BASIS

FOUNDATION MATH FOR AI

Linear Algebra for AI

The 12 Ideas That Matter

Everything in this guide is explained visually,
one video at a time, on the Basis channel.

The smallest set of vectors that builds everything else.

Watch the full course: youtube.com/@Basis

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How to use this guide

This is a map, not a textbook. Each page holds one idea from linear algebra — the version you actually need to understand modern AI — stated plainly, with the reason it matters.

Read it once end to end. It takes about fifteen minutes, and afterwards the whole subject has a shape in your mind.

Then keep it beside you while you watch the videos. Every idea here is one full lesson on the channel, built with animations you can follow step by step.

The one sentence to remember

Linear algebra is the art of adding and scaling.

Every operation ahead — matrices, transformations, eigenvalues, neural networks — is built from those two moves.

01 A vector is a package of numbers

Two apples and three oranges cannot be added into one number — they measure different things. So we stack them into a column and carry them as ONE object. That is a vector: several related numbers, kept separate but travelling together.

Notation	v = [3, 2] — one number per direction
Why it matters	A house is [price, size, bedrooms]. A word in an AI model is 768 numbers. Same idea, more lanes.

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02 One vector, three faces

The same object shows up in three costumes, and fluent people switch between them without thinking.

Physics	an arrow — it has length and direction
Computer science	a list of numbers — an array in memory
Geometry	a point — where the arrow lands

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03 Coordinates turn places into numbers

Two perpendicular axes give every point on a flat surface an exact address. Three axes do it for space. Above three you cannot draw it — and it does not matter, because the algebra never changes.

2D	a map: [east, north]
3D	the sky: [east, north, height]
nD	data and AI: hundreds of lanes, same rules

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04 Addition happens lane by lane

To add vectors, add the numbers that share a lane: east with east, north with north. Geometrically, place the second arrow at the tip of the first — the sum is the shortcut home.

Rule	[2,1] + [1,3] = [3,4]
In the world	Life adds vectors for you: two walks, a boat plus a current, Monday's sales plus Tuesday's.

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05 Scaling stretches, shrinks, or flips

A scalar is just a single number. Multiply a vector by it and every component scales at once — the arrow keeps its line but changes size, and reverses if the scalar is negative.

c > 1	stretch
0 < c < 1	shrink
c < 0	flip to the other side

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06 Subtraction measures the gap

v – w is just v + (–1)w — nothing new. But the picture is worth memorising: the arrow points FROM the tip of w TO the tip of v.

Meaning	Where is that, compared to me?
Everywhere	this week minus last week; final speed minus starting speed

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07 The dot product measures agreement

Multiply lane by lane, then add — and out comes ONE number that says how much two directions agree.

Positive	the directions broadly agree
Zero	perpendicular — the instant right-angle test
Negative	they oppose
In AI	attention inside a language model is dot products between word vectors

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08 Magnitude is Pythagoras, in any dimension

A vector is the hypotenuse of its own components, so its length is the square root of the sum of squares. Signs die inside the squares — direction never changes length.

Formula	||v|| = sqrt(v1^2 + v2^2 + ... + vn^2)
Distance	the length of the difference: ||b - a||
In AI	'similar' means small distance between vectors

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09 Unit vectors are pure direction

Divide a vector by its own length and you get a compass needle: same direction, length exactly one. Every vector splits cleanly into magnitude times direction.

Normalising	v-hat = v / ||v||
In AI	cosine similarity — a dot product of normalised vectors — is how search decides two sentences mean the same thing

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10 A basis is the smallest building set

Vectors that (1) build everything and (2) contain no freeloaders form a BASIS. i-hat and j-hat are the standard one — and coordinates are simply how many of each you need.

Key insight	coordinates are a CHOICE, not a law
Dimension	every basis of a space has the same size — that size IS the dimension

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11 A matrix moves all of space

A matrix is a grid of numbers — but really it is a machine that transforms every vector at once. Its COLUMNS tell you exactly where i-hat and j-hat land, which is the whole motion.

Read the columns	and you can read the transformation
Multiplication	is composition: one motion after another
In AI	every neural network layer is y = Wx + b

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12 Eigenvectors are the directions that survive

Most directions get knocked off their line by a transformation. A few refuse to turn — they only stretch. Those are eigenvectors, and the stretch factor is the eigenvalue.

Equation	Av = (lambda)v
In AI	PCA compresses data along top eigenvectors; vanishing and exploding gradients are eigenvalues out of range

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Where to go next

You now have the map. The territory is on the channel:

Chapter 1 · Vectors — the objects themselves
Chapter 2 · Matrices — grids that act on vectors
Chapter 3 · Linear Transformations — matrices moving space
Chapter 4-6 · Solving systems, determinants, inverses
Chapter 7-8 · Vector spaces, basis, eigenvalues
Chapter 9-10 · Decompositions, SVD, and AI applications

Every lesson is free, animated, and built to be understood the first time — no prior background assumed.

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