

PHIL 143 - Modal Logic

Professor Wes Holliday
UC Berkeley, Fall 2020

TuTh 2-3:30
on Zoom

Syllabus¹

Description

This course is an introduction to the logical study of modality in its many forms: reasoning about necessity, knowledge, obligation, time, counterfactuals, provability, and other modal notions. Modal logic has a long history in philosophy, beginning in the Ancient world with Aristotle, Diodorus Chronus, Chrysippus, and others, continuing in the Middle Ages with Duns Scotus, Ockham, Buridan, and more, and leading to major advances in the 20th century by some of the most influential analytic philosophers, including C.I. Lewis, Rudolf Carnap, Ruth Barcan Marcus, Saul Kripke, and David Lewis. Today modal logic is studied at the cutting-edge of several areas of philosophy, including metaphysics, epistemology, and the philosophy of language, as well as in interdisciplinary contexts: e.g., applications of deontic logics to normative systems and legal reasoning, applications of temporal logics in hardware and software verification, applications of epistemic logics to game theory and multi-agent systems, and more. In this course, we will study some of the same problems of modality studied by our ancient, medieval, and 20th century predecessors in philosophy, but now armed with 21st century tools from formal logic. The course covers the core concepts and basic metatheory of propositional modal logic, including relations to first-order logic; the basics of quantified modal logic; and selected philosophical applications ranging from epistemology to ethics, from metaphysics to mathematics.

Prerequisites

12A (or equivalent) or consent of instructor. A solid grasp of the material on propositional and first-order logic from 12A is essential for understanding the content of this course.

Textbook

- *Modal Logic for Open Minds* by Johan van Benthem, available from the bookstore.
- Additional readings will be posted on [bCourses](#) (see the Readings section below).

Requirements

- Weekly problem sets, due on Tuesdays before class (45% of grade)
- Term paper of around 7-8 pages, due on Dec. 13 (35% of grade)
- Final exam from 8-11am on Dec. 15 (20% of grade)

Class, section, and [Piazza](#) participation will be taken into account for borderline grades.

For graduate students in philosophy, this course satisfies the formal philosophy course requirement. Graduate students should contact Professor Holliday about assignments.

¹The electronic version at philosophy.berkeley.edu/people/page/123 contains hyperlinks to readings and resources.

Sections

All enrolled students must attend a weekly discussion section. Sections will be led by GSI Yifeng Ding, a Ph.D. candidate in the Group in Logic and Methodology of Science.

Contact

Prof. Holliday | wesholliday@berkeley.edu | OHs: Fridays 2-4 on Zoom

Yifeng Ding | yf.ding@berkeley.edu | OHs: Mondays 2-4 on Zoom

Schedule

Part I: Basic Concepts and Theory of Propositional Modal Logic

Aug. 27 (Th) **Course Overview**

Reading: none.

Sept. 1 (Tu) **Sets, Relations, and Functions; Proofs by Induction**

Reading: [Partee et al. 1990](#), chs. 1-3 on sets, relations and functions; [van Dalen 2008](#), pp. 5-14 on induction.

Sept. 3 (Th) **Basic Language and Semantics**

Reading: [van Benthem 2010](#), ch. 2; [Pacuit 2009](#), §1.

- Problem Set 1 due before class Sept. 8.

Sept. 8 (Tu) **Expressive Power and Invariance I**

Reading: [van Benthem 2010](#), ch. 3; [Pacuit 2009](#), §3 (not including §3.1).

Sept. 10 (Th) **Expressive Power and Invariance II**

Reading: [van Benthem 2010](#), ch. 3; [Pacuit 2009](#), §3 (not including §3.1).

- Problem Set 2 due before class Sept. 15.

Sept. 15 (Tu) **Validity and Decidability I**

Reading: [van Benthem 2010](#), ch. 4; [Pacuit 2009](#), §2.

Sept. 17 (Th) **Validity and Decidability II**

Reading: [van Benthem 2010](#), ch. 4; [Pacuit 2009](#), §2.

- Problem Set 3 due before class Sept. 22.

Sept. 22 (Tu) **Axioms, Proofs, and Completeness I**

Reading: [van Benthem 2010](#), ch. 5; [Pacuit 2009](#), §4.

Sept. 24 (Th) **Axioms, Proofs, and Completeness II**

Reading: [Blackburn et al. 2001](#), §4.2.

