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Linear Algebra

Laboratory Activity No. 6

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# Matrices

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## I. Objectives

This laboratory activity aims to implement the principles and techniques of matrices and matrix operations using Python as the programming language.

## II. Methods

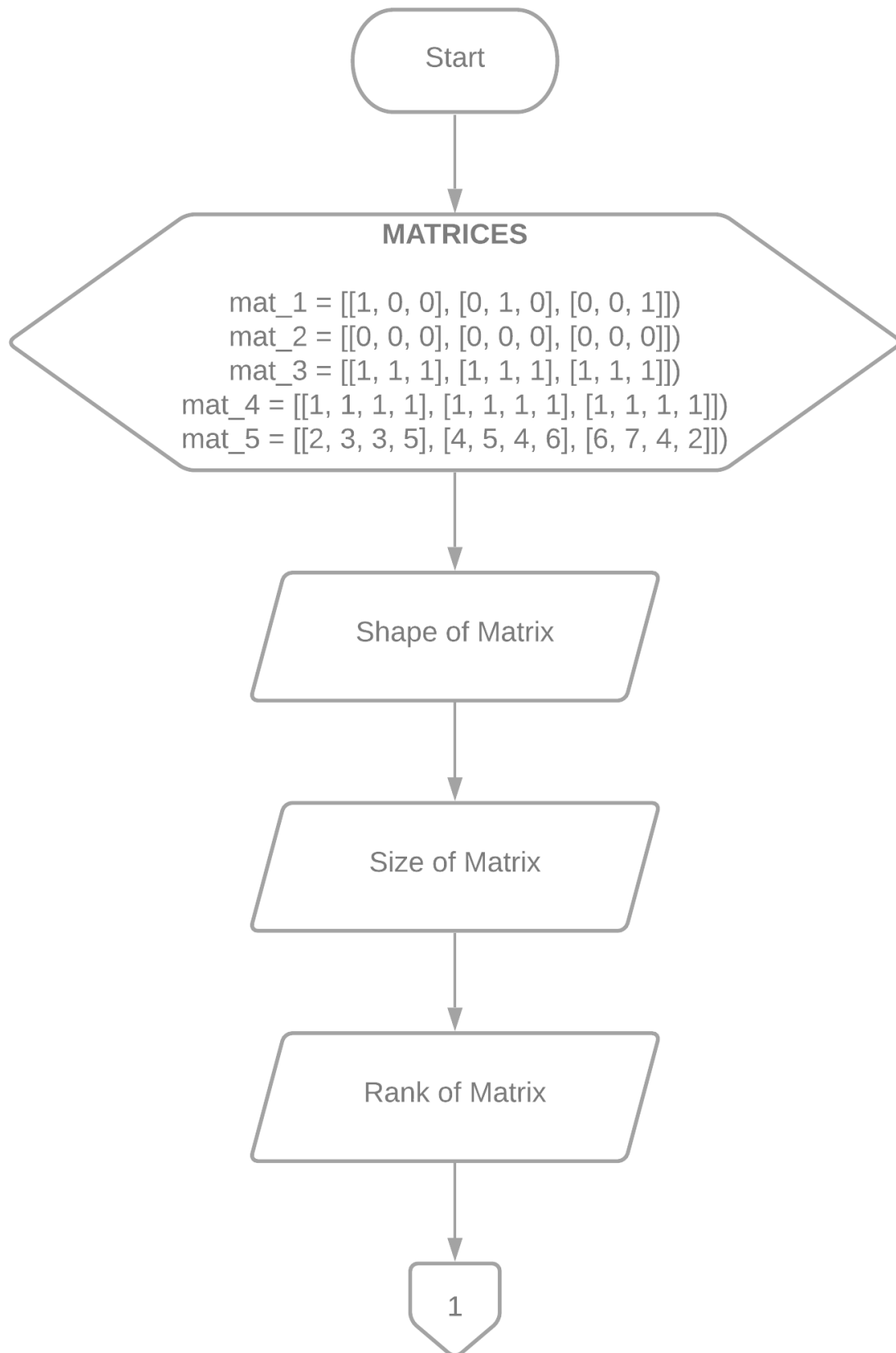


Figure 1 The Flowchart for Task 1 part 1

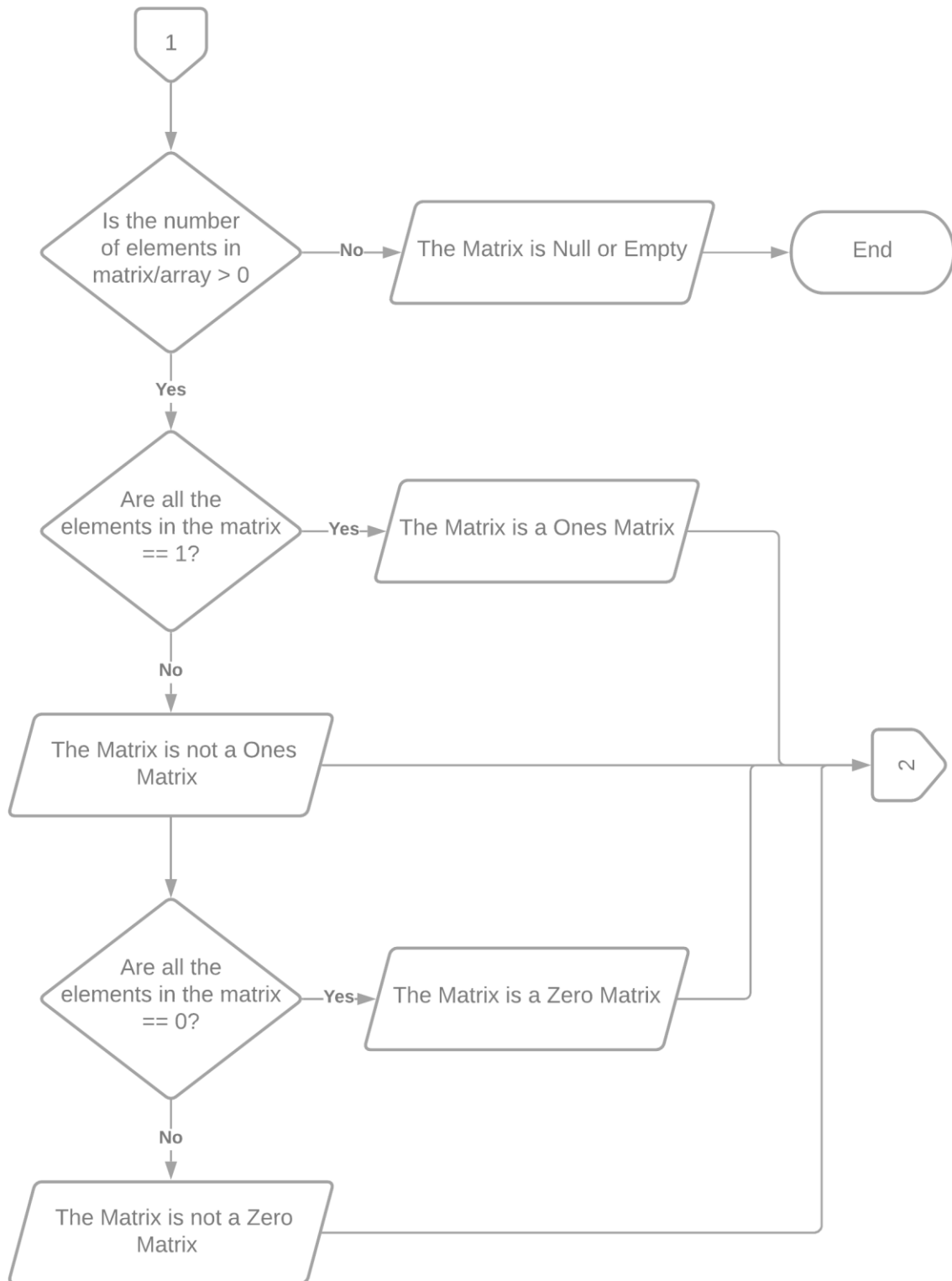


Figure 2 The Flowchart for Task 1 part 2

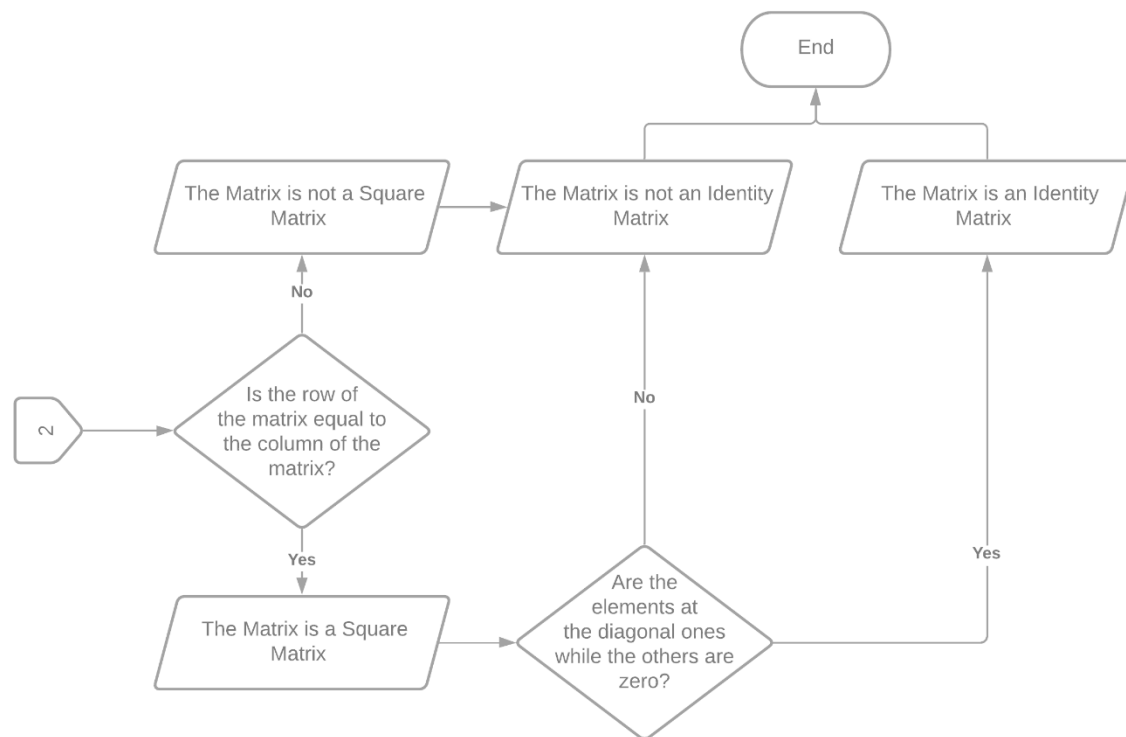


Figure 3 The Flowchart for Task 1 part 3

Figures 1 to 3 show the flowchart that was used to create the program in task 1 which describes a matrix. The program starts by displaying the shape, size, and rank of the matrix and then determine if there are elements in the matrix to determine if the matrix is null. Afterward, determine if the matrix is a one, zero, square, or identity matrix. If all the elements in the matrix are 1, the matrix is a ones matrix but if all the elements in the matrix are 0, the matrix is a zero matrix. If the rows and columns of the matrix are equal, the matrix is square, and if the elements on the diagonal are all 1 while 0 elsewhere, then the matrix is also an identity matrix.

