Logic I: Symbolic

24.241, Fall 2022

Instructor Info

Josh Hunt

Office Hrs: Wed. 11:05–11:55
Friday 1:30–2:30
subject to change!

32-D962 (Inner Office) or surrounding environs

See Canvas & *Carnap*!

joshhunt@mit.edu

Course Info

Prereq: Euclidean geometry–jk!

Mondays & Wednesdays

9:35-10:55am (actual times)

32-144 (by the coffee stand)

P-Set Info (HW)

Due every Friday

5pm sharp

Typically online on *Carnap*; Sometimes on printed paper

Overview

During the first part, we will study sentential logic (SL), also known as truth-functional (TFL) or propositional logic. This is the logic of truth-functional connectives, including 'not,' 'and,' 'or,' 'if-then,' and 'if and only if.' But watch out: 'if-then' will not mean what you think it means! Nor will 'or.' During the second part, we will study quantifer logic (QL), also known as first order logic (FOL) or predicate logic. This is the logic of 'for all' and 'some,' plus our earlier sentential logic. In both parts, we will develop syntax and semantics for these logics. Syntax will include both symbolization of natural language sentences and proof/derivation systems. Semantics will include interpretations of our symbolizations. For both parts, we will do basic meta-logic, proving that our syntactic proof systems are both (i) sound and (ii) complete.
By the end of the course, you will be complete. Sound good?

Material

Required Text (but it's a free PDF! Print your own at the FedEx on Main St.!)
Ichikawa, J. & Magnus, P.D. *ForAllX: MIT Edition FA22 (modified to instructor's tastes)*.

Optional Text (not free—unless you know where to look!)
Bergmann, M., Moor, J. & Nelson, J. *The Logic Book*. 6th Edition. McGraw Hill 2014.

Other
Any other required readings will be provided on Canvas.
I will also post supplemental readings written in a more philosophical vein.

Grading Scheme

55%	Problem Sets (11 total at 5% each)
18%	Midterm Exam
27%	Final Exam

Letter Grades as follows: $90 \leq$ A- $< 93 \leq$ A $< 97 \leq$ A+
$80 \leq$ B- $< 83 \leq$ B $< 87 \leq$ B+ < 90
and so on for the C and D ranges. F < 60 (don't do this!).
Curving is very unlikely because this is basic logic, and you're at MIT.

Problem Sets

There will be 12 graded problem sets, due almost every Friday by 5pm. Your lowest score will be dropped. Many of these will be online using a majestic program called 'Carnap' so that you can get real-time feedback as you work. All work submitted MUST BE YOUR OWN, manifesting a direct causal relation to your own pen, pencil, or keyboard—written in your own voice (where even logic leaves room for creativity). You are welcome to work with ≤ 2 other students. If so, please indicate your teammates' names at the top of your assignment (often in a textbox).

Make-up Policy

Make-up exams or problem-sets are only permitted for students in the midst of a medical or family emergency. I may require evidence that would satisfy even a licensed epistemologist. Making arrangements IN ADVANCE of the due date is required except in particularly unfortunate circumstances (in which case I will do my best to support YOU).

FAQs

Is this really a philosophy course?

No. But unless you think math IS logic, it's not a math course either! Since it is being taught in a philosophy department—by a licensed philosopher—we will do some philosophy on the side.

What is logic?

No clue. When someone says 'logic,' we have a picture of a certain style of reasoning in our minds, but the truth is that 'logic' doesn't have a settled meaning. It is hotly contested, giving rise to a whole subject called 'Philosophy of Logic.'

What is your favorite logic?

Intuitionistic Logic, which assumes neither the law of excluded middle ($p \vee \neg p$) nor double negation elimination ($\neg\neg p \Rightarrow p$). This logic provides an elegant foundation for those with finitist or constructivist sympathies about math.

Isn't logic just a matter of following rules?

Yes: like most disciplines, learning logic is a matter of learning how to apply a series of rules. Also like most disciplines, we will find that it is quite hard to successfully apply these rules.

What does it even mean to follow a rule?

That is a very deep question, forcing us to grapple with identity, sameness, and normativity.