- Problem Set 4 due before class Sept. 29.

Sept. 29 (Tu) **Correspondence Theory**

Reading: [van Benthem 2010](#), §9.1-9.2; [Pacuit 2009](#), §3.1.

Oct. 1 (Th) **The Landscape of Normal Modal Logics**

Reading: [van Benthem 2010](#), ch. 8.

- Problem Set 5 due before class Oct. 6.
- Review first-order logic in section with your GSI before Oct. 8.

Oct. 6 (Tu) **Non-normal Modal Logics**

Reading: [van Benthem 2010](#), §10.4; [Pacuit 2007](#), §1, §2.2-2.3.

Oct. 8 (Th) **Modal Fragment(s) of First-Order Logic**

Reading: [van Benthem 2010](#), §A.1, §7.1-7.3, §7.5, §25.1.

- Problem Set 6 due before class Oct. 13.

Start thinking about paper topics as we cover applications in Part II.
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Recommended readings can provide inspiration for paper topics.
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Part II: Applications of Propositional Modal Logic

Oct. 13 (Tu) **Temporal Logic I**

Reading: [Fitting and Mendelsohn 1998](#), §1.10; [van Benthem 2010](#), §18.1-18.3; [Venema 2001](#), §1-3 (up to Theorem 3.1), §4-5.

Oct. 15 (Th) **Temporal Logic II**

Aristotle's Sea Battle and the Master Argument of Diodorus Cronus

Reading: [Fitting and Mendelsohn 1998](#), 35-40.

Recommended: [MacFarlane 2003](#) on future contingents.

- Problem Set 7 due before class Oct. 20.

Oct. 20 (Tu) **Counterfactuals I**

Reading: [Lewis 1973](#), §1.1-1.4, §2.3.

Oct. 22 (Th) **Counterfactuals II**

Counterfactual Fallacies

Reading: [Lewis 1973](#), §1.5-1.8.

Recommended: [Moss 2012](#) on the pragmatics of counterfactuals.

- Problem Set 8 due before class Oct. 27.

Oct. 27 (Tu) **Deontic Logic I**

Reading: [Hilpinen 2001](#), 159-170¶2.

Oct. 29 (Th) **Deontic Logic II**

Chisholm's Paradox of Contrary-to-Duty Obligations

Reading: Lewis 1973, §5.1.

Recommended: Fusco 2015, 2019 on deontic paradoxes.

- Problem Set 9 due before class Nov. 3.

Nov. 3 (Tu) **Epistemic Logic I**

Reading: van Benthem 2010, ch. 12, §13.1-13.3; Holliday 2018.

Nov. 5 (Th) **Epistemic Logic II**

The Surprise Examination Paradox

Reading: Sorensen 1988, 253-255, 289-292, 317-320.

Recommended: Yap 2014 on idealization in epistemic logic; Smets and Velázquez-Quesada 2019 on combining knowledge and other modalities.

- Problem Set 10 due before class Nov. 10.

Nov. 10 (Tu) **Dynamic Epistemic Logic I**

Reading: van Benthem 2010, §15.1-15.4, §15.6-15.7.

Nov. 12 (Th) **Dynamic Epistemic Logic II**

Fitch's Paradox of Knowability

Reading: van Benthem 2004.

Recommended: Liu et al. 2014 for an application of dynamic epistemic logic to belief and social epistemology.

- Problem Set 11 due before class Nov. 17.

Please email a short description of your paper topic to your GSI by Nov. 19 at the latest.
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Part III: Quantified Modal Logic

Nov. 17 (Tu) **Quantified Modal Logic I**

Reading: Fitting and Mendelsohn 1998, §4.1-4.6.

Recommended: Lindström and Segerberg 2007, §1 on history of QML in philosophy.

Nov. 19 (Th) **Quantified Modal Logic II**

Reading: Fitting and Mendelsohn 1998, §4.7-4.8; van Benthem 2010, §11.1-11.2.

- Problem Set 12 due before class Nov. 24.

Nov. 24 (Tu) **Quantified Modal Logic III**

Reading: [Fitting and Mendelsohn 1998](#), §4.9, §6.1-6.3; [van Benthem 2010](#), §11.3 -11.4.

- Problem Set 13 due before class Dec. 1.

Recommended: [Aloni 2005](#) on quantified epistemic logic.

