher-order logic and type theory.

Learning Objectives: Precondition

A *learning objective* for a course is something the student is expected to know and understand or to be able to do. The *precondition* of the course is

the set of learning objectives that the student is expected to have achieved before the start of the course. The precondition for this course is that the student is familiar with basic mathematics, set theory (including cardinality), propositional logic, recursive definitions, mathematical proof (including proof by induction), and decidability.

Learning Objectives: Postcondition

The *postcondition* of a course is the set of learning objectives that the student is expected to have achieved by the end of the course. The postcondition for this course is given below.

1. Students should know and understand:
 - a. The logical principles underlying predicate logics such as first-order logic and simple type theory.
 - b. The general and standard semantics for simple type theory.
 - c. What mathematical structures are and how they can be specified in a simple type theory like Alonzo.
 - d. How to reason with undefinedness in a simple type theory like Alonzo that admits undefined expressions.
 - e. Proof systems for simple type theory.
 - f. What kinds of software systems support the use of simple type theory.
2. Students should be able to:
 - a. Express mathematical ideas in simple type theory.
 - b. Write a theory in simple type theory to specify an individual mathematical structure or a collection of similar mathematical structures.
 - c. Build a mathematics library as a collection of theory developments connected by theory morphisms.

Resources

1. W. M. Farmer, **Simple Type Theory: A Practical Logic for Expressing and Reasoning about Mathematical Ideas** [abbreviated **STT**], 2021. Available on Avenue.
2. W. M. Farmer, **LaTeX macros and environments** for writing expressions and theories in Alonzo. Available on Avenue.

Schedule

Lectures: MoTh 3:30–4:45 online

Course Web Site

This course will be administered via *Avenue to Learn* (*Avenue* for short). Go to

<http://avenue.mcmaster.ca/>.

to access the course's Avenue page. Please send only normal email to the instructional staff; do not send mail via Avenue.

Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster email accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the Instructor.

It is the student's responsibility to be aware of the information on the course's Avenue pages and to check regularly for announcements.

Work Plan

There will be lectures, a bio sheet, M&Ms, a discussion forum, assignments, and two projects.

Two 75-minute lectures will be given online each week by the Instructor. The lectures will be recorded and made available on Microsoft Stream. Slides for the lectures will be posted on Avenue.

Each student is required to submit a bio sheet about themselves using the Instructor's bio sheet as a model (which is posted on Avenue under Content / Course Information).¹ Bio sheets are submitted as an assignment on Avenue under Assessments / Assignments / Bio Sheets.

At the end of each week, the students are required to submit a short paragraph (2–4 sentences) describing something from the week's lectures or reading that was (1) especially meaningful or memorable to the student or (2) not understood by the student. These *meaningfuls and memorables* (*M&Ms*) are intended to help the student to reflect on what she is learning and to give the Instructor feedback on what the students are experiencing in the course. The M&Ms are submitted to a discussion topic on Avenue under Communication / Discussions.

The discussion forum is located on Avenue under Communication / Discussions. Students are encouraged to use the forum to discuss the course material and to ask and answer questions. The Instructor will monitor the forum and participate in the discussion as needed.

¹I would like to thank Dr. Lydell Wiebe for communicating the bio sheet idea to me.

The assignments will be posted on Avenue periodically during the term under Content / Assignments. They will involve solving problems; proving conjectures; expressing mathematical ideas in Alonzo; and formulating theories, developments, and morphisms in Alonzo.

There will be two projects. The first will be a *development project* in which the student will specify and develop a chosen mathematical model as a theory graph in Alonzo. The second will be a *software system project* in which the student will study a chosen software system that supports simple type theory. Each project will be done in groups of two or three and will consist of a paper and an oral presentation. Further details on the project will be presented in a document entitled “Projects” that will be posted on Avenue under Content / Projects.

There will be no midterm tests or final exam.

Midterm Course Review

In the middle of the term, the students will have the opportunity to complete a survey on Avenue about how the course is going. In addition, each student will be invited to attend an online course review session in which she can ask the Instructor questions about the course and give feedback directly to the Instructor. Attendance is optional. The feedback that is received from the course survey and course review sessions may be used to modify how the course is working.

End-of-Term Course Evaluation

Near the end of the term, each student will have the opportunity to evaluate the effectiveness of this course. The feedback that is received from the course evaluation is very valuable to the Instructor and will be used to improve the course in subsequent years.

Discrimination

The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem, that cannot be resolved by discussion among the persons concerned, individuals are reminded that they should contact their Department Chair and the *Human Rights and Equity Services (HRES)* office as soon as possible.

Academic Integrity

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. It is your responsibility to understand what constitutes academic dishonesty.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This

behavior can result in serious consequences, e.g., the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: “Grade of F assigned for academic dishonesty”), and/or suspension or expulsion from the university.

For information on the various types of academic dishonesty please refer to the *Academic Integrity Policy*, located at <https://secretariat.mcmaster.ca/app/uploads/Academic-Integrity-Policy-1-1.pdf>. The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g., the submission of work that is not one’s own or for which other credit has been obtained.
2. Improper collaboration in group work.
3. Copying or using unauthorized aids in tests and examinations.

Your work must be your own. Plagiarism and copying will not be tolerated! If it is discovered that you plagiarized or copied, it will be considered as academic dishonesty.

Students may be asked to defend their written work orally.

Conduct Expectations

As a McMaster graduate student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning, and working communities. These expectations are described in the *Code of Student Rights & Responsibilities* (*Code* for short). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g., use of Avenue 2 Learn, WebEx, or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students’ access to these platforms.

Academic Accommodation for Students with Disabilities

Students with disabilities who require academic accommodation must contact *Student Accessibility Services (SAS)* at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University’s *Academic Accommodation of Students with Disabilities* policy.

Academic Accommodation for Religious, Indigenous, or Spiritual Observances (RISO)

Students requiring academic accommodation based on religious, indigenous, or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

Copyright and Recording

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical, and artistic work, including lectures by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the Instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

Extreme Circumstances

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L, and/or McMaster email.

Other Policy Statements

1. Significant study and reading outside of class is required.
2. The student is expected to ask questions during the lectures.
3. Assignments may not be submitted late without *prior* approval from the Instructor.
4. Suggestions on how to improve the course and the Instructor's teaching methods are always welcomed.

Marking Scheme

The course grade will be based on the student's performance on the bio sheet, M&Ms, assignments, project, midterm test, and final exam as follows:

Bio sheet	2%
M&Ms	8%
Assignments	50%
Development project	20%
Software project	20%
Total	100%

Notes:

1. The *bio sheet mark* is 0 if it is not submitted; 1 if submitted after October 17; and 2 if submitted before or on October 15.
2. The *M&Ms mark* is the percentage of weekly M&Ms that the student submitted during the term.
3. The *development and software projects* are each worth 10% for the written presentation and 10% for the oral presentation.
4. There is no mark for participation in the discussion forum.

Syllabus

- 0 Introduction (Chapters 1–2 of STT).
- 1 Mathematical Structures (Chapter 3).
- 2 Alonzo: Syntax and Semantics (Chapters 4–7).
- 3 Alonzo: Proof Systems (Chapter 8).
- 4 Alonzo: Theories (Chapters 9–10).
- 4 Alonzo: Libraries (Chapters 11–13).
- 5 Software Support (Chapter 15).