

## Logic

Lecturer: Dr. Catharine Diehl

Office Hours: By appointment both on Zoom and in person

Office: P.J. VETH 2.04

E-mail: [c.e.diehl@phil.leidenuniv.nl](mailto:c.e.diehl@phil.leidenuniv.nl) (This is the best way to contact me.)

Lectures: Wednesday 15:15-17:00

Class Room: P.J. VETH 1.01

### Introduction:

Logic begins by asking what distinguishes a well- from a poorly constructed deductive argument. The features of well-built argumentation can then be investigated in their own right using the basic tools of mathematics and formal analysis. When we do so, we uncover fascinating results concerning the nature and limitations of reasoning itself. Logic is thus central to the philosophical enterprise.

This course will introduce students to the fundamentals of logic: the syntax and semantics of propositional and predicate logic, the formalization of English sentences and arguments, methods for determining validity in propositional and predicate logic (truth tables, natural deduction), and identity and definite descriptions. By the end of this course, you will have the tools to analyze rigorously where arguments such as that in the cartoon on this page go wrong.



**Logic: another thing that  
penguins aren't very good at.**

### Learning Objectives:

This course aims to teach students the basic concepts and tools for the formal study of arguments (validity, soundness, consistency), the syntax and semantics of propositional and predicate logic, the formalization of English arguments using propositional and predicate logic, and techniques for proof in both systems.

Students who successfully complete the course will have a good understanding of:

- key concepts in logic (such as validity, soundness, and consistency), the syntax and semantics of propositional and predicate logic, formalizations, natural deduction, and identity.

Students who successfully complete the course will be able to:

- translate natural-language sentences and arguments into propositional and/or predicate form and vice versa;
- use formal methods of proving validity (such as truth tables and natural deduction), both for sentences and for whole arguments;
- apply these methods to the study of philosophical texts.

### **Teaching Methods:**

Each week, I will deliver a lecture introducing the material for the week, along with tips for practicing it. I will also note the philosophical significance of some of the technical results, as well as open questions, when these arise. During these lectures, you will need to actively participate by completing short exercises and answering spot-comprehension questions on WooClap. You will thus need a device (phone, laptop, or tablet) with internet access. Please do the assigned reading beforehand and come to lecture prepared to participate, as you will get the most from class if you are actively engaged.

Unlike most philosophy classes, the content of this course is largely technical, and the material may be reminiscent of math courses. To master the content, it's essential that you regularly practice these skills. There will be ten problem sets to be given to your tutorial leader at the start of lecture. You may work with each other in small groups to complete these problem sets, but please indicate with whom you have worked at the top of the problem set. The due dates for these problem sets are marked on the week-by-week calendar. Problem sets are always due prior to lecture. Some, but not all, of these problem sets will be graded, so be sure to do your best to solve them correctly.

Each student will also participate in a Tutorial with me (Catharine Diehl) or our TA, Nas Abshari. During these tutorials, you will have a chance to practice the material introduced in the lectures by working through sample problems together, as well as to ask questions regarding material from the weekly problem sets.

### **Course Texts:**

- Students must possess a copy of Volker Halbach (2010), *The Logic Manual*, Oxford University Press. ISBN 9780199587841 (*LM*).
- Additional resources, including useful supplemental exercises, can be found at <http://users.ox.ac.uk/~logicman/>.
- Your weekly problem sets will be posted on Brightspace one week before they are due. They are adapted from, but not identical to, those found on Halbach's logic exercises, so make sure to use the exercises posted on Brightspace.

### **Evaluation:**

- Problem sets (20%)
- Midterm written examination (30%)
- Final written examination (50%)

The questions on the assignments will be largely technical in nature and will consist in exercises to assess mastery of the skills taught (including translations, proofs, and short answers applying the concepts taught.)

Satisfactory completion of the weekly assignments is a prerequisite for sitting the exams.

