Adamson University
College of Engineering
Computer Engineering Department

Linear Algebra

Laboratory Activity No. 6

Matrices

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I. Objectives

This lab activity aims to implement the principles and methods of matrices and matrix operations using Python as a programming language.

II. Methods

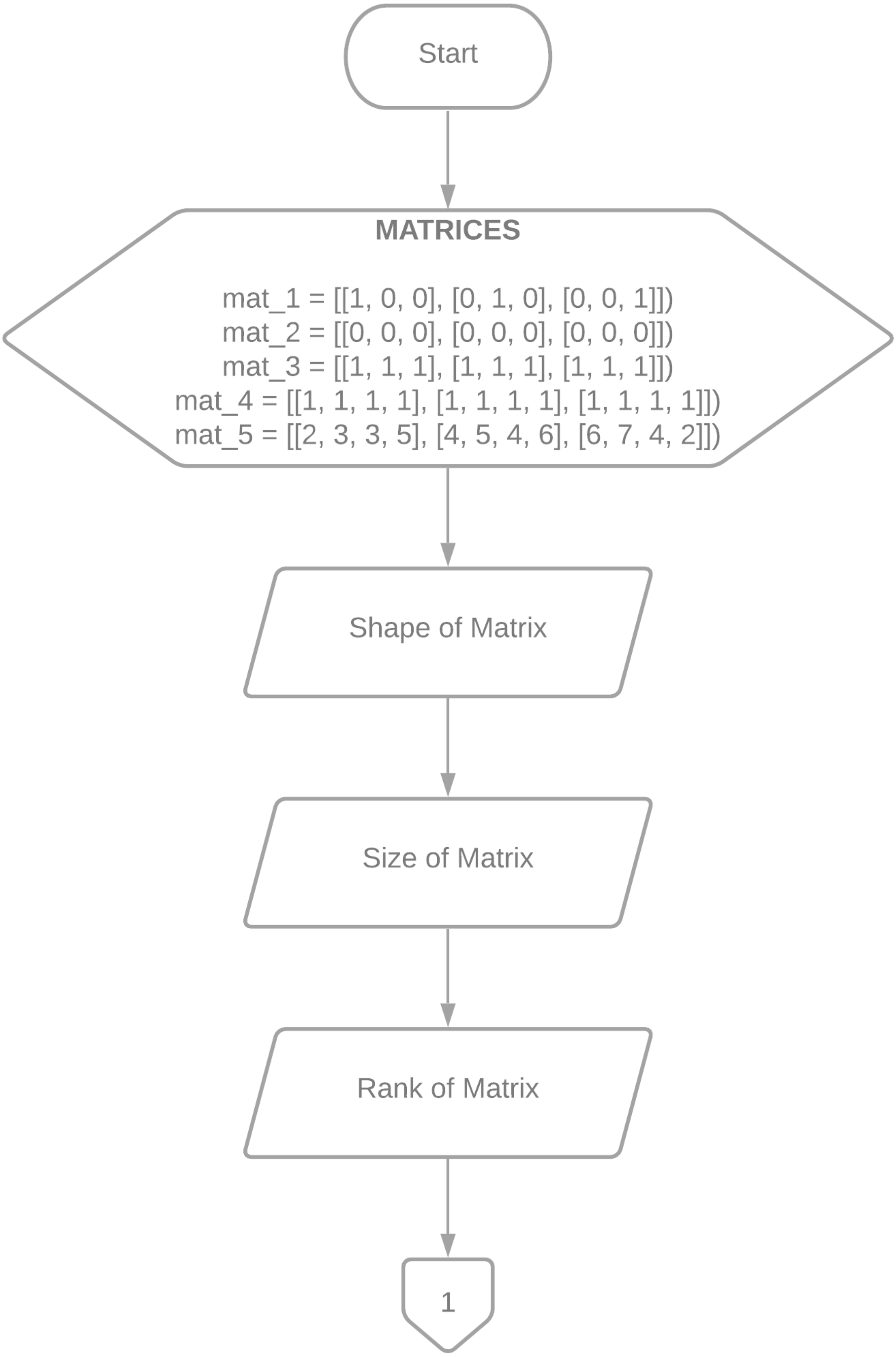

Figure 1 The Flowchart for Task 1 part 1