Cheating Detection (Academic Integrity)

We will take advantage of basic game theory: if you gain compelling evidence that a classmate is cheating, you are incentivized to report it to me (and disincentivized to stay quiet). I will 100% honor your confidentiality.
–If your report is accurate, you will get 1% extra credit (equivalent to one-fifth of a problem-set). The cheater will lose 3%. Additional correct reports will gain 0.5% extra credit (up to 5% total—One can't pass a class by being a vigilante).
–If you gain compelling evidence that someone ELSE knows about cheating but hasn't reported it within 24 hours, you can report that to earn 1% extra credit. The person who failed to report will lose 1%. If all witnesses report, no one loses points except the cheater(s). In this case, no one gains points either (since then you could form cartels to gain extra credit). I reserve the right to modify this policy!
–What this all means: if you cheat in a group, you are at the mercy of your group-members. If you witness cheating, but don't report it, you are at the mercy of other witnesses. If a cheater reports themselves first, they lose 2%.

Blindly copying someone else's solution (either written or typed) counts as cheating. In contrast, talking through a solution step-by-step with a classmate—evincing understanding at each step—then writing this solution up yourself step-by-step does NOT count as cheating (even if you end up with exactly the same steps). This is logic after-all: there's not that much room for creativity.

If you cheat on an exam, there will be hell to pay (i.e. the academic consequences will be severe). But remember: school is just school, and there is much more to life than this. So don't fret about any of this grade stuff. Have fun, be free, and live the life you've imagined. It is more fun to learn and fail than fail to learn.

Learning Objectives

- Practice regimenting a large family of natural language sentences into a first-order language, based on truth-functional connectives and quantifiers.
- Learn how to assess complex natural language arguments for deductive validity (and impress your friends!).
- Distinguish syntax from semantics (at least pragmatically).
- Practice applying syntactical systems with tedious rules (rules that will annoy and frustrate you!) and that you are unlikely to remember after this course. This activity mirrors what Big Tech (and others!) will demand of you.
- Develop an appreciation for proofs *about* our proof systems, written in a meta-language. This is called 'meta-logic'—a true triumph of human cognition!
- *Enrichment*: do some philosophy! We'll talk about what logic *means*, the nature of truth, logical explanation (grounding), difficulties surrounding rule-following, and the value of having different ways to solve the same problem.

Diversity and Inclusivity Statement

In all course-related activities and communications, you will be treated with respect. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability, 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 who respects this policy (we may schematize this serpentine sentence in Week 8).

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, 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 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 I will be HIGHLY sympathetic!

Class Schedule

Unit 1: Sentential Logic (SL): 'Truth-Functional' or 'Propositional'

Week 0	Welcome & Basic Concepts	ForallX Ch. 0
Sep. 7	Problem Set 0 = meet '*Carnap*' (not graded!)	
Week 1	Syntax & Symbolization in SL	ForallX Ch. 1
	Distinction between Use and 'Mention'	
Sep. 12 &14	Problem Set 1 Due Friday 9/16	
Week 2	Intro to Semantics in SL: Truth Tables	ForallX Ch. 2
	Semantics in SL: Truth-functional Entailment, Validity, and Consistency	ForallX Ch. 3
Sep. 19 & 21	Problem Set 2 Due Friday 9/23	
Week 3	Mathematical Induction & Recursive Definitions	Handout; Logic Book §6.1
	More Induction and Recursion! Compactness?	
Sep. 26 & 28	Problem Set 3 Due Friday 9/30	
Week 4	Proof System 1: Trees! (STD)	ForallX Ch. 4
	More Trees or start Metalogic	
Oct. 3 & 5	Problem Set 4 Due Friday 10/7	
Week 5	SL Metalogic 1: Soundness & Completeness of STD	ForallX Ch. 5
Oct. 12	Problem Set 5 Due Friday 10/14	
Week 6	Proof System 2: Natural Deduction (SND)	ForallX Ch. 6
	Practice with SND	
Oct. 17 & 19	Problem Set 6 Due Friday 10/21	
Week 7	Midterm Review & More SND Practice	Review Handout and Practice Problems
	MIDTERM! (In class!) *Oct. 26*	
Oct. 24 & 26	'Problem Set 7' = A survey (not graded!)	

