Logic I

24.241, Fall 2024

Instructor Info

Benjamin Brast-McKie

Office Hrs: Tu & Th 11am-12pm

32-D962

Carnap Website

Canvas Website

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TA Info

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Course Info

Prereq: None

Tues & Thurs

9:30am - 11am

32-124

Problem Sets

Due Fridays

5pm sharp

Online or scanned

Overview

During the first part of this course, we will study *propositional logic* (PL). This is the logic of truth-functional connectives including: 'not', 'and', 'or', 'if-then', and 'if and only if'. In the second part, we will study *first-order logic* (FOL). This is the logic of 'for all', 'some', and later 'is' together with the connectives from propositional logic.

In both parts, we will present a syntax for a formal language which we will use to regiment arguments in natural language. We will also introduce a model theoretic semantics in order to interpret our the formal languages and define logical consequence. Lastly, we will introduce a proof system for each of our formal languages, defining what it is to be a proof in that system. For both parts of the course, we will cover basic metalogic, proving that our proof systems are sound and complete.

Required Text

ForAllX: MIT Edition (Fall 2024).
Chapters will be released each week on Canvas.

Grading Scheme

50%	Problem Sets (10/12 at %5 each)
20%	Midterm
30%	Final Exam

Grades will not be curved. A+ = 97-100; A = 93-96; A- = 90-92; B+ = 87-89; B = 83-86; B- = 80-82; C+ = 77-79; C = 73-76; C- = 70-72; D = 60-69; F $<$ 60.

Problem Sets

There will be 12 graded problem sets due on Fridays by 5pm. Your two lowest score will be dropped. Late work will not be excepted. Certain problem sets will make use of the online program called 'Carnap'. All work submitted MUST BE YOUR OWN, instantiating a direct causal relation to your own pen, pencil, or keyboard, written in your own voice without someone there with you or texting you answers. As you will find, even logic leaves room for creativity, and it will be important to get a sense of that for yourself. You are welcome to work through the problem set with at most two other students IN PREPARATION, but when it comes time to submit answers, you must be on your own. If you choose to work with others, please indicate your collaborators' names at the top of each assignment.

Carnap

Parts of some of the problem sets will be assigned on Carnap. You will need to enroll which you can find demonstrated here. Using Carnap will require some syntactic care: it is fussy about how things are entered, so you will have to learn to use the right syntax. Please don't hesitate to get in touch if you run into any issues.

LaTeX

There will also be written problem sets. If your handwriting is very clear, you may scan and upload a PDF with your solutions. Alternatively, you are encouraged to use LaTeX where I will provide optional templates with examples so as to make it easy to typeset the problem set each week. If you are new to LaTeX, this is a great chance to begin to practice. You can also find links to the configurations that I maintain for using VSCodium and NeoVim to write in LaTeX and Markdown.

FAQs

Is logic math?

We will use formal symbols as in mathematics, but this does not make logic a type of math any more than it makes physics a type of mathematics. Rather, logic has a subject mater all its own, though saying what this is will require some care.

Is logic philosophy?

Philosophical Logic includes the development and application of logical systems to the problems of philosophy as well as the ambition to provide a philosophical account of logic. *Mathematical Logic* concerns the formal properties that logical systems have and falls considerably closer to mathematics. We will be doing a bit of both.

Is logic a descriptive science?

No! Logic is a *normative* science insofar as it aims to regiment how we ought to reason in an artificial language, not merely how we happen to reason in a natural language like English.

Why learn logic?

Logic seeks to describe an ideal for reasoning. Of course, we are all engaged in reasoning. Learning logic is something akin to upgrading your firmware. It will literally change how you think.

What does logic have to show for itself?

Logic played a critical role in putting mathematics on a solid foundation (ZFC is accepted by most working mathematicians) and gave birth to the modern theory of computation as well as modern linguistics.

Academic Integrity

Blindly copying someone else's solution (written or typed) is cheating. By contrast, you are encouraged to talk through a solution step-by-step with a classmate or two where in doing so, everyone involved comes to understand each part. However, when it comes time to write up and submit the solutions, it is important that you do this for yourself without consulting others throughout the process.

Learning logic requires practice! Compare learning to speak a natural language like English. There are some tricks and techniques to get acquainted with where once you gain some familiarity, this course should be fun. But getting comfortable using these techniques takes time, making this a very difficult course to cram for the night before an exam. The good news is that with consistent practice, you should be able to master the techniques of this course long in advance of the exam.

