CSCI-SHU 210 Data Structures

Homework Assignment4 Matrix Abstract Data Types (2-D Array)

We now turn our attention to the implementation of the Matrix ADT (2-D array). There are several approaches that we can use to store and organize the data for a 2-D array. Two of the more common approaches include the use of a single 1-D array to physically store the elements of the 2-D array by arranging them in order based on either row or column, whereas the other uses an array of arrays. We are going to use the latter approach to implement the Array2D abstract data type.

In the Python file, you will be given two classes: class Array2D and class Matrix.

- Class Matrix is built on class Array2D. **You should not modify class Array2D**. But you should take a look at class Array2D to understand the implementation.

```
Class Matrix:
__init__( self, numRows, numCols )                    # Constructor, builds on class Array2D
numRows( self )                    # Get number of rows
numCols( self )                    # Get number of columns
__getitem__( self, ndxTuple )      # Support Matrix[row, column]
__setitem__( self, ndxTuple, scalar )    # Support Matrix[row, column] = value
max_value(self)              # Return the max value within the n x n matrix     #Task 1
scaleBy( self, scalar )            # Support Matrix * integer                    #Task 2
tranpose( self )                                                               # Task 3
__add__( self, rhsMatrix )         # Support Matrix1 + Matrix2                   #Task 4
__sub__( self, rhsMatrix )         # Support Matrix1 – Matrix2                   # Task 5
__mul__( self, rhsMatrix )         # Support Matrix1 * Matrix2                   # Task 6
__str__(self)                      # Support printing
```

Guidelines & hints:

1. Only modify five functions (Task 1, 2, 3, 4, 5) to finish this homework.
2. Please make sure the test code provided runs without any modification to the test code.
3. You don't have to handle matrix size error. I will test your implementation with only valid matrix sizes.
4. To access row i, column j, enter matrix[i, j], or self[i, j] if you are coding within matrix class.
5. Your implementation should also work for larger matrixes.

Task 1: max_value(self)

Return the maximum value of this matrix. This matrix should remain unchanged after the function call.

And in our case,

```
>>> m1 = Matrix(3,2)    # 3 Rows, 2 Columns

######### add some values in matrix m1 with code

>>> print(m1.max())
if m1 is
9          6
7          8
6          0

Then
9

Should be printed.
```

Task 2: scaleBy(self, scalar)

Scales the original matrix by the given scalar.
Return: nothing. **Modification is done on original matrix.**

We have scaling operations as follows. Here we scale the matrix by a factor of 3.

$$3\begin{bmatrix} 6 & 7 \\ 8 & 9 \\ 1 & 0 \end{bmatrix} = \begin{bmatrix} 3*6 & 3*7 \\ 3*8 & 3*9 \\ 3*1 & 3*0 \end{bmatrix} = \begin{bmatrix} 18 & 21 \\ 24 & 27 \\ 3 & 0 \end{bmatrix}$$

And in our case,

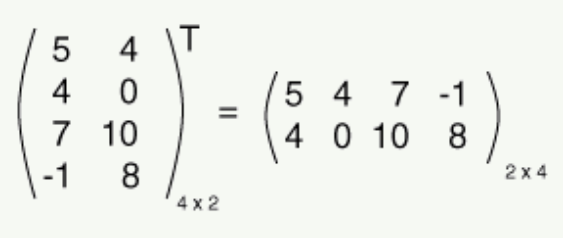
```
>>> m1 = Matrix(3,2)
### add some values in the matrix with code
>>> m1.scaleBy(3)
>>> print(m1)
if m1 is
9          6
7          8
6          0

Then
27         18
21         24
18         0

Should be printed.
```

Task 3: transpose(self)

Creates and **returns a new matrix** that is the transpose of this matrix.
The original matrix should not be modified.



And in our case,

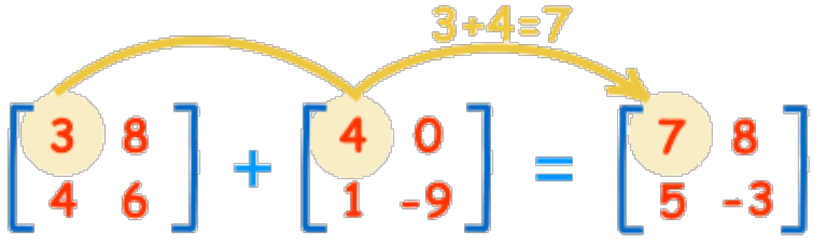
```
>>> m1 = Matrix(3,2)
### add some values in the matrix with code
>>> print(m1.transpose())
if m1 is
9          6
7          8
6          0

Then
9          7          6
6          8          0

Should be printed.
```

Task 4: __add__(self, rhsMatrix)

Creates and **returns a new matrix** that results from matrix addition.
m1, m2 remains unchanged.



And in our case,

```
>>> m1 = Matrix(3,4)
>>> m2 = Matrix(3,4)
### Some Code to fill matrix
>>> print(m1 + m2)
If m1 is
9       6       -1      -6
6       8       -4      7
-3      -6      4       9
If m2 is
-8      9       -1      -4
-6      -1      4       -4
-2      6       7       0
Then
1       15      -2      -10
0       7       0       3
-5      0       11      9
Should be printed.
```

Task 5: __sub__(self, rhsMatrix)

Creates and **returns a new matrix** that results from matrix subtraction.
m1, m2 remains unchanged.

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix} - \begin{bmatrix} 9 & 8 & 7 \\ 6 & 5 & 4 \\ 3 & 2 & 1 \end{bmatrix} = \begin{bmatrix} 1-9 & 2-8 & 3-7 \\ 4-6 & 5-5 & 6-4 \\ 7-3 & 8-2 & 9-1 \end{bmatrix}$$

$$= \begin{bmatrix} -8 & -6 & -4 \\ -2 & 0 & 2 \\ 4 & 6 & 8 \end{bmatrix}$$

And in our case,

```
>>> m1 = Matrix(3,2)
>>> m2 = Matrix(3,2)
### Some Code to fill matrix
>>> print(m1 – m2)
If m1 is
5          2
4          3
7          9
If m2 is
4          3
1          1
1          6
Then

1          -1
3          2
6          3
Should be printed.
```

Task 6: __mul__(self, rhsMatrix)

Creates and **returns a new matrix** resulting from matrix multiplication.

$$\mathbf{A} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \\ a_{31} & a_{32} \end{pmatrix}, \mathbf{B} = \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \end{pmatrix}$$

$$\mathbf{AB} = \begin{pmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} & a_{11}b_{13} + a_{12}b_{23} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} & a_{21}b_{13} + a_{22}b_{23} \\ a_{31}b_{11} + a_{32}b_{21} & a_{31}b_{12} + a_{32}b_{22} & a_{31}b_{13} + a_{32}b_{23} \end{pmatrix}$$

$$\mathbf{BA} = \begin{pmatrix} b_{11}a_{11} + b_{12}a_{21} + b_{13}a_{31} & b_{11}a_{12} + b_{12}a_{22} + b_{13}a_{32} \\ b_{21}a_{11} + b_{22}a_{21} + b_{23}a_{31} & b_{21}a_{12} + b_{22}a_{22} + b_{23}a_{32} \end{pmatrix}$$

And in our case,

```
>>> m1 = Matrix(3,2)
>>> m2 = Matrix(2,3)
### Some Code to fill matrix
>>> print(m1 * m2)
If matrix 1 is:
5       4
4       5
1       8

matrix 2 is:
8       0       6
2       0       1

Then

48      0       34
42      0       29
24      0       14
Should be printed.
```