

Part I: Logic

- Understand propositions and logical operators, and be able to build their truth tables.
- Be able to translate back and forth between English statements and symbolic logical propositions.
- Be able to prove the logical equivalence of a pair of propositions by building truth tables or by using a 2-column proof.
- Be able to negate propositions using De Morgan's Laws and other equivalences.
- Understand predicates and quantifiers and be able to determine the truth value of statements involving predicates and/or quantifiers. Also be able to translate English statements into statements involving one or more predicates and quantifiers.
- Be able to negate statements involving predicates and quantifiers and be able to recognize free and bound variables.
- Know the definition of an argument and how to use either a truth table or a 2-column proof to determine whether a given argument form is valid.
- Know the standard rules of inference for arguments with statements involving propositions and for arguments with statements involving predicates and quantifiers.
- Be able to recognize from the form of a short argument whether it is a known valid argument form or a known fallacy.

Part II: Proof Methods

- Understand the basic terminology for paragraph proofs.
- Understand how to use a *counterexample* to show that a statement is false.
- Be able to write short proofs making use of: Direct proof, Contraposition, and Proof by Contradiction.
- Understand the definition of odd numbers, even numbers, and rational numbers.
- Understand and be able to utilize Proof by Cases and be able to rule out unnecessary cases.
- Understand and be able to carry out an existence proofs and uniqueness proofs.
- Understand the role of counterexamples and conjectures in proving and disproving statements.
- Understand how to prove results using "backwards reasoning"
- Understand the principle of mathematical induction and be able to prove theorems using mathematical induction and using strong induction.

Part III: Sets

- Understand the definitions of sets, elements, subsets, and proper subsets, as well as symbolic notation for these terms.
- Understand both roster and set builder notation, and be able to determine whether a given set is well defined.
- Understand the definition of set equality, the cardinality of a set, the universal set, the empty set, singleton sets, the power set of a set, and know how to form the Cartesian Product of two sets.
- Understand the definition of the basic set operations.
- Understand what it means for two sets to be disjoint and know how to compute the cardinality of the union of two sets using the principle of inclusion-exclusion.
- Be able to determine which elements are in a set resulting from multiple set operations. Also be able to draw a Venn diagram representing such a set.
- Know the basic set identities (set equalities) and be able to prove them using membership tables, two-column proofs, or paragraph (double containment) proofs.

Part IV: Binary Relations and Functions

- Know the definition of a function, including the definition of the domain, co-domain, and range of a function.
- Understand and be able to apply the definitions of image and preimage (for both individual elements and sets of elements).
- Know the definition of one-to-one and onto, and be able to determine whether or not a given function satisfies these definitions.
- Understand the definition of function addition, subtraction, multiplication, division and composition and be able to prove facts about the results of applying these operations to a pair of functions.
- Understand the definition of an inverse function and know the properties that a function must satisfy in order to have an inverse.
- Understand the definition of the graph of a function, and be able to draw the graph of a given function.
- Know the definition of the floor function and the ceiling function and be able to apply this definition to investigate the graphs and/or properties of related functions.
- Know the definition of an binary relation and how it is represented as a set of ordered pairs.
- Be able to determine whether a given relation on a set is reflexive, irreflexive, symmetric, antisymmetric, or transitive.
- Be able to combine relations to form new ones using union, intersection, complementation, difference, symmetric difference, and composition.
- Understand how to represent a relations using matrices and graphs.
- Be able to recognize whether a relation on a set is reflexive, irreflexive, symmetric, antisymmetric, or transitive by looking at its matrix or its directed graph.