Nov. 26 (Th) **No Class** (Thanksgiving)

Dec. 1 (Tu) **Intuitionistic Logic** or **Provability Logic** (depending on student interest)

Reading: ch. 21 or ch. 22 of [van Benthem 2010](#).

Recommended: [Moschovakis 2018](#) on intuitionistic logic; [Verbrugge 2017](#) on provability logic.

[Part IV: Conclusion](#)

Dec. 3 (Th) **Course Review**

Reading: none.

- Term paper due Dec. 13.

Dec. 15 **Final Exam** (8-11am)

Readings

Maria Aloni. [Individual Concepts in Modal Predicate Logic](#). *Journal of Philosophical Logic*, 34(1): 1–64, 2005.

Patrick Blackburn, Maarten de Rijke, and Yde Venema. *Modal Logic*. Cambridge, 2001.

Melvin Fitting and Richard L. Mendelsohn. *First-Order Modal Logic*. Kluwer, Dordrecht, 1998.

Melissa Fusco. [Deontic Modality and the Semantics of Choice](#). *Philosophers Imprint*, 15(28):1–27, 2015.

Melissa Fusco. [Naturalizing Deontic Logic](#). *Philosophical Perspectives*, 32(1):165–187, 2019.

Risto Hilpinen. [Deontic Logic](#). In Lou Goble, editor, *The Blackwell Guide to Philosophical Logic*, pages 159–182. Blackwell, 2001.

Wesley H. Holliday. [Epistemic Logic and Epistemology](#). In Sven Ove Hansson and Vincent F. Hendricks, editors, *Introduction to Formal Philosophy*, pages 351–369. Springer, 2018.

David Lewis. *Counterfactuals*. Blackwell, 1973.

Sten Lindström and Krister Segerberg. [Modal Logic and Philosophy](#). In P. Blackburn, J. van Benthem, and F. Wolter, editors, *Handbook of Modal Logic*, pages 1149–1214. Elsevier, 2007.

Fenrong Liu, Jeremy Seligman, and Patrick Girard. [Logical dynamics of belief change in the community](#). *Synthese*, 191:2403–2431, 2014.

John MacFarlane. [Future Contingents and Relative Truth](#). *The Philosophical Quarterly*, 53(212): 321–336, 2003.

Joan Moschovakis. [Intuitionistic Logic](#). In Edward N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, winter 2018 edition, 2018.

Sarah Moss. [On the Pragmatics of Counterfactuals](#). *Noûs*, 46(3):561–586, 2012.

Eric Pacuit. [Neighborhood Semantics for Modal Logic: An Introduction](#). 2007.

Eric Pacuit. [Notes on Modal Logic](#). 2009.

Eric Pacuit. [Neighborhood Semantics for Modal Logic](#). Springer, 2017.

Barbara H. Partee, Alice ter Meulen, and Robert E. Wall. *Mathematical Methods in Linguistics*. Springer, 1990.

Sonja Smets and Fernando Velázquez-Quesada. [Philosophical Aspects of Multi-Modal Logic](#). In Edward N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, summer 2019 edition, 2019.

Roy Sorensen. *Blindspots*. Oxford University Press, 1988.

Johan van Benthem. [What One May Come to Know](#). *Analysis*, 64(2):95–105, 2004.

Johan van Benthem. *Modal Logic for Open Minds*. CSLI Publications, 2010.

Dirk van Dalen. *Logic and Structure*. Springer, 4th edition, 2008.

Yde Venema. [Temporal Logic](#). In L. Goble, editor, *The Blackwell Guide to Philosophical Logic*, pages 203–223. Blackwell, 2001.

Rineke (L.C.) Verbrugge. [Provability Logic](#). In Edward N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, fall 2017 edition, 2017.

Audrey Yap. [Idealization, epistemic logic, and epistemology](#). *Synthese*, 191:3351–3366, 2014.

Other Resources

Supplements to Part I

[Blackburn et al. 2001](#) is an excellent source for mathematical treatment of normal propositional modal logics. For more on areas of contemporary research, see the [Handbook of Modal Logic](#) (2006). For non-normal modal logics, the standard text is now [Pacuit 2017](#). For a crash course, see Pacuit's [Course on Neighborhood Structures for Modal Logic](#).

Supplements to Part II

The [Stanford Encyclopedia of Philosophy](#) contains articles on many of the applications from Part II, which serve as good gateways to the relevant literatures.