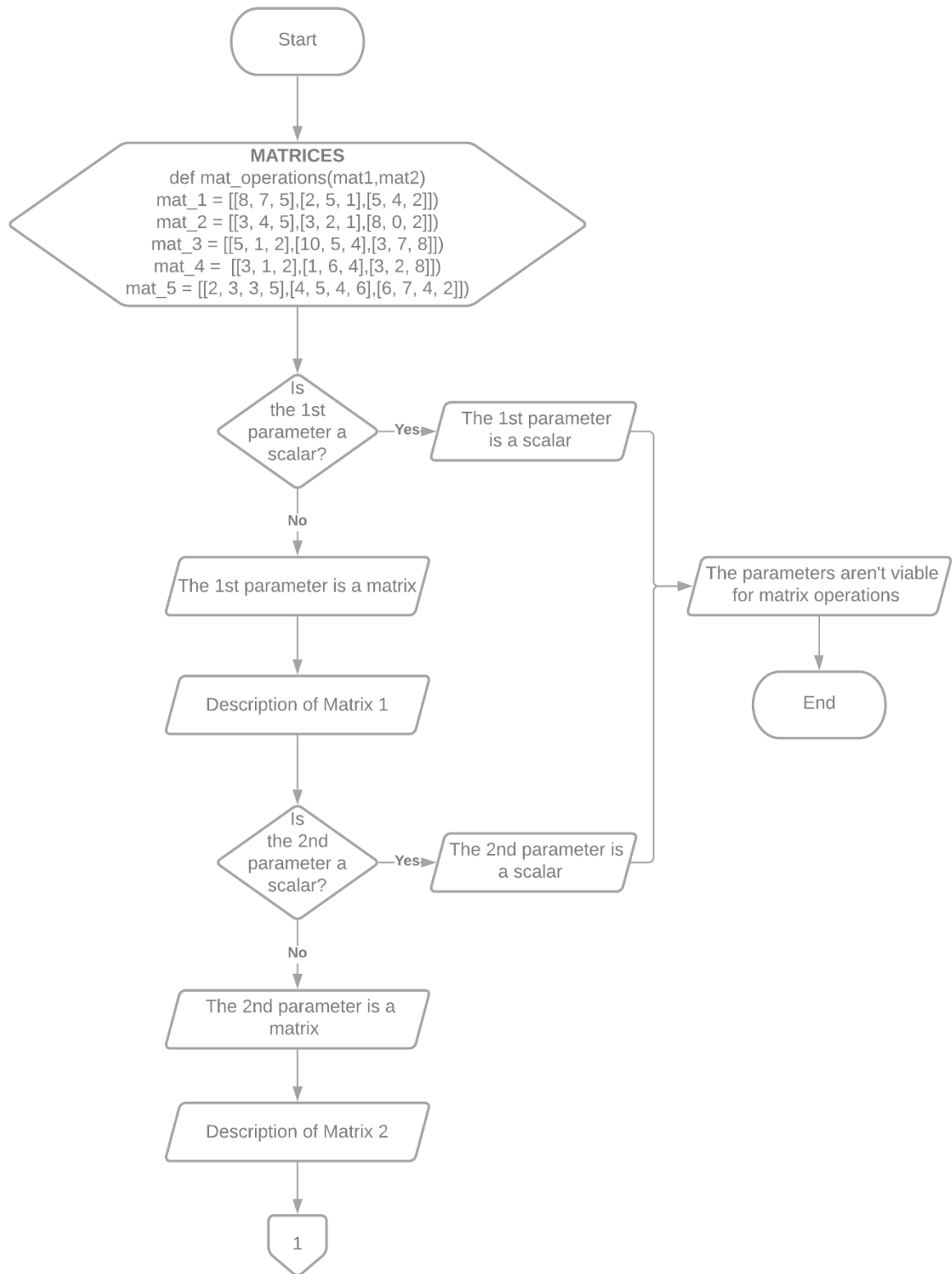


Figure 4 The Flowchart for Task 2 part 1

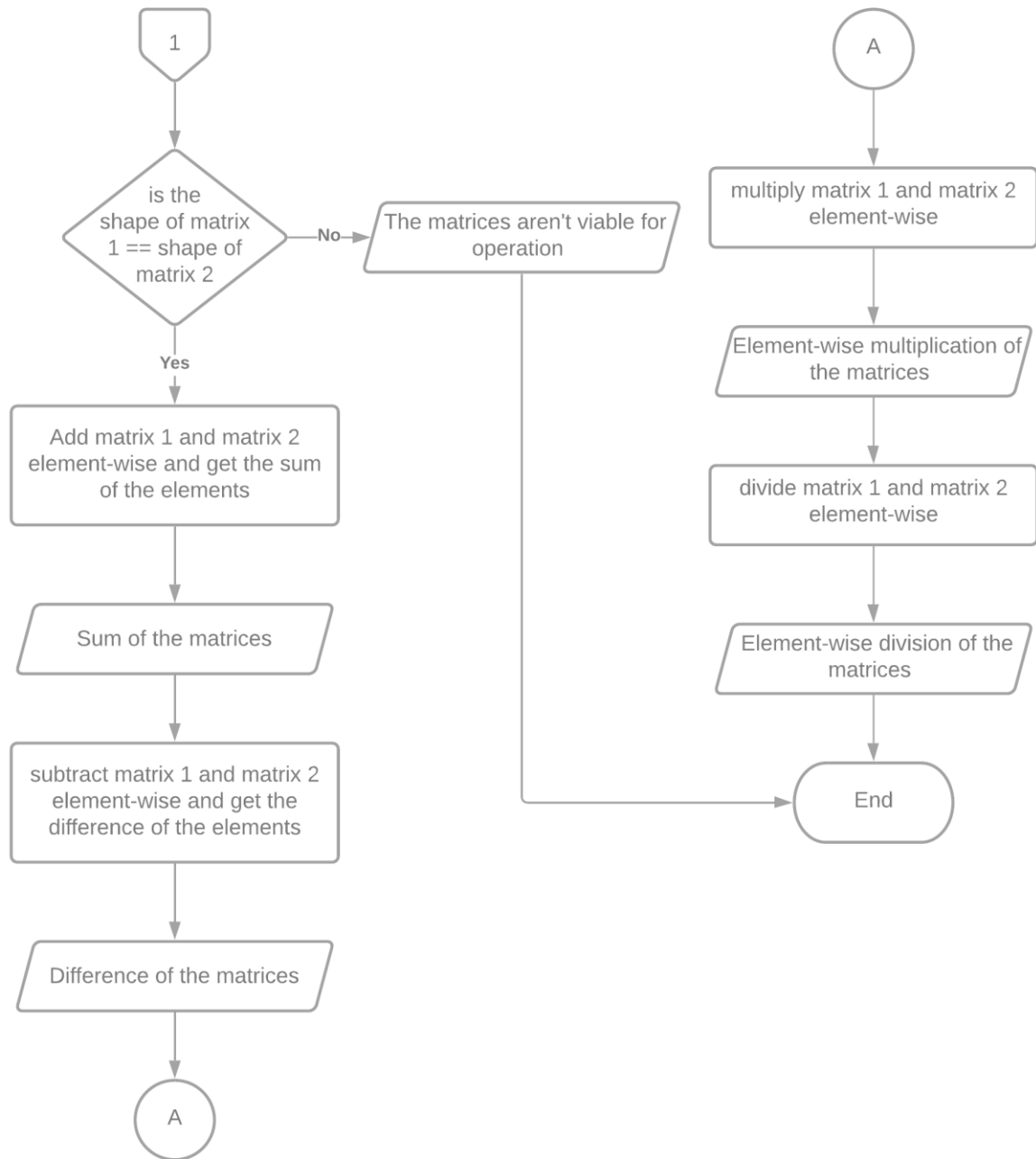


Figure 5 The Flowchart for Task 2 part 2

Figure 4 to 5 shows the flowchart that was used to create the program in task 2 which takes in 2 matrices or scalars and uses matrix operations to get the sum, difference, element-wise multiplication, and element-wise division of the matrices. The program starts by checking if the 1<sup>st</sup> and 2<sup>nd</sup> parameters are either matrices or scalars. If one of the parameters is a scalar, the program would show that it is a scalar and that it isn't viable for matrix operations and then end the program. If both the parameters are matrices, the program would show the description of both the matrices like it did in task 1. Afterward, it would check if the shape of the 1<sup>st</sup> matrix is equal to the shape of the 2<sup>nd</sup> matrix. If the shape wasn't the same, the program would output

the matrices aren't viable for operation since they aren't broadcastable. However, if the shape of the 1<sup>st</sup> matrix is equal to the shape of the 2<sup>nd</sup> matrix then it would get the sum, difference, element-wise multiplication, and element-wise division of the matrices and end the program.

```