Unit 2: Quantifer Logic (QL): 'Predicate Logic' or 'First-order Logic'

Week 8	Quantifier Logic (QL) Syntax	ForallX Ch. 8
	QL Symbolization	
Oct. 31 & Nov. 2	Problem Set 8 Due Friday 11/4	
Week 9	Quantifer Logic Semantics	ForallX Ch. 9
	Models in QL	
Nov. 7 & 9	Problem Set 9 Due Friday 11/11	
Week 10	Natural Deduction in QL (QND)	ForallX Ch. 10
	More practice with QND!	
Nov. 14 &16	Problem Set 10 Due Friday 11/18	
Week 11	First-order Logic with Identity	ForallX Ch. 11
	Russell's Theory of Definite Descriptions	Calgary §V.27; Sider §5.3; Goldfarb
Nov. 21 & 23	Problem Set 11 Due Friday 11/25	
	(shorter PS due to Thanksgiving this week)	

Unit 3: META-Logic let's GOOOOOOOOOOOOOOOOO

Week 12	SL Metalogic 2: Soundness of SND	Logic Book §6.3
	SL Metalogic 3: Completeness of SND	Logic Book §6.4
Nov. 28 & 30	Problem Set 12 Due Friday 12/2	
Week 13	QL Metalogic 1: Soundness of QND	Supplement
	QL Metalogic 2: Completeness of QND	Supplement
Dec. 5 & 7	Problem Set 13 (12th graded PS) Due Friday 12/9	
Week 14	Catch-up if behind; otherwise Bonus Material!	TBD
	Review for Final	Handout
Dec. 12 &14	No Problem Set this week!	
Week 15	*FINAL EXAM* (TBD by Registrar in third week)	Dec. 16th ∨ 19th–22nd;
		up to 3-hours allowed

Health and Wellness Resources!

As my father always says, "Your health is your greatest wealth!" And that includes your mind! Almost everyone goes through a lot of stuff in their lives that can be difficult to handle. I encourage you to think freely and talk openly about the adversities you are going through and try to take appropriate steps to manage them on a regular basis. I am not a mental health professional, but I am a sympathetic ear. I encourage you to take advantage of the bevy of resources available to you, some of which are listed below.

If your adversities ever relate to school, try to remember that school is just school and that you are the arbiter of your own success. If your adversities relate at all to relationships, try to remember that there are many places and people in this great big sea of humanity to look for support. In any case, many people take time off and go on to live superbly happy, fulfilling lives! You've got a multitude of options, many more than you realize now! Try not to ever feel stuck in a corner!

More than anything, I hope you can remember the following facts: *You are enough. You are loved.*

Links and deets:

- *Student Mental Health & Counseling Services*
  - Phone number: 617-253-2916.
  - "Mental health clinicians are available 24 hours a day for urgent matters."
  - Provides evaluations, consultations, treatment, referrals!
- *Self-care Resources*!
  - Lots of helpful videos and podcasts addressing common stressors! (e.g. imposter syndrome, anxiety, procrastination, perfectionism, etc.)
- *Alcohol and Other Drug Services (AODS)*
  - Support for issues related to alcohol and other drug abuse, stress, and violence.
  - Substance addiction can be incredibly difficult. I would take this seriously!
- *VPR (Violence Prevention and Response)*
  - 617-253-2300 (9am to 5pm Monday thru Friday or afterhours to be directed to 24/7 resources)
  - Support for individuals who are dealing with issues such as sexual assault, dating and domestic violence, stalking, and sexual harassment.
  - "If you are unable to speak safely in your current situation, scheduled VPR advocacy appointments can be text- or chat-based."
  - Hotline available 24 hours a day during the school year
  - This should go without saying, but *please please please* do not be part of the problem on these absolutely devastating and gut-wrenching issues. *Always* show your fellow humans the respect that they deserve.
  - Additionally, if you see someone who IS part of the problem and feel safe doing so, speak up! We must never tolerate this egregious behavior from *anyone*.
- *A list of some additional resources*!
- If you've had experience with additional resources that you think belong here, please let me know so that I can add them!

Quotes!

"[One] will be imprisoned in a room with a door that is unlocked and opens inwards; as long as it does not occur to [them] to pull rather than push it."
–Ludwig Wittgenstein (in *Culture and Value*)

"It is a sign of strength to recognize these kinds of concerns and make a plan to deal with them constructively."
– MIT Mental Health & Counseling

"We often don't realize we've gone downhill until we have to go up again. We'll all get there in our own way." –Your instructor

"The future belongs to those who believe in the beauty of their dreams."
–Eleanor Roosevelt