# PHIL 370 - Logical Theory I: Metatheory

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| Instructor: | Eric Pacuit (pacuit.org) |
| Semester: | Spring 2021 |
| Email: | epacuit@umd.edu |
| Course Website: | myelms.umd.edu/courses/1269229 |
| Class Times: | MW 10:00am - 10:50am |
| Office Hours: | Wednesdays 12 - 1 |

## Course Description

The goal of this course is to provide students with a basic understanding of the proof theory and semantics of classical propositional and first-order logic; we prove fundamental metatheoretic results, including equivalences between different proof-theoretic systems, soundness, and completeness. By the end of the term, students should have a good understanding of these results, as well as the techniques involved in establishing them and in constructing proofs about formal systems more generally. Although the subject of symbolic logic was developed by mathematicians and philosophers for their own special purposes (which we may discuss), logical concepts and techniques have found applications in a variety of disciplines including computer science, economics, law, linguistics, and psychology. Students in any of these subjects can benefit from the ideas studied in this course.

> **WARNING**: Although this course builds on material from PHIL 170, it is very different in character. In this course, we prove theorems *about* logical systems (and not *in* logical systems). Doing well in PHIL 170 is no guarantee that this will come easy to you.

## Textbook

All the required reading for this course will be available on ELMS. Much of the primary text is based on the open logic textbook (an open source logic text): openlogicproject.org

**About the Open Logic Project**: The *Open Logic Text* is an open-source, collaborative textbook of formal meta-logic and formal methods, starting at an intermediate level (i.e., after an introductory formal logic course). Though aimed at a non-mathematical audience (in particular, students of philosophy and computer science), it is rigorous.

The project operates in the spirit of open source. Not only is the text freely available, we provide the LaTeX source under the Creative Commons Attribution license, which gives anyone

the right to download, use, modify, re-arrange, convert, and re-distribute our work, as long as they give appropriate credit.

Please see the Open Logic Project website at openlogicproject.org for additional information.

**Additional Readings**.

- `http://www.logicinaction.org`: A free online textbook providing a general introduction to logic.
- H. Enderton, *A Mathematical Introduction to Logic* (second edition), Academic Press, 2002.
- G. Boolos, J. Burgess and R. Jeffrey, *Computability and Logic*, Cambridge University Press, 2007.
- Graham Priest, *An Introduction to Non-Classical Logic*, Cambridge University Press, 2008.

## In-Class Quizzes

There will be in-class quizzes given periodically during the lectures. These will be delivered using the tools from tophat.com. Please sign up for a subscription at tophat.com, the join code for this course is **049479**.

## Communication about this course

I will use email to convey important information, and students are responsible for keeping their email address up to date, and must ensure that forwarding to another address functions properly. Failure to check email, errors in forwarding, and returned email are the responsibility of the student, and do not constitute an excuse for missing announcements or deadlines.

All announcements (e.g., changes to the schedule, hints about the problem sets) about the course will be posted on the ELMS announcement page.

`https://myelms.umd.edu/courses/1269229/announcements`

Please make sure that you check this page regularly and/or receive the email notifications from ELMS when the page is updated.

## Grading Policy

The course requirements are:

- Participation (20%),
- Problem Sets (40%),
- Exam 1 (10%)
- Exam 2 (10%)
- Final Exam (20%)

I will grade on a curve (this means that, for example, a final average of 90% may turn out to be an $A$ rather than an $A-$). See the undergraduate catalogue for the official description of grades, e.g., A+, A, A-, etc.: `http://www.umd.edu/catalog/index.cfm/show/content.section/c/27/ss/1584/s/1534`.

**Participation**: Active participation in the course is very important. The only way to learn the material is to

Throughout the semester, I will give short in-class quizzes. These in-class quizzes will generally not be announced and could take place at any time during the lecture. The purpose of these in-class quizzes is to encourage participation and to test basic comprehension of the material. There are no make-ups for missed in-class quizzes. The lowest scores of 10% of the total number of quizzes will be dropped (so if there are 50 in-class quizzes, then the lowest 5 quiz scores will be dropped).

Although I will not take attendance, students are *strongly encouraged to attend all lectures.* This is a fast-paced course, so you will quickly fall behind if you miss lectures. Students are responsible for any announcement made during the lectures.

