CST 3613 Java Application Development Fall 2022 hlocklear@cuny.edu



Homework 2

THE MATRIX AS A 2-DIMENSIONAL NUMERIC ARRAY

General

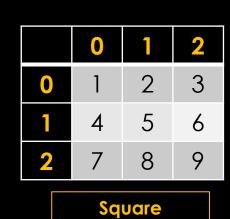
- Some of the problems, we are going to solve in our course are much easier to understand if we could represent them graphical.
- Later in our course, we will explore Processing which is a graphical software program that will allow us to visualize our problem solving.
 - https://processing.org/
- ▶ To get a solid foundation of how we will use Processing to solve these more complex problems, we need a good understanding of vectors and matrices.
- ▶ In this exercise, we explore matrices as natural extension of a 2D array and build a collection of tools that we can use when we get to Processing.

Understanding 2-Dimensional Arrays

- ▶ In computer science, <u>we use 2-Dimensional arrays a lot</u>.
- We often refer to them as matrices when they contain numeric values.
- Matrices can be square or rectangular.
 - ▶ A 2D array in which the **length of the array is different from the length of the individual arrays** in the 2D array is a **non-square (rectangular) array**. This may be specified as (row x column) 3 x 2, 2 x 4 etc.
 - ▶ A 2D array in which the **length of the array is same as the length of each individual array** in the 2D array is a **square array**. This may be specified as (row x column) 3 x 3, 4 x 4 etc.
- ► A 2D array in which the length of the array is different from the length of the individual arrays and the individual arrays have different lengths is a ragged array.









Describing Matrices

A matrix consist of rows and columns and its dimensions are written as a combinations of rows and columns.

	0	1	2
0	1	2	3
1	4	5	6
2	7	8	9

0 1 2 1 2 3

	VI	
0	1	2
4	5	6



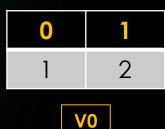
3 x 3

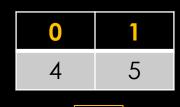
0 1
 0 1 2
 1 4 5
 2 7 8

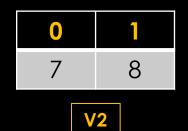
...we might, for practical purposes, think of the columns as vectors but mathematically this is not true.

We can think of the rows in the matrix as individual vectors.









3 x 2

Rows and Columns



```
The columns in A are represented by the indices:
```

```
[0][0] [1][0] [2][0] ...Column 0
[0][1] [1][1] [2][1] ...Column 1
```

A

```
      0
      1
      2

      0
      1
      2
      3

      1
      4
      5
      6
```

```
[0][0] [1][0] ...Column 0
[0][1] [1][1] ...Column 1
```

[0][2] [1][2] ...Column 2

В



The columns in C are represented by the indices:

```
[0][0] [1][0] [2][0] ...Column 0
```

[0][1] [1][1] [2][1] ...Column 1

[0][2] [1][2] [2][2] ...Column 2

Notice the relationship between indices when specifying a column.

...and of course, the rows in any matrix are just the individual arrays in the 2D Array.

Main Diagonal and Transpose

- Square matrices have a main diagonal.
- The sum of the values on the main diagonal is known as the Trace of the matrix.

	0	1	2
0	1	2	3
1	4	5	6
2	7	8	9

The main diagonal for this matrix is represented by the indices: [0][0] [1][1] [2][2] ...main diagonal

The Trace of the matrix is 15.

▶ If we switch the rows with the columns, we create a Transpose of a matrix

	0	1	2
0	1	2	3
1	4	5	6
2	7	8	9



		0	1	2
	0	1	4	7
>	1	2	5	8
	2	3	6	9

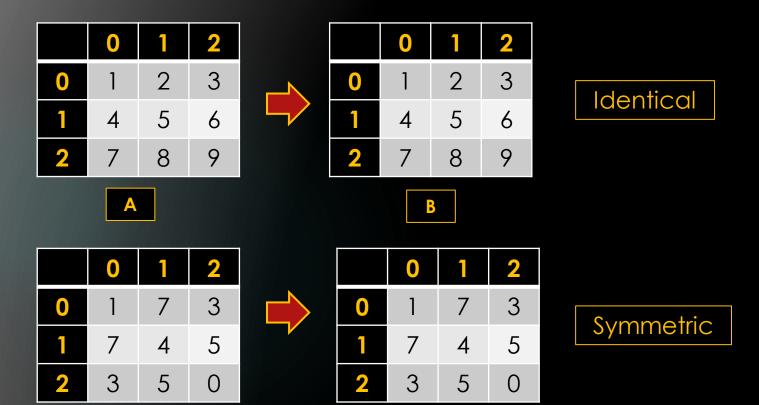
	0	1
0	1	2
1	4	5
2	7	8

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	\neg

	0	1	2
0	1	4	7
1	2	5	8

Identical and Symmetric Matrices

- Two matrices are identical if they have the same elements at the same indices.
- A matrix is symmetric if it is equal to its transpose.