### **Resit:**

The resit consists of one examination for both the midterm and final examination, consisting of a written exam covering the entire course content. The mark for the resit will replace all previously earned marks for the midterm and final exam (80%). No separate resits will be offered for mid- term tests.

Satisfactory completion of weekly assignments is a prerequisite for taking the resit and the grades for weekly assignments remain in place.

### **Exam review and feedback:**

How and when an exam review will take place will be disclosed together with the publication of the exam results at the latest. If a student requests a review within 30 days after publication of the exam results, an exam review will have to be organized.

### **Plagiarism:**

See <https://www.organisatiegids.universiteitleiden.nl/en/regulations/general/plagiarism>

### **Accessibility:**

Every student has the right to a learning experience that meets their needs. You are very welcome to discuss any accessibility issues or other requirements you have during my office hours. Moreover, if you have any questions or need advice you are welcome to contact Fenestra Disability Centre, Leiden University's information centre for students with a disability. Fenestra's experienced and professional staff are there to help you successfully complete your studies at Leiden University.

## **Tentative Weekly Plan**

This plan is preliminary and may change over the course of the semester in response to students' needs.

### **Week 1      What is logic? Validity, Soundness**

This week's lecture will first introduce you more precisely to the discipline of formal logic—we will consider what it means to treat reasoning 'formally' and the benefits of doing so. In particular, we will focus on why formal logic is a core part of philosophy and why the mastery of the skills introduced in this course will help you in your further studies.

You will also be informally—but rigorously—introduced to the central notions of argument, validity, soundness, and contradiction. These notions are used both in natural-language reasoning, as well as within formal logic. They will thus recur throughout the course.

Lecture: 11.09.2024

- Reading: *LM* §§1.5-1.6 (pp. 17-26)

### **Week 2      Set Theory, Relations, Functions, and Quotation**

This week we will introduce the basic mathematical notions that will be used throughout this course: the fundamentals of set theory, relations, and functions. Next, we will examine the concept of *quotation* in philosophy and acquaint ourselves with the central distinction between *use* and *mention*.

Lecture: 18.09.2024

Assignment:

- Problem set 1 due
- Reading: *LM* §§1.1-1.4 (pp. 5-16) and §2.1 (pp. 27-29)

### **Week 3      The Syntax and Semantics of Propositional Logic**

This week we will look at our first formal language—the language of propositional logic,  $L_1$ . We will first examine the syntax (grammar) of this language: what is the vocabulary of  $L_1$  and what are the rules for forming  $L_1$  sentences. We will also look at the conventions for abbreviating sentences. Next, we will look at the semantics (meaning) of  $L_1$ . We will consider the notion of an  $L_1$  structure and see how truth-values for the sentences of  $L_1$  can be calculated using *truth tables*.

Lecture: 25.09.2024

Assignment:

- Problem set 2 due
- Reading: *LM* §§2.2-2.4

#### **Week 4      Working with Truth Tables and an Introduction to Formalization in Propositional Logic**

This week we will continue our study of the semantics of propositional logic and practice using truth tables to determine whether sentences are tautologies, contradictions, or neither, as well as whether arguments are valid. We will then examine the central notion of *truth-functionality* and consider the difference between the connectives of  $L_1$  and connectives in English. Finally, we will introduce the notion of the *logical form* of an English sentence. This form is the key to translating between sentences in natural language and sentences within a formal language.

Lecture: 2.10.2024

Assignment:

- Problem set 3 due (to be discussed in Tutorial after Leidens Onzet)
- *LM* Chapter 3

#### **Week 5      Formalization in Propositional Logic Continued**

We will look at the nitty-gritty of translating sentences from English to the language of propositional logic. We will use this method to check the validity of arguments in English. We'll pay particular attention to the concept of *scope*, which will be important in our work for the rest of the semester (as well as in the rest of your study of philosophy).

