Course C.6-3: Elements of Logic

General

This course approaches logic not as an independent, purely formal science, but as a direct extension of ontology (the study of reality) and harmology (the study of the ordering of realities).

Starting from the dual historical origins of Western thought—the dialogical-eristic dialectic and the mathematical reasoning of the Pythagoreans—the course is organized around the three classical human operations of thought: the theory of concepts (focusing on definitions, taxonomy, sets, induction, algorithms and the individuology of the unique), the theory of judgement (analyzing the proposition as a relationship between an original and a model, with attention to meaning-receiving versus meaning-creating statements, as well as analytic versus synthetic statements), and the theory of reasoning (examining in depth the hypothetical condition "if/then", categorical and hypothetical syllogisms, forms of argumentation and proof by contradiction).

The course continually connects these classical logical principles with a wide range of applications, from computer science, neural networks and chemical retrosynthesis to deconstruction, criminal investigation methods and genetic identification.

Summary

1: Foundations, history and nature of logic

The course presents logic as the science of valid reasoning, necessarily grounded in ontology (the existence of being) and harmology (the ordered nature of reality). Because reality itself exhibits logical structure and order, human beings can reason about it in an orderly way. According to I.M. Bochenski, logic has undergone three major periods of flourishing: ancient logic (4th–3rd centuries BCE), medieval scholastic logic (12th–13th centuries) and modern mathematical logic, or *logistics*, from around 1850 onwards.

Western logic also has a dual origin: on the one hand, the dialogical dialectic that emerged among the Eleatics, such as Zeno of Elea, was developed further by the Sophists and Plato, and was established by Aristotle as the independent science of "Analytics" (*Organon*); on the other hand, there was the mathematical mode of reasoning of the early Pythagoreans, who constructed operations of thought and definitions at an early stage.

Aristotle distinguished three types of reasoning: apodictic reasoning (based on objectively true premises), dialectical reasoning (based on probable

premises) and rhetorical reasoning (aimed at persuasion). It was only with the Stoics that the theory of thought acquired the name *logikè*.

The course also emphasizes the distinction between logic and epistemology: genuine logic considers the formal and hypothetical validity of a relationship ("if/then"), independently of the empirical truth or testability of the individual statements.

2: Theory of concepts: definition, classification and induction

The concept is the first of the three classical operations of thought (concept, judgement, reasoning) and represents an essential form in the mind. A concept has two correlated aspects: its content (connotation or intension) and its scope (denotation or extension), which are inversely proportional: the richer the content of a concept, the smaller the range of elements to which it applies. Leibniz called a concept *clear* when its scope makes all the objects it covers readily recognizable, and *distinct* when its defining features are sharply present to the mind.

In the theory of definition, a definition is described as formulating the content of an idea in the form of a symmetrical or reciprocal statement. A successful definition must represent what is being defined exclusively (*de solo*) and comprehensively (*de omni et toto*). Scientific work is a dynamic process that moves from a provisional or lemmatic definition (an initial working diagnosis or operative concept) to a completed or analytical definition. Ontologically, definition often proceeds through the universal genus (*genus*) and the specific difference (*differentia specifica*).

Opposed to definition, which formulates content, is classification or taxonomy, which organizes scope. A good classification must be exhaustive (omitting no elements) and irreducible (containing no redundancy). Plato used the diairetic method (moving from the general to the particular) and the synoptic method (viewing data together). These methods were later visualized by Porphyry in the "Tree of Porphyry".

The theory of concepts also includes induction as a method of generalization. An essential distinction is made between:

- *Summative induction*: summarizing cases that have already been tested individually into a totality or inventory (backward-looking information).
- *Amplificative induction*: extrapolating verified cases to cases that have not yet been tested but are verifiable, on the basis of a hypothesis (forward-looking information that expands knowledge). This includes Socratic induction (from

individual cases to the universal set) as well as Baconian or causal induction (generalizing causal relationships).

3: Set theory, algorithms and algorithmic thinking

Collecting is the explicit mapping of the scope of a concept. This ability has existed since archaic times as an intuitive, "mantic" or subliminal skill, as illustrated by the Xhosa, who can survey their herds without explicitly counting them.

In the history of mathematics, this developed through the Platonic *stoicheiotic* method (factor analysis or the study of elements) and the lemmatic-analytic method into the modern algebra of letters or concepts associated with François Viète, René Descartes, Isaac Newton and Gottfried Wilhelm Leibniz. Cantor formalized this in modern set theory (*Mengenlehre*), while Giuseppe Peano axiomatized arithmetic using pasigraphic symbols and mathematical induction.

