PHIL210 – Introduction to Deductive Logic
Mon. & Wed. 11:35 - 12:25 AM
Room: Adams Auditorium (Adams Building – 3450 Rue University)

Instructor: Valérie Lynn Therrien

Office Hours: Thursdays 13:00-14:30 and by appointment.
Room: Leacock Building, Room 925.

Conferences and Office Hours: You must sign up for (only) one conference on Minerva, which will be on Thursdays and Fridays. There will be 8 to choose from in total.They start on the week of the 12th of September and correspond to the "Friday lecture". Registration opens the 9th of September. Please note that you do not need to restrict yourself to the office hours of the TA who is conducting your conference. If their office hours don't work in your schedule, you are free to go to another TAs office hours.

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*.

In the **first half of the class** we will first introduce Truth Functional Logic (TFL) – also known as propositional or zeroth-order logic – 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 – the Fitch system – 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! Around this point, we will introduce you to two important meta-results: Soundness and Completeness with respect to a given deductive system.

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 natural 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**. 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. This course is uniquely **PRACTICE BASED**, and there is simply *no substitute for doing all available practice questions*. A WORD OF ENCOURAGEMENT: Some of you may struggle with the material starting from the first half. I have encountered many students who "bombed" the first half and finished the course with an A. Those who did were students who doubled down on the practice – so don't give up! It is my firm belief that **the only way to get really good at logic is to make countless mistakes and learn from them**.

Course Material:

1. The basis of the course will be the Open Source textbook *Forall x: Calgary* (Richard Zach *et al.*). 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 – Fall 2022". 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's a sign-up link: [Redacted]
    - 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 online nature of the asignments and the global pandemic, you will need 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.

Grading and Evaluation: There will be **three assignments**, each worth 15% of your final grade. There will be one **mid-term** worth 20% of your grade. The assignments will be released on Fridays at 17h EDT, and due the following Monday at 23h59 EDT (Assignment 3

will exceptionally be available until Tuesday at 23h59 EDT). The first portion of the assignments and mid-term (worth 10% and 15% respectively) will be a timed online assessment, 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. The remaining 5% will be earned by answering 2-4 questions in short essay format. This portion will not be timed, and you will have the full three days to reflect on them.

Additionally, for each assignment and mid-term, you will have the opportunity to gain 3% of your final grade by answering 1-2 BONUS QUESTIONS on the essay portion. This is an opportunity to boost your grade by a full letter grade. These questions will ask you to reflect a little more critically on material that goes beyond what we will see in class: MOTIVATIONS FOR ALTERNATIVE LOGICS. No additional research is required to answer these questions. These are reflection questions and the prompts will tell you everything you need. Additionally, I will prepare some material to help prepare you for the first round of these.

Finally, there will be an **in-person final exam** worth 35% of your final grade. The exam will be cumulative, and questions will be similar to questions you will have encountered in the assignments and the mid-terms. However, longer essay questions will be replaced by shorter questions about definitions and important logical concepts.

POLICY FOR EXTENSIONS AND LATE WORK: Extensions will be granted only in exceptional circumstances (illness (incl. mental health), 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 Disciplinary Procedures. (See www.mcgill.ca/integrity for more information).*

2. *In the event of extraordinary circumstances beyond the University's control, the content and/or eval- uation 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*

Class Schedule:

Week	Dates	Topics	Chapter	Ass./Ex.
0	Aug. 31	Intro. the course, basic terminology	1-2 & 4	
Part IA: Truth-Functional Logic: Translations and Truth-Tables				
1	Sept. 7	Symbolizations, connectives	5 & 7-9	
2	Sept. 12-14	truth-functions, truth-tables for (in)validity	6, 10-11	
3	Sept. 19-21	T.t. for equivalence, tautology and satisfiability	3 & 12	
Part IB: Truth-Functional Logic: Proof System				
4	Sept. 26-28	Fitch rules for $\wedge$, $\rightarrow$, $\leftrightarrow$, R, proof w/o premises	15 & 16.1-6	**Ass. 1**
5	Oct. 3-5	Fitch rules for $\vee$, $\neg$, X, IP, Sound./Complete.	16.7-8 & 19	
6 (R.W.)	Oct. 12-13	Strategy, derived rules	17	
Part IIA: First-Order Logic: Translations and Interpretations				
7	Oct. 17-19	Names, predicates, variables	22-24	**Mid-term**
8	Oct. 24-26	Existential and Universal quantifiers, identity	24-25.1	
9	Oct. 31-Nov. 2	Translating uniqueness and other numerical terms	25-28	
10	Nov. 7-9	Interpretations, validity, equivalence	29-33	
Part IIB: First-Order Logic: Proof System				
11	Nov. 14-16	Fitch Rules for $=$, $\forall E$, $\exists I$	34.1-2 & 37	**Ass. 2**
12	Nov. 21-23	Fitch Rules for $\forall I$ and $\exists E$	34-35	
13	Nov. 28-30	Strategy, important proof patterns		**Ass. 3**
13.5	Dec. 5	Proving Soundness/ Completeness (PHIL310)		
Final Exam: Date TBA (during exam period)				