Mathematical Logic

Department: Fudan International Summer Session 2026

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<tr><td>Course Code</td><td colspan="7">PHIL20013</td></tr>
<tr><td>Course Title</td><td colspan="7">Mathematical Logic</td></tr>
<tr><td>Credit</td><td>2</td><td>Experiment (including Computer) Credit</td><td>0</td><td>Practice Credit</td><td>0</td><td>Aesthetic Education Credit</td><td>0</td></tr>
<tr><td>Credit Hours Per Week</td><td>9 credit hours per week.
36+3 tutorial hours in total (one credit hour is 45 minutes)</td><td>Education on The Hard-Working Spirit Credit Hours</td><td></td><td>Language of Instruction</td><td>English</td><td>Honors Course</td><td>□Yes
☑No</td></tr>
<tr><td rowspan="2">Course Type</td><td rowspan="2" colspan="4">□Core General Education Course □Specific General Education Course □Basic Course in General Discipline
☑Others</td><td colspan="3">2+X Major ：
□Professional Core Course
□Professional Advanced Course</td></tr>
<tr><td colspan="3">Non 2+X Major ：
□Professional Compulsory Course
□Professional Elective Course</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Value: To cultivate a rigorous way of thinking and a critical appreciation for the structure of arguments. To understand the necessity of logic in clarifying thought, distinguishing valid reasoning from fallacies, and its foundational role in mathematics, philosophy, and computer science.
Knowledge: To master the fundamental systems of logic, including Aristotelian syllogisms, Propositional Logic (syntax, semantics, natural deduction), and First-Order Predicate Logic. To gain familiarity with the soundness and complete theorems of logics, basic Set Theory and Type Theory, and to understand the meta-issues regarding the limits of logic and its relationship with Artificial Intelligence.
Ability: To develop the skill of translating between natural language and formal logical languages. To proficiently judge the validity of arguments using tools like truth tables and formal derivation. To acquire the ability to write rigorous mathematical proofs (e.g., using induction) and to apply logical analysis to abstract problems.</td></tr>
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Course Description	This course provides a comprehensive introduction to Mathematical Logic, serving as a toolkit for clear thinking and a foundation for advanced studies in philosophy and sciences. We will begin with the basics of argumentation and traditional syllogistic logic, then move to the core of modern symbolic logic: Propositional Logic and First-Order Predicate Logic. Students will learn how to analyze the syntax and semantics of these systems and construct formal proofs. The course also covers essential mathematical tools such as basic Set Theory and mathematical induction. Furthermore, we will explore the frontiers of logic, including an introduction to Type Theory, the connection between logic and computation, and the relation of logic with computation and modern Artificial Intelligence. Throughout the course, we will reflect on philosophical questions: What is logic about? What are its limits?

Course Requirements:
Prerequisites: None.

Teaching Methods:
Lectures: The primary mode of instruction will be lectures, delivered by the course instructors, introducing key logical systems, definitions, proof rules, and their philosophical foundations.
Practice: A significant portion of the course is dedicated to the skill of formalization. Students will practice translating arguments from everyday natural language and scientific reasoning into formal logical notation. This process bridges the gap between intuitive thought and rigorous logical structure, allowing students to analyze the validity of real-world claims.
Tutorial Sessions: These sessions focus on the explanation and discussion of problem sets. Instructors (or TAs) will review assigned homework, walk through solutions to challenging derivation problems, correct common errors, and answer technical questions to ensure students master the application of logical tools.

Course Director's Academic Background:
Ruizhi Yang is an Associate Professor in the School of Philosophy at Fudan University. His research centers on the philosophy of mathematics, set theory, and computability theory. He received his Ph.D. in Logic from the Department of Philosophy at Peking University in 2012. Dr. Yang has held visiting positions at Harvard University (2010-2011) and the City University of New York (CUNY) (2017-2018).

Instructor's Academic Background:
Ibid.