From a praxeological perspective, an algorithm is defined as a goal-directed sequence of actions: starting from a problem situation (the initial state), a final state or goal is reached through a series of unambiguous instructions or steps. Algorithms occur in many forms, ranging from magical and culinary recipes to Chomsky's generative grammar and modern computer programs.

In computer programming, iterative (repetitive), sequential (order-dependent) and selective (choice-dependent) algorithms are distinguished. Nevertheless, thinkers such as Joseph Weizenbaum and Jacques Ellul warn against the limitations and one-sided "computer tyranny" of purely algorithmic thinking. Neural networks, which simulate the structure of the human brain without a fixed classical program, and the chemical retrosynthesis developed by Nobel Prize winner Elias J. Corey also demonstrate that algorithmic structures continue to evolve and expand into other scientific fields.

4: Individuology: the logic of the unique

Individuology, or idiography, is the logical study and description of the singular, unique or rare. Although classical scholasticism maintained that the individual as such cannot be expressed (*individuum ineffabile*) and that no abstract science of the individual exists, the Jesuits of Coimbra (the Conimbricenses) showed that something unique can be defined through the irreducible convergence of all its characteristics.

The unique can be captured through two specific methods of definition:

- *Ostensive-characterizing definition*: defining by directly showing and explaining something in an illustrative way.
- *Singular-situational (or concrete) definition*: situating the unique item within its specific context by means of the network of essential form, Gestalt, place, origin, name, homeland and time (*forma, figura, locus, stirps, nomen, patria, tempus*).

When a unique item cannot be accessed directly, the indirect method or convergence method (also called the detective method) is used. Separately, inconclusive signs, traces or probabilities are gathered; together, they point in one direction and build evidential force. This principle operates in literature and semiotics (Sherlock Holmes, Umberto Eco's *The Name of the Rose*), in the tracking of computer hackers (as demonstrated by Cliff Stoll), in modern biology through the identification of individuals by their unique genetic profile (DNA fingerprinting), and in linguistics through a speaker's unique idiolect.

5: Theory of judgement: the structure of the proposition

Judgement, or the proposition, is the second operation of thought and connects at least two concepts. The course approaches judgement through model theory: the subject functions as the original, while the predicate provides information about that original as a model, based on complete or partial identity. A judgement may be metaphorical (based on similarity and a distributive structure) or metonymic (based on connection and a collective structure).

A distinction is also made between:

- *Meaning-receiving judgements*: statements that record immediate evidence or an observation of reality (*pistis atechnos*).
- *Meaning-creating judgements*: statements that assign meaning to data through reasoning, interpretation or projection (*pistis entechnos*).

Immanuel Kant and, later, the logical positivists (Rudolf Carnap) divided judgements into analytic judgements (in which the predicate is already contained in the conceptual content of the subject; these do not expand knowledge and are tautological) and synthetic judgements (in which the predicate adds new information through empirical testing and thus expands knowledge).

In contemporary philosophy, Jacques Derrida analyses how contradictory judgements and texts can be deconstructed by exposing their underlying premises and social "commonplaces".

6: Theory of reasoning, syllogistics and argumentation theory

Reasoning is the third operation of thought and consists of deriving a conclusion from one or more premises. At its core lies the hypothetical structure ("if A, then B"), in which the premise states a necessary or sufficient condition. This rests on the ontological principle of sufficient reason: everything has a condition of possibility, either within itself or outside itself. Plato distinguished between a forward (axiomatic-deductive) hypothesis and a backward (reductive/regressive) hypothesis.

According to Charles Sanders Peirce, there are three fundamental forms of reasoning:

- *Deduction*: analytically deriving the particular from the general.
- *Induction*: synthetically generalizing from particular facts to a general rule.
- *Abduction* (hypothesis): synthetically proposing a possible explanatory premise for an observed fact.

The classical core of the theory of reasoning is syllogistics, or the theory of syllogisms. A syllogism consists of two premises (major and minor) and a conclusion. In addition to categorical syllogisms (which, at a deeper structural level, are disguised hypothetical statements), there are hypothetical syllogisms and numerous combinations of figures and moods. Irregular syllogisms include the enthymeme (with an unstated premise), the polysyllogism, the sorites and the epicheirema.

In argumentation theory and rhetoric, an argument serves to justify an opinion and obtain the audience's assent. A distinction is made between rhetorical arguments (based on probability), dialectical arguments (based on plausible scientific hypotheses) and apodictic arguments (based on absolutely certain premises).

Common forms of reasoning include the argument from authority (*argumentum ex auctoritate*, which must be critically assessed in terms of its field of application), the *argumentum ad hominem*, paralogical or sophistical reasoning (such as false dilemmas), and proof by contradiction (*reductio ad absurdum* or apagogical proof).