

# Product Requirement Document

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## *Python Matrix Calculator*

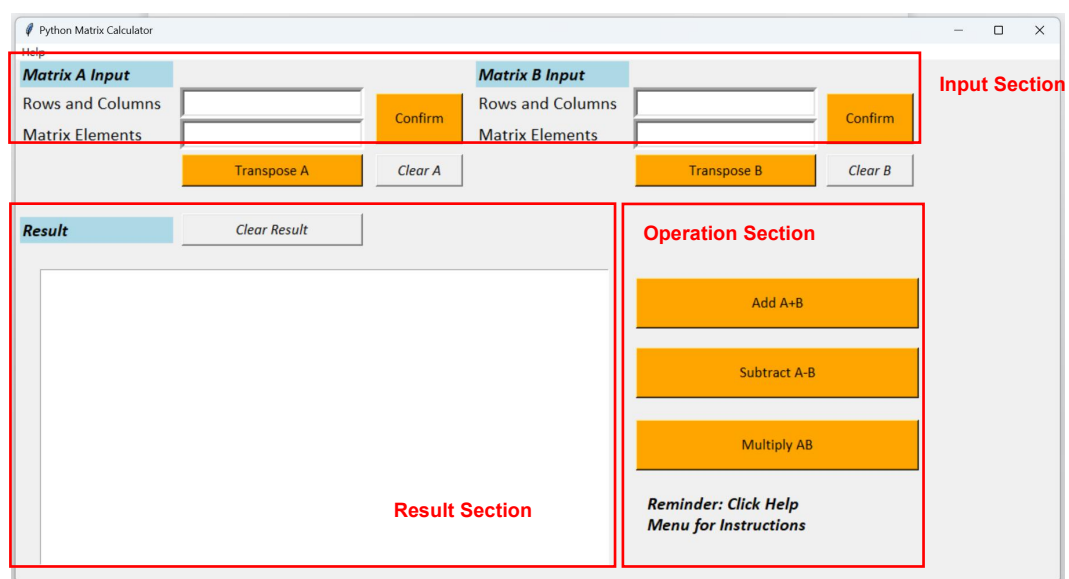
### Background and Motivation

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- When dealing with mathematical problems, Architectural Environment Engineers often encounter some matrix operation problems.
- Therefore, this simple python based matrix calculator is designed to save the time for calculation process and verification, and accordingly improve working efficiency.
- The calculator can conduct some basic matrix calculations including addition, subtraction, multiplication and transposition, and it is designed in graphical user interface.

### Key Functions

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- This software can perform simple matrix operations by entering the content of both matrix elements and the number of matrix rows and columns.
- After input of matrices and confirmation, the different operations can be achieved by clicking the related buttons such as "Transpose", "Add A+B" and "Multiply AB".
- The processing results will be displayed correspondingly when the inputs satisfy the requirements for matrix calculation.

## Scientific Methods

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A matrix is an array of numbers arranged in rows and columns. The dimensions of a matrix are typically denoted as  $m \times n$ .

Matrix operations such as addition, multiplication, subtraction, etc., are similar to basic arithmetic and algebra, but differ in some ways and are subject to certain constraints. Descriptions of the matrix operations below are algorithms behind this software.

- **Addition and Subtraction**

If  $A$  and  $B$  are of the same order, then we may add corresponding elements to obtain

$$A + B = \begin{pmatrix} a_{11} + b_{11} & a_{12} + b_{12} & \cdots & a_{1n} + b_{1n} \\ \vdots & & & \\ a_{m1} + b_{m1} & a_{m2} + b_{m2} & \cdots & a_{mn} + b_{mn} \end{pmatrix}$$

or subtract  $B$  from  $A$  to obtain

$$A - B = \begin{pmatrix} a_{11} - b_{11} & a_{12} - b_{12} & \cdots & a_{1n} - b_{1n} \\ \vdots & & & \\ a_{m1} - b_{m1} & a_{m2} - b_{m2} & \cdots & a_{mn} - b_{mn} \end{pmatrix}$$

**Example:** Given  $A = \begin{pmatrix} 1 & 2 \\ 0 & 4 \end{pmatrix}$  and  $\begin{pmatrix} 0 & 3 \\ 1 & 4 \end{pmatrix}$ . Find  $A + B$  and  $A - B$ .

**Solution:**

$$A + B = \begin{pmatrix} 1+0 & 2+3 \\ 0+1 & 4+4 \end{pmatrix} = \begin{pmatrix} 1 & 5 \\ 1 & 8 \end{pmatrix}$$
$$A - B = \begin{pmatrix} 1-0 & 2-3 \\ 0-1 & 4-4 \end{pmatrix} = \begin{pmatrix} 1 & -1 \\ -1 & 0 \end{pmatrix}$$

**Example:** If

$$A = \begin{pmatrix} 1 & 2 \\ 0 & 4 \end{pmatrix} \text{ and } \begin{pmatrix} 0 & 3 & 2 \\ 1 & 4 & 1 \end{pmatrix}$$

then  $A + B$  and  $A - B$  do not make sense because  $A$  and  $B$  have different orders.

