Key Mathematical Symbols Guide for Systems Science and Discrete Mathematics

Prepared for Independent Study

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1	Set Theory and Logic (Foundational)	
1.	1 Basic Set Notation	
	• \in : "is an element of"	
	• \notin : "is not an element of"	
	• \subseteq : "is a subset of"	
	\bullet \subset : "is a proper subset of"	
	\bullet \cup : union	
	\bullet \cap : intersection	
	$ullet$ \ : set difference	
	\bullet \emptyset : empty set	
	• $ A $: cardinality (size) of set A	
1.	2 Set Construction	
	• $\{x: P(x)\}$: set builder notation	
	• $\{a, b, c\}$: set enumeration	
	• $[n] = \{1, 2, \dots, n\}$: set of first n positive integers	
1.	3 Power Set	
	• 2^X : power set of X (set of all subsets)	
	• 2 . power set of A (set of all subsets)	

1.4 Logic Symbols

- ∀ : universal quantifier ("for all")
- ∃ : existential quantifier ("there exists")
- $\bullet \land : logical AND$
- \vee : logical OR
- \neg : logical NOT
- \Rightarrow : implication ("if...then")
- ⇔ : equivalence ("if and only if")

2 Relations and Functions

2.1 Basic Relation Notation

- $\bullet \ R \subseteq A \times B$: relation R from A to B
- \bullet aRb: a is related to b under relation R
- $\langle a, b \rangle$: ordered pair

2.2 Function Notation

- $f:A\to B$: function from A to B
- f(x): value of function f at x

2.3 Special Relations

- \bullet \leq : less than or equal to
- \bullet < : less than
- \bullet \geq : greater than or equal to
- \bullet > : greater than
- \bullet = : equal to
- $\bullet \neq :$ not equal to

- \approx : approximately equal to
- \sim : equivalence relation

3 Graph Theory

3.1 Basic Graph Notation

- $\bullet \ G = (V, E)$: graph G with vertex set V and edge set E
- $\{u, v\}$: undirected edge between vertices u and v
- (u, v): directed edge from u to v

3.2 Graph Properties

- deg(v): degree of vertex v
- |V|: number of vertices
- |E|: number of edges

3.3 Special Graphs

- K_n : complete graph on n vertices
- C_n : cycle graph on n vertices
- P_n : path graph on n vertices

4 Linear Algebra

4.1 Vector Notation

- $\vec{x} = \langle x_1, x_2, \dots, x_n \rangle$: vector
- $\|\vec{x}\|$: norm (length) of vector \vec{x}

4.2 Matrix Notation

- $A = [a_{ij}]$: matrix A with elements a_{ij}
- A^T : transpose of matrix A
- A^{-1} : inverse of matrix A

4.3 Matrix Operations

• A + B: matrix addition

 \bullet AB: matrix multiplication

• det(A): determinant of matrix A

5 Order Theory

5.1 Partial Orders

 $\bullet \le :$ partial order relation

• < : strict partial order relation

5.2 Lattice Notation

• \vee : join (least upper bound)

• \wedge : meet (greatest lower bound)

 \bullet \top : top element

• \perp : bottom element

6 Advanced Set Theory and Algebra

6.1 Cartesian Product

• $A \times B$: Cartesian product of sets A and B

6.2 Boolean Algebra

• \oplus : exclusive OR (XOR)

• ⊙ : equivalence (XNOR)

6.3 Group Theory

 \bullet e: identity element

• a^{-1} : inverse of element a

7 Systems and Network Theory

7.1 System Notation

• S = (X, Y, f): system with input set X, output set Y, and function f

7.2 Network Flow

- c(u, v): capacity of edge (u, v)
- f(u, v): flow on edge (u, v)

7.3 Hypernetworks

• H = (V, E): hypergraph with vertex set V and hyperedge set E

8 Blockchain-Specific Notation

8.1 Blockchain Elements

- \bullet B: set of all blocks
- \bullet T: set of all transactions
- \bullet A: set of all addresses

8.2 Blockchain Functions

- prev(b): previous block of block b
- tx(b): set of transactions in block b
- \bullet sender(t): sender of transaction t
- receiver(t): receiver of transaction t