Introduction to Logic, PHILOS W12A
Summer 2018

Four (4) semester credits

Please note that this syllabus is subject to change.

Course Description

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 online summer 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.

Prerequisites

There are no prior course requirements.

Course Objectives

After successfully completing this course, you will be able to:

- Grasp basic logical notions such as of *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

Instructor Information, Contact, Office Hours, & Communication

Course Instructor

Professor Wesley H. Holliday

Graduate Student Instructors (GSIs)

While the instructor will interact with the whole class and will oversee all activities and grading, as well as being available to resolve any issues that may arise, the GSIs will be your main point of contact. Your GSIs are responsible for assisting you directly with your questions about assignments and course requirements, as outlined in the Assignments and Calendar. The GSIs will also facilitate ongoing discussion and interaction with you on major topics in each module.

GSIs:

- Douglas Blue
- Reid Dale
- James Walsh
- Pia Schneider

Office Hours

The course instructor and GSIs will hold weekly virtual office hours using Zoom. There will be specific times posted under Online Office Hours, with information for how to access the virtual meeting. Students will also be able to communicate in real time (synchronously) using the Chat tool. While these chats are optional they can be valuable for discussion, answering questions, and reviewing for exams. Chats are optional; no points are awarded for participation.

Course Mail

Make sure to check the Course Mail for messages from the instructor. You can access course email within the Learning Management System by clicking on the Inbox link on the Corner Help toolbar (see also Canvas Overview Video) or choose to have your course mail forwarded to your personal email account or your cell phone.

Question & Answer Forum

There will be a discussion forum in Piazza that will be used as the Q&A platform. Please use this forum to post questions about the course material, assignments, the learning management system or online homework.

The instructor/GSIs will monitor this forum, but you should also feel free to post answers to help other students. This helps to create a general FAQ so that all students in the course may benefit from the exchange.

Course Materials and Technical Requirements

Educational Approach

In this course, students will learn via various approaches including (but not limited to) video lectures, Q&A forums (Piazza), homework assignments, quizzes, and online office hours. In order to make the most of your experience, we encourage you to participate as much as possible in the Q&A forums and partake in the online office hours.

Required Materials

As our textbook, we will use the freely available online logic text:

- *Logic in Action* at http://www.logicinaction.org

The instructor will also post other materials to the course webpage for your review.

Technical Requirements

This course is built on a Learning Management system (LMS) called Canvas and you will need to meet these computer specifications to participate within this online platform.

Optional

Canvas allows you to record audio or video files of yourself and upload them in the course. Although doing so is not required for any of the activities, using these features will enhance your engagement in the course. If you would like to use these features, you will need to have a webcam and a microphone installed on your computer.

Technical Support

If you are having technical difficulties please alert one of the GSIs immediately. However, understand that neither the GSIs, nor the professor can assist you with technical problems. You must call or email tech support and make sure you resolve any issues immediately. Be sure to document (save emails and transaction numbers) for all interactions with tech support.

Extensions and late submissions will not be accepted due to "technical difficulties".

For 24/7 Tech Help Support: Call **1-855-308-2758** or e-mail support@instructure.com

Learning Activities

Academic Integrity

VERY IMPORTANT
You won't be able to access your course material until you read and make your pledge to Academic Integrity. Click the button below to navigate to and complete the Academic Integrity pledge.

ACADEMIC INTEGRITY PLEDGE

Sections

For grading purposes, each of you has been assigned to one of the course GSIs and placed within his/her section. Your particular GSI will grade all of your work, as well as that of your section-mates, and engage with you in the course discussions. You can see whose section you've been placed in by exploring the "Section" column within the "People" page or by examining your discussion group's title, which includes your GSI's name.

Modules

A module is a grouping of topics related to one area of study, typically with readings, lectures and various kinds of assignments. Each module contains a list of Learning Outcomes for the module. Your assignments reflect the learning activities to perform to reach those outcomes. Each module correlates to a week's worth of work.

Course Activities

You are expected to fully participate in all the course activities described here.

1. Read the assigned textbook pages
2. Watch and listen to the lecture presentations
3. Complete homework assignments
4. Complete weekly quizzes
5. Participate in Q&A discussion on Piazza
6. Read web-based announcements and postings assign during the course
7. Complete the midterm exam and final exam

Reading Assignments

Each week will contain readings from the textbook for each section covered. You are responsible for all readings, as content from the readings will be included in the homework assignments, quizzes, midterm, and final exam.