**Problem Sets**: There will be some short problem sets. The problem sets will be assigned on ELMS and your solutions must be submitted on ELMS. You will receive 5 points for completing the problem set on time (this grade is only based on whether you completed the problem set). We will discuss the solutions in class. To receive full credit for the problem sets, you must submit your (corrected) solutions to the problem sets as a single pdf document by the end of the semester.

**Exams**: There will be several in-class exams throughout the semester and a final exam. The dates of the exam depends on how fast we move through the material. Exams will be announced at least a week in advance and a review sheet will be provided. Make-up exams will not be scheduled after the exam date (except for emergencies such as illness or death in the family).

The final will be an in-class exam given during finals week. It will be a cumulative exam covering all the topics discussed throughout the semester (a review sheet will be provided towards the end of the semester).

Final exam week is **December 11 - 17**. The official final exam schedule is not available until mid-semester. Consult

`https://ntst.umd.edu/soc/exam/search?courseId=&sectionId=&termId=201908`

for the Fall 2019 exam schedule.

A student may seek to reschedule final examinations so that he or she has no more than three (3) examinations on any given day. It is the responsibility of the student to initiate the rescheduling or be responsible for taking the examination as originally scheduled. If requesting to reschedule the exam, please notify the instructor at least 2 weeks before the scheduled exam date.

## Topics

Below is a list of topics that we will discuss during the semester. This is an ambitious list, which may change given the students' background and interests. (Consult the ELMS course site for the most up-to-date information about due dates for the problem sets and dates of the exams).

1. Elementary set theory
   (a) Sets, relations, functions
   (b) Properties of relations and functions
   (c) Induction
   (d) Possible topic: size of sets
2. Propositional logic: syntax, basic proof theory
   (a) Fitch-style natural deduction
   (b) Hilbert-style axiomatic systems
   (c) Tableaux systems
   (d) Syntactic metatheorems (e.g., deduction theorem)
   (e) Possible topic: Equivalence of formulations
3. Propositional logic: Semantics, soundness, completeness
   (a) Semantics for classical propositional logic
   (b) Functional completeness
   (c) Soundness and completeness for Hilbert systems
   (d) Possible topic: Soundness and completeness for Tableaux systems
4. First-order logic: Syntax and basic proof theory
   (a) Syntax (terms and formulas)
   (b) Hilbert-style axiom system
   (c) Natural deduction system
   (d) Possible topic: Tableaux system
   (e) Syntactic metatheorems
5. First-order logic: Semantics, soundness, completeness
   (a) Semantics for first-order logic
   (b) Soundness and completeness for Hilbert systems
   (c) Adding identity
   (d) Possible topic: Soundness and completeness for tableaux systems
   (e) Possible topic: Compactness, Lowenheim-Skolem theorem

(f) Possible topic: Interpolation, Beth definability

6. Some nonclassical logics (time permitting)
   (a) Some modal logics
   (b) Intuitionistic logic
   (c) Many-valued logics
7. Introduction to computability (time permitting)
   (a) Models of computation
   (b) Decidability of propositional logic
   (c) Undecidability of first-order logic

## Learning Outcomes

Students who successfully complete this course will be prepared to:

- Define the logical systems propositional logic and first order logic
- Be proficient with basic set-theoretic reasoning and mathematical induction
- Explain the similarities and differences between propositional logic and first order logic
- Reproduce the proofs of important meta-logical theorems (completeness and compactness)

## Class Cancelations

The University may be closed in the event of an emergency, in which case class will be cancelled. To find out if the University is closed you can check its main site (`http://www.umd.edu`), its emergency preparedness site (`http://www.umd.edu/emergencypreparedness/`), or call the "snow phone line" at 301-405-7669 (which covers more than just snow caused closings). If class is cancelled while the University remains open, then there will be an announcement posted on the course ELMS page.

**Emergency protocol**: In the case of an extended closure to the University (e.g., because of inclement weather), consult the ELMS course page for announcements and changes to any due dates.

## Academic Support

You should make sure you are familiar with the rules regarding proper academic conduct as outlined at `http://www.shc.umd.edu/`.

**Accommodations**. Students who require special accommodations should inform the instructor at the beginning of the course, and must provide the appropriate documentation from the DSS office (see `http://www.counseling.umd.edu/DSS/`).

## Course Procedures and Policies

Consult the following webpage for the official procedures and policies for this course:

www.ugst.umd.edu/courserelatedpolicies.html