Preliminary Tasks

Create a static method that:

- 1. Returns true if a matrix is square.
- 2. Returns the dimensions of a matrix.
- 3. Prints a matrix to the console in matrix form.
- 4. Returns a square integer matrix of a specified length whose elements are random integers between 1 and 9.
- 5. Returns a rectangular integer matrix with a specified dimensions whose elements are random integers between 1 and 9.
- 6. Returns a specified row from a matrix.
- 7. Returns a specified column from a matrix.
- 8. Returns the main diagonal from a square matrix.
- 9. Returns the Transpose of a matrix.
- 10. Returns the Trace of a square matrix.
- 11. Return true if two matrices are identical.
- 12. Return true if a matrix is symmetric.

	0	1	2
0	1	2	3
1	4	5	6
2	7	8	9

	0	1	2
0	6	5	4
1	3	2	1
2	7	1	1



	0	1	2
0	7	7	7
1	7	7	7
2	14	9	10

A+B

A

В

Δ_	R
_	u

	0	1	2
0	1	2	3
1	4	5	6
2	7	8	9

	0	1	2
0	6	5	4
1	3	2	1
2	7	1	1



	0	1	2
0	-5	-3	-1
1	1	3	5
2	0	7	8

...if matrices have the same dimensions they can be added or subtracted.

A

B

	0	1	2
0	1	2	3
1	4	5	6
2	7	8	9



	0	1	2
0	3	6	9
1	12	15	18
2	21	24	27

...We can scale a matrix by multiplying each element by some scalar (a value)

A

3A

	0	1	2
0	3	6	9
1	9	12	15
2	18	21	27



	0	1	2
0	1	2	3
1	3	4	5
2	6	7	8

...there is no such thing as division of a matrix, but we can scale a matrix by the reciprocal.

A

1/3A

	0	1	2
0	1	2	3
1	4	5	6
2	7	8	9

	0	1	2
0	2	3	1
1	1	2	3
2	3	1	2



	0	1	2
0	13	10	13
1	31	28	31
2	49	46	49

A

В

AB

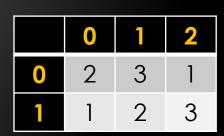
...We can multiply matrices, but the process has some specific rules.

Matrices must have compatible dimensions and involves rows being multiplied by columns

	0	1	2
0	R1C1	R1C2	R1C3
1	R2C1	R2C2	R2C3
2	R3C1	R3C2	R3C3

	0	1	2
0	1 x 2	1 x 3	1 x 1
	2 x 1	2 x 2	2 x 3
	3 x 3	3 x 1	3 x 2
	13	10	13
1	4 x 2	4 x 3	4 x 1
	5 x 1	5 x 2	5 x 3
	6 x 3	6 x 1	6 x 2
	31	28	31
2	7 x 2	7 x 3	7 x 1
	8 x 1	8 x 2	8 x 3
	9 x 3	9 x 1	9 x 2
	49	46	49





3 X 2

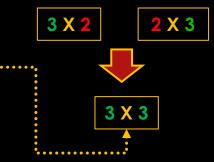
2 X 3

	0	1	2
0	4	7	7
1	13	22	19
2	22	37	31

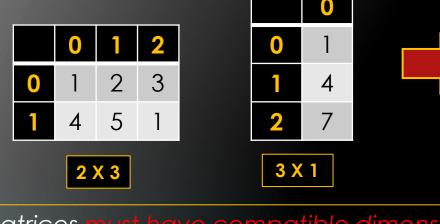
AB

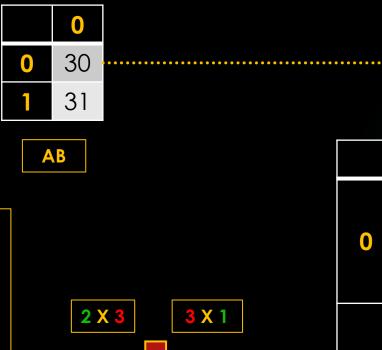
Matrices must have compatible dimensions and involves rows being multiplied by columns

- For matrix multiplication, the number of columns in the first matrix must be equal to the number of rows in the second matrix.
- The resulting matrix has the number of rows of the first and the number of columns of the second matrix.



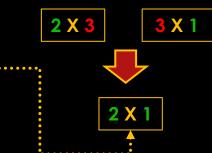
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	0	1	2	
0	1 x 2	1 x 3	1 x 1	
	2 x 1	2 x 2	2 x 3	
	4	7	7	
1	4 x 2	4 x 3	4 x 1	
	5 x 1	5 x 2	5 x 3	
	13	22	19	
2	7 x 2	7 x 3	7 x 1	
	8 x 1	8 x 2	8 x 3	
	22	37	31	





Matrices must have compatible dimensions and involves rows being multiplied by columns

- For matrix multiplication, the number of columns in the first matrix must be equal to the number of rows in the second matrix.
- The resulting matrix has the number of rows of the first and the number of columns of the second matrix.



0	3 x 7 30
1	4 x 1 5 x 4 1 x 7 31

 1×1

Matrix Tasks

Create a static method that:

- 1. Returns true if two matrices a compatible for a specified operation.
- 2. Returns the matrix that results from adding two matrices.
- 3. Returns the matrix that results from subtracting two matrices.
- 4. Returns the matrix that results from scaling a matrix by a specified scalar.
- 5. Returns the matrix that results from multiplying two matrices.