Lecture: 9.10.2024

Assignment:

- Chapter 3 continued

#### **Week 6      Natural Deduction for Propositional Logic**

This week presents an important method of proof for the language of propositional logic—the method of natural deduction. We will examine the so-called introduction and elimination rules for propositional logic and learn to construct simple natural deduction proofs.

Lecture: 16.10.2024

Assignment:

- Problem set 4 due
- *LM* §6.1

## **Week 7      Natural Deduction and Review Session**

There will be a sample midterm distributed in advance. Please look over the problems and attempt to solve them, ideally before the lecture but at the latest by the tutorial sessions.

Lecture: 23.10.2024

Assignment:

- Problem set 5 due

**\*\*\*Midterm Examination Nov 1st, 15:15-17:00, Lipsius 0.11\*\*\***

## **Week 8      Syntax of Predicate Logic**

We turn from  $L_1$ , the language of propositional logic, to a richer language,  $L_2$ , which allows us to capture the validity of more intuitively valid arguments. This language of *predicate logic* allows us to—so to speak—‘look inside’ an atomic sentence by distinguishing between designators and predicates. This week, we will study the vocabulary and syntax of this new language. We will pay particular attention to the tricky distinction between *free* and *bound* occurrences of variables.

Lecture: 6.11.2024

Assignment:

- *LM* chapter 4

## **Week 9      The Semantics of Predicate Logic**

This week concerns the semantics of the language  $L_2$  of predicate logic. We first define an  $L_2$  structure, introduce the idea of a variable assignment, and use these to define the *satisfaction* of a formula in a variable assignment. This, in turn, allows us to define the notion of truth for sentences within a structure. We will use these definitions to show how to construct proofs of the truth of  $L_2$  sentences in structures. Finally, we will introduce the crucial method of constructing *counterexamples*.

Lecture: 13.09.2024

Assignment:

- Problem set 6 due
- *LM* chapter 5

## **Week 10      Natural Deduction for Predicate Logic**

We will continue our study of natural deduction by expanding this system of proof to include the proof rules of predicate logic. The rules for quantifier introduction and elimination require special care, and at this point the previously introduced distinction between free and bound variables will be of central importance. We will also look at strategies for constructing proofs using natural deduction.

Lecture: 20.11.2024

Assignment:

- Problem set 7 due
- *LM* §6.2

## **Week 11      Formalization in Predicate Logic**

We begin by looking at some central *metalogical* results—that is, results about logic itself. These results connect validity and provability within natural deduction. With them in hand, we know that the proof system of natural deduction is adequate for the semantics of  $L_2$  and, more broadly, that syntactic and semantic notions match up in  $L_2$ .

Next, we turn to two tricky topics in the formalization of English sentences in  $L_2$ —ambiguity and extensionality. Here, we will see a further application of the notion of *scope* introduced earlier.

We will use these techniques to analyze arguments in English using the tools of predicate logic, such as natural deduction and the method of counterexamples. This week will demonstrate the usefulness of formal tools for the analysis of arguments. We will also consider some tricky aspects of rendering English sentences in predicate logic.

Lecture: 27.10.2024

Assignment:

- Problem set 8 due
- Chapter 7

## **Week 12      Identity and Definite Descriptions**

The notion of numerical identity—the notion of being one and the same thing. This notion is of preeminent metaphysical importance and is thus often formalized by a special symbol,  $=$ . We enrich the language  $L_2$  with this symbol and examine the syntax, semantics, and natural deduction proof rules for this enriched language. Enriching our language in this way allows us to capture important additional features of English-language arguments. We will study one such use: the analysis of definite descriptions.

Lecture: 4.12.2024

Assignment:

- Problem set 9 due
- *LM* chapter 8

## **Week 13      Review**

This week we'll look at trouble spots from throughout the semester. We will also close by looking at some further paths in the study of logic.

Lecture: 11.12.2023

Assignment:

- Problem set 10 due

**\*\*\* Final Examination 17 Dec, 12 pm – 3 pm, Lipsius, 0.11\*\*\***