## Function area
def mat_desc(matrix):
    # prints the shape, size, and rank of the matrix
    print(f'{matrix}\n\n')
    f'The shape of the matrix is: {matrix.shape}\n'
    f'The size of the matrix is: {np.product(matrix.shape)}\n'
    f'The rank of the matrix is: {matrix.ndim}')
    # matrix.size determines the total number of elements in an array
    if matrix.size > 0:
        # np.all checks if all the elements in the array is 1
        is_ones = True if np.all((matrix == 1)) else False
        # np.all checks if all the elements in the array is 0
        is_zero = True if np.all((matrix == 0)) else False
        # checks if row is equal to column
        is_square = True if matrix.shape[0] == matrix.shape[1] else False
        # checks if the matrix is a square matrix and an identity matrix using np.allclose
        is_identity = True if matrix.shape[0] == matrix.shape[1] and np.allclose(matrix, np.eye(matrix.shape[0])) else False
        # prints if the matrix is a square, identity, ones, and/or zero
        print(f'Is the matrix a ones matrix?: {is_ones}\n')
        f'Is the matrix a zero matrix?: {is_zero}\n'
        f'Is the matrix a square?: {is_square}\n'
        f'Is the matrix an identity matrix?: {is_identity}\n\n')
    else:
        print("The Matrix is Null or Empty")
```