- Be able to apply the operations union, intersection, complementation, difference, symmetric difference, and composition to matrices of relations and to directed graphs of relations.
- Know the definition of an equivalence relation and be able to prove whether a given relation is an equivalence relation. Also be able to find the equivalence class of a given element.
- Understand the relationship between equivalence classes and partitions of the underlying set. Be also to tell whether or not a given family of subsets is a partition, and if so, be able find the equivalence relation described by the partition.
- Know the definition of a partial order and be able to prove whether a given relation is a partial order.
- Understand definition of a total ordered set and a well ordered set. Also know the lexicographic order, and be able to order a given pair of elements with respect to this ordering.
- Be able to draw the Hasse diagram for a poset. Also understand the definition of maximal elements, minimal elements, greatest elements, least elements, upper bounds, lower bounds, least upper bounds, greatest lower bounds, and the definition of a lattice. Also be able to find these (when they exist) in a given poset.

Part V: Graphs and Trees

- Understand the definitions of the different types of graph models and know how various types of graphs can be used to model real world applications.
- Understand the basic graph terminology and main results like the Handshaking Theorem.
- Know the main classes of simple graphs like K_n , C_n , W_n , Q_n , and $K_{m,n}$.
- Understand the definition of a bipartite graph and be able to prove whether or not a given graph is bipartite. Also be able to use bipartite graphs to solve matching problems.
- Understand how to form subgraphs of a graph, the union of two graphs, and how to find the complement of a simple graph.
- Understand how to represent both directed and undirected graphs using Adjacency Lists, Adjacency Matrices, and Incidence Matrices. Also know the definitions of a graph isomorphism and a graph invariant.
- Given a pair of graphs, be able to prove whether or not the given pair are isomorphic.
- Know the definitions of paths and circuits.
- Understand what it means for a graph to be connected, strongly connected, and weakly connected. Also be able to find the connected components (or strongly connected components) of a given graph.
- Understand the path length is a graph invariant, and be able to use this fact in graph isomorphism proofs.
- Understand the definition of Euler Paths, Euler Circuits, Hamilton Paths, and Hamilton Circuits. Also understand how these are used in graph models.
- Given a specific (di)graph, be able to determine whether or not the graph has an Euler Path, an Euler Circuit, a Hamilton Path or a Hamilton Circuit by using key theorems. Also be able to find and label them in a graph when they exist.
- Understand the definition of and be able to identify cut vertices and bridge edges in a given graph.
- Understand Dijkstra's algorithm and be able to use it to find the shortest path between a pair of vertices in a weighted graph.
- Understand the definition of a planar representation of a graph and be able to find a planar representation for a graph (when one exists).
- Memorize Euler's Formula and the corollaries to Euler's Formula and be able to use them to show that a graph is or is not planar. Also Know and be able to apply Kuratowski's Theorem.
- Be able to find the vertex or edge chromatic number of a given graph.
- Be able to use graph vertex colorings to solve applications problems (like scheduling and radio frequency assignments).
- Understand the definition of a tree, a forest, a simple circuit. Also know the main theorems about both trees and rooted trees.
- Understand the definition of a binary search tree and be able to construct a binary search tree for a given list of elements from a totally ordered set.
- Understand how to find the universal address system for a given rooted m -ary tree.
- Be able to find the preorder, inorder, and postorder traversal for a given m -ary tree.
- Be able to draw the tree of a computation in prefix, infix, or postfix form, and be able to evaluate the computation.
- Know the definition of a spanning tree for a connected graph and be able to find a spanning tree for a graph using either a depth first search or a breadth first search.
- Understand how to use Prim's Algorithm and Kruskal's Algorithm to find a minimum spanning tree for a given connected weighted graph.

Part VI: Boolean Algebra

- Understand Boolean Operations, Boolean Expressions, and be able to compute the value of an expression.
- Understand Boolean functions and know the Boolean identities and be able to verify identities using value tables and 2-column proofs.
- Be able to find the sum-of-products representation of a function. Also understand how to verify that a set of Boolean operations is functionally complete and be able to rewrite expressions in terms of a given set of operations.
- Be able to find a circuit for a given Boolean function and be able to find the output of a given circuit. Also know how to find a circuit to perform a given task (such as binary addition, etc.)
- Be able to use K-maps to find a minimal expression for a Boolean function.