INTRODUCTION TO DEDUCTIVE LOGIC

McGill University
Philosophy Department
PHIL 210
Summer 2021

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Practice Session 2 Day/Time: **Fri, 14-15h**

Class Location: **Held Online**
Class Day/Time: **(officially) Mon-Thurs, 13h35-15h55**
Class Day/Time: **(in reality) Daily Pre-Recorded Lectures**

Practice Session Location: **Zoom tab on MyCourses**
Practice Session 1 Day/Time: **Fri, 9-10h**
Practice Session 3 Day/Time: **Fri, 20-21h**

COURSE DESCRIPTION: This course will serve as a general introduction to the science of deductive logic. This discipline is mainly concerned with identifying patterns of valid and invalid argumentation, by proving whether or not the conclusion follows from the premises. When the conclusion does follow from the premises, we will say that this is a **valid inference** or that the conclusion is a **logical consequence** of the premises. However, in order to identify these patterns, it is imperative that we abstract away from any information contained in the set of statements that are of no logical import. When considering whether an argument is valid, most information just turns out to be background noise. As such, we will first introduce Truth Functional Logic (TFL), which is built on a simplified artificial language designed to facilitate the study of *propositional logic*. The idea is that given some atomic sentences, *logical connectives* can be used to build complex sentences. Next we will proceed to evaluate the validity of arguments by 'checking' all the possible combinations of *truth-values* we can give to these sentences. Truth tables will give us a means to manually verify the validity and invalidity of sentences and arguments. However, it will also give us a way to manually verify whether sets of sentences are satisfiable, and even whether a sentence turns out to be logically equivalent to another. Once we have a better handle of what all these theoretical concepts mean in practice, we will then introduce a system of natural deduction which will allow us to prove that an argument is valid, based on strategic reasoning. For instance, knowing beforehand that two sentences are logically equivalent and why this is the case, we will be able to identify a strategy for proving this without resorting to manually verifying a truth table. This is very freeing, as the more complex an argument is, the bigger the truth table!

In the second half of the course, we will expand on our artificial language to account for subtleties in sentences that TFL is blind to. In order to prove things we ought to be able to prove, but can't in TFL, we will introduce four key elements: *names*, *variables* the *identity relation*, and *quantifiers*. This will be our language for First-Order Logic (also known as *quantificational logic*).While we will now be able to express, for instance, that "there are no more than three red cats", this will also introduce an added layer of complexity. Here, truth-tables are not up to the task to manually verify whether an argument is valid or invalid. First, we will introduce the notion of an *interpretation* and you will be asked to produce an interpretation which contains a counter-example in order to prove that an argument is invalid. Finally, we will update our Fitch system to accommodate our new language, and we will go on to show that we can prove any and all valid argument in FOL. Finally, while we will prove neither soundness nor completeness for FOL, we will explain what these results means and what their implications are for any field that deploys logic.

STUDENT LEARNING OUTCOMES
The successful PHIL 210 student should be able to:

- ***Learn two artificial languages***: You will learn both TFL and FOL and gain the ability to translate substantial parts of languages into these artifical languages, as well as the ability to parse the meaning of sentences in these artificial languages.
- ***Reason with truth tables***: you will learn to construct and interpret truth-tables so as to evaluate the properties of sentences and arguments (determine whether a sentence is a tautology, a contradiction or a contingent sentence, whether a set of sentences are jointly satisfiable, whether an argument is valid or invalid).
- ***Understand key logical concepts***: You will become familiar with basic semantic concepts such as validity, entailment and logical equivalence. Finally, you will become adept at identifying patterns of valid argumentation (syllogism).
- ***Proof techniques***: You will learn a particular system of natural deduction called the Fitch system. You will learn to construct derivations and, in so doing, identify the correct strategy required to prove that an argument (or a sentence) is valid.
- ***Produce Counter-examples***: You will also learn how to produce counter-examples to show that a particular argument must be invalid. You will learn to do so in a formal way (that is, given an abstract argument). In other words, you will learn to distinguish when an argument is wrong because of the facts of the matter, or when it is the argumentation itself that is fallacious – and you will be able to prove that the argument is fallacious.
- ***Learn basic Meta-Theoretical Results***: Finally, you will get a brief introduction to some of the most important theoretical results which have wide ranging implications: the soundness and completeness theorems for TFL and FOL.

WARNING: Many find the second half of the course substantially more difficult than the first half. This is normal but due to the accelerated nature of the course, be prepared to dedicate more time in the second half of the course. The second half will build on what we've done in the first half so it is equally imperative not to neglect the material in the first half, as it will be almost impossible to catch up. This course is uniquely practice based, and there is simply no substitute for doing all available practice questions. Officially, you should plan for 10 hours of practice a week. However, you may find yourself needing more practice than this.

DELIVERY OF COURSE MATERIAL: Due to the ongoing global pandemic, this course will take place online. As it is a very large course, it will not be possible to do live classes over Zoom. As such, 2-3 videos will be uploaded a day, totalling 10 hours of lecture per week. I will upload both a video as well as the slides. Occasionally, handouts may be uploaded. As well, TA Sophie Osiecki will upload one short video each Wednesday which will function as a tutorial for that week's Carnap exercises. Weekly exercises will be available on Carnap.io each Tuesday, and I strongly encourage you to complete them as soon as possible. The earlier you realize you don't know how to solve a problem, the more time you have to consult me or Sophie. Every Friday, Sophie will hold three **optional** practice sessions: the goal is for you to come with questions or problems you cannot solve, and we will work collaboratively on solving them. Please note that we will conduct a survey on the first day of class, and the times of these optional practice sessions may change according to your responses.

