CARRY THESE

Six cards, and the next rung

σ vs Σ Lower case is a quantity; upper case is an operator. One is a number; the other is a loop.	δ vs Δ Small change vs large change. Same letter, different scale.
$\mathbb{R}$ The reals — a *type*. It tells you what a symbol is allowed to be.	$\bar{x}$ vs $\hat{x}$ The bar is an average of what you measured; the hat is a guess at what you did not.
Upright vs italic A name stands up (sin, log); a thing leans (x, θ).	$\backslash\|$ x|$ | The norm: a length. Not an absolute value, though it behaves like one.

Where this sits

0 name it | **1 say it** | 2 parse it | 3 write it | 4 code it | 5 read unaided

You can name the parts. Next: the grammar — what binds tighter, and how to draw the tree.

KEY

Before Issue 2. Open any paper. Copy one line of symbols onto a card. Name each. Keep the ones you could not, and throw the rest away.

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PARSING MATHEMATICS

1

GLYPHS, AND WHAT THEY SIGNAL

The Alphabet

Greek, blackboard bold, and the decorations. Once you can name a symbol you can stop being frightened of it.

A NOTATION COURSE FOR PEOPLE WHO ALREADY THINK IN CODE

INSIDE

1. the Greek set
2. blackboard bold
3. the decorations
4. case signals
5. the symbol key

SAY | PARSE | SCOPE | PRODUCE

THE LETTERS YOU WILL ACTUALLY MEET

The alphabet

Greek letters are not decoration. In practice they are used for the things that do not have a natural Latin name: a rate, a difference, a parameter, a small quantity, a boundary. Learn fourteen of them and you have covered almost everything.

LETTER	NAME	USUALLY
α	alpha	an angle, a rate, a first parameter
β	beta	a second parameter, a coefficient
γ	gamma	a third, or a ratio
δ	delta	a **small** change, or a boundary
Δ	Delta (capital)	a **large** change, or a difference operator
ε	epsilon	an arbitrarily small quantity
θ	theta	an angle, or an unknown parameter
λ	lambda	a rate, an eigenvalue
μ	mu	a mean
π	pi	3.14159..., or a projection
ρ	rho	a density, a correlation
σ	sigma	a standard deviation
Σ	Sigma (capital)	**sum** — a completely different thing
ϕ	phi	1.618..., or a phase, or a map
ω	omega	an angular frequency

KEY

The one that catches everybody. σ and Σ are the same letter. Lower case is a *quantity*; upper case is an *operator*. One is a number, the other is a loop.

ANSWERS · FOLD UNDER BEFORE YOU LOOK

What the drill was testing

Drill A

- Σ — "Sigma", capital: the sum operator.
- σ — "sigma", lower case: a standard deviation. Same letter, different job.
- Δ — "Delta", capital: a large change, or a difference operator.
- δ — "delta", lower case: a small change, or a boundary.
- $\mathbb{R}$ — "the reals": every point on the number line.
- $\bar{x}$ — "x bar": the mean of the x values.
- $\hat{\theta}$ — "theta hat": an estimate of the parameter θ.
- $\|v\|$ — "the norm of v": the length of the vector v.

Drill B

- $\hat{\theta} = \frac{1}{n}\sum_{i=1}^{n} x_i$ — "theta hat equals one over n, times the sum from i equals one to n, of x-sub-i." That is: an *estimate* is the *average* of the observations.
- $\|x - \bar{x}\|^2$ — "the norm of x minus x bar, squared."
- $f : \mathbb{R}^n \to \mathbb{R}$ — "f, from R-n to R": a function taking a list of n numbers and returning one number.

KEY

The habit. Every symbol you could not name in this issue goes on a card. Those cards are your alphabet, and there are fewer of them than you fear.

DRILL B · SAY THE WHOLE THING

Marks, then letters

Read each aloud, in words, naming every mark. Write the spoken form first; the speaking is the proof.

$$\hat{\theta} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

$$\|x - \bar{x}\|^2$$

$$f : \mathbb{R}^n \to \mathbb{R}$$

$$p(x \mid \mu, \sigma) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$$

IF IT HELPS

Start with the outermost thing — a fraction, a square, an arrow — and name it before you name anything inside it.