Figure 6 The mat\_desc() method code in Task 1

```
# Matrix declarations
mat_1 = np.array([
    [1, 0, 0],
    [0, 1, 0],
    [0, 0, 1]
])
mat_2 = np.array([
    [0, 0, 0],
    [0, 0, 0],
    [0, 0, 0]
])
mat_3 = np.array([
    [1, 1, 1],
    [1, 1, 1],
    [1, 1, 1]
])
mat_4 = np.array([
    [1, 1, 1, 1],
    [1, 1, 1, 1],
    [1, 1, 1, 1]
])
mat_5 = np.array([
    [2, 3, 3, 5],
    [4, 5, 4, 6],
    [6, 7, 4, 2]
])
```

Figure 7 The Sample Matrix Declarations in Task 1



```

## Test Areas
print("Matrix 1:")
mat_desc(mat_1)
print("Matrix 2:")
mat_desc(mat_2)
print("Matrix 3:")
mat_desc(mat_3)
print("Matrix 4:")
mat_desc(mat_4)
print("Matrix 5:")
mat_desc(mat_5)

```

Figure 8 Calling the mat\_desc() Method

```

## Function area
def mat_operations(mat1,mat2):
    alpha = 10**-10
    if np.isscalar(mat1):
        print("The first parameter is a scalar")
    else:
        print(f'1st matrix:\n {mat1}\n\n')
        f'The shape of the 1st matrix is: {mat1.shape}\n'
        f'The size of the 1st matrix is: {np.product(mat1.shape)}\n'
        f'The rank of the 1st matrix is: {mat1.ndim})'
        if mat1.size > 0:
            # np.all checks if all the elements in the array is 1
            is_ones = True if np.all((mat1 == 1)) else False
            # np.all checks if all the elements in the array is 0
            is_zero = True if np.all((mat1 == 0)) else False
            # checks if row is equal to column
            is_square = True if mat1.shape[0] == mat1.shape[1] else False
            # checks if the matrix is a square matrix and an identity matrix using np.allclose
            is_identity = True if mat1.shape[0] == mat1.shape[1] and np.allclose(mat1, np.eye(mat1.shape[0])) else False
            # prints if the matrix is a square, identity, ones, and/or zero
            print(f'Is the matrix a ones matrix?: {is_ones}\n')
            f'Is the matrix a zero matrix?: {is_zero}\n'
            f'Is the matrix a square?: {is_square}\n'
            f'Is the matrix an identity matrix?: {is_identity}\n\n')
        )
    else:
        print("The Matrix is Null or Empty")
    if np.isscalar(mat2):
        print("The second parameter is a scalar\n")
    else:
        print(f'2nd matrix:\n {mat2}\n\n')
        f'The shape of the 2nd matrix is: {mat2.shape}\n'
        f'The size of the 2nd matrix is: {np.product(mat2.shape)}\n'
        f'The rank of the 2nd matrix is: {mat2.ndim})'
        if mat2.size > 0:
            # np.all checks if all the elements in the array is 1
            is_ones = True if np.all((mat2 == 1)) else False
            # np.all checks if all the elements in the array is 0
            is_zero = True if np.all((mat2 == 0)) else False
            # checks if row is equal to column
            is_square = True if mat2.shape[0] == mat2.shape[1] else False
            # checks if the matrix is a square matrix and an identity matrix using np.allclose
            is_identity = True if mat2.shape[0] == mat2.shape[1] and np.allclose(mat2, np.eye(mat2.shape[0])) else False
            # prints if the matrix is a square, identity, ones, and/or zero
            print(f'Is the matrix a ones matrix?: {is_ones}\n')
            f'Is the matrix a zero matrix?: {is_zero}\n'
            f'Is the matrix a square?: {is_square}\n'
            f'Is the matrix an identity matrix?: {is_identity}\n\n')
        else:
            print("The Matrix is Null or Empty")
    if np.isscalar(mat1) == False and np.isscalar(mat2) == False:
        if (mat1.shape == mat2.shape):
            print(f'The sum of the matrices is: \n{np.sum(np.add(mat1,mat2))}\n')
            f'\n\nThe difference of the matrices is: \n{np.diff(np.subtract(mat1,mat2))}\n'
            f'\n\nThe element-wise multiplication of the matrices is: \n{np.multiply(mat1,mat2)}\n'
            f'\n\nThe element-wise division of the matrices is: \n{np.divide(mat1,mat2+alpha)}\n')
        else:
            print("The matrices aren't viable for operation\n")
    else:
        print("The parameters aren't viable for matrix operation\n")

```

Figure 9 The mat\_operations() method code in Task 2

```

## Matrix declarations
mat_1 = np.array([
    [8, 7, 5],
    [2, 5, 1],
    [5, 4, 2]
])
mat_2 = np.array([
    [3, 4, 5],
    [3, 2, 1],
    [8, 0, 2]
])

mat_3 = np.array([
    [5, 1, 2],
    [10, 5, 4],
    [3, 7, 8]
])

mat_4 = np.array([
    [3, 1, 2],
    [1, 6, 4],
    [3, 2, 8]
])

mat_5 = np.array([
    [2, 3, 3, 5],
    [4, 5, 4, 6],
    [6, 7, 4, 2]
])

