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### PHIL 410.01: Formal Logic - Scope and Limits

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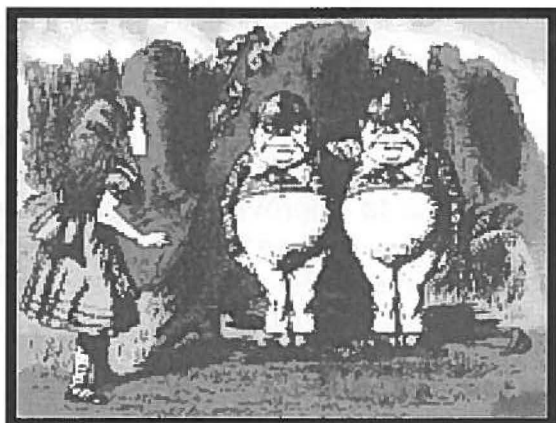
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# FORMAL LOGIC

Spring, 2001



"I know what you're thinking about," said Tweedledum: "but it isn't so, nohow."

"Contrariwise," continued Tweedledee, "if it was so, it might be; and if it were so, it would be; but as it isn't, it ain't. That's logic."

In Philosophy 210, you learned the basic structures of the propositional and predicate logics, focusing primarily on using those structures. In 410, we will again study these logical systems, but this time our emphasis will be on reasoning about them rather than simply accepting and reasoning with them. We will review what you learned about the logical systems introduced in Philosophy 210 and, especially for the logic of relations, even extend a bit your capacity to use them. We will, however, be concerned primarily with proving certain truths about these logical systems, with establishing their metatheory; rather than simply accepting a logical system as a tool for reasoning about other matters, we will reason about the logical system itself, exploring its properties and its foundations.

In Philosophy 210, for example, you were simply given a set of rules for natural deduction and asked to prove the validity of various arguments by means of that set of rules. Now we will ask (and answer) the question, Is that set of rules a good set? Is it adequate to prove the validity of every inference which is in fact valid? [Imagine your frustration were it to be the case that your failure to prove the validity of an argument on a Philosophy 210 exam was the result, not of your lack of skill or ingenuity, but of a fundamental inadequacy of the rules themselves!] We will show that systems for propositional logic (the logic of truth functions) are sound (no invalid inferences licensed, no theorems that are not tautologies), complete (every valid inference licensed, every tautology provable), and decidable (a mechanical procedure available to decide validity or theoremhood). We will then show that systems for predicate logic (the logic of quantifiers, properties and relations) are also sound and complete, but, perhaps surprisingly, not decidable - i.e., no mechanical test exists that is assured of determining correctly whether any given sentence is a logical truth. Along the way to establishing these basic metatheoretical properties of classical first-order logic, we will discuss the relation of formal systems of reasoning to machine reasoning and algorithmic procedures. We will also establish a version of Gödel's Theorem, a philosophically interesting and important result establishing the impossibility of capturing all the truths of higher-order logic in any formal system (the logic of the properties of properties, the essence of mathematics). We will conclude with a brief discussion of issues concerning minds, machines, and formal systems.

There will not be a textbook for the course. You will be expected to come to class regularly, to take good notes, and to ask good questions. Extensive background notes and exercises for the class will be posted on ERES, the Mansfield Library's electronic reserve system. The anticipated timing given below may need to be adjusted in minor ways as the term develops. Any changes in the timing or other features outlined below will be discussed in class with a reasonable lead time.

Evaluation will be based upon four exams. The first exam (Feb. 23, 22%) will cover translation skills for statements involving multiple quantification and identity. This exam, and this exam only, may be repeated in alternate forms to improve your score. The second exam (22%) will cover metatheory for the sentential logic and will (probably) be given Mar. 16. The third exam (Apr. 20, 22%) will cover the metatheory for predicate logic, excluding decidability. The final exam (34%, Tuesday, May 15, 10:10-12:10) will focus on decidability and incompleteness, but will also include review questions from throughout the term.

Homework exercises will regularly be assigned and discussed, evaluated when that will be helpful for full feedback, but will not be counted as part of the determining formula for the course grade.

A word concerning the work for the course: This course has a reputation as a difficult one. While the reputation is quite probably worse than the reality, there is no doubt that the material for the course will prove challenging for many of you. Those who have been willing to apply themselves and to seek help when needed have rarely failed to complete the course with a respectable grade, however. Those who have difficulty completing the course are almost always those who react to its challenge by turning away, skipping classes and asking for no help with the material. Those who hound me with questions and demands to be helped when the material is not clear to them get through the course in good shape. As your experience with Logic 210 has shown you, logic does not allow vague and uncertain patterns of understanding to generate acceptable levels of performance (and neither should the material for other courses, though admittedly it too often does). You will need to press yourself to get clear, and, when that is proving difficult to do, to press me to help you to understand. Test your understanding by writing it down, explaining concepts and reasoning to yourself on paper, then later reading (or having me or some other read) to see whether you have made sense. Understanding is not at all beyond your reach if you will just insist of yourself and of me that it be achieved. And further, as many have been pleased to discover, there is some fun stuff to learn here!

Goals for the course are: (1) to understand the nature and the basis of the standard metatheoretical properties of first-order logic with identity; (2) to further skills in representing complex ideas in the full quantificational logic of relations; (3) to enhance fundamental skills in analysis and expression. Progress will be aided by homework exercises and their discussion, and assessed through traditional exams.

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HOURS: Daily 2-3 & by appt. (don't hesitate to ask for appointments).

HOME PHONE: 549-9083 (You are welcome to call me at home when I am off campus.)

❖ Last day to drop a class: Mar. 12 (Feb. 16 to avoid financial penalty) ❖