Multimedia Lectures

Multimedia lectures will be given each week that break down the topics covered in the readings. You are expected to take notes while reviewing the lectures, as you would in a regular classroom. A handout of the slides will also be made available to the students in PDF format. Recorded lectures support your readings and assignments but also contain additional material that may be included in the exams.

Homework Assignments

Each week there will be homework assignments comprised of problem sets to be completed. These assignments will be graded on completion and correctness and are meant to prepare you for the quizzes, midterm, and final exams.

There will be problem sets in each week, that will be due at the end of each week. You may turn them in early, but late assignments will not be accepted. If you submit your assignment early, you may update your submission by uploading a new file at any time before the deadline for the assignment.

Problem sets are designed to be harder than the exams, and they will require thinking and analysis on your part.

Participation

We will use the bCourses discussion forum for handling all questions and answers about the course. Students are expected to participate in the weekly discussion by reading articles and answering questions about the articles in the discussion forum. Students are also encouraged to ask and answer questions pertaining to the content of the course in the General Discussion Forum. The analytics provided by bCourses will be taken into account when determining participation grades. Participation will also involve online office hours via Zoom.

Midterm Exam

You will complete a midterm exam at the end of Week 4. The exam covers the content of Weeks 1-4 and contains problems to be solved. A sample midterm exam will be provided for you to practice. The exam will be available for a 24-hour window in Week 4. You must take it within the prescribed 24-hour window. The date will be posted in bCourses.

While the exam is considered an open-book examination, it cannot be taken collaboratively with other students. The learning management system keeps detailed records of logins and submissions. Please review the ethics guideline for online courses provided at the beginning of this class and the UC Berkeley code of conduct.

Final Exam

You will take a three hour, closed-book final exam on paper. The final exam will take place on **Weds, August 8th, from 1-4pm**. The location will be announced.

There will be no make-up exam. Students must take the final examination in person or possibly arrange to have the examination proctored if you cannot come to campus.

If you are unable to make it onto campus for your final exam, you may have the option to take it under the supervision of a proctor to receive credit for the course. Review the Proctor Information page, located in the left navigation menu of bCourses.

Off-site proctor applications must be submitted prior to June 13, 2018.

Reminder: Your Course End Date

Your course will end on August 10, 2018. As you work through the course, please keep the end date in mind, and if you want to save any commentary or assignments for future reference, please make sure to print or copy/paste those materials before your access ends.

Grading and Course Policies

Your final course grade will be calculated as follows:

Table 1: Final Grade Percentages

Category	Percentage of Grade
Homework Assignments/Problem sets	40%
Participation/Discussion Assignments	10%
Midterm Exam	20%
Final Exam	30%

Final grades are assigned according to the following percentages:

Letter Grade	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
Percentage	100-94	93-90	89-86	85-83	82-80	79-76	75-73	72-70	69-66	65-63	62-60	< 60

It is important to note that not all components are graded online and included in the online course grade book. Because of this, the online course grade book will not display your overall course grade at any given time or your final grade. It should simply be used to assess your performance on the components that are included within it: the discussions, written assignments and midterm exam. Your final letter grade will be mailed to you by the registrar's office.

Late Work Policy

No late work will be accepted and no extensions will be granted, but please note that the lowest problem set score will be dropped.

Gradebook Disclaimer

It is important to note that not all components are graded online and included in the online course grade book. Because of this, the online course grade book will not display your overall course grade at any given time or your final grade. It should simply be used to assess your performance on the components that are included within it. Your final letter grade will be mailed to you by the registrar's office.

Course Policies

Promptness

Homework assignments and discussion forum postings all have specific final due dates and times. You will not receive full credit if assignments are submitted after the indicated due date.
Furthermore, each online activity must be submitted through the course website by the due date. Fax or mail submission will not be accepted. Students who wait until the final hours prior to a submission deadline risk having problems with their ISP, hardware, software, or various other site access difficulties. Therefore, it is advisable to submit assignments and tests through the course website early. The multiple days allowed for submission are to accommodate the busy schedules of working professionals, not to accommodate procrastination. Students should plan accordingly and get into the habit of checking the course website several times each week, and submitting and posting early.

