

**Keyword**  
**Presentation**  
**Linear**  
**Algebra**

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# Three ways of defining Linear Algebra

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Classification	Definition
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Elementary	Linear Algebra is the study of vectors, matrices, systems of linear equations, and problems that can be solved using linear algebraic techniques
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Abstract	Axler defines Linear Algebra as "the study of the study of linear maps on finite-dimensional spaces" (Axler, 2015)
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Computational	"Linear Algebra is the study of vectors and ways of manipulating vectors" (Deisenroth, 2020)
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There are three core concepts in linear algebra

Scalar  $\lambda \in \mathbb{R}$

We can think of a scalar as a single value, usually a real number

Vector

Example Vector  $a = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} \in$

$\mathbb{R}^3$  Vectors are objects that we add together and multiply by a scalar to get another vector.

Matrix A  $m \times n$  matrix is a collection of elements consisting of  $m$  rows and  $n$  columns. We can think of matrices as a collection of vectors or a linear transformation

Example Matrix

$$A = \begin{bmatrix} 1 & 3 & 5 \\ 8 & 2 & 1 \\ 3 & 3 & 4 \end{bmatrix}$$

# History of Linear Algebra

Linear algebra encompasses many techniques that evolved over time and in several places including China, Europe, Greece, and Egypt

In the 19th century James Joseph Sylvester and Arthur Cayley introduced algebraic techniques for linear algebra and coined the term matrix, which comes from the Latin term for womb

# What does Linear mean?

Linear transformations are functions that map one vector to another

## Formal Definition

A transformation  $L()$  is called linear if the following properties hold

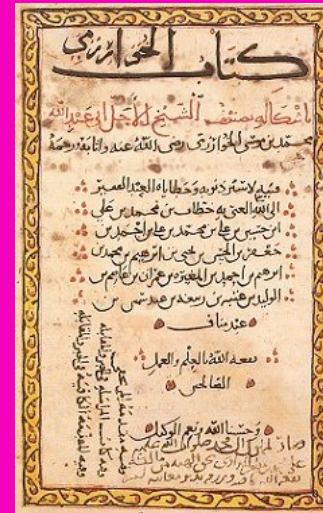
Addition:  $L(v + w) = L(v) + L(w)$

Scalar Multiplication:  $L(\lambda v) = \lambda \cdot L(v)$

# What is Algebra?

Algebra comes from the name the text Al-jabr (الجبر) written by polymath Muhammad ibn Musa al-Khwarizmi who worked in Baghdad in the 9th century

Algebra broadly refers to the formal manipulation of abstract symbols



# How Linear Algebra is used in Machine Learning

Machine learning models represent data as vectors and use many Linear Algebra to represent and transform complex collections of data. In this way vectors are used to abstractly represent data as points in space

## Common uses of Linear Algebra

- Data Representation
- Word Embeddings, i.e using vectors to represent words for NLP
- Calculating Similarity between data points

# Sources

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