**Symbolic Logic Sample Syllabus\***

(schedule of guest lectures subject to change)

New York City College of Technology

Social Science Department

## COURSE CODE: PHIL2202

## TITLE: Symbolic Logic

## Number of class hours, lab hours if applicable, credits

3 credits, 3 hours

COURSE DESCRIPTION:

The course covers fundamental elements of propositional and quantificational logic, including translating English to symbolic logic, constructing truth tables, and utilizing derivations and proofs. Though not required, it is recommended that students first take Logical Thinking, PHIL2102.

COURSE CO/PREREQUISITE (S):

MAT 1190 or higher

RECOMMENDED/TYPICAL/REQUIRED TEXTBOOK (S) and/or MATERIALS\*

Patrick J. Hurley, *A Concise Introduction to Logic*, 11th Edition (Belmont: Thomson Wadsworth Publishers, 2003).

SAMPLE SEQUENCE OF TOPICS AND TIME ALLOCATIONS\*

**Week 1** T**he Language of Logic**

* *Tasks to be completed for class:* Read chapter 1 in *A Concise Introduction to Logic*.
* *Learning Objective:* Identify and understand what an argument is, including which are inductive and deductive arguments, as well as what makes arguments valid or invalid. Understand the purpose of learning a symbolic language.

\***Guest Lecture: Professor Candido Cabo, CST** – Topic: Computational Thinking. Professor Cabo presents the relatively new movement in education called “computational thinking” which is an approach to solving problems that connect to computer programming. Studying logic supports computational thinking through its procedures of reducing complexity of expressions to symbols and operations, abstracting from concrete information to more general patterns, and providing regular algorithms for solving problems.

**Week 2 Categorical Propositions, Immediate Inferences and Venn Diagrams**

* *Tasks to be completed for class:* Read sections 4.1, 4.2, and 4.3 in *A Concise Introduction to Logic*.
* *Learning Objective:* Identify and understand what a categorical proposition and syllogism is, as well as how to assess the validity and invalidity of categorical syllogistic forms using the Venn diagram in the modern point of view.

**Week 3 Categorical Propositions, Immediate Inferences, and Operations**

* *Tasks to be completed for class:* Read sections 4.4, 4.5, and 4.6 in *A Concise Introduction to Logic*.
* *Learning Objective:* Identify and understand the differences between the modern and traditional points of view, oppositional relationships between categorical syllogistic forms versus operations, and learn how to test for validity and invalidity in the traditional point of view using Venn diagrams.

**Test 1 – Categorical Syllogisms, Immediate Inferences, and Venn Diagrams**

**Week 4 Propositional Logic, Atomic Sentences, and Translation**

* *Tasks to be completed for class:* Read section 6.1 in *A Concise Introduction to Logic*.
* *Learning Objective:* Learn to symbolize ordinary language into symbolic form. Identify, translate, and apply the five logical operators.

\***Guest Lecture: Caner Koca, MAT** – Topic: Professor Koca elaborates and expands the lesson on translation by using mathematical examples. This module helps math students and other students understand the relationship between natural language and mathematical formulas. Professor Koca draws parallels and distinctions between using logical operators to prove math problems and analyzing valid and invalid arguments, and explains how the logical ‘or’ can be inclusive or exclusive depending on the disciplinary perspective.

**Week 5 Truth Functions and Truth Tables**

* *Tasks to be completed for class:* Read section 6.2-6.4 in *A Concise Introduction to Logic*.
* *Learning Objective:* Learn how to construct a truth table for connectives and arguments.

\***Guest Lecture: Benito Mendoza, CET** – Topic: Logical Circuits. Professor Mendoza demonstrates how logical circuits function according to “Boolean Logic”, basically relying on four logical operators: ‘and’, ‘or’, and ‘not’, as well as the ubiquitous ‘if…then’, and the binary codes of ‘0’ and’1’ (corresponding to false and truth in philosophical logic). Students will be given an opportunity to apply the logical operators as it flows according to 0 and 1 to circuits. The aim of logical circuits in computer engineering is to drive inputs towards programmed outputs. Students distinguish the aims of this engineering function to the philosophical pursuit of employing logical operators towards generating valid arguments.