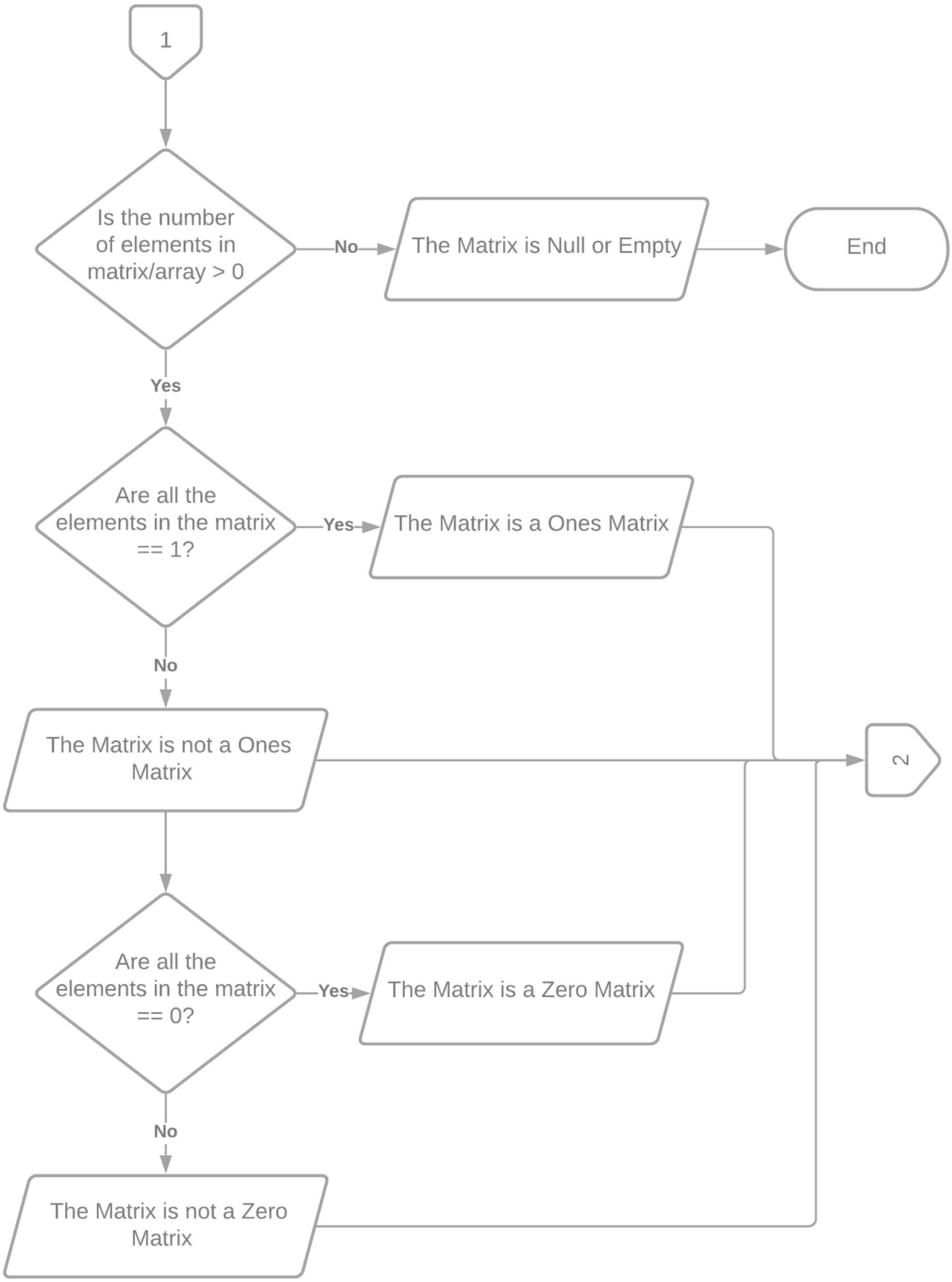

Figure 2 The Flowchart for Task 1 part 2

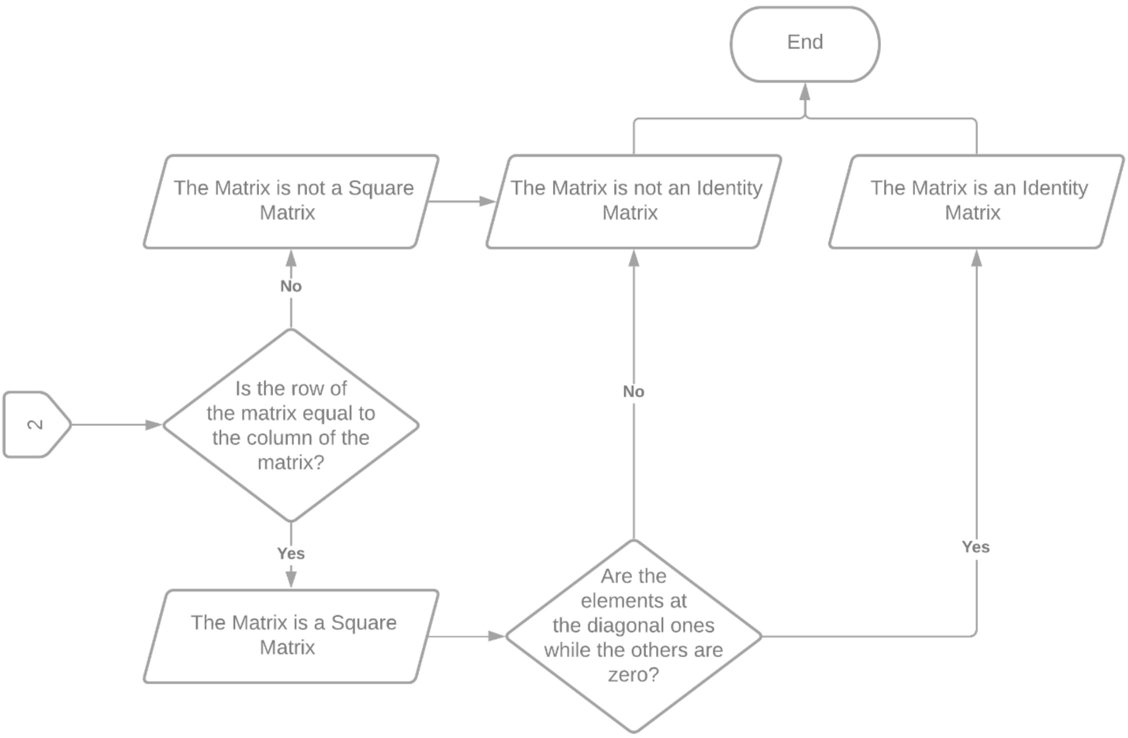

Figure 3 The Flowchart for Task 1 part 3

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.

