# What Are Tensors?

A **tensor** is a **multidimensional array** — a generalization of:

- **Scalars (0D)**
- **Vectors (1D)**
- **Matrices (2D)**

Tensors can represent data of any number of dimensions, making them a **fundamental data structure** in machine learning and deep learning.

Simply put: **Tensors = Containers for data of any dimension**

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## Types of Tensors by Dimensionality

### 1. 0D Tensor (Scalar)

- A single number (e.g., 5)
- No axes
- Shape: ()

**Ex:** x = 5

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### 2. 1D Tensor (Vector)

- A list of numbers
- Has 1 axis
- Shape: (n,) where n = number of elements

**Ex:** x = [1, 2, 3] → shape (3,)

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### 3. 2D Tensor (Matrix)

- A grid of numbers: rows × columns
- Has 2 axes
- Shape: (rows, columns)

**Ex:**

x = [[1, 2, 3],
[4, 5, 6]] → shape (2, 3)

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## 4. ND Tensor (3D, 4D, 5D...)

As dimensions increase, tensors can represent:

- **3D**: Stack of matrices (like colored image channels) — shape (depth, height, width)
- **4D**: Batch of images — shape (batch_size, channels, height, width)
- **5D**: Video or sequence of batches — shape (batch, time, channels, height, width)

These are especially common in **deep learning models (e.g., CNNs, RNNs)**.

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## Key Concepts: Rank, Axes, Shape

| Term | Meaning | Example (x = [[1, 2], [3, 4]]) |
|---|---|---|
| **Rank** | Number of axes (dimensions) | 2 (since it's a 2D matrix) |
| **Axes** | Each individual dimension in the tensor | Axis-0: rows, Axis-1: columns |
| **Shape** | Size along each axis | (2, 2) |

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## Practical Tensor Examples

| Tensor Type | Example | Shape |
|---|---|---|
| **1D** | [1, 2, 3, 4] | (4,) |
| **2D** | [[1, 2], [3, 4], [5, 6]] | (3, 2) |
| **3D** | [[[1,2],[3,4]], [[5,6],[7,8]]] | (2, 2, 2) |
| **4D** | Batch of 3 images, each 2×2×3 (RGB) | (3, 2, 2, 3) |
| **5D** | Sequence of batches, each with image data | e.g., (2, 3, 3, 32, 32) |

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## Tensor Use in Machine Learning

Tensors are the **backbone of ML frameworks** like:

- **TensorFlow**
- **PyTorch**
- **Keras**

They are used to:

- Store **input data**, like images, text, and sound
- Hold **model parameters**, like weights and biases
- Pass data through **layers in deep learning models**

Tensor operations = matrix algebra = how deep learning happens

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## Summary

| Concept | Explanation |
|---|---|
| **Tensor** | A general n-dimensional array |
| **0D (Scalar)** | Single value |
| **1D (Vector)** | List of values |
| **2D (Matrix)** | Rows × columns table |
| **3D+** | Stacks or batches of matrices/images |
| **Rank** | Number of dimensions |
| **Shape** | Size along each dimension |
| **Axes** | Indexable directions (rows, columns, etc.) |

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## Final Thought:

Tensors aren't just math,they are how machines **see, learn, and think** in the world of deep learning.

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