```

Figure 10 The Sample Matrix Declarations in Task 2

```

## Test Areas
print("1st pair of matrices:\n")
mat_operations(mat_1,mat_2)
print("\n2nd pair of matrices:\n")
mat_operations(mat_3,mat_4)
print("\n3rd pair of matrices:\n")
mat_operations(mat_1,mat_5)

```

Figure 8 Calling the mat\_operations() Method

The practices of the activity consist of using the functions in the Numpy library. The methods that were used were `mat_desc()` and `mat_operations()`. The method `mat_desc()` was used in task 1 to show the description of the matrices while the method `mat_operations()` were used in task 2 to perform matrix operations. The functions that were used were `np.array()` to create an array [1] that would represent the matrix/matrices, `np.ndarray.shape` to get the current shape of the matrix [2], `np.prod()` to get the product of the elements in the matrix [3], `np.ndarray.ndim` to get the dimension or rank of an matrix [4], `np.ndarray.size` to get the number of elements in the matrix [5], `np.allclose()` to check if two matrix are equal element-wise [6],

`np.eye()` to create a matrix with ones on the diagonal and zeros elsewhere or an identity matrix [7] to use as basis for the `np.allclose()` function, `np.all()` to test whether all matrix elements are equal to either 0 or 1 to determine if it is a zero matrix or ones matrix [8], `np.isscalar()` to check if the elements are scalar [9], `np.add()` to add the two matrices element-wise [10], `np.sum()` to get the sum of matrix elements [11], `np.subtract()` to subtract the two matrices element-wise [12], `np.diff()` was used to get the difference of the matrix [13], `np.multiply()` to multiply the two matrices element-wise [14], and `np.divide()` to divide the two matrices element-wise [15]. These practices were used to achieve the deliverables of the laboratory activity which is to be familiar with matrices and perform matrix operations using Python.

### III. Results

```
Matrix 1:
[[1 0 0]
 [0 1 0]
 [0 0 1]]

The shape of the matrix is: (3, 3)
The size of the matrix is: 9
The rank of the matrix is: 2
Is the matrix a ones matrix?: False
Is the matrix a zero matrix?: False
Is the matrix a square?: True
Is the matrix an identity matrix?: True
```

Figure 9 1<sup>st</sup> Matrix in Task 1

Figure 9 shows the 1<sup>st</sup> matrix in task 1. The shape of the matrix is (3,3) since the rows are 3 while the columns are also 3. The size of the matrix is 9 for the reason that  $3 \times 3 = 9$ . The rank of the matrix is 2 for it is a 2-dimensional array. The matrix isn't a ones matrix because not all the elements are 1. Also, it isn't a zero matrix seeing that not all the elements are 0. The matrix is a square matrix seeing that the rows and columns are of the same value. Since the diagonal values are 1 while the others are 0, the matrix is an identity matrix.

```

Matrix 2:
[[0 0 0]
 [0 0 0]
 [0 0 0]]

The shape of the matrix is: (3, 3)
The size of the matrix is: 9
The rank of the matrix is: 2
Is the matrix a ones matrix?: False
Is the matrix a zero matrix?: True
Is the matrix a square?: True
Is the matrix an identity matrix?: False

```

Figure 10 2<sup>nd</sup> Matrix in Task 1

Figure 10 shows the 2<sup>nd</sup> matrix in task 1. The shape of the matrix is (3,3) since the rows are 3 while the columns are also 3. The size of the matrix is 9 for the reason that  $3 \times 3 = 9$ . The rank of the matrix is 2 for it is a 2-dimensional array. The matrix isn't a ones matrix because not all the elements are 1 but it is a zero matrix because all the elements are 0. The matrix is a square matrix seeing that the rows and columns are of the same value. The matrix is not an identity matrix since the diagonal values aren't 1.

```

Matrix 3:
[[1 1 1]
 [1 1 1]
 [1 1 1]]

The shape of the matrix is: (3, 3)
The size of the matrix is: 9
The rank of the matrix is: 2
Is the matrix a ones matrix?: True
Is the matrix a zero matrix?: False
Is the matrix a square?: True
Is the matrix an identity matrix?: False

```

Figure 11 3<sup>rd</sup> Matrix in Task 1

Figure 11 shows the 3<sup>rd</sup> matrix in task 1. The shape of the matrix is (3,3) since the rows are 3 while the columns are also 3. The size of the matrix is 9 for the reason that  $3 \times 3 = 9$ . The rank of the matrix is 2 for it is a 2-dimensional array. The matrix is a ones matrix because all the elements are 1 but it is not a zero matrix because not all the elements are 0. The matrix is a square matrix seeing that the rows and columns are of the same value. The matrix is not an identity matrix since the diagonal values aren't 1 while the others are 0.

```
Matrix 4:  
[[1 1 1 1]  
 [1 1 1 1]  
 [1 1 1 1]]  
  
The shape of the matrix is: (3, 4)  
The size of the matrix is: 12  
The rank of the matrix is: 2  
Is the matrix a ones matrix?: True  
Is the matrix a zero matrix?: False  
Is the matrix a square?: False  
Is the matrix an identity matrix?: False
```

