

### Information Theory.

- Syntax and Semantics;
  - Alphabet and Code;
  - Bits (Binary Numbers and Binary Codes);
  - Code Length and Data Representation;
    - Relation between a Code Length  $L$  and the Number of Different Codes of Length  $L$ ;
  - Signed and Unsigned Integers;
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- Information Content of a Message Associated with a Certain Probability;
- Average Information Content (Entropy) of a System of Messages;
- Average Word Length of a System of Messages;
- Redundancy of a System of Messages;
- Shannon's Coding Theorem.

### Boolean Algebra (Propositional Logic).

- Boolean Variables and Functions (Atoms and Propositional Formulas);
- Boolean Operators (Logical Connectives):
  - Conjunction ( $\wedge$ ), Disjunction ( $\vee$ ), Negation ( $\neg$ );
  - Identity/Zero Element/Idempotence/Negation/Distributivity/Commutativity/Associativity Axioms;
  - DeMorgans' Axioms;
  - Two more “standard” boolean operators: Implication ( $\implies$ ), Equivalence ( $\Leftrightarrow$ );
  - Precedence of Boolean Operators ( $\neg, \wedge, \vee, \implies, \Leftrightarrow$ );
  - XOR boolean operator;
- Truth Tables of Boolean Functions;
- Tautology/Contradiction/Satisfiable Boolean Function.

## **Predicate Logic.**

- Variables, Domains, Predicates;
- Logical Connectives ( $\neg, \wedge, \vee, \implies, \Leftrightarrow$ );
- Universal ( $\forall$ ) and Existential ( $\exists$ ) Quantifiers;
- DeMorgan's Axiom for Quantifiers;
- Distributivity and Non-distributivity Properties for Quantified Predicates;
- Bound and Free Variables;
- Scope of Quantifiers;
- Quantifiers over Formulas without Quantified Variables;
- Math-Reasoning Quantifiers: ANZ, SUM, MIX, MAX.

## **Binary Relations.**

- Binary Relations (and n-ary Relations);
- Reflexivity;
- Irreflexivity;
- Symmetry;
- Antisymmetry;
- Asymmetry;
- Non-symmetry;
- Transitivity;
- Transitive Closure of a Relation;
- Total Relations;
- Acyclic Relations;
- Equivalence Relations and Equivalence Classes;
- Partial Orders;
- Total (Linear) Orders;
- Strict Partial Orders;
- Upper Bounds and Least Upper Bound of Partially Ordered Sets;

## Program Verification.

- Programs and Specification;
- Hoare Triple;
- Partial Program Correctness;
- Weakest Precondition;
- Weakest Precondition Calculus Rules (scalar assignments, sequencing, conditional, loops);
- Loop Invariants;
- Program Verification using Weakest Precondition Calculus;
- Verification Conditions.

## Trees.

- Root, Children and Leaf Nodes;
- Subtrees;
- Paths and their Length;
- Height of a Node and of a Tree;
- Depth (Level) of a Node;
- Degree of a Tree;
- Ordered Trees;
- Isomorphic Trees;
- Binary Trees:
  - Trees versus Binary Trees;
  - Empty Binary Tree;
  - Left and Right Binary Subtrees;
  - Full Binary Trees:
    - Relation between the Number of Nodes and Tree Height;
  - Syntax Trees;
  - Prefix Traversal;
  - Infix Traversal;
  - Postfix Traversal;
  - Binary Search Trees.

## Graphs.

- (Undirected) Graphs:
  - Adjacent and Incident Nodes;
  - Adjacency Matrix (List) of a Graph;
  - Degree of Nodes;
  - Critical Nodes, Critical Edges, Articulation Points;
  - Isolated Nodes;
  - Graphs and Symmetric Binary Relations;
  - Complete Graphs;
  - Weighted Graphs;
  - Bipartite Graphs;
  - Paths and their Length;
  - Cycles;
  - Loops;
  - Hamiltonian Paths and Cycles;
  - Eulerian Paths and Cycles;
  - Spanning Trees;
  - Components and Biconnected Components;
  - Subgraphs;
  - Cliques;
- Directed Graphs and Binary Relations:
  - Weakly and Strongly Connected Components.

## Complexity.

- $O$ -Notation and Worst-Case (Upper-Bound) Complexity;
- Calculus Rules and Properties of  $O$ -notation;
- $\Omega$ -Notation and Best-Case (Lower-Bound) Complexity;
- $\Theta$ -Notation and Average-Case Complexity;
- Worst/Best/Average-Case Complexity of Programs.