PHIL 12A - Introduction to Logic

Prof. Wes Holliday
UC Berkeley

TuTh 12:30-2:00pm
Li Ka Shing 245

Syllabus version of March 10, 2019

Course Overview

Logical reasoning is essential in most areas of human inquiry. The discipline of Logic treats logical reasoning itself as an object of study. Logic has been one of the main branches of philosophy since Aristotle; it revolutionized the foundations of mathematics in the 20th century; and it has been called "the calculus of computer science," with applications in many areas. Logic has also played an important role in the investigation of language and the mind, as the basis for formal semantics in linguistics and automated reasoning in artificial intelligence. Today, Logic is an interdisciplinary subject with many applications.

PHILOS 12A is intended as a first course in logic for students with no previous exposure to the subject. The course treats *symbolic* logic. Students will learn to formalize reasoning in symbolic languages with precisely defined meanings and precisely defined rules of inference. Symbolic logic is by nature a mathematical subject, but the course does not presuppose any prior coursework in mathematics—only an openness to mathematical reasoning.

The Spring 2019 version of 12A concentrates on three systems of symbolic logic: *propositional logic* (also known as sentential logic); *syllogistic logic*; and *predicate logic* (also known as first-order logic). Propositional logic formalizes reasoning involving "propositional connectives" such as *and*, *or*, *not*, *if...then*, and *if and only if*, as these words are used in mathematics. Syllogistic logic formalizes reasoning involving basic patterns of "quantification" such as *all whales are mammals* or *some animals are carnivores*. Finally, predicate logic formalizes reasoning involving a greater variety of patterns of quantification, plus the attribution of properties to objects, both of which are on display in a statement such as *for every number that is prime, there is a larger number that is prime*.

Students from philosophy, mathematics, computer science, and linguistics will find important connections between the symbolic logic covered in 12A and their other coursework.

Learning Objectives

- grasp basic logical notions such as *validity*, *consequence*, *consistency*, and *contradiction*.
- translate fragments of natural language into the symbolic languages presented in the course
- give mathematically precise meanings (semantics) to the terms and sentences of the symbolic languages
- construct formally correct arguments in the logics presented in the course, mirroring valid arguments in mathematical, philosophical, or ordinary reasoning
- comprehend the metalogic notions of *soundness* and *completeness* of a logic
- understand the idea—and some specific examples—of algorithms for deciding the validity or consistency of logical formulas, as well as the idea of undecidability
- reduce certain practical problems to questions about the consistency of logical formulas
- understand basic connections between propositional logic and closely related ideas in other fields (e.g., Boolean algebra in mathematics, digital circuits in computer science)
- use the precise syntax and semantics of predicate logic to disambiguate sentences of natural language
- distill the logical structure of an informal mathematical proof using a formal logical deduction
- see how to formalize fragments of mathematics by adding non-logical axioms to the base system of predicate logic
- appreciate the sense in which predicate logic augmented with principles for reasoning about sets of objects can be said to provide a foundation for mathematics

Course Materials

As our textbook, we will use the freely available online logic text *Logic in Action* at http://www.logicinaction.org, as well as materials posted on bCourses by the instructors.

Course Questions

We will use the online Q&A platform **Piazza** to handle all questions about course content or logistics (Piazza also allows private questions), aside from questions raised in lecture, sections, and office hours. For private questions intended only for your GSI or professor, please use bCourses messages or email.

Requirements

- Weekly problem sets, due on Tuesdays in class (45% of grade)
- Midterm exam on March 21 in class (20% of grade)
- Final exam on May 16 from 3-6pm (35% of grade)

Class, section, and Piazza participation will be taken into account for borderline grades.

Sections

All enrolled students must attend a discussion section held by one of the GSIs.

Instructors

Wes Holliday | OHs: M 11-1 in 246 Moses

Raha Ahmadianhosseini (GSI) | Sections: TuTh 11-12, 2-3 | OHs: Th 4-6, Moses 301
Mathias Boehm (GSI) | Sections: TuTh 9-10, 10-11 | OHs: Th 3-5, Moses 301
Mikayla Kelley (GSI) | Sections: MW 10-11, 11-12 | OHs: Th 2-4, Evans 1060
Matthew McCauley (GSI) | Sections: MW 8-9, 9-10 | OHs: TuTh 3-4, Evans 737

Schedule

Part 1: Propositional Logic

Syntax and Semantics of Propositional Logic

1/22 Course Overview
Reading: Ch. 1 of *Logic in Action*

1/24 Liars and Truth-Tellers In-Class Activity

Reading: none.

1/29 What is Propositional Logic? Truth-Functional Connectives. The Truth-Functional Conditional. Valid Forms of Argument.
Reading: "Conditional" by Warren Goldfarb. §2.1, §2.2, and §2.3 of *Logic in Action*.

