Mathematical Notation Reference

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1 Geometry and Linear Algebra

Symbol	Meaning	Definition	Example
$\perp$ `\perp`	Orthogonal	Two vectors or subspaces whose inner product is zero.	$\mathbf{u} \perp \mathbf{v}$
$\parallel$ `\parallel`	Parallel	Objects with identical direction that never intersect.	$\ell_1 \parallel \ell_2$
$\langle \cdot, \cdot \rangle$ `\langle \cdot ,\cdot \rangle`	Inner product	Bilinear form encoding angle and magnitude.	$\langle x, y \rangle$
$\\| \cdot \\|$ `|\cdot |`	Norm	Function measuring vector magnitude.	$\\|x\\|$
$\times$ `\times`	Cross product	Vector product producing a perpendicular direction in $\mathbb{R}^3$.	$a \times b$
$\cdot$ `\cdot`	Dot product	Scalar product measuring alignment.	$a \cdot b$
$\mathrm{span}(\cdot)$ `\mathrm {span}(\cdot )`	Linear span	All linear combinations of given vectors.	$\mathrm{span}\{v_1, v_2\}$
$\oplus$ `\oplus`	Direct sum	Decomposition into independent subspaces.	$V = U \oplus W$

2 Sets and Logic

Symbol	Meaning	Definition	Example
$\cup$ `\cup`	Union	Elements belonging to at least one set.	$A \cup B$
$\cap$ `\cap`	Intersection	Elements common to both sets.	$A \cap B$
$\emptyset$ `\emptyset`	Empty set	A set containing no elements.	$A = \emptyset$
$\in$ `\in`	Element of	Denotes membership in a set.	$x \in A$
$\notin$ `\notin`	Not an element of	Denotes non-membership.	$x \notin A$
$\subseteq$ `\subseteq`	Subset	All elements of one set lie in another.	$A \subseteq B$
$\subset$ `\subset`	Proper subset	Subset strictly smaller than the parent set.	$A \subset B$
$\setminus$ `\setminus`	Set difference	Elements in one set but not another.	$A \setminus B$
Δ `\Delta`	Symmetric difference	Elements belonging to exactly one of two sets.	$A \Delta B$
$\mathbb{R}$ `\mathbb {R}`	Real numbers	Set of all real-valued numbers.	$x \in \mathbb{R}$

3 Probability and Statistics

Symbol	Meaning	Definition	Example
$\sim$ `\sim`	Distributed as	Specifies a probability distribution.	$X \sim \mathcal{N}(0,1)$
$\perp$ `\perp`	Independence (informal)	Indicates absence of dependence.	$X \perp Y$
$\perp\!\!\!\perp$ `\perp \!\!\!\perp`	Independence (formal)	Formal symbol for probabilistic independence.	$X \perp\!\!\!\perp Y$
$\mathbb{E}[\cdot]$ `\mathbb {E}[\cdot ]`	Expectation	Mean value under a distribution.	$\mathbb{E}[X]$
$\mathrm{Var}(\cdot)$ `\mathrm {Var}(\cdot )`	Variance	Measure of dispersion around the mean.	$\mathrm{Var}(X)$
$\mathrm{Cov}(\cdot,\cdot)$ `\mathrm {Cov}(\cdot ,\cdot )`	Covariance	Joint variability of two variables.	$\mathrm{Cov}(X,Y)$
$\to$ `\to`	Convergence	Limiting behaviour of a sequence.	$X_n \to X$
$\Rightarrow$ `\Rightarrow`	Implies	Logical implication.	$A \Rightarrow B$

4 Probability and Statistics (Core Additions)

Symbol	Meaning	Definition	Example
$\mathbb{P}(\cdot)$ `\mathbb {P}(\cdot )`	Probability	Probability measure assigning a value in $[0,1]$ to an event.	$\mathbb{P}(A)$
$\mid$ `\mid`	Conditioning bar	Used to denote conditional probability or conditional distributions.	$\mathbb{P}(A \mid B)$
$\mathbb{P}(A \mid B)$ `\mathbb {P}(A\mid B)`	Conditional probability	Probability of event A given that event B occurred.	$\mathbb{P}(A \mid B) = \dfrac{\mathbb{P}(A \cap B)}{\mathbb{P}(B)}$
$p(x)$ `p(x)`	PMF (discrete)	Probability mass function: $p(x) = \mathbb{P}(X = x)$ for discrete X.	$X \in \{0,1\},\ p(1) = 0.3$
$f(x)$ `f(x)`	PDF (continuous)	Probability density function such that $\mathbb{P}(a \le X \le b) = \int_a^b f(x)\,dx$.	$\mathbb{P}(0 \le X \le 1) = \int_0^1 f(x)\,dx$
$F(x)$ `F(x)`	CDF	Cumulative distribution function: $F(x) = \mathbb{P}(X \le x)$.	$F(0) = \mathbb{P}(X \le 0)$
$\mathbf{1}_A$ `\mathbf {1}_{A}`	Indicator function	Equals 1 if the condition/event A holds, otherwise 0.	$\mathbf{1}_{\{X>0\}}$

