

MODULE SPECIFICATION

Module Title	Logic
Module Code	MTH 205
Originating Department/School	Department of Mathematics
Module Credits	4
Pre-requisites (including Year 1)	First Year Math Course

Description

Course Overview
This course introduces students to the principles of formal logical reasoning and their applications in mathematics, computer science, and analytical problem solving. Students examine the structure of arguments, develop formal symbolic representations of statements, and evaluate the validity of reasoning using logical systems. Topics include propositional logic, predicate logic, formal proof techniques, logical fallacies, and computational logic. The course also explores logic programming and selected topics from Gödel's incompleteness theory to demonstrate the philosophical and computational significance of formal logic.
Method of Teaching and Learning
This module will be taught using a combination of lectures, tutorials and consultation hours. Learning will also be reinforced by appropriate readings from the course text.
Syllabus
<p>Modules</p> <p>Module 1 - Foundations of Logical Reasoning</p> <p>Topics</p> <ul style="list-style-type: none"> • Nature and purpose of logical reasoning • Deductive reasoning and argument structure • Statements, propositions, and logical form • Contrapositive, converse, and inverse relationships <p>Activities</p> <ul style="list-style-type: none"> • Logic puzzles and introductory reasoning exercises <p>Assignment</p> <p>Problem Set 1</p> <p>Module 2 - Truth Tables and Logical Structure</p> <p>Topics</p> <ul style="list-style-type: none"> • Evaluating logical expressions using truth tables • Logical equivalence

- Tautologies, contradictions, and contingencies
 - Satisfiable vs. unsatisfiable formulas
- Assignment
Problem Set 2

Module 3 - Logical Normal Forms

Topics

- Conjunctive Normal Form (CNF)
 - Disjunctive Normal Form (DNF)
 - Logical transformations and equivalence rules
 - Resolution refutation methods
- Assignment
Problem Set 3

Module 4 - Semantic Tableaux and Inference

Topics

- Semantic tableau method
 - Rules of inference in formal reasoning
 - Constructing and analyzing well-formed formulas
 - Logical interpretation of structured arguments
- Assignment
Problem Set 4

Module 5 - Validity and Logical Fallacies

Topics

- Validity vs. soundness in arguments
 - Types of logical fallacies
 - Evaluating arguments in real-world contexts
 - Argument reconstruction and critique
- Assignments
- Problem Set 5
 - Fallacy discussion post

Module 6 - Predicate Logic

Topics

- First-order logic
 - Quantifiers and predicates
 - Translating natural language into symbolic form
 - Constructing well-formed predicate expressions
- Assignment
Problem Set 6

Module 7 - Foundations of Mathematical Proof

Topics

- Axiomatic systems
 - Structure of mathematical proofs
 - Basic proof strategies in formal logic
- Assignment
Problem Set 7

Module 8 - Proof Techniques in Logic

Topics

- Direct proof
- Proof by contradiction
- Logical deduction and structured reasoning
- Applications of formal proof methods

Assignment

Problem Set 8

Module 9 - Predicate Logic Resolution

Topics

- Prefix normal form
- Resolution methods for predicate logic
- Logical derivations in first-order systems

Assignment

- Problem Set 9
- Review for Midterm 1

Module 10 - Examination 1

Coverage

- Propositional logic
- Predicate logic
- Proof techniques

Assessment

Midterm 1

Module 11 - Introduction to Logic Programming

Topics

- Logic programming concepts
- Foundations of Prolog
- Syntax and structure of Prolog programs
- Logical rules and queries

Assignment

Coding Assignment 1

Module 12 - Advanced Logic Programming

Topics

- Recursive reasoning in Prolog
- Complex logic problems
- Knowledge representation using logical rules

Assignment

Coding Assignment 2

Module 13 - Logic and Decision Problems

Topics

- Decision problems in logic
- Logic-based representations of reasoning processes

- Introduction to computational reasoning and machine learning concepts
Assignment
Coding Assignment 3

Module 14 - Constraint Logic Programming and SAT Solvers

Topics

- Constraint logic programming
- SAT solving techniques
- Davis-Putnam algorithm
- DPLL algorithm
Assignment
- Coding Assignment 4
- Begin reading Gödel's Proof

Module 15 - Historical Foundations of Gödel's Theorem

Reading

Gödel's Proof - Chapter 1: Introduction

Topics

- Historical development of formal logic
- Hilbert's program
- The search for certainty in mathematics

Module 16 - Consistency in Formal Systems

Reading

Gödel's Proof - Chapter 2: The Problem of Consistency

Topics

- Formal axiomatic systems
- Meaning of consistency in mathematical logic
- Challenges of proving consistency
Midterm 2

Module 17 - Attempts at Absolute Consistency Proofs

Reading

Gödel's Proof - Chapter 3: Absolute Proofs of Consistency

Topics

- Early efforts to prove consistency
- Meta-mathematical reasoning
- Limitations of classical approaches

Module 18 - Formalization of Logical Systems

Reading

Gödel's Proof - Chapter 4: The Systematic Codification of Formal Logic

Topics

- Symbolic logical languages
- Formal inference rules
- Structure of formal systems

Module 19 - Mapping Logic to Arithmetic

Reading Gödel's Proof - Chapters 5-6 Topics <ul style="list-style-type: none"> • Examples of consistency proofs • Mapping logical statements to numbers • Foundations of Gödel numbering • Arithmetization of logical reasoning
Module 20 - Gödel's Incompleteness Theorem and Implications Reading Gödel's Proof - Chapters 7-8 Topics <ul style="list-style-type: none"> • Gödel numbering and meta-mathematics • Self-referential statements in logic • The incompleteness theorem • Philosophical and mathematical implications Assessment Final Exam

Assessment

Assessment Type	% of Final Mark
Midterm Exam 1	20%
Midterm Exam 2	20%
Final Exam	20%
Homework (Problem Sets, Discussions, Coding Assignments)	30%
Course Participation	10%

<i>Range</i>	<i>Letter Grade</i>
90% - 100%	A
80% - 89%	B
70% - 79%	C
60% - 69%	D
< 60%	U

Textbooks

Mandatory Textbooks

Title	Author	ISBN/Publisher
Gödel's Proof	Ernest Nagel and James Newman	NYU Press

Optional Textbooks

Title	Author	ISBN/Publisher
-------	--------	----------------

Reference Textbooks

Title	Author	ISBN/Publisher
-------	--------	----------------