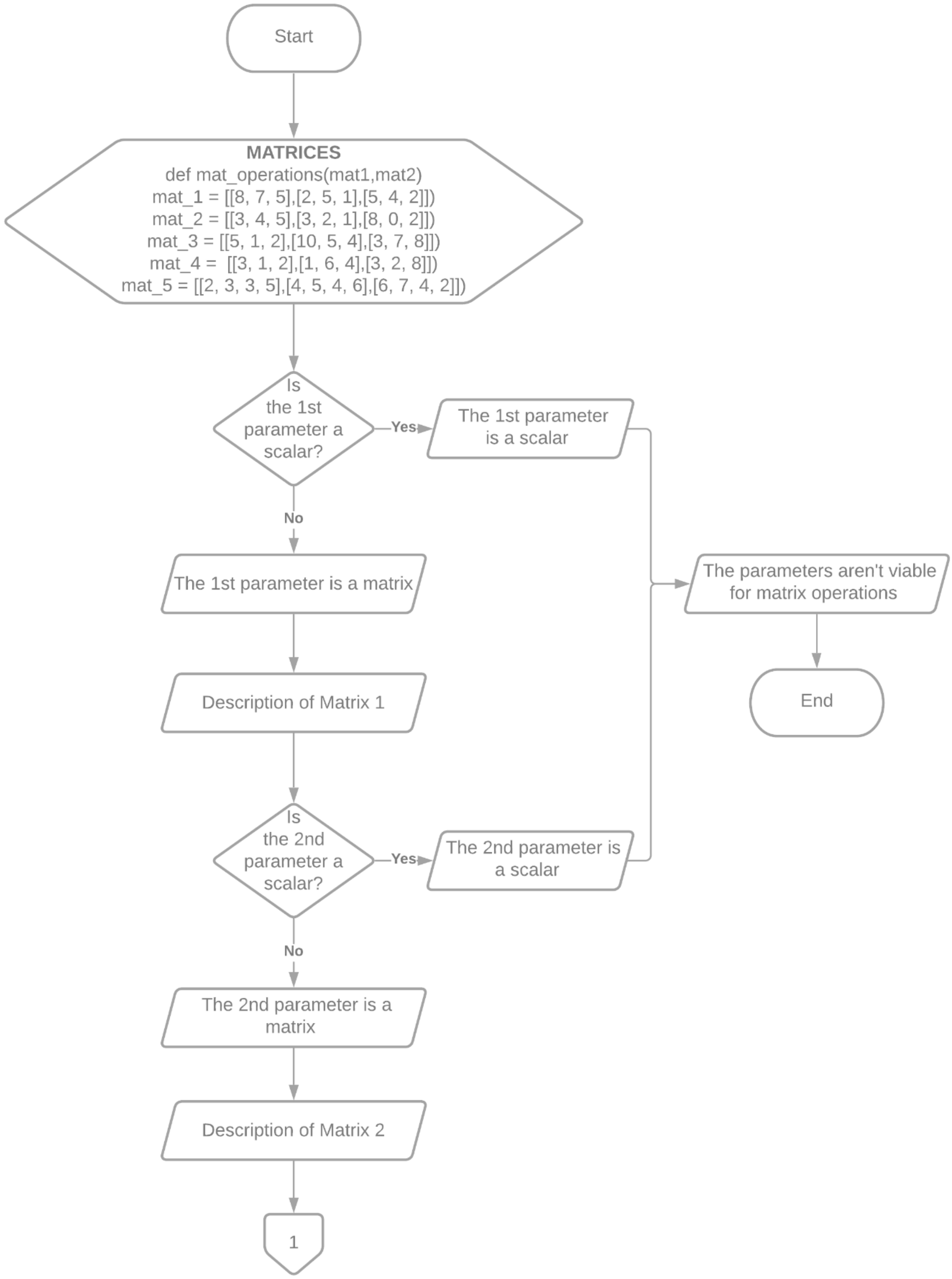

Figure 4 The Flowchart for Task 2 part 1

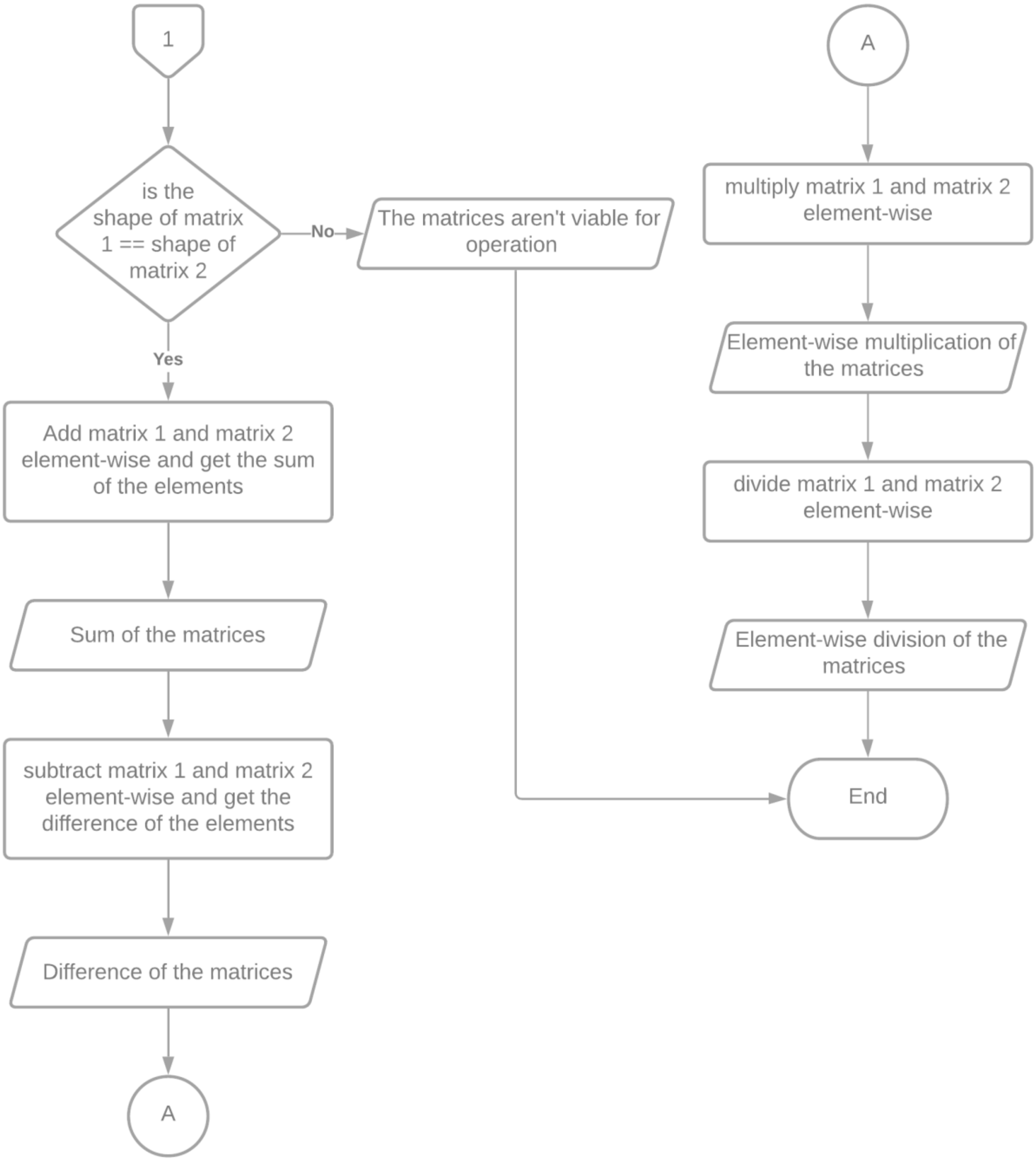

Figure 5 The Flowchart for Task 2 part 2

In the figure, Figure 4-5 shows how to write a program that takes two matrices or scalars in Problem 2 and uses matrix operations to get the sums, differences, multiplications by elements, and divisions by elements. Shows the block diagram used. The program starts by checking if the first and second parameters are matrices or scalars. If one of the parameters is a scalar, the program indicates that it is a scalar and is not suitable for matrix operations before exiting the program. If both parameters are matrices, the program will display a description of both matrices, as in Problem 1. Then check if the format of the first matrix matches the format of the second matrix. If the forms are not the same, the program will not be broadcast and will generate a matrix that cannot be used for work. However, if the shape of the first matrix is the same as the shape of the second matrix, it will receive the matrix sums, differences, element-by-element multiplications, and element-by-element divisions and exit the program

```python
## 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

```python
# 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

```python
## 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 m
at_desc() Method

```python
## 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'\nThe difference of the matrices is: \n{np.diff(np.subtract(mat1,mat2))}\n'
                f'\nThe element-wise multiplication of the matrices is: \n{np.multiply(mat1,mat2)}\n'
                f'\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

```python
## 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

```python
## 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 1st Matrix in Task 1

Figure 9 shows the 1st 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 2nd Matrix in Task 1