- **Multiplication**

**Multiplication** of one matrix by another is more involved than we might expect!

Let  $A$  be an  $m \times n$  matrix,  $B$  be a  $p \times q$  matrix. Then  $AB$  exists if  $n = p$ , i.e. the "inner dimensions" agree. The result,  $AB$  is an  $m \times q$  matrix. Thus

$$\underbrace{A \quad B}_{n=p}$$

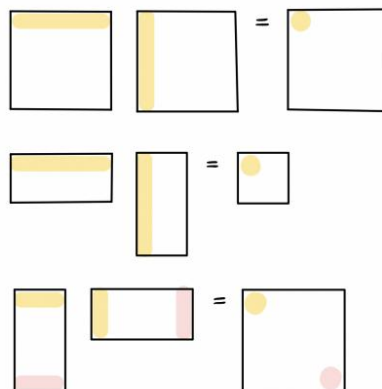
If  $n \neq p$ ,  $AB$  does not exist, i.e. the number of columns of  $A$  must equal the number of rows of  $B$ .

For example, if  $A$  is a  $3 \times 2$  matrix and  $B$  is a  $2 \times 2$  matrix, then  $AB$  exists and is a  $3 \times 2$  matrix, but  $BA$  does not exist.

**Rule for matrix multiplication:**

When  $C = AB$  exists, the element  $c_{ij}$  in the  $i$ th row and  $j$ th column of  $C$  is obtained by taking the "product" of the  $i$ th row of  $A$  with the  $j$ th column of  $B$ . By "product", we mean

$$c_{ij} = \sum_r a_{ir} b_{rj}.$$



**Example:**

a)  $\begin{pmatrix} 1 & -1 \\ 2 & 1 \end{pmatrix} \begin{pmatrix} 0 & 1 \\ 3 & 2 \end{pmatrix}$

b)  $\begin{pmatrix} 0 & 1 \\ 3 & 2 \end{pmatrix} \begin{pmatrix} 1 & -1 \\ 2 & 1 \end{pmatrix}$

**Solution:**

a)

$$\begin{pmatrix} 1 & -1 \\ 2 & 1 \end{pmatrix} \begin{pmatrix} 0 & 1 \\ 3 & 2 \end{pmatrix} = \begin{pmatrix} -3+0 & 1-2 \\ 0+3 & 2+2 \end{pmatrix} = \begin{pmatrix} -3 & -1 \\ 3 & 4 \end{pmatrix}$$

b)

$$\begin{pmatrix} 0 & 1 \\ 3 & 2 \end{pmatrix} \begin{pmatrix} 1 & -1 \\ 2 & 1 \end{pmatrix} = \begin{pmatrix} 0+2 & 0+1 \\ 3+4 & -3+2 \end{pmatrix} = \begin{pmatrix} 2 & 1 \\ 7 & -1 \end{pmatrix}$$

- **Transposition**

The transpose of the  $m \times n$  matrix  $A$  is an  $n \times m$  matrix denoted by  $A^T$  and obtained by interchanging the rows and columns of  $A$ .

If

$$A = \begin{pmatrix} 3 & 2 & 1 \\ 4 & 5 & 6 \end{pmatrix}, \quad B = \begin{pmatrix} 1 \\ 4 \end{pmatrix}, \quad C = \begin{pmatrix} 1 & 2 & 3 \\ 0 & 5 & 1 \\ 2 & 4 & 7 \end{pmatrix}$$

then their transposes are

$$A^T = \begin{pmatrix} 3 & 4 \\ 2 & 5 \\ 1 & 6 \end{pmatrix}, \quad B^T = (1 \quad 4), \quad C^T = \begin{pmatrix} 1 & 0 & 2 \\ 2 & 5 & 4 \\ 3 & 1 & 7 \end{pmatrix}$$

## Similar Products in Markets

1. <https://www.calculator.net/matrix-calculator.html>

2. <https://matrixcalc.org/>

3. <https://matrix.reshish.com/>

The screenshot shows the homepage of the matrix.reshish.com website. The header features the logo "matrix RESHISH" in orange and grey, with a navigation bar containing "Matrix Calculator" (highlighted in orange) and "Graphing Calculator". On the left, a vertical sidebar lists various matrix operations: Gauss-Jordan Elimination, Cramer's Rule (highlighted in brown), Inverse Matrix Method, Matrix Rank, Determinant, Inverse Matrix, Matrix Power, Matrix Transpose, Matrix Multiplication, and Matrix Addition/Subtraction. The main content area is titled "Matrix Calculator" and contains two paragraphs of text. The first paragraph describes the website as a free online matrix calculator with basic operations and a "very detailed solution" feature. The second paragraph highlights the ability to use complex numbers and the continuous calculation mechanism.

matrix.reshish.com is the most convenient free online **Matrix Calculator**. All the basic matrix operations as well as methods for solving systems of simultaneous linear equations are implemented on this site. For methods and operations that require complicated calculations a 'very detailed solution' feature has been made. With the help of this option our calculator solves your task efficiently as the person would do showing every step.

The key feature of our matrix calculator is the ability to use **complex numbers** in any method. Also, we have the mechanism of continuous calculation. This means that after you used one of the methods, you can continue calculation using another method with the original or result matrix. You can read more about this in the **instructions**.