1/31 Formulas. Construction.
Reading: §2.4 of *Logic in Action*

2/5 Induction. Recursion.
Reading: §2.4 of *Logic in Action*

2/7 Truth. Valid Argument Forms.
Reading: §2.5, §2.6, and §2.8 of *Logic in Action*

Basic Theory of Propositional Logic

2/12 Validity and Equivalence. Satisfiability.
Reading: §2.5, §2.6, and §2.8 of *Logic in Action*

2/14 Economy of Language.
Reading: §2.9 of *Logic in Action*

2/19 Truth Functions. Truth-Functional Completeness.
Reading: §2.9 of *Logic in Action*

2/21 Digital Circuits. Algorithms I: Algorithm for CNF. Algorithms II: Resolution.
Reading: §2.9 of *Logic in Action*

2/26 Algorithms III: Complexity. Combinatorial Problems.

Reading: "Boolean Satisfiability" by Sharad and Zhang

Natural Deduction for Propositional Logic

2/28 Conditional Introduction. Conditional Elimination. Reiteration.
Reading: §9.1 of *Logic in Action*

3/5 A Proof System. Conjunction. Biconditional.
Reading: §9.1 of *Logic in Action*

3/7 Negation Introduction. Negation Elimination. Reductio Ad Absurdum.
Reading: §9.1 of *Logic in Action*

3/12 Disjunction Introduction. Disjunction Elimination.
Reading: §9.1 of *Logic in Action*

Syllogistic Logic

3/14 Syllogistic Logic
Reading: Ch. 3 of *Logic in Action*
3/19 Syllogistic Logic
Reading: Ch. 3 of *Logic in Action*

3/21 In-Class Midterm (on material from 1/29 to 3/12)

3/26 Spring Break. No class.
3/28 Spring Break. No class.

Part 2: Predicate Logic

Syntax and Semantics of Predicate Logic

4/2 Pure Monadic Predicate Logic I and II.
Reading: §4.1, §4.2, and §4.3 of *Logic in Action*

4/4 Constants. Functions.
Reading: §4.9 (Function Symbols) of Logic in Action

4/9 Identity. Substitution.
Reading: §4.9 (Identity) of Logic in Action.

4/11 Predicates of Higher Arity. Functions of Higher Arity.
Reading: §4.4, §4.5, §4.6, §4.7, §4.9 (Function Symbols), and §4.12 of *Logic in Action*

Proofs for Predicate Logic

4/16 Identity. Universal Elimination.
Reading: §9.2 of Logic in Action

4/18 Universal Introduction
Reading: §9.2 of Logic in Action

4/23 Existential Introduction. Existential Elimination.
Reading: §9.2 of Logic in Action

Applications of Predicate Logic

4/25 Arithmetic
Reading: §4.10 and §9.3 of *Logic in Action*. "Formally Verified Mathematics" by Avigad and Harrison.

4/30 Arithmetic. Set Theory.
Reading: §6.1 and §6.2 of "The Philosophy of Set Theory" by Mary Tiles

5/2 Set Theory
Reading: §6.1 and §6.2 of "The Philosophy of Set Theory" by Mary Tiles

Course Policies

Academic Integrity

"Any test, paper or report submitted by you and that bears your name is presumed to be your own original work that has not previously been submitted for credit in another course unless you obtain prior written approval to do so from your instructor.

In all of your assignments, including your homework or drafts of papers, you may use words or ideas written by other individuals in publications, web sites, or other sources, but only with proper attribution. "Proper attribution" means that you have fully identified the original source and extent of your use of the words or ideas of others that you reproduce in your work for this course, usually in the form of a footnote or parenthesis."

—Report of the UCB Academic Dishonesty and Plagiarism Subcommittee, June 18, 2004

- Students who are found to have plagiarized or cheated in the course will receive an F.

Extensions and Late Work

- Extensions will be granted only in case of medical or family emergencies or DSP accommodations.
- Late problem sets without prior notification of an emergency or DSP accommodation will not be accepted.
- Your lowest two scores on problem sets during the semester will be dropped.

Accommodations for Students with Disabilities

If you have a letter of accommodation from the Disabled Students Program, please let us know as soon as possible so that we can do whatever we can to help you in the course.

Our Policy on Sexual Violence and Harassment

Sexual violence and sexual harassment have no place in a learning environment. Therefore, in alignment with Title IX of the Education Amendments of 1972, it is the policy of the University of California (Sexual Harassment and Sexual Violence Policy) to prohibit sexual harassment, sexual assault, domestic/dating violence, and stalking. The UC Sexual Violence and Sexual Harassment Policy requires that the University immediately implement interim remedies and permanent support measures, when necessary, for victims/survivors. If you or someone you know experiences sexual violence or harassment, there are options, rights, and resources, including assistance with academics, reporting, and medical care. Visit survivorsupport.berkeley.edu or call the 24/7 Care Line at 510-643-2005.