Honor Code

The student community at UC Berkeley has adopted the following Honor Code: "As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others." The expectation is that you will adhere to this code.

Collaboration and Independence

Reviewing lecture and reading materials and studying for exams can be enjoyable and enriching things to do with fellow students. This is recommended. However, unless otherwise instructed, homework assignments and the online exam are to be completed independently

and materials submitted as homework should be the result of one's own independent work.

Cheating

A good lifetime strategy is always to act in such a way that no one would ever imagine that you would even consider cheating. Anyone caught cheating on a quiz or exam in this course will receive a failing grade in the course and will also be reported to the University Center for Student Conduct. Exams are to be completed without the assistance of other people, and without reference to texts, notes, and other materials. The expectation is that you will be honest in the taking of exams.

Plagiarism

To copy text or ideas from another source without appropriate reference is plagiarism and will result in a failing grade for your assignment and usually further disciplinary action. For additional information on plagiarism and how to avoid it, explore the resources linked below:

UC Berkeley Library Citation Page, Plagiarism Section
GSI Guide for Preventing Plagiarism

Academic Integrity and Ethics

Cheating on exams and plagiarism are two common examples of dishonest, unethical behavior. Honesty and integrity are of great importance in all facets of life. They help to build a sense of self-confidence, and are key to building trust within relationships, whether personal or professional. There is no tolerance for dishonesty in the academic world, for it undermines what we are dedicated to doing - furthering knowledge for the benefit of humanity.

Incomplete Course Grade

Students who have substantially completed the course but for serious extenuating circumstances, are unable to complete the final exam, may request an Incomplete grade. This request must be submitted in writing or by email to the GSI and course instructor. You must provide verifiable documentation for the seriousness of the extenuating circumstances. According to the policy of the college, Incomplete

grades must be made up within the first three weeks of the next semester.

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 do help you in the course.

Any students requiring course accommodations due to a physical, emotional, or learning disability must contact the Disabled Students' Program (DSP). They will review all requests on an individual basis. Request your Disabled Student Program Specialist to send the instructor a formal request before the official course start date by email

In addition, notify the instructor and your Online Learning Support Specialist, which accommodations you would like to use.
Your Online Learning Support Specialist is Tracie Allen and her email is: summer_online_support@berkeley.edu

End of Course Evaluation

Course Evaluation

UC Berkeley is committed to improving its courses and instruction. Please take a few minutes to participate in the Course Evaluation, which will be emailed to you. UC Berkeley instructors and administrators are interested in your online learning experience, and your candid feedback will help to plan for the future and make improvements. Please complete the evaluation before August 8th. The evaluation does not request any personal information, and your responses will remain strictly confidential.

Course End Date

Your access to the online classroom will expire on August 10th at midnight, which is indicated in the initial e-mail you received when you enrolled.

As you work through the course, please keep August 10th in mind, and if you want to save any commentary or assignments for future

reference, please make sure to print or copy/paste those materials before your access ends.

Course Outline

PART 1: PROPOSITIONAL LOGIC

Week 1: Syntax and Semantics of Propositional Logic

Learning Objectives:

- Identify propositional connectives and distinguish between truth-functional and non-truth-functional propositional connectives
- Grasp the concept of a valid form of argument and the truth table method for checking the validity of forms of argument involving truth-functional connectives
- Translate sentences of natural language into formulas of a precisely defined formal language of propositional logic
- Give mathematically precise meanings (semantics) to the formulas of the propositional logical language

Reading for Weekly Discussion Question:
§1 and §2 of "Do Conditionals Have Truth Conditions?" by Dorothy Edgington

Unit 1.0 What is Logic?

Reading: Ch. 1 of *Logic in Action*

Unit 1.1 Semi-Formal Introduction to Propositional Logic

Video Lectures:
1.1.1 – What is propositional logic?
1.1.2 – Truth-functional connectives
1.1.3 – The Truth-Functional Conditional
1.1.4 – Valid Forms of Argument I
1.1.5 – Valid Forms of Argument II

Associated Readings:
1.1.3 – "Conditional" by Warren Goldfarb
1.1.4 and 1.1.5 – §2.1, §2.2, and §2.3 of *Logic in Action*

Unit 1.2 The Language of Propositional Logic

Video Lectures:
1.2.1 – Formulas
1.2.2 – Construction
1.2.3 – Induction
1.2.4 – Recursion