Figure 12 4<sup>th</sup> Matrix in Task 1

Figure 12 shows the 4<sup>th</sup> matrix in task 1. The shape of the matrix is (3,4) since the rows are 3 while the columns are 4. The size of the matrix is 12 for the reason that  $3 \times 4 = 12$ . The rank of the matrix is 2 for it is a 2-dimensional array. The matrix is a ones matrix because all the elements are 1 but it is not a zero matrix because not all the elements are 0. The matrix is not a square matrix seeing that the rows and columns are not the same value. The matrix is not an identity matrix since it is not a square matrix and the diagonal values aren't 1 while the others are 0.

```
Matrix 5:  
[[2 3 3 5]  
 [4 5 4 6]  
 [6 7 4 2]]  
  
The shape of the matrix is: (3, 4)  
The size of the matrix is: 12  
The rank of the matrix is: 2  
Is the matrix a ones matrix?: False  
Is the matrix a zero matrix?: False  
Is the matrix a square?: False  
Is the matrix an identity matrix?: False
```

Figure 13 5<sup>th</sup> Matrix in Task 1

Figure 13 shows the 5<sup>th</sup> matrix in task 1. The shape of the matrix is (3,4) since the rows are 3 while the columns are 4. The size of the matrix is 12 for the reason that  $3 \times 4 = 12$ . The rank of the matrix is 2 for it is a 2-dimensional array. The matrix is not a ones matrix because not all the elements are 1. Also, it is not a zero matrix because not all the elements are 0. The matrix is not a square matrix seeing that the rows and columns are not the same value. The matrix is not an identity matrix since it is not a square matrix and the diagonal values aren't 1 while the others are 0.

```

1st pair of matrices:

1st matrix:
[[8 7 5]
 [2 5 1]
 [5 4 2]]

The shape of the 1st matrix is: (3, 3)
The size of the 1st matrix is: 9
The rank of the 1st matrix is: 2
Is the matrix a ones matrix?: False
Is the matrix a zero matrix?: False
Is the matrix a square?: True
Is the matrix an identity matrix?: False

2nd matrix:
[[3 4 5]
 [3 2 1]
 [8 0 2]]

The shape of the 2nd matrix is: (3, 3)
The size of the 2nd matrix is: 9
The rank of the 2nd matrix is: 2
Is the matrix a ones matrix?: False
Is the matrix a zero matrix?: False
Is the matrix a square?: True
Is the matrix an identity matrix?: False

The sum of the matrices is:
67

The difference of the matrices is:
[[-2 -3]
 [ 4 -3]
 [ 7 -4]]

The element-wise multiplication of the matrices is:
[[24 28 25]
 [ 6 10  1]
 [40  0  4]]

The element-wise division of the matrices is:
[[2.66666667e+00 1.75000000e+00 1.00000000e+00]
 [6.66666667e-01 2.50000000e+00 1.00000000e+00]
 [6.25000000e-01 4.00000000e+10 1.00000000e+00]]

```

Figure 14 1<sup>st</sup> Pair of Matrices in Task 2

Figure 14 shows the 1<sup>st</sup> pair of matrices in task 2. The shape of the 1st matrix is (3,3) since the rows are 3 while the columns are also 3. The size of the matrix is 9 for the reason that  $3 \times 3 = 9$ . The rank of the matrix is 2 for it is a 2-dimensional array. The matrix is not a ones matrix because not all the elements are 1. Also, it is not a zero matrix because not all the elements are 0. The matrix is a square matrix seeing that the rows and columns are the same

value. The matrix is not an identity matrix since it is not a square matrix and the diagonal values aren't 1 while the others are 0.

The shape of the 2nd matrix is (3,3) since the rows are 3 while the columns are also 3. The size of the matrix is 9 for the reason that  $3 \times 3 = 9$ . The rank of the matrix is 2 for it is a 2-dimensional array. The matrix is not a ones matrix because not all the elements are 1. Also, it is not a zero matrix because not all the elements are 0. The matrix is a square matrix seeing that the rows and columns are the same value. The matrix is not an identity matrix since it is not a square matrix and the diagonal values aren't 1 while the others are 0.

The sum of the matrices is 67 while the difference of the matrices is  $\begin{bmatrix} -2 & -3 \\ 4 & -3 \\ 7 & -4 \end{bmatrix}$ . The

element-wise multiplication of the matrices is  $\begin{bmatrix} 24 & 28 & 25 \\ 6 & 10 & 1 \\ 40 & 0 & 4 \end{bmatrix}$  while the element-wise division

of the matrices is  $\begin{bmatrix} 2.67 & 1.75 & 1.00 \\ 6.66 & 2.50 & 1.00 \\ 6.25 & 4.00 & 1.00 \end{bmatrix}$  rounded off to the nearest hundredths.

```

2nd pair of matrices:

1st matrix:
[[ 5  1  2]
 [10  5  4]
 [ 3  7  8]]

The shape of the 1st matrix is: (3, 3)
The size of the 1st matrix is: 9
The rank of the 1st matrix is: 2
Is the matrix a ones matrix?: False
Is the matrix a zero matrix?: False
Is the matrix a square?: True
Is the matrix an identity matrix?: False

2nd matrix:
[[3 1 2]
 [1 6 4]
 [3 2 8]]

The shape of the 2nd matrix is: (3, 3)
The size of the 2nd matrix is: 9
The rank of the 2nd matrix is: 2
Is the matrix a ones matrix?: False
Is the matrix a zero matrix?: False
Is the matrix a square?: True
Is the matrix an identity matrix?: False

The sum of the matrices is:
75

The difference of the matrices is:
[[ -2   0]
 [-10  1]
 [ 5 -5]]

The element-wise multiplication of the matrices is:
[[15  1  4]
 [10 30 16]
 [ 9 14 64]]

The element-wise division of the matrices is:
[[ 1.66666667  1.  1.  ]
 [10.  0.83333333  1.  ]
 [ 1.  3.5  1.  ]]

