# Module 5: Vectors and Matrices

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# Learning outcomes

Understand what vectors and matrices are, how to work with them in Python, and why they matter for data in agriculture.

**Key Topics**

- Scalar . Vector . Matrix
- Vectors in Python
- Vector operations
- Matrices in Python
- Dot Product
- NumPy basic overview

# Scalar · Vector · Matrix  What is the difference?

**Key idea:** These are three ways to organize numbers. You already know scalars (single numbers) and lists, vectors and matrices are just the mathematical names for them.

**Scalar:**

A scalar is a number, like 3, -5, 0.368, etc.

Example: temperature = 23.5

You already use these every day

**Vector:**

A vector is a list of numbers (can be in a row or column)

Example: [12.4, 9.8, 14.1]

Like a Python list.

**Matrix:**

A grid of numbers. A matrix is an array of numbers (one or more rows, one or more columns)

Example: sensor readings per field per day. Like a spreadsheet.

Scalar

24

Vector

$$\begin{bmatrix} 2 & -8 & 7 \end{bmatrix}$$

row

or column

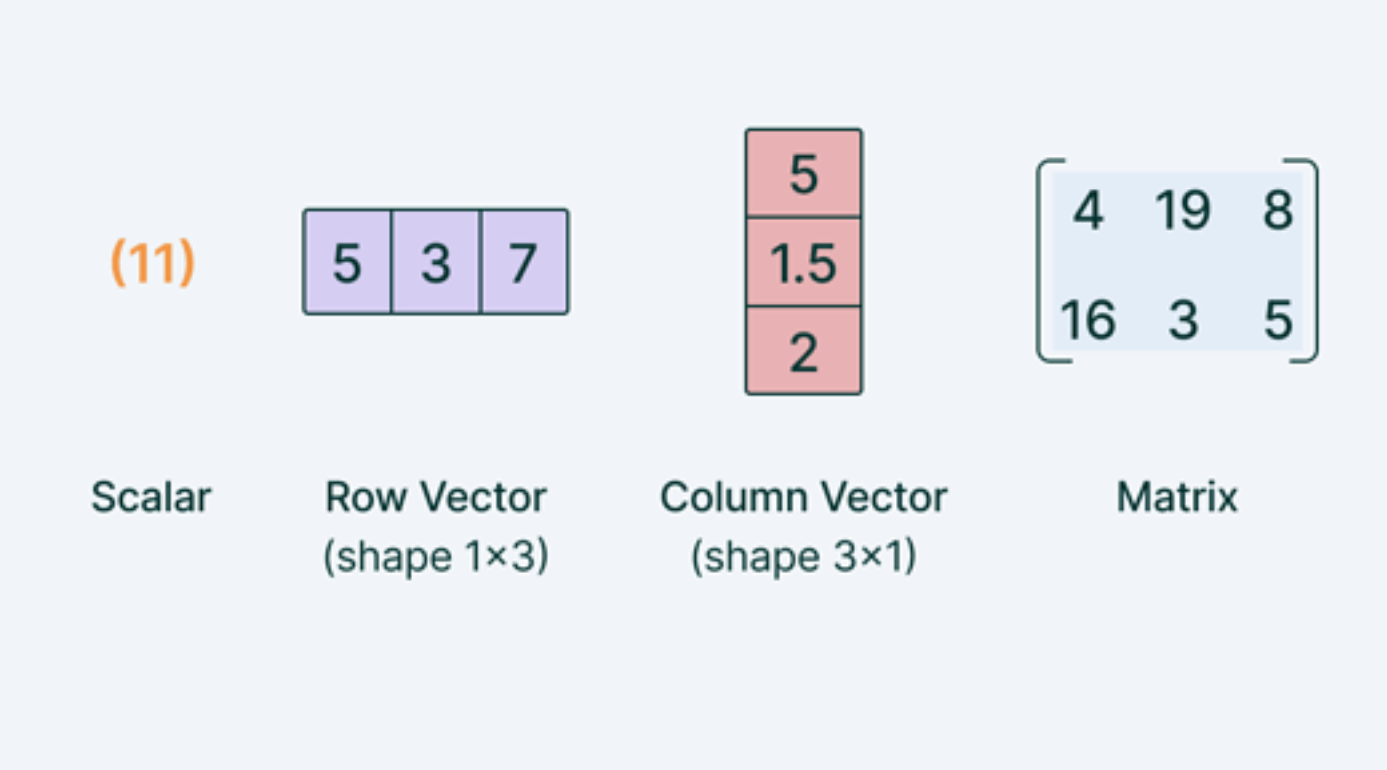
$$\begin{bmatrix} 2 \\ -8 \\ 7 \end{bmatrix}$$