Associated Readings:
§2.4 of *Logic in Action*

Unit 1.3 Semantics for the Propositional Language

Video Lectures:
1.3.1 – Truth
1.3.2 – Valid Argument Forms
1.3.3 – Validity and Equivalence
1.3.4 – Satisfiability

Associated Readings:
1.3.1 – §2.5 of *Logic in Action*
1.3.2 – §2.6 and §2.8 of *Logic in Action*
1.3.3 and 1.3.4 – §2.6 of *Logic in Action*

Week 2: Basic Theory of Propositional Logic

Learning Objectives:

- Prove that every formula of propositional logic is equivalent to a formula containing only certain connectives
- Understand the correspondence between propositional formulas, truth functions, and digital circuits
- Learn algorithms for deciding the validity/satisfiability of propositional logical formulas and reflect on the complexity of these algorithms
- Reduce certain practical problems to questions about the satisfiability of propositional logical formulas

Reading for Weekly Discussion Question:
"Boolean Satisfiability" by Sharad Malik and Lintao Zhang

Unit 2.1 Economy of Language

Video Lectures:
2.1.1 – Economy of Language I
2.1.2 – Economy of Language II

Associated Readings:
§2.9 of *Logic in Action*

Unit 2.2 Theory and Applications of Truth Functions

Video Lectures:
2.2.1 – Truth Functions I
2.2.2 – Truth Functions II
2.2.3 – Truth-Functional Completeness I
2.2.4 – Truth-Functional Completeness II (Extra Credit)
2.2.5 – Digital Circuits

Associated Readings:
§2.9 of *Logic in Action*

Unit 2.3 Algorithms and Combinatorial Problems

Video Lectures:
2.3.1 – Algorithm I: An Algorithm for CNF
2.3.2 – Algorithm II: Resolution
2.3.3 – Algorithm III: Complexity
2.3.4 – Combinatorial Problems

Associated Readings:
§8.1 of *Logic in Action*

Week 3: Natural Deduction for Propositional Logic

Learning Objectives:

- Construct formally correct arguments in propositional logic, mirroring valid arguments in mathematical, philosophical, or ordinary reasoning
- Distill the propositional-logical structure of an informal mathematical proof using a formal propositional-logical deduction
- Comprehend the metalogic notions of soundness and completeness of propositional logic

Reading for Weekly Discussion Question:
"The Justification of Deduction" by Susan Haack

Unit 3.1 Natural Deduction Part 1

Video Lectures:
3.1.1 – Natural Deduction I: Conditional Introduction
3.1.2 – Natural Deduction II: Conditional Elimination
3.1.3 – Natural Deduction III: Reiteration
3.1.4 – Natural Deduction IV: A Proof System for the Conditional
3.1.5 – Natural Deduction V: Conjunction
3.1.6 – Natural Deduction VI: Biconditional

Associated Readings:
§9.1 of *Logic in Action*

Unit 3.2 Natural Deduction Part 2

Video Lectures:
3.2.1 – Natural Deduction VII: Negation Introduction
3.2.2 – Natural Deduction VIII: Negation Elimination
3.2.3 – Natural Deduction IX: Reductio Ad Absurdum
3.2.4 – Natural Deduction X: Disjunction Introduction
3.2.5 – Natural Deduction XI: Disjunction Elimination

Associated Readings:
§9.1 of *Logic in Action*

Week 4: Axioms, Algebras, and Syllogisms

Learning Objectives:

- Grasp the concept of *independence* of axioms in an axiomatic system

- Understand basic connections between propositional logic and *Boolean Algebra*
- Translate sentences of natural language into formulas of the syllogistic language
- Give mathematically precise meanings (semantics) to the formulas of the syllogistic language
- Understand an algorithm for deciding the validity of a syllogistic inference

Reading for Weekly Discussion Question:
"The Semantics and Pragmatics of Logical Connectives" by Masoud Jasbi and Michael Frank

Unit 4.1 Axiomatic Proof

Video Lectures:
3.2.1 – Axiomatic Proof
3.2.2 – Independence of the Axioms

Associated Readings:
§2.7 of *Logic in Action*

Unit 4.2 Boolean Algebra

Video Lectures:
4.2.1 – Boolean Algebra

Associated Readings:
§2.10 and §3.3 of *Logic in Action*

Unit 4.3 Syllogistic Logic

Video Lectures:
4.3.1 – Syllogistic Logic

Associated Readings:
Ch. 3 of *Logic in Action*

Midterm Exam

The exam covers the content of Weeks 1-4 and contains problems to be solved. The exam is timed. You will have a 24 hour period to

download the exam questions, complete them and upload them back to bCourses within that 24 hour window. While the exam is considered an open-book examination, it cannot be taken collaboratively with other students.