There are also a number of books that cover philosophical applications of modal logic, including: *Philosophical Applications of Modal Logic* by Humberstone (2015); *Modal Logics and Philosophy* by Girle (2009); *Modal Logic for Philosophers* by Garson (2006); *Possibilities and Paradox* by Beall and van Fraassen (2003); *Logic for Philosophy* by Sider (2010); *An Introduction to Non-Classical Logic* by Priest (2008); *Philosophical Logic* by Burgess (2009); *A Companion to Philosophical Logic* edited by Jacquette (2005); *The Blackwell Guide to Philosophical Logic* edited by Goble (2001).

Supplements to Part III

In addition to [Fitting and Mendelsohn 1998](#), the books by Garson, Priest, and Sider, and the *Handbook of Modal Logic* cited above contain chapters on quantified modal logic.

LaTeX

For your problem sets, neatly handwritten submissions are fine. However, we recommend that you try [LaTeX](#) for typing your problem sets. LaTeX will beautifully typeset all of the logical symbols that you need to use in this course. Not only is this nice for those grading your work, but also it should help you to create clear and well-organized content. Knowing how to use LaTeX is a useful skill for other courses too. For help getting started with LaTeX, see Arc Kocurek's LaTeX page: www.actual.world/latex/.

Course Policies

Academic Integrity

- You are welcome to work together on solving problems, but you must write up answers on your own and indicate on your submission the student(s) with whom you worked.
- Students who are found to have plagiarized or cheated in the course will receive an F.

“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

Extensions and Late Work

- Extensions will be granted only in case of medical and family emergencies.
- Late problem sets without prior notification of an emergency will not be accepted.
- Your lowest score on a problem set during the semester will be dropped.
- Term papers submitted after the deadline will immediately lose one grade step (e.g., from B+ to B) and an additional step every 24 hours thereafter.

Regrades

- You have one week after a problem set is returned to request a regrade of a problem.
- Requests must come with a written explanation of why you would like a regrade.
- When a problem is regraded, the score may go up, down, or remain the same.
- Regrade requests are for problem sets only. Term papers will not be regraded.

Classroom Climate

We are all responsible for creating a learning environment that is welcoming, inclusive, equitable, and respectful. The expectation in this class is that we all live up to this responsibility, even during vigorous debate or disagreement, and that we will intervene if exclusionary or harassing behavior occurs. If you feel that these expectations are not being met, you can consult your instructors or seek assistance from campus resources.

Accommodations for Students with Disabilities

UC Berkeley is committed to creating a learning environment that meets the needs of its diverse student body including students with disabilities. If you anticipate or experience any barriers to learning in this course, please feel welcome to discuss your concerns with us. If you have a disability, or think you may have a disability, you can work with the Disabled Students' Program (DSP) to request an official accommodation. The Disabled Students' Program (DSP) is the campus office responsible for authorizing disability-related academic accommodations, in cooperation with the students themselves and their instructors. You can find more information about DSP, including contact information and the application process here: dsp.berkeley.edu. If you have already been approved for accommodations through DSP, please let us know so we can develop an implementation plan together.

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.

Our Policy on Nondiscrimination

The University of California, Berkeley, in accordance with applicable Federal and State law and University policy, does not discriminate on the basis of race, color, national origin, religion, sex, gender identity, pregnancy, physical or mental disability, medical condition (cancer related or genetic characteristics), ancestry, marital status, age, sexual orientation, citizenship, or service in the uniformed services. The University of California, Berkeley also prohibits sexual harassment. Complaints of discrimination should be directed to the [Office for the Prevention of Harassment and Discrimination](#) (OPHD). Email: ask_ophd@berkeley.edu, or telephone: 510-643-7985.

Conflicts with Extracurricular Activities

- “It is the student’s responsibility to notify the instructor(s) in writing by the second week of the semester of any potential conflict(s) and to recommend a solution, with the understanding that an earlier deadline or date of examination may be the most practicable solution.”
- “It is the student’s responsibility to inform him/herself about material missed because of an absence, whether or not he/she has been formally excused.”

—Spring 2014 Academic Calendar - Campus Policies and Guidelines email, January 8, 2014

For recommendations about handling scheduling conflicts, see:

teaching.berkeley.edu/checklist-scheduling-conflicts-academic-requirements