Matrix

$$\begin{bmatrix} 6 & 4 & 24 \\ 1 & -9 & 8 \end{bmatrix}$$

row(s) × column(s)

# Scalar · Vector · Matrix  What is the difference?



# Vectors in Python

**A vector is just a Python list. A sequence of numbers, each at a numbered position (index).**

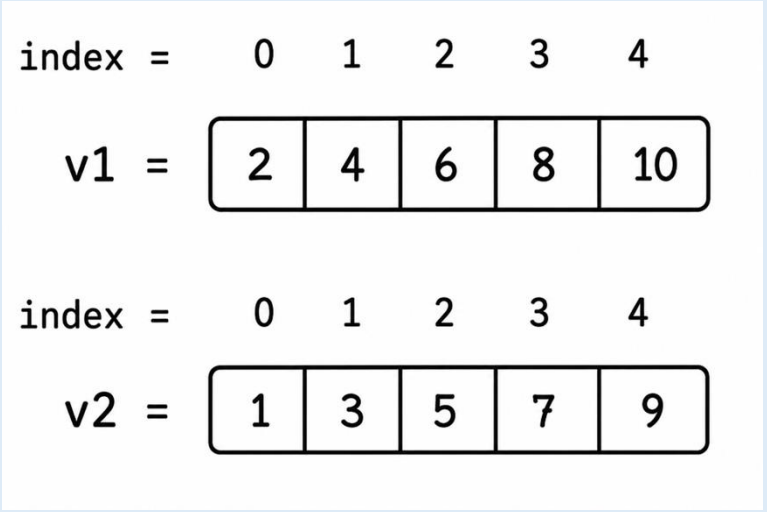
```
# plain Python list
# Vector 1
v1 = [2, 4, 6, 8, 10]
# Vector 2
v2 = [1, 3, 5, 7, 9]
```

**Accessing Values Using Index**

Remember:

```
index 0 → first value
index 1 → second value
index 2 → third value. And so on till the length
```

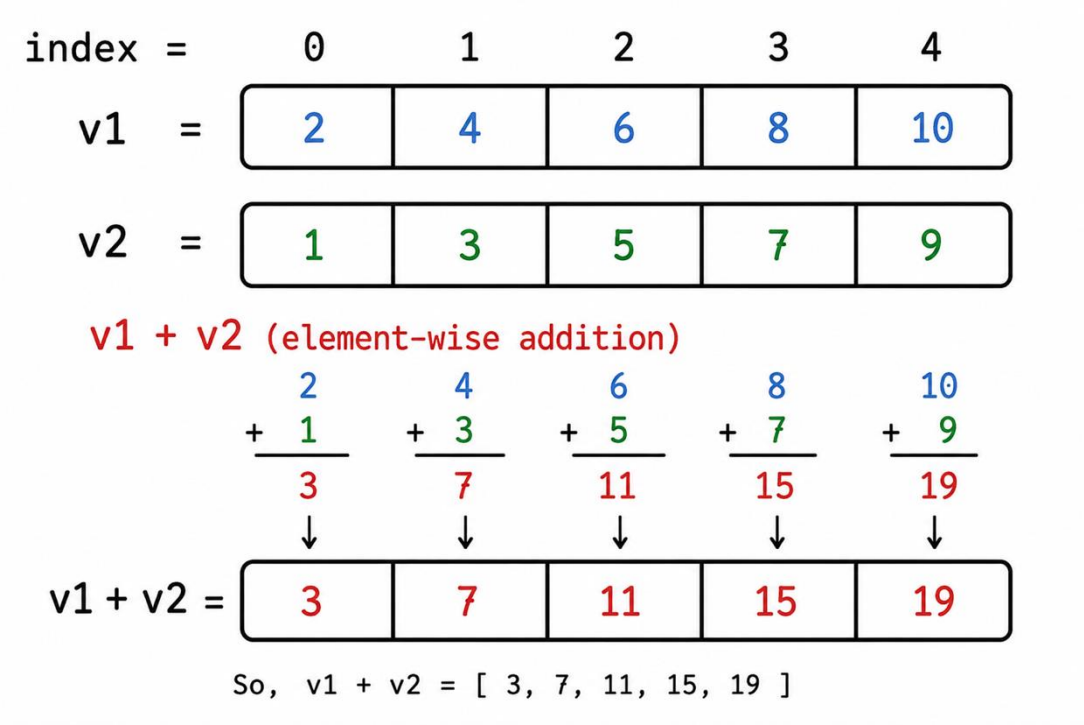
```
v1 = [2, 4, 6, 8, 10]
print(v1[0])   # first value. Output 2
print(v1[4])   # fifth value. Output 10
```