```

Figure 15 2<sup>nd</sup> Pair of Matrices in Task 2

Figure 15 shows the 2<sup>nd</sup> pair of matrices in task 2. The shape of the 1st matrix is (3,3) since the rows are 3 while the columns are also 3. The size of the matrix is 9 for the reason that



$3 \times 3 = 9$ . The rank of the matrix is 2 for it is a 2-dimensional array. The matrix is not a ones matrix because not all the elements are 1. Also, it is not a zero matrix because not all the elements are 0. The matrix is a square matrix seeing that the rows and columns are the same value. The matrix is not an identity matrix since it is not a square matrix and the diagonal values aren't 1 while the others are 0.

The shape of the 2nd matrix is (3,3) since the rows are 3 while the columns are also 3. The size of the matrix is 9 for the reason that  $3 \times 3 = 9$ . The rank of the matrix is 2 for it is a 2-dimensional array. The matrix is not a ones matrix because not all the elements are 1. Also, it is not a zero matrix because not all the elements are 0. The matrix is a square matrix seeing that the rows and columns are the same value. The matrix is not an identity matrix since it is not a square matrix and the diagonal values aren't 1 while the others are 0.

The sum of the matrices is 75 while the difference of the matrices is  $\begin{bmatrix} -2 & 0 \\ -10 & 1 \\ 5 & -5 \end{bmatrix}$ . The

element-wise multiplication of the matrices is  $\begin{bmatrix} 15 & 1 & 4 \\ 10 & 30 & 16 \\ 9 & 14 & 64 \end{bmatrix}$  while the element-wise division of the matrices is  $\begin{bmatrix} 1.67 & 1.00 & 1.00 \\ 10.00 & 0.83 & 1.00 \\ 1.00 & 3.50 & 1.00 \end{bmatrix}$  rounded off to the nearest hundredths.

```

3rd pair of matrices:

1st matrix:
[[8 7 5]
 [2 5 1]
 [5 4 2]]

The shape of the 1st matrix is: (3, 3)
The size of the 1st matrix is: 9
The rank of the 1st matrix is: 2
Is the matrix a ones matrix?: False
Is the matrix a zero matrix?: False
Is the matrix a square?: True
Is the matrix an identity matrix?: False

2nd matrix:
[[2 3 3 5]
 [4 5 4 6]
 [6 7 4 2]]

The shape of the 2nd matrix is: (3, 4)
The size of the 2nd matrix is: 12
The rank of the 2nd matrix is: 2
Is the matrix a ones matrix?: False
Is the matrix a zero matrix?: False
Is the matrix a square?: False
Is the matrix an identity matrix?: False

The matrices aren't viable for operation

```

Figure 16 3<sup>rd</sup> Pair of Matrices in Task 2

Figure 16 shows the 3<sup>rd</sup> pair of matrices in task 2. The shape of the 1st matrix is (3,3) since the rows are 3 while the columns are also 3. The size of the matrix is 9 for the reason that  $3 \times 3 = 9$ . The rank of the matrix is 2 for it is a 2-dimensional array. The matrix is not a ones matrix because not all the elements are 1. Also, it is not a zero matrix because not all the elements are 0. The matrix is a square matrix seeing that the rows and columns are the same value. The matrix is not an identity matrix since it is not a square matrix and the diagonal values aren't 1 while the others are 0.

The shape of the 2nd matrix is (3,4) since the rows are 3 while the columns are 4. The size of the matrix is 12 for the reason that  $3 \times 4 = 12$ . The rank of the matrix is 2 for it is a 2-dimensional array. The matrix is not a ones matrix because not all the elements are 1. Also, it is not a zero matrix because not all the elements are 0. The matrix is not a square matrix seeing

that the rows and columns are not the same value. The matrix is not an identity matrix since it is not a square matrix and the diagonal values aren't 1 while the others are 0.

The matrices aren't viable for operation since the matrices are not broadcastable to a common shape hence the output "The matrices aren't viable for operation".

## IV. Conclusion

This laboratory proves that the matrix can be declared, categorized, and solved in Python. In this laboratory activity, it was shown that matrices can be thoroughly described using the different functions that can be found using the Numpy Library. It can describe the shape, size, and rank. It can also determine whether it is a square, empty, identity, ones, or zero matrices by analyzing the elements of the matrices. Since matrix algebra exists, the laboratory also showed that matrices can be solved using the functions in the Numpy library. It can return the sum, difference, element-wise multiplication, and element-wise division of the matrices and also determine whether or not the matrices are viable for operation.

Matrix operations can be used in solving agricultural problems by creating an awareness-adoption matrix strategic decision making in agricultural development projects [16]. It can be a tool to identifies weak and strong aspects of research and development projects to attain the adoption of technologies and contribute to strategic decision-making for developing effective cropping technologies in agriculture [16].

## References

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## **Appendix**

Github Link - [https://github.com/Sus102/LA\\_Lab/tree/master/LA\\_LAB\\_6](https://github.com/Sus102/LA_Lab/tree/master/LA_LAB_6)