Doing problem sets is the best way to practice throughout the course. Cheating on problem sets will be to your own disadvantage in preparing for the exams. If you cheat on an exam, the academic consequences will be severe, so please don't consider it. There is more to life than grades; don't let them distract from learning!

Instead of worrying about your grade, I recommend that you focus on mastering logic, doing your best work and feeling good about it. Logic is an extremely deep subject, and foundational for this information age that we are all a part of. This course should provide you with an important tool kit that I hope you enjoy learning to use and that will serve you well beyond the end of this semester.

Make-up Policy

Make-up exams or problem-sets are only permitted for students in the midst of a medical or family emergency. Making arrangements IN ADVANCE of the due date is required except in particularly difficult circumstances.

Learning Objectives

- Regiment natural language arguments in formal languages.
- Evaluate arguments for validity, producing minimal countermodels if any.
- Write formal proofs within a proof system.
- Develop an appreciation for meta-logical proofs about our proof systems and their corresponding semantic theories.
- Contemplate the philosophy of logic, exploring such questions as: What is logic? What unites logic as a discipline? What is logic good for, and what are its limits? Do the rules of logic describe something universal or conventional?

Diversity and Inclusivity Statement

In all course-related activities and communications, you will be treated with respect. I welcome individuals of all ages, backgrounds, cultures, beliefs, ethnicities, gender identities and expressions, national origins, religious affiliations, abilities, sexual orientations, and other visible and non-visible differences. All members of this class are expected to help create a respectful, welcoming, and inclusive environment for every other member of the class.

Accommodations for Students with Disabilities

If you are a student with learning needs that require accommodation, please contact Disability and Access Services at `das-student@mit.edu` (or for assistive technology, `atic-staff@mit.edu`) as soon as possible, to make an appointment to discuss your needs and to obtain an accommodations letter. Please also e-mail me as soon as possible to set up a time to discuss your learning needs. As someone who has used these services in the past, you can assume that you will have my full support.

Class Schedule

Any changes to this schedule will be announced on Canvas.

Part 1: Propositional Logic (PL)

Week 0	Introduction to Logic	ForAllX Ch. 0
Sep 05		Problem Set 0 (meet Carnap — not graded)
Week 1	Syntax for PL & Recursive Definitions	ForAllX Ch. 1
Sep 10, 12	Regimentation in PL	Problem Set 1 Due Friday 9/13
Week 2	Semantics for PL	ForAllX Ch. 2
Sep 17, 19	Logical Consequence & Countermodels	Problem Set 2 Due Friday 9/20
Week 3	Natural Deduction System (PL)	ForAllX Ch. 3
Sep 24, 26	Natural Deduction Proofs	Problem Set 3 Due Friday 9/27

Part 2: Metalogic (PL)

Week 4	Mathematical Induction	ForAllX Ch. 4
Oct 1, 3	Soundness	Problem Set 4 Due Friday 10/4
Week 5	Completeness	ForAllX Ch. 5
Oct 8, 10	Midterm Review	Problem Set 5 Due Friday 10/11
Week 6	MIDTERM	80 minute in class exam
Oct 17		No Problem Set 6

Part 3: First-Order Logic (FOL)

Week 7	Syntax for FOL	ForAllX Ch. 7
Oct 22, 24	Regimentation in FOL	Problem Set 7 Due Friday 10/25
Week 8	Semantics for FOL	ForAllX Ch. 8
Oct 29, 31	Logical Consequence & Countermodels	Problem Set 8 Due Friday 11/1
Week 9	Syntax FOL$^{=}$	ForAllX Ch. 9
Nov 5, 7	Semantics for FOL$^{=}$	Problem Set 9 Due Friday 11/9
Week 10	Natural Deduction System (FOL)	ForAllX Ch. 10
Nov 12, 14	Identity Rules (FOL$^{=}$)	Problem Set 10 Due Friday 11/15

Part 4: Metalogic (FOL)		
Week 11	Soundness ($FOL^{=}$)	ForAllX Ch. 11
Nov 19, 21		Problem Set 11 Due Friday 11/22
Week 12	Completeness ($FOL^{=}$)	ForAllX Ch. 12
Nov 26		No Problem Set
Week 13	Completeness ($FOL^{=}$)	ForAllX Ch. 13
Dec 3, 5	Compactness	Problem Set 12 Due Friday 12/6
Week 14	Review for the Final	Handout
Dec 10		Problem Set 13 Due Wednesday 12/18
Week 15	FINAL EXAM (3 hours)	Time & Location TBD