Notes on Essentials of $Discrete\ Mathematics$

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Logical Thinking

1.1 Formal Logic

1.1.1 Inquiry Problems

Foo

1.1.2 Connectives and Propositions

Name	Symbol
and	\wedge
or	\vee
not	\neg
implies (ifthen)	\rightarrow
if and only if	\leftrightarrow

1.1.3 Truth Tables

Foo

1.1.4 Logical Equivalences

1.2 Propositional Logic

1.2.1 Tautologies and Contradictions

Foo

1.2.2 Derivation Rules

Foo

1.2.3 Proof Sequences

Foo

1.2.4 Forward-Backward

Foo

1.3 Predicate Logic

1.3.1 Predicates

Foo

1.3.2 Quantifiers

Foo

1.3.3 Translation

Foo

1.3.4 Negation

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1.3.5 Two Common Constructions

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1.4 Logic in Mathematics

1.4.1 The Role of Definitions in Mathematics

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1.4.2 Other Types of Mathematical Statements

Foo

1.4.3 Counterexamples

Foo

1.4.4 Axiomatic System

Foo

1.5 Methods of Proof

1.5.1 Direct Proofs

Foo

1.5.2 Proof by Contraposition

Foo

1.5.3 Proof by Contradiction

Relational Thinking

2.1 Graph

2.1.1 Edges and Vertices

Foo

2.1.2 Terminology

Foo

2.1.3 Modeling Relationships with Graphs

Foo

- 2.2 Sets
- 2.2.1 Membership and Containment

Foo

2.2.2 New Sets from Old

2.2.3 Identities

Foo

2.3 Functions

2.3.1 Definition and Examples

Foo

2.3.2 One-to-One and Onto Functions

Foo

2.3.3 New Functions from Old

Foo

2.4 Relations and Equivalences

2.4.1 Definition and Examples

Foo

2.4.2 Graphs of Relations

Foo

2.4.3 Relations vs. Functions

Foo

2.4.4 Equivalence Relations

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2.4.5 Modular Arithmetic

Foo

2.5 Partial Orderings

2.5.1 Definition and Examples

Foo

2.5.2 Hasse Diagrams

Foo

2.5.3 Topological Sorting

Foo

2.5.4 Isomorphisms

Foo

2.5.5 Boolean Algebras

Foo

2.6 Graph Theory

2.6.1 Graphs: Formal Definitions

Foo

${\bf 2.6.2} \quad {\bf Isomorphisms \ of \ Graphs}$

2.6.3 Degree Counting

Foo

2.6.4 Euler Paths and Circuits

Foo

2.6.5 Hamilton Paths and Circuits

Foo

2.6.6 Trees

Recursive Thinking

	T-	-	
3.1	Recurrence	\mathbf{D}_{Δ}	lotiona
	Recurrence	пе	IALIONS

3.1.1 Definition and Examples

Foo

3.1.2 The Fibonacci Sequence

Foo

3.1.3 Modeling with Recurrence Relations

Foo

- 3.2 Cosed-Form Solutions and Induction
- 3.2.1 Guessing a Closed-Form Solution

Foo

3.2.2 Polynomial Sequences: Using Differences

3.2.3 Inductively Verifying a Solution

Foo

3.3 Recursive Definitions

3.3.1 Definition and Examples

Foo

3.3.2 Writing Recursive Definitions

Foo

3.3.3 Recursive Geometry

Foo

3.3.4 Recursive Jokes

Foo

3.4 Proof by Induction

3.4.1 The Principle of Induction

Foo

3.4.2 Examples

Foo

3.4.3 Strong Induction

3.4.4 Structural Induction

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3.5 Recursives Data Structures

3.5.1 Lists

Foo

3.5.2 Efficiency

Foo

3.5.3 Binary Search Trees Revisited

Quantitative Thinking

4.1	Basic	Counting	Techniques
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4.1.1 Addition

Foo

4.1.2 Multiplication

Foo

4.1.3 Mixing Addition and Multiplication

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4.2 Selections and Arrangements

4.2.1 Permutations: The Arrangement Principle

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4.2.2 Combinations: The Selection Principle

4.2.3 The Binomial Theorem

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4.3 Counting with Functions

4.3.1 One-to-One Correspondences

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4.3.2 The Pigeonhole Principle

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4.3.3 The Generalized Pigeonhole Principle

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4.3.4 Ramsey Theory

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4.4 Discrete Probability

4.4.1 Definitions and Examples

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4.4.2 Applications

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4.4.3 Expected Value

4.5 Counting Operations in Algorithms

4.5.1 Algorithms

Foo

4.5.2 Pseudocode

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4.5.3 Sequences of Operations

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4.5.4 Loops

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4.5.5 Arrays

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4.5.6 Sorting

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4.6 Estimation

4.6.1 Growth of Functions

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4.6.2 Esitmation Targets

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4.6.3 Properties of Big- Θ

Analytical Thinking

5.1 Algorithms

5.1.1 More Pseudocode

Foo

5.1.2 Preconditions and Postconditions

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5.1.3 Iterative Algorithms

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5.1.4 Functions and Recursive Algorithms

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5.2 Three Common Types of Algorithms

5.2.1 Traversal Algorithms

5.2.2 Greedy Algorithms

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5.2.3 Divide-and-Conquer Algorithms

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5.3 Algorithm Complexity

5.3.1 The Good, the Bad, and the Average

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5.3.2 Approximate Complexity Calculations

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5.4 Bounds on Complexity

5.4.1 Algorithms as Decisions

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5.4.2 A Lower Bound

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5.4.3 Searching an Array

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5.4.4 Searching

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5.4.5 *P* vs. *NP*

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5.5 Program Verification

5.5.1 Verification vs. Testing

Foo

5.5.2 Verifying Recursive Algorithms

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5.5.3 Searching and Sorting

Foo

5.5.4 Towers of Hanoi

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5.6 Loop Invariants

5.6.1 Verifying Iterative Algorithms

Foo

5.6.2 Searching and Sorting

Foo

5.6.3 Using Invariants to Design Algorithms

Thinking through Applications

6.1 Patterns in DNA

6.1.1 Mutations and Phylogenetic Distance

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6.1.2 Phylogenetic Trees

Foo

6.1.3 UPGMA

Foo

- 6.2 Social Networks
- 6.2.1 Definitions and Terminology

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6.2.2 Notions of Equivalence

6.2.3 Hierarchical Clustering

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6.2.4 Signed Graphs and Balance

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6.3 Structure of Languages

6.3.1 Terminology

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6.3.2 Finite-State Machines

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6.3.3 Recursion

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6.3.4 Further Issues in Linguistics

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6.4 Discrete-Time Population Models

6.4.1 Recursive Models for Population Growth

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6.4.2 Fixed Points, Equilibrium, and Chos

6.4.3 Predator-Prey Systems

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6.4.4 The SIR Model

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6.5 Twelve-Tone Music

6.5.1 Twelve-Tone Composition

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6.5.2 Listing All Permutations

Foo

6.5.3 Transformations of Tone Rows

Foo

6.5.4 Equivalence Classes and Symmetry