THE TWO ALPHABETS YOU CANNOT AVOID

Blackboard bold, and what it is telling you

Five letters, drawn double-struck, name the number systems. They are a *type*: they tell you what kind of thing a symbol is allowed to be.

$$\mathbb{N} \subset \mathbb{Z} \subset \mathbb{Q} \subset \mathbb{R} \subset \mathbb{C}$$

SYMBOL	NAME	WHAT IT CONTAINS
$\mathbb{N}$	the naturals	$0, 1, 2, 3, \ldots$
$\mathbb{Z}$	the integers	$\ldots, -2, -1, 0, 1, 2, \ldots$
$\mathbb{Q}$	the rationals	every fraction of two integers
$\mathbb{R}$	the reals	every point on the line
$\mathbb{C}$	the complex	the reals, plus $i = \sqrt{-1}$

Read the chain aloud: *the naturals are a subset of the integers, which are a subset of the rationals…* — and every $\subset$ is a claim that everything on the left is also on the right.

THE RULE OF THUMB

If it is a name, it stands up. If it is a thing, it leans. Functions with names are set upright; variables are italic. That is why $\sin x$ looks different from sin.

Case and slope

A letter's **case** is a type annotation. Almost everywhere, in the same order:

- lower case italic — a scalar, or a single element: x, n, θ
- upper case — a set, a matrix, or a random variable: X, A, Ω
- **upright** — a *name*, not a thing: $\sin$, $\log$, $\max$, $\exp$, $\mathrm{d}x$

The four that are not Greek or Latin

- ℓ — "ell": a length, or a line.
- $\aleph_0$ — "aleph nought": the size of the naturals — an infinity.
- $\hbar$ — "h bar": the reduced Planck constant.
- $\varnothing$ — "the empty set": a set with nothing in it.

EVERY MARK ON A LETTER MEANS SOMETHING

Hats, bars, tildes and stars

A symbol is rarely bare. The marks above and beside a letter are a small vocabulary of their own, and they are *conventional* rather than fixed — so check the paper's own key. But these are the defaults.

MARK	READS AS	USUALLY MEANS
$\hat{x}$	"x hat"	an estimate, or a unit vector
$\bar{x}$	"x bar"	a mean (an average)
$\tilde{x}$	"x tilde"	a transformed or approximate version
$\dot{x}$	"x dot"	a derivative with respect to time
x'	"x prime"	a derivative, or the next value
x^*	"x star"	an optimal value, or a conjugate
$\vec{v}$	"v vector"	a vector
$\|x\|$	"norm of x"	a length
$\langle x, y \rangle$	"inner product"	a projection, a similarity

KEY

The trap. $\bar{x}$ and $\hat{x}$ are not the same mark and not the same idea: the bar is an average of what you *measured*, the hat is a guess at what you *did not*. In statistics the difference is the whole subject.

Brackets mean things

BRACKETS	READS AS	WHAT IT IS
(a, b)	"the pair a, b" — or "the open interval"	a pair, or everything strictly between
$[a, b]$	"the closed interval"	everything between, ends included
$\{a, b\}$	"the set of a and b"	a collection
$\langle u, v \rangle$	"the inner product of u and v"	a projection, a similarity

DRILL A · NAME EVERY SYMBOL

Build the symbol table

Copy each symbol into the table, then write its name and what it is. Guessing is fine; a guessed entry that is wrong is worth more than a blank one.

SYMBOL	NAME	WHAT IT IS
Σ		
σ		
Δ		
δ		
$\mathbb{R}$		
$\bar{x}$		
$\hat{\theta}$		
$\|v\|$		
λ		
μ		
∇		
∂		

The test. Cover the right-hand column and name each symbol aloud. If you can name it, you can read it. If you cannot, nothing else on the page will work.

And your own

Three symbols from your own reading that you could not name. Write them here, and carry them until you can.

SYMBOL	NAME	WHAT IT IS