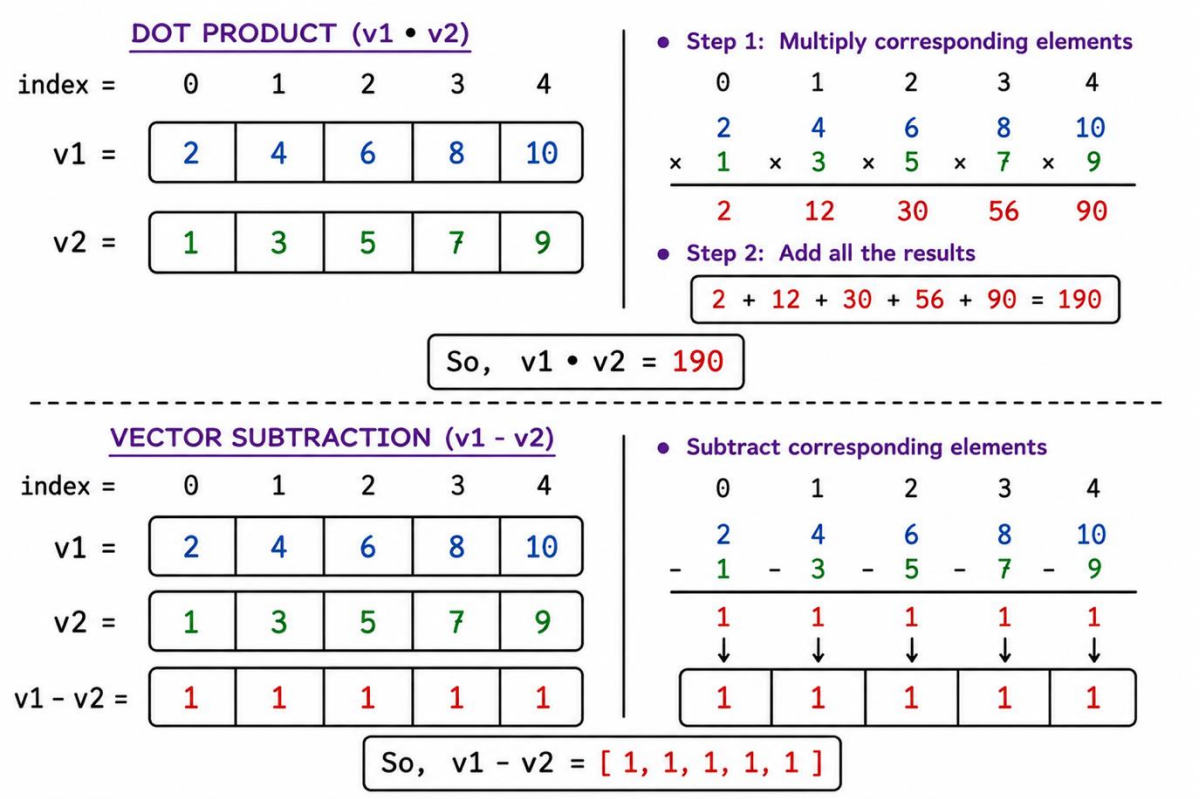
# Vector operations (element by element)

**Key idea**: When you add, subtract or multiply a vector, the operation happens to every element. **NumPy** does this automatically.