5 Analysis and Asymptotics

Symbol	Meaning	Definition	Example
$\to$ `\to`	Tends to	Approaches a limit.	$x \to \infty$
$\approx$ `\approx`	Approximately	Numerical closeness.	$\pi \approx 3.14$
$\sim$ `\sim`	Asymptotically equal	Same growth rate asymptotically.	$f(n) \sim g(n)$
$\mathcal{O}(\cdot)$ `\mathcal {O}(\cdot )`	Big-O	Upper bound on growth rate.	$n^2 + 3n = \mathcal{O}(n^2)$
$o(\cdot)$ `o(\cdot )`	Little-o	Strictly smaller growth rate.	$n = o(n^2)$
$\Theta(\cdot)$ `\Theta (\cdot )`	Tight bound	Exact asymptotic order.	$n^2 + 3n = \Theta(n^2)$
∞ `\infty`	Infinity	Unbounded growth.	$x \to \infty$

6 Linear Maps and Operators

Symbol	Meaning	Definition	Example
$\mapsto$ `\mapsto`	Mapping	Defines input-output relation.	$x \mapsto x^2$
$\circ$ `\circ`	Composition	Function application chaining.	$(f \circ g)(x)$
∇ `\nabla`	Gradient	Vector of partial derivatives.	∇f
∂ `\partial`	Partial derivative	Derivative with respect to one variable.	$\partial_x f$
Δ `\Delta`	Laplacian	Sum of second derivatives.	Δf
$\dagger$ `\dagger`	Adjoint	Generalised transpose operator.	$A^\dagger$
T `^T`	Transpose	Row–column swap of a matrix.	A^T

7 Advanced and Commonly Seen Symbols

Symbol	Meaning	Definition	Example
$\otimes$ `\otimes`	Tensor product	Constructs product spaces.	$A \otimes B$
$\odot$ `\odot`	Hadamard product	Elementwise multiplication.	$(A \odot B)_{ij}$
$\mathcal{H}$ `\mathcal{H}`	Hilbert space	Complete inner-product space.	$\mathcal{H} = L^2([0,1])$
$\mathcal{L}$ `\mathcal{L}`	Operator / loss	Linear operator or loss function.	$\mathcal{L}(\theta)$
$\mathcal{O}$ `\mathcal{O}`	Operator / set	Generic operator notation.	$\mathcal{O}(n^2)$
$\rightleftharpoons$ `\rightleftharpoons`	Reversible	Bidirectional dynamics.	$A \rightleftharpoons B$
$\rightharpoonup$ `\rightharpoonup`	Weak convergence	Weak limit notion.	$x_n \rightharpoonup x$
$\langle\!\langle \cdot \rangle\!\rangle$ `\langle \!\langle \cdot \rangle \!\rangle`	Ensemble average	Average over realizations.	$\langle\!\langle X \rangle\!\rangle$
$\lceil \cdot \rceil$ `\lceil \cdot \rceil`	Ceiling	Smallest integer above.	$\lceil 3.2 \rceil = 4$
$\lfloor \cdot \rfloor$ `\lfloor \cdot \rfloor`	Floor	Largest integer below.	$\lfloor 3.2 \rfloor = 3$

8 Quantifiers and Number Systems

Symbol	Meaning	Definition	Example
$\forall$ `\forall`	For all / for every	Universal quantifier asserting a statement holds for all elements.	$\forall x \in \mathbb{R},\ x^2 \geq 0$
$\exists$ `\exists`	There exists	Existential quantifier asserting at least one element satisfies a property.	$\exists x \in \mathbb{R} :\ x^2 = 4$
$\exists!$ `\exists !`	Exists uniquely	Asserts existence of exactly one element satisfying a condition.	$\exists! x :\ x^2 = 1,\ x \geq 0$
$\neg$ `\neg`	Not	Logical negation of a statement.	$\neg(A \cap B = \emptyset)$
$\Rightarrow$ `\Rightarrow`	Implies	Logical implication between statements.	$A \Rightarrow B$
$\Leftrightarrow$ `\Leftrightarrow`	If and only if	Logical equivalence (necessary and sufficient).	$A \Leftrightarrow B$
$\mathbb{N}$ `\mathbb {N}`	Natural numbers	Set of non-negative integers (convention-dependent).	$n \in \mathbb{N}$
$\mathbb{Z}$ `\mathbb {Z}`	Integers	Set of positive, negative, and zero integers.	$k \in \mathbb{Z}$
$\mathbb{Q}$ `\mathbb {Q}`	Rational numbers	Numbers expressible as ratios of integers.	$q = \frac{p}{r} \in \mathbb{Q}$
$\mathbb{R}$ `\mathbb {R}`	Real numbers	Continuous number line including rationals and irrationals.	$x \in \mathbb{R}$
$\mathbb{C}$ `\mathbb {C}`	Complex numbers	Numbers of the form $a + bi$ with $i^2 = -1$.	$z \in \mathbb{C}$