PART 2: PREDICATE LOGIC

Week 5: Syntax and Semantics of Monadic Predicate Logic

Learning Objectives:

- Translate sentences of natural language into formulas of the monadic predicate logical language
- Give mathematically precise meanings (semantics) to the formulas of the monadic predicate logical language
- Understand what it means for the validity problem of pure monadic predicate logic to be *decidable*

Reading for Weekly Discussion Question:
"Are There Nonexistent Objects?" by Terence Parsons

Unit 5.1 Pure Monadic Predicate Logic

Video Lectures:
5.1.1 – Pure Monadic Predicate Logic I
5.1.2 – Pure Monadic Predicate Logic II

Associated Readings:
§4.1, §4.2, and §4.3 of *Logic in Action*
"Burn All Your Textbooks" by Varol Akman

Unit 5.2 Constants and Functions

Video Lectures:
5.2.1 – Constants
5.2.2 – Functions

Associated Readings:
5.2.2 – §4.9 (Function Symbols) of *Logic in Action*

Unit 5.3 Identity and Substitution

Video Lectures:
5.3.1 – Identity
5.3.2 – Substitution

Associated Readings:
5.3.1 – §4.9 (Identity) of *Logic in Action*

Week 6: Syntax and Semantics of Full Predicate Logic

Learning Objectives:

- Translate sentences of natural language into formulas of the predicate logical language
- Give mathematically precise meanings (semantics) to the formulas of the predicate logical language
- Understand what it means for the validity problem of predicate logic to be *undecidable*

Reading for Weekly Discussion Question:
"The Identity of Indiscernibles" by Max Black

Unit 6.1 Predicate of Higher Arity

Video Lectures:
6.1.1 – Predicates of Higher Arity

Associated Readings:
§4.4, §4.5, §4.6, §4.7, and §4.12 of *Logic in Action*

Unit 6.2 Functions of Higher Arity

Video Lectures:
6.2.1 – Functions of Higher Arity

Associated Readings:
§4.9 (Function Symbols) of *Logic in Action*

Week 7: Proofs for Predicate Logic

Learning Objectives:

- Construct formally correct arguments in predicate logic, mirroring valid arguments in mathematical, philosophical, or ordinary reasoning

- Comprehend the metalogic notions of *soundness* and *completeness* of predicate logic

Reading for Weekly Discussion Question:
"Formally Verified Mathematics" by Jeremy Avigad and John Harrison

Unit 7.1 Natural Deduction for Identity

Video Lectures:
7.1.1 – Natural Deduction XII: Identity

Associated Readings:
§9.2.1 of *Logic in Action*

Unit 7.2 Natural Deduction for Quantifiers

Video Lectures:
7.2.1 – Natural Deduction XIII: Universal Elimination
7.2.2 – Natural Deduction XIV: Universal Introduction
7.2.3 – Natural Deduction XV: Existential Introduction
7.2.4 – Natural Deduction XVI: Existential Elimination

Associated Readings:
§9.2 of *Logic in Action*

Unit 7.3 Axiomatic Proofs for Predicate Logic

Video Lectures:
None

Readings:
§4.8 of *Logic in Action*

Week 8: Applications of Predicate Logic

Learning Objectives:

- Distill the predicate-logical structure of an informal mathematical proof using a formal predicate-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

Reading for Weekly Discussion Question:
Pages 215-222 of "The Iterative Conception of Set" by George Boolos

Unit 8.1 Arithmetic

Video Lectures:
8.1.1 – Arithmetic I
8.1.2 – Arithmetic II
8.1.3 – Arithmetic III

Readings:
§4.10 and §9.3 of *Logic in Action*

Unit 8.2 Set Theory

Video Lectures:
8.2.1 – Set Theory I
8.2.2 – Set Theory II
8.2.3 – Set Theory III

Readings:
§6.1 and §6.2 of "The Philosophy of Set Theory" by Mary Tiles