IDMA 2025: Summary of Course Contents

The Basic Computer Model

RAM model (memory consisting of big array of fixed-size words)
Unit time cost for (essentially) all simple operations that can be performed on a single word

Asymptotic analysis

Big-oh notation: Meaning and use
Complexity analysis for algorithms (algorithms covered in the course + simple algorithms in exercises)

Basic Data Structures

Stacks
Queues
Lists (implemented as arrays and as singly or doubly linked lists)
Heaps (min heaps and max heaps)
Priority queues

Sorting and Searching

Linear search
Binary search
Insertion sort
Merge sort
Heap sort

Basic Arithmetic and Set Theory

Quotient, remainder, mod function, divisibility
Prime numbers and prime factorization
Greatest common divisor (GCD), Euclidean algorithm
Least common multiple (LCM)
Representation of numbers in different bases (decimal, binary, octal, hexadecimal)
Sets, subsets, power sets, intersection, union, complement, Venn diagrams
Inclusion-exclusion principle
Different functions: polynomials, exponentials, logarithms
Sequences and sums and ways to specify them (explicit, recursive)
Connections to asymptotic analysis
Sums of n first numbers, n first squares, n first cubes; geometric sums

Logic, Mathematical Proofs, and Proof Techniques

Propositional logic, connectives, truth tables, satisfiability, tautologies, contradictions
Predicate logic, universal and existential quantifiers
Direct proofs
Proofs by contraposition
Proofs by contradiction
Mathematical induction (and reasoning with invariants)

Combinatorics and Probability

Multiplication principle

How to choose k elements out of k with and without repetition and caring or not caring about order

Sequences, permutations, multisets, sets

Binomial coefficients ("n choose k")

Combinatorial proofs (show that two sets have the same size b exhibiting a bijection)

Pigeonhole principle

Basic probability theory (for uniform distribution, with outcomes equally likely, this is just counting)

Matrices and Linear Algebra

Matrices, square matrices, diagonal matrices, and identity matrices

Addition and multiplication of matrices

Boolean multiplication

Matrix transpose and symmetric matrices

Relations

Cartesian product of sets

Relations as subsets of Cartesian products

Domain, range, R-relative sets, in-degree and out-degree

Representation or relations as matrices or directed graphs

Relations R^n and R^∞

Functions: total and partial, surjective/onto, injective/one-to-one, bijective

Reflexive and irreflexive relations

Symmetric, asymmetric, and antisymmetric relations

Transitive relations

Equivalence relations (reflexive, symmetric, transitive) and partitions

Complement and inverse relations

Reflexive, symmetric, and transitive closure

Partial orders (reflexive, antisymmetric, transitive) and partially ordered sets (posets)

Hasse diagrams

Lattices, greatest lower bound, least upper bound

Graph Theory

Graph representation: adjacency matrix, adjacency lists; graphs as binary relations

Directed and undirected graphs; weighted graphs

Neighbours, vertex degree (in-degree, out-degree), paths/walks, simple paths

Connected (undirected) graphs

Graph isomorphism

Trees: root, leaves, children, parents, siblings, ancestors, descendants

Spanning trees of (undirected) graphs

Forests

Graph traversal: Breadth-first search and depth-first search

Topological sort

Strongly connected components

Minimum spanning trees, Prim and Kruskal

Single-source shortest path, Dijkstra