Figure 10 shows the 2nd 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 3rd Matrix in Task 1

Figure 11 shows the 3rd 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 4th Matrix in Task 1

Figure 12 shows the 4th 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^{th} Matrix in Task 1

Figure 13 shows the 5^{th} 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 1st Pair of Matrices in Task 2

Figure 14 shows the 1st 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 2nd Pair of Matrices in Task 2

Figure 15 shows the 2nd 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 3rd Pair of Matrices in Task 2

Figure 16 shows the 3rd 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 2dimensional 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 lab proved that matrix can be declared, classified and solved in data. In this lab activity, it was shown that the matrix can be fully described using various functions found using the NumPy library. It can define shape, size and level. It can also be used to analyze the elements of a matrix to determine whether it is a square, blank, identifiable, single or zero matrix. Since matrix algebra exists, the lab has also shown that matrix can be solved using the functions of the NumPy library. It can be divided by the amount, the difference, the multiplication by the factor, and the factor of the ranks, and it can also determine whether the arrays for the operation are workable or not. Matrix operations can be used to address agricultural issues in agricultural development projects by creating a matrix of strategic decision making [16]. This can be a means of identifying the strengths and weaknesses of research and development projects and contributing to strategic decisions for the development of efficient crop technology in agriculture to achieve the adoption of this technology. [16]

References

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Appendix

Github Link - https://github.com/LorenzoMiguelColumba/LinAlg_Lab6.git