



SAGE- “SYSTEM FOR ALGEBRA EXPERIMENTATION

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Abstract: In this paper, we will discuss the various applications of Sage Math. We will explore how this mathematical software can be used. By the end of the discussion, we will better understand the versatility of Sage Math and how it can be utilized to solve complex mathematical problems related to matrices.

Index Terms – Sage Math, Jupyter Notebook, Matrices

I. INTRODUCTION



Sage Math is a free open-source mathematics software system and it has the GPL (General Public License) license. Sage math can be used as a scientific pocket calculator.

It is a computer algebra system that has aspects of mathematics like algebra, graph theory, numerical analysis, number theory, calculus, and statistics.

Sage math can handle expressions including square roots, exponents, logarithms, trigonometric functions, integration, limits, etc.

In linear algebra, it computes vectors, matrices, and subspaces. It is easy to compile.

Sage math is an alternative to Matlab and Mathematica. Sage Math was initially released on 24 February 2005.

An American, William Stein a mathematician at the University of Washington is the originator and the leader of this project.

The website for sage math is www.sagemath.org. It runs on web browsers like Firefox, Opera, Conqueror, Google Chrome, and Safari.

Sage math can be written in Python or Cython. Linux, MacOS, Microsoft Windows, Android, and iOS are the operating systems that can perform the sage math operations.

II. NEED OF THE STUDY

1. To research the application of sage math for solving matrices.
2. Attempting to find the rank, inverse, and product of matrices using Sage Math.
3. Making Observations on the simplicity of using this software for the operations.

ADVANTAGES OF SAGE MATH

Python-Based: SageMath uses Python as its programming language. Python is known for its simplicity and readability, making it accessible to a broad audience, including mathematicians and programmers.

Interactive Interface: SageMath provides an interactive interface through a Jupyter notebook, making it easy for users to explore mathematical concepts, perform calculations, and visualize results.

Easy to compile: Sage can easily be compiled from source for Linux, and Windows users. This provides more flexibility.

Well Documented: Numerous tutorials, guides, reference manuals, and different examples and discussions of background mathematics.

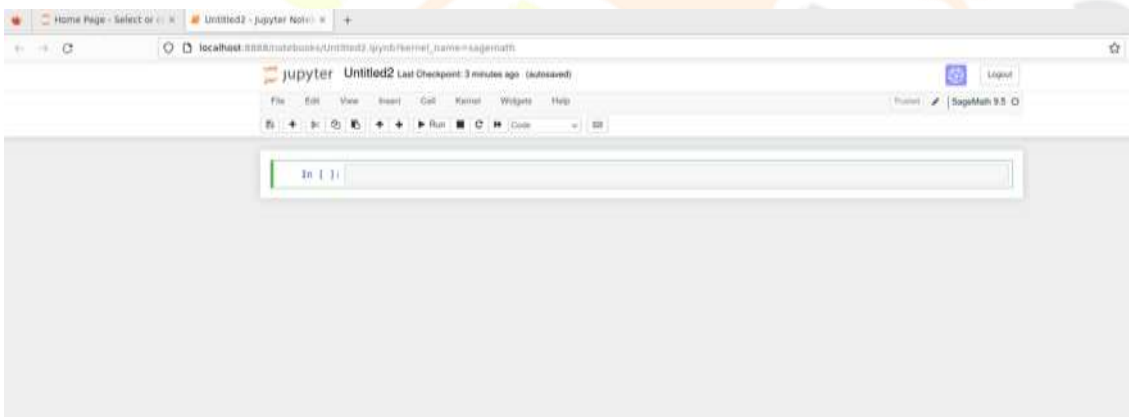
APPLICATIONS OF SAGE MATH

The various applications of sage math for linear algebra are listed:

Rank of a matrix
Inverse
Product
Reduced row echelon Form
Characteristic polynomial
Eigenvalues
Eigen Vectors
System of linear equations
Inner product
Norm
Gram-Schmidt Process

III. RESEARCH METHODOLOGY

After downloading the software from www.sagemath.org we can access it from the jupyter notebook.



Here, we can enter various operations for an output.

