Vectors –

Vectors are best understood as arrows in space, with both magnitude (length) and direction.

They can represent physical quantities like displacement, velocity, or force.

Vectors can be written as coordinate pairs/triples, e.g., (x, y) or (x, y, z).

Addition of vectors corresponds to placing arrows head-to-tail → forming a parallelogram.

Scalar multiplication stretches or shrinks a vector while keeping its direction (unless multiplied by a negative, which reverses direction).

Vectors form the foundation of linear algebra since they are the “objects” that transformations act on

Eigen Values and Eigen Vectors –

A linear transformation (like rotation, scaling, or shearing) changes most vectors’ direction and length.

Eigenvectors are special vectors that do not change direction under a transformation.

Each eigenvector has an associated eigenvalue → a scalar that tells how much the vector is stretched (|λ| > 1) or squished (|λ| < 1).

Example: If a transformation doubles the length of a certain vector but keeps it on the same line, that vector is an eigenvector with eigenvalue 2.

Geometrically: eigenvectors reveal the principal directions of a transformation, and eigenvalues reveal the scaling factor along those directions.

Eigenvalues and eigenvectors are fundamental in applications like:

Principal Component Analysis (PCA) in machine learning.

Quantum mechanics.

Google’s PageRank algorithm.

Stability analysis in engineering.