**Vector Addition**

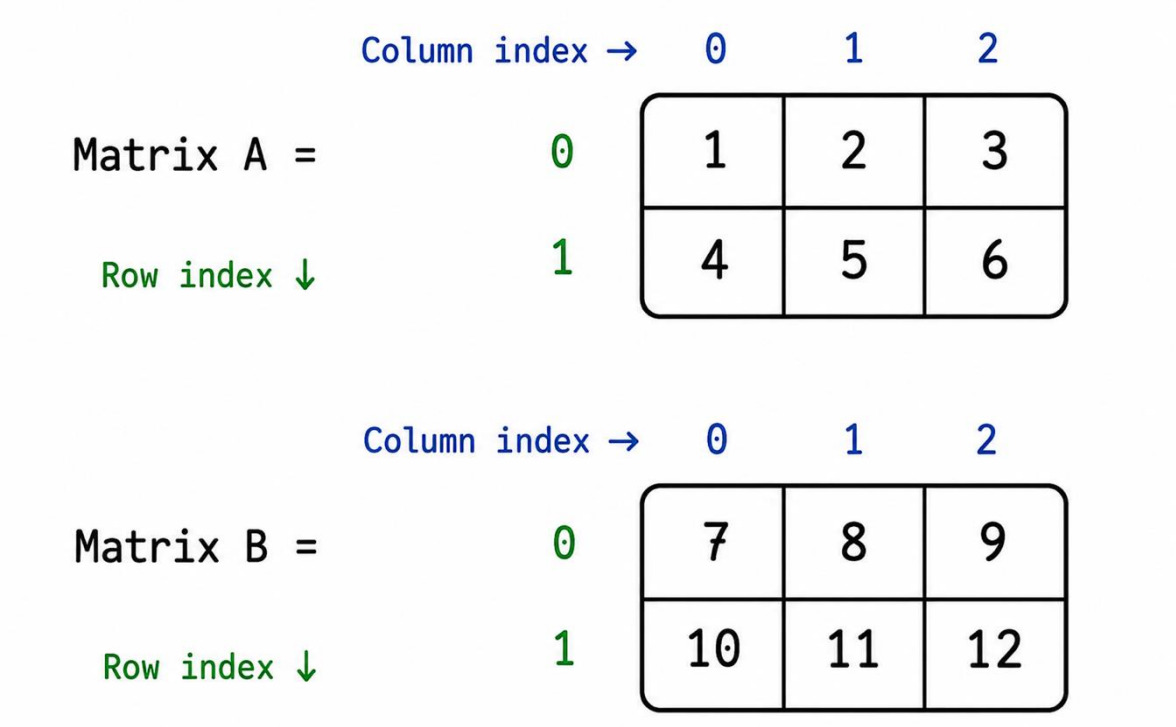


# Vector operations (element by element)

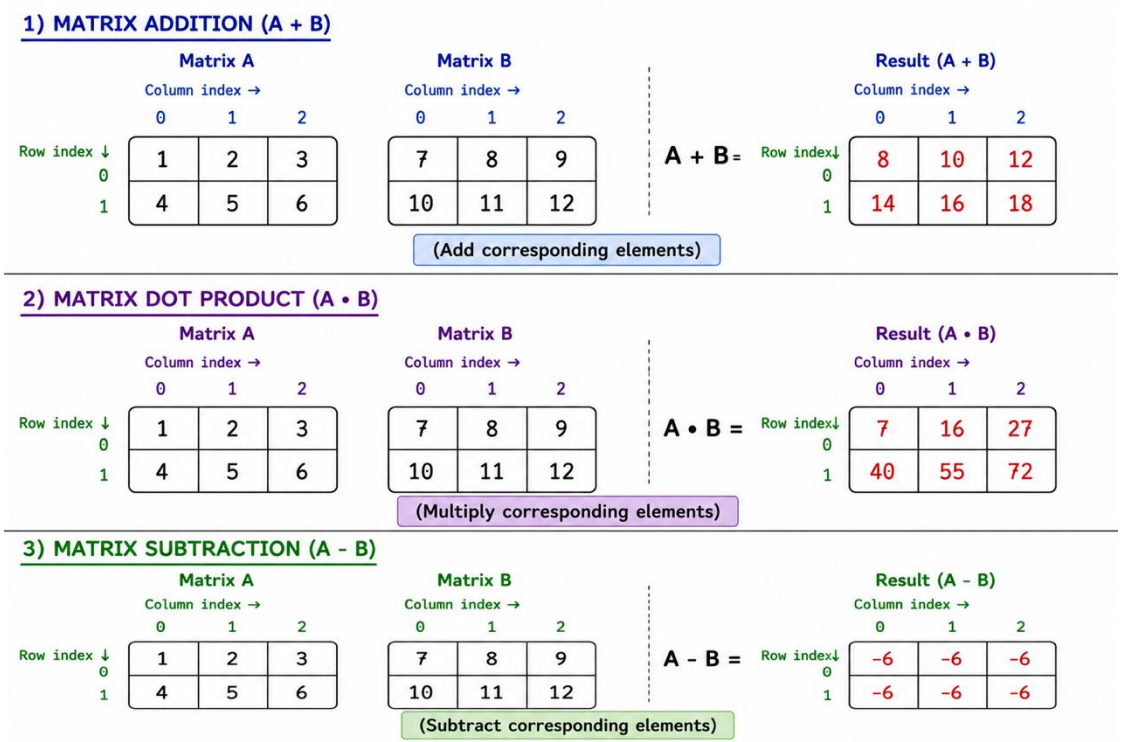


# Matrices

**What it is**: A matrix is a 2D grid (rows and columns). Think of it as a spreadsheet or a table of sensor readings



# Matrices Operations



# NumPy (your toolkit for vectors and matrices)

**What it is:** NumPy is a Python library that makes working with vectors and matrices fast and simple. You will use it in almost every data science project.
**install**: pip install numpy,
**import**: *import numpy as np*
then use *np.array(), np.dot(),* etc.

**Why not plain Python lists?**
NumPy arrays are much faster for math's and work with the whole array at once.

```python
# Import NumPy library
import numpy as np

# Vector 1
v1 = np.array([2, 4, 6, 8, 10])

# Vector 2
v2 = np.array([1, 3, 5, 7, 9])

# VECTOR Operations
addition = v1 + v2 # Adds corresponding elements
subtraction = v1 - v2 # Subtracts corresponding elements
multiplication = v1 * v2 # Multiplies matching positions
dot_product = np.dot(v1, v2)

print(addition) # Output  [ 3  7 11 15 19]
print(subtraction) # [1 1 1 1 1]
print(multiplication) # [ 2 12 30 56 90]
print(dot_product) # 190
```

# Overview of key content

- Scalar = one number · Vector = a list of numbers · Matrix = a grid of numbers
- A vector in Python is a NumPy array, accessed by index, starting at 0
  v = np.array([12.4, 9.8, 14.1]) → v[0] is 12.4, v[1] is 9.8

- Operations on vectors happen to every element automatically
  v + 2 adds 2 to every value. v + w adds element by element. No loops needed. NumPy does it all at once.

- Dot product = multiply pairs then add up, gives a single number
  np.dot(weights, readings) gives a weighted sum. Both vectors must have the same length.
  The result is always one number.

# Thank you!

## Contact Detail

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For any questions, please feel free to use the Moodle-Course Forum!