For matrices,

Syntax: `matrix name=matrix([[m1,n1],[m2,n2],...[mi,nj]])`.

```
In [7]: C=matrix([[8,7],[-65,43]])
In [8]: show(C)
Output:

$$\begin{pmatrix} 8 & 7 \\ -65 & 43 \end{pmatrix}$$

```

RANK OF A MATRIX

To find the rank of a matrix in Sage Software we have to use the syntax as follows
Matrixname.rank() or rank(matrixname)

- a) Let us find the rank for matrix $A = \begin{bmatrix} 2 & 3 \\ -4 & 17 \end{bmatrix}$

```
In [16]: A=matrix([[2,3],[-4,17]])
In [17]: show(A)
      ( 2  3 )
      (-4 17 )
In [18]: rank(A)
Out[18]: 2
In [ ]:
```

The rank of the matrix is generated as 2.

- b) Let us find the rank of the matrix $B = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$

```
In [4]: B=matrix([[1,1],[1,1]])
In [5]: show(B)
      ( 1  1 )
      ( 1  1 )
In [6]: rank(B)
Out[6]: 1
```

The rank of the matrix is generated as 1.

INVERSE OF A MATRIX

To find the inverse of the matrix in Sage
Syntax: matrixname.inverse()

Let us find the inverse for the matrix $C = \begin{bmatrix} 30 & 15 \\ 20 & 15 \end{bmatrix}$

```
In [7]: C=matrix([[30,15],[20,15]])
In [8]: show(C)
      ( 30  15 )
      ( 20  15 )
In [9]: C.inverse()
Out[9]: [ 1/10 -1/10 ]
        [-2/15  1/5 ]
```

The inverse has been generated.

- a) Let us find the inverse for the matrix $D = \begin{bmatrix} 200 & 50 \\ 40 & 600 \end{bmatrix}$

```
In [11]: D=matrix([[200,50],[40,600]])
```

```
In [12]: show(D)
```

$$\begin{pmatrix} 200 & 50 \\ 40 & 600 \end{pmatrix}$$

```
In [13]: D.inverse()
```

```
Out[13]: [ 3/590 -1/2360]
          [-1/2950 1/590]
```

The inverse has been generated.

PRODUCT OF TWO MATRICES

To find the product, we need to define two matrices and use (*)

- a) Matrix $L = \begin{bmatrix} 2 & 3 & 4 \\ 5 & 4 & 2 \\ 8 & 5 & 9 \end{bmatrix}$ and Matrix $M = \begin{bmatrix} 9 & 0 & 7 \\ 6 & 2 & 5 \\ 5 & 2 & 1 \end{bmatrix}$

```
In [49]: L=matrix([[2,3,4],[5,4,2],[8,5,9]])
          M=matrix([[9,0,7],[6,2,5],[5,2,1]])
```

```
In [50]: show(L)
```

$$\begin{pmatrix} 2 & 3 & 4 \\ 5 & 4 & 2 \\ 8 & 5 & 9 \end{pmatrix}$$

```
In [51]: show(M)
```

$$\begin{pmatrix} 9 & 0 & 7 \\ 6 & 2 & 5 \\ 5 & 2 & 1 \end{pmatrix}$$

```
In [52]: L*M
```

```
Out[52]: [ 56 14 33]
          [ 79 12 57]
          [147 28 90]
```

The product is generated.

- b) Matrix $G = \begin{bmatrix} 4 & 6 \\ 9 & 10 \end{bmatrix}$ and let Matrix H be its identity matrix.

```
In [34]: G=matrix([[6,8],[7,9]])
          H=identity_matrix(2,2)
```

```
In [35]: show(G)
```

$$\begin{pmatrix} 6 & 8 \\ 7 & 9 \end{pmatrix}$$

```
In [36]: show(H)
```

$$\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

```
In [37]: G*H
```

```
Out[37]: [6 8]
          [7 9]
```

The product is generated.

IV. CONCLUSION

- Sage math is a free open-source
- Using this software, operations related to matrices can be easily solved.
- We were able to find the rank, inverse, and product using simple syntaxes.
- It is beginner-friendly for mathematicians to use.
- In future works related to this software, we plan to explore the application of this software for calculus-based operations.

V. REFERENCES

[1] <http://sagemath.org/>

[2] Linear Algebra-Sage Tutorial http://doc.sagemath.org/html/en/tutorial/tour_linalg.html