**Presentations – Deductive, Inductive Reasoning and Falsifiability**

**Week 6 Truth Functions and Truth Tables**

* *Tasks to be completed for class:* Read section 6.5-6.6 in *A Concise Introduction to Logic*.
* *Learning Objective:* Learn how to and understand the implications of truth functions for validity, invalidity, tautological arguments, logical equivalence, and contradiction.

 **Test 2 – Atomic Sentences and Truth Tables**

**Week 7 Rules of Implication and Replacement**

* *Tasks to be completed for class:* Read section 7.1-7.2 in *A Concise Introduction to Logic* .
* *Learning Objective:* Identify and understand the rules of implication and replacement.

**Week 8 Rules of Implication and Replacement**

* *Tasks to be completed for class:* Read section 7.3-7.5 in *A Concise Introduction to Logic* .
* *Learning Objective:* Identify and understand the rules of implication and replacement.

\***Guest Lecture: Prof. Caner Koca** – Topic: Rules of Replacement in solving math problems. Prof. Koca reiterates the rules that mathematicians use in demonstrating proofs and solving problems in the field of mathematics. Students learn how to shift disciplinary perspective in using similar tools of logic towards solving different problems. Prof. Koca and Prof. Park also discuss the differences in the rules between the two perspectives.

**Week 9 Indirect Proofs and Proving Tautologies**

* *Tasks to be completed for class:* Read section 7.6-7.7 in *A Concise Introduction to Logic* .
* *Learning Objective:* Understand indirect proofs and apply them to proving tautologies.

**Test 3 – Rules of Implication, Replacement, and Indirect Proofs**

**Week 10 Translating Ordinary Language into Predicate/Quantificational Logic**

* *Tasks to be completed for class:* Read section 8.1 in *A Concise Introduction to Logic*.
* *Learning Objective:* Learn to translate ordinary sentences into quantifiers and predicate logical form. Understand how certain sentences fit universal, existential, and relational patterns, and what roles variables and constants play. Demonstrate the application of these rules in generalizing and instantiating constants.

\***Guest Lecture: Jonas Reitz, MAT** – Topic: Set Theory. Prof. Reitz elaborates upon the close relationship between quantificational logic and set theory, and demonstrates their application to the field of mathematics. Prof. Reitz and Prof. Park discusses what the role ontology plays in how set theory functions between the two perspectives.

**Week 11 Rules regarding Quantifiers: Generalizing, Instantiating, and Equivalence**

* *Tasks to be completed for class:* Read sections 8.2-8.3 in *A Concise Introduction to Logic*.
* *Learning Objective:* Understand the relationships between generalizing a statement and instantiating one, and which rules apply in governing universal and existential statements. Understand equivalence and identity of forms.

**Week 12 Rules regarding Quantifiers: Generalizing, Instantiating, and Equivalence**

* *Tasks to be completed for class:* Read sections 8.2-8.3 in *A Concise Introduction to Logic*.
* *Learning Objective:* Understand the relationships between generalizing a statement and instantiating one, and which rules apply in governing universal and existential statements. Understand equivalence and identity of forms.

\***Guest Lecture: Caner Koca** – Topic – Professor Koca reiterates the rules governing quantificational logic by applying the rules to solving problems in math, demonstrating at the level of quantification that there are parellels and connections between natural language and argumentation to mathematical formulas and demonstrating proofs.

 **Test 4 – Translating and Applying Rules to Quantificational Logic**

**Week 13 Conditional and Indirect Proofs and Proving Invalidity**

* *Tasks to be completed for class:* Read sections 8.4-8.5 in *A Concise Introduction to Logic*.
* *Learning Objective:* Adapt conditional and indirect proofs to predicate logic, and apply them in proving invalidity.

**Week 14 Rules regarding Relational Predicates and Identity**

* *Tasks to be completed for class:* Read sections 8.6-8.7 in *A Concise Introduction to Logic*.
* *Learning Objective:* Understand and translate relational and identity statements, as well as overlapping quantifiers. Learn the rules of inference in regards to identity statements.

**Group Presentations**

**Week 15 Final Exam**

* Demonstrate learning objectives, including course content and reading, writing, critical thinking, evaluative, and reflective competencies through an in-class exam.