Members of Teaching Team

Name	Gender	Professional Title	Department	Responsibility
Ruizhi Yang	Male	Associate Professor	Philosophy	Director, Instructor, Lecturer
Zhaokuan Hao	Male	Professor	Philosophy	Instructor, Lecturer
Ningyuan Yao	Male	Professor	Philosophy	Instructor, Lecturer

Course Schedule: **Lecture 1:** Introduction to Logic. What is logic about? The examples of the phenomenon of logic. The structure of arguments (premises and conclusions); validity vs. truth; natural language vs. formal language; why do we need logic? **Lecture 2:** Propositional Logic (Syntax and Semantics). Logical connectives (conjunction, disjunction, negation, implication); well-formed formulas; truth tables; tautologies, contradictions, and contingencies; logical equivalence. **Lecture 3:** Propositional Logic (Formal Proofs). The concept of formal deduction; rules of inference (Modus Ponens, Modus Tollens, etc.); Hilbert style Axiom system and Natural Deduction systems; strategies for constructing proofs. **Lecture 4:** The meta-theorems about propositional logic deduction systems. Prove by induction, the soundness theorems and the completeness theorems. **Lecture 5:** The Classical Tradition: Syllogisms. Categorical propositions; the structure of syllogisms; rules of validity; Venn diagrams; the relation between syllogisms and propositional logic, limitations of Aristotelian logic. **Lecture 6:** First-Order Predicate Logic (Syntax and Semantics). The need for quantifiers (Universal and Existential); predicates and individual constants; scope of quantifiers; translating complex natural language sentences into First-Order Logic; models and interpretations. **Lecture 7:** First-Order Predicate Logic (Proof System). Hilbert style Axiom system and Natural Deduction systems. Deduction rules for quantifiers (Universal Instantiation/Generalization, Existential Instantiation/Generalization); logical truths involving identity; working with multiple quantifiers. **Lecture 7:** The meta-theorems about first-order predicate logic. More on structure and models, the soundness and completeness theorems. **Lecture 8:** Arithmetic and Set Theory Basics. Brief introduction to sets, subsets, and elements; set operations (union, intersection, complement); relations and functions; cardinality; Russell's Paradox, coding by numbers or sets, the incompleteness. **Lecture 9:** Computability theory, Type Theory and Artificial Intelligence. Brief introduction to computability theory, type theory (as an alternative foundation). **Lecture 10:** Meta-Logic and The Limits of Logic. Undecidability; the limits of formal systems (brief intro to Gödel’s Incompleteness); the relation between logic and modern AI. **Review Session:** One session will be dedicated to the discussion of problem sets, feedback on exercises, and a comprehensive review of the course material. **Final Examination:** The last session will be an in-class written examination testing the mastery of logical systems and proof techniques.
The design of class discussion or exercise, practice, experience and so on: **Formalization Exercises:** Students are encouraged to submit translations of arguments from everyday natural language and scientific research into formal logical notation. This practice cultivates the ability to identify logical phenomena in real-world contexts, apply logical tools for formalization, and evaluate the validity of reasoning.

Problem Set Discussions: Solutions to after-class exercises will be explained and discussed by the instructors and teaching assistants to ensure mastery of the material.

If you need a TA, please indicate the assignment of assistant:
Grading formalization exercises and final examination; leading review sessions; answering technical questions.

Grading & Evaluation:
Formalization Exercises 30%: Students will identify arguments from everyday life or scientific contexts. Evaluation is based on the meaningfulness and complexity of the selected natural language text, the reasonableness of the translation into formal logic, and the correctness of the subsequent validity assessment.
In-class Discussion 30%: Students are expected to actively participate in lectures and tutorial sessions. Grades are awarded for asking insightful questions, providing feedback, and contributing to the analysis of problems.
Final Examination 40%: A comprehensive written exam at the end of the course to test the mastery of logical syntax, semantics, and proof techniques.

Usage of Textbook: □Yes(complete textbook information form below) ☑No
Textbook Information (No more than two textbooks) **:**

Title	Author	ISBN	Publishing Time	Publisher	Type I	Type II
					□Self-compiled Textbook (Published) □Non-mainland Textbook □Other Textbook (Published)	□National Planning Textbook □Provincial and Ministerial Planning Textbook □School Level Planning Textbook □Others
					□Self-compiled Textbook (Published) □Non-mainland Textbook □Other Textbook (Published)	□National Planning Textbook □Provincial and Ministerial Planning Textbook □School Level Planning Textbook □Others

Teaching Materials & References:
A Mathematical Introduction to Logic (2nd Edition), Herbert B. Enderton, 2001, Academic Press.