COURSE MATERIAL:

1. The basis of the course will be the Open Source textbook *Forall x* (P. D. Magnus). This book currently exists in 3 different versions, the latest being *Forall x: Calgary* (Richard Zach et al.), which builds on *Forall x: Cambridge* (Tim Button). It is available for download here: `http://forallx.openlogicproject.org/` as well as on MyCourses.

- Note that we will not use all chapters in this textbook, and some additional material will also be covered in Lectures. You should therefore view the textbook as essential supplementary material that will facilitate understanding of the material. As well, there are many exercises there and you should aim to do them all. Some will be assigned as practice and you will able to test out your answers on carnap.io.

2. For both Exercises and Assignments, we will make use of the following open-source online system: `http://carnap.io`. To be able to use this, you have to register with it, with a Google address, for example a gmail address. Once registered, you will then be able to choose a course (there are many), and you will choose "McGill PHIL 210 Summer 2021 (Intensive)". As the course progresses, more and more things will appear under "Assignments", and it will be clear from the title what this is for, i.e., whether it's for practice or a graded assignment.

   - Here is a sign up link: `https://carnap.io/enroll/McGill%20PHIL210%20Summer%202021%20%28Intensive%29`
   - The Carnap interface is very easy to use. It accepts ordinary keystrokes instead of special symbols, and will produce for you the special symbols (*e.g.* for the special symbol '$\wedge$' which we use, Carnap will accept any of '&', 'and' and more, but will display '$\wedge$' back to you in its output. Similarly, for the symbol '$\forall x$', it will accept ordinary things like 'Ax' or 'All x').
   - That being said, it is in your best interest to do all the available practice questions and familiarize yourself **as early as possible** with the platform. Trying to learn it during a timed graded assignment will be a huge source of additional stress.

3. McGill's *MyCourses* system will be crucial for the course. This is where the Slides, Videos, Handouts, Discussion Board, *etc* will also be posted. It's also where Announcements will appear with important details. It is your responsibility to check *MyCourses* regularly (even on the weekend in case of a major technical issues with one of the assignments).

4. Due to the unique online nature of this course and the global pandemic, you will a 'good enough' internet connection and either a desktop or a laptop. Unfortunately, barring truly exceptional circumstances, we cannot accept assignment submissions other than through Carnap. Should you find yourself in a one-time exceptional circumstance, we will work out modalities privately.

CLASS SCHEDULE:

Week 1: Key Notions of Deductive Logic; Truth-Functional Languages (TFL); Truth Tables.

(**Part I-III** of *Forall x: Calgary*)
Assignment 1: Released Friday May 7th 17h EDT – Due Monday May 10th 23h59 EDT.

Week 2: Fitch Proof System for TFL.

(**Part IV** of *Forall x: Calgary*)
Assignment 2: Released Friday May 14th 17h EDT – Due Monday May 17th 23h59 EDT.

Week 3: Extending Key Notions to First-Order Languages (FOL).

(**Part V and VI** of *Forall x: Calgary*)
Assignment 3: Released Friday May 21st 17h EDT – Due Monday May 24th 23h59 EDT.

Week 4: Fitch Proof System for FOL; Review of Soundness and Completeness results for FOL.

(**Part VII** of *Forall x: Calgary* and lecture/handout)
Assignment 4: Released Friday May 28th 17h EDT – Due Monday May 31st 23h59 EDT.

GRADING AND EVALUATION: There will be four (4) weekly assignments, each worth 25% of your final grade. **Assignments will be released each Friday at 17h EDT, and due the following Monday at 23h59 EDT.** These will be times online assessments, completed on Carnap.io. The assignments should take one and a half hours to complete, and you will be given 3 hours to do so. **Completion of all assignments is mandatory**. As well, each week you will have the opportunity to gain 3-4 bonus points (at least 12% of your final grade), by answering two or three theoretical questions in short essay format, which you must upload as a PDF document to *MyCourses* (same due date, the title of the document must be "YourLastName, Assignment X", where 'X' is the number associated with the assignemnt).

POLICY FOR EXTENSIONS AND LATE WORK: Extensions will be granted only in exceptional circumstances (illness, death of a family member, political instability, major power outages, that sort of thing). Late work without a granted extension will be penalized at the rate of a full letter grade (12.5%) per day overdue. Should you need an extension, please notify me as soon as possible.

MCGILL UNIVERSITY POLICIES:

1. *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 DisciplinaryProcedures. (See* `www.mcgill.ca/integrity` *for more information).*

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

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

4. *As instructors of this course, the Lecturer and TAs endeavor to provide an inclusive learning environment. If you experience barriers to learning in this course, do not hesitate to discuss them with us or with Student Affairs, or with the Office for Students with Disabilities,* `https://www.mcgill.ca/osd`*, tel.: 514-398-6009.*

5. *McGill University is on land which is the traditional and unceded territory of the Kanien'keha:ka (Mohawk), a place which has long served as a site of meeting and exchange amongst nations.*