### COURSE INTENDED LEARNING OUTCOMES/ASSESSMENT METHODS

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| **LEARNING OUTCOMES** | ASSESSMENT METHODS |
| **1.**Understand the major categories of logic, including categorical syllogisms, propositional logic, and predicate logic.  | **1.**Regular homework assignments will assess students’ ability to recognize logical systems. Tests will be opportunities to evaluate the student’s ability to differentiate the various kinds of logical systems. |
| **2.**Learn how to translate and interpret natural language sentences, its operators and elements into logical form. Understand the underlying patterns that various natural language sentences share.  | **2.**Regular homework assignments will assess students’ ability to translate and interpret natural language into logical form and to recognize the underlying patterns that logic makes bare. Tests will be opportunities to evaluate students’ ability to translate natural language into logical form. Two exams will further assess proficiency in these areas. |
| **3.**Learn and apply analytical tools such as venn diagrams, truth tables, and proofs in evaluating the validity and invalidity of arguments. | **3.**Regular homework assignments will assess students’ ability to apply analytical tools in evaluating the validity and invalidity of arguments. Tests will evaluate the success students demonstrate in determining whether an argument is valid or not by properly employing these tools and analyzing the results correctly. |
| **4.**Learn the rules of derivation, instantiation, and universalization, and apply them in creatively solving problems. | **4.** Regular homework assignments will assess students’ ability to learn and apply rules in solving logical problems. Tests will further assess the sophistication by which students can solve problems by creatively employing rules in combination with each other to resolve the problems. Exams will further assess how proficient students are in employing the correct rules. A group project will evaluate whether students have mastered the rules enough to be able to complete a culminating project in which each group masters its topic and teaches it to other peer groups. |

### GENRAL EDCUATION LEARNING OUTCOMES/ASSESSMENT METHODS

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| **LEARNING OUTCOMES** | ASSESSMENT METHODS |
| 1. KNOWLEDGE:

Develop knowledge of logical concepts and rules in order to understand and recognize its relation to other fields. Logical concepts and rules lay out patterns that can be found in natural language, computer programming language, mathematical proofs, and other fields. Deepen knowledge of logical concepts and rules by employing, demonstrating, and creatively applying them in analyzing the validity and invalidity of arguments. In gaining knowledge of logical concepts, the student sets up a framework that can serve as a lifelong tool for thinking critically and examining arguments and truth-functional claims. | **1.** Class discussion and regular homework assignments assess student acquisition of logical concepts and rules, and how to employ them in assessing arguments for validity. Tests further evaluates students’ successful application of concepts and rules in more sophisticated problems, demonstrating deep knowledge of the rules. Exams and a group project assess the refinement and mastery of the knowledge and employment of logical concepts and rules. |
| 1. SKILLS:

Learn and acquire skills for inquiry, analysis, problem resolution, and effective communication. Logic distills patterns underlying thought and communication that helps students to formulate questions for inquiry and to understand and analyze solutions. It uses quantitative rules, derivations, and analysis to determine formal validity of arguments, but it also deciphers semantic content in translating natural and field-specific language into universal, logical forms. It requires creative and productive thinking in order to apply rules to novel problem sets, which can be solved in a variety of ways. | **2**. Class discussion and regular homework assignments assess student acquisition of the skills necessary for translating, analyzing, and employing logic to solve problems. Tests further evaluates students’ successful application of concepts and rules to more sophisticated problems, and to apply them creatively to novel problems. Exams and a group project assess the depth of student formulation of questions for inquiry, analysis, problem-solving, and the ability to communicate their facility of such skills through verbal and written communication. |
| 1. INTEGRATION:

Understand and navigate logical systems and how they correlate with other disciplinary systems. Employ natural and field-specific data in filling out the content and meaning of sentences, quantificational statements, and arguments. Logic is uniquely poised to integrate divergent areas of study as it examines the patterns that operate beneath natural and technical languages, as well as employ the binary T/F (0/1) method as also found in technical language. | **3.** Class discussion and regular homework assignments assess student understanding of logical systems and their correlation to other systems. Tests further evaluates students’ successful application of systems to natural and technical examples. Exams and a group project assess the level of integrative thinking. |
| 1. VALUES, ETHICS, AND RELATIONSHIPS:

Develop community and civic engagement through dialogue and cooperative work. Evaluate the truth-claims of ethical, political, and social issues employing logical tools. Build personal and academic integrity through abidance to the academic integrity policy, and working with peers with respect to diversity, taking responsibility, and consensus-building. | **4.** Class discussions are opportunities to assess the development of respectful and meaningful communication. Regular homework assesses student employment of logical tools to assess truth-claims of value statements and arguments. Tests and exams also assesses the development of logical tools in evaluating valuative claims and arguments. The group project assesses student development in the area taking responsibility, respecting student diversity, and the ability to build consensus. |

SCOPE OF ASSIGNMENTS and other course requirements\*

The scope of assignments include regular homework assignments, a paper, a group project, an exam, and tests. A mid-term paper requires students to employ the concepts of deductive and inductive reasoning, and validity and invalidity to the scientific concept of *falsifiability*. Students will read an excerpt from Karl Popper’s *A Logic of Scientific Discovery*, and write a paper analyzing his critique of the inductive method, and the role observation plays in falsifying abstract hypotheses/theories. Students will also be presenting their findings by applying the concept of falsifiability in the field by setting a hypothesis and testing it through observation. The culminating final group project will consist of members working towards mastery of a given topic in symbolic logic in order to teach it to their peers. They will use powerpoint to create slides and make a visual and oral presentation in which they thoroughly cover their assigned topic. For example, one group may take ownership of teaching rules of implication by presenting the general principles that govern their application and by using specific problems to demonstration their applications. The goal is to provide a thorough review of topics for the final exam.

METHOD OF GRADING – elements and weight of factors determining the students’ grade\*

5% Class Participation

15% Homework / Classwork

40% Tests (4 tests worth 10% each)

10% Paper and presentation

10% Group Project

20% Final Exam

ACADEMIC INTEGRITY POLICY STATEMENT

Students and all others who work with information, ideas, texts, images, music, inventions, and other intellectual property owe their audience and sources accuracy and honesty in using, crediting, and citing sources. As a community of intellectual and professional workers, the College recognizes its responsibility for providing instruction in information literacy and academic integrity, offering models of good practice, and responding vigilantly and appropriately to infractions of academic integrity. Accordingly, academic dishonesty is prohibited in The City University of New York and at New York City College of Technology and is punishable by penalties, including failing grades, suspension, and expulsion. The complete text of the College policy on Academic Integrity may be found in the catalog.

\*depending on department policy these may be uniform and required of all instructors of the course or there may be guidelines or samples from which instructors may select or adapt):

## Attached course outline written by: Laureen Park and Jonas Reitz Date: 2/16/15

## Reviewed/Revised by: Laureen Park Date: 11/5/18

*Bibliography*

Ambrose, Alice and Lazerowitz, Morris. *Logic: The Theory of Formal Inference.* New York: Holt, Rinehart, Winston, 1961.

Barker-Plummer, David, Barwise, Jon, and Etchemendy, John. *Language, Proof, and Logic*, 2nd Edition. Stanford: CSLI Publication, 2011.

Deschamps, Jean-Pierre, Valderrama, Elena, and Terés, Lluís. *Digital Systems: From Logic Gates to Processors*. New York: Springer, 2016.

Gabbar, Hossam. *Modern Formal Methods and Applications*. Dordrecht: Springer, 2006.

Hausman, Alan, Khane, Howard, Tidman, Paul. *Logic and Philosophy: A Modern Introduction*, 10th edition. Belmont: Thomson Wadsworth, 2007.

Hurley, Patrick J. *A Concise Introduction to Logic*, 10th Edition. Australia: Thomson Wadsworth Publishers, 2003.

Gaddis, Tony. *Starting Out with Programming Logic and Design*, 5th edition. New York: Pearson, 2018.

Kleene, Stephen Cole. *Mathematical Logic.* Mineola: Dover, 1967.

Mano, Morris, Kime, Charles. *Logic and Computer Design Fundamentals*. New York: Pearson, 1999.

Mazur, Joseph. *Euclid in the rainforest : discovering the universal truth in logic and math*. New York: Plume, 2006.

Shapiro, Stewart, Ed. *The Oxford handbook of philosophy of mathematics and logic*. Oxford: Oxford University Press, 2007.

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Stillwell, John. *Roads to Infinity*. Boca Raton: CRC Press, Taylor and Francis Group, 2010.

Van Benthem, Johan and ter Meulen, Alice, editors. *Handbook of Logic and Language*. MIT Press: Cambridge, MA, 1997.