CSE 121 – Lesson 15
Miya Natsuhara
Autumn 2023

Music: 121 23au Lecture Tunes 🐐

TAs: Trey Christina Sahej Vinay Kriti
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    Annie Janvi Jonus Shreya Vivian
    Jasmine Arkita Lydia Andy Nicole
    Christian Vidhi Luke Nicolas Simon
    Lucas Ritesh Andras Shayna Jessie
    Logan Hibbah Archit Hannah Lydia
    Jacob Julia Ayesha Aishah Yijia

sli.do #cse121
Announcements, Reminders

- P3 released later today – last assignment!
  - Focused on 2D arrays!
  - No dedicated resubmission cycle
    (Feedback will not be released the following Tuesday)
  - Extending P3's planned deadline to **Thursday** next week (12/7)...
    so you have an additional 2 days to work on it!

- Gumball (& friends) Visit on Monday, December 11 1:00pm-3:00pm

- Final Exam: **Wednesday, Dec 13 12:30pm-2:20pm**
  - [Left-Handed Seating Requests Form](#), closes end-of-day Monday, Dec 4.
Final Exam Details

- Final Exam: **Wednesday, December 13 12:30pm-2:20pm**
- In-person, on paper, with assigned seating
- No collaboration – should be completed individually
- You may bring in **one 8.5x11-inch** sheet of notes, handwritten or typed, double-sided
- Focused on behavior (not style)
- You should make every attempt to write correct Java syntax
- Next week will be focused on Final Exam review and preparation
  - We are also planning a Final Exam Review Session on Tuesday of finals week (12/12)
- More details on [course website](#)
public static void main(String[] args) {
    int x = 0;
    int[] a = new int[4];
    x++;

    mystery(x, a);
    System.out.println(x + " " + Arrays.toString(a));
    x++;
    mystery(x, a);
    System.out.println(x + " " + Arrays.toString(a));
}

public static void mystery(int x, int[] a) {
    x++;
    a[x]++;
    System.out.println(x + " " + Arrays.toString(a));
}
public static void main(String[] args) {
    int x = 0;
    int[] a = new int[4];
    x++;

    mystery(x, a);
    System.out.println(x + " " + Arrays.toString(a));

    x++;
    mystery(x, a);
    System.out.println(x + " " + Arrays.toString(a));
}

public static void mystery(int x, int[] a) {
    x++;
    a[x]++;
    System.out.println(x + " " + Arrays.toString(a));
}
2D Arrays

An array of arrays!

- The ElementType of the array is another array itself!
  - Your first example of “nested data structures”
    - There will be more in CSE 122!

```
int[][] a = new int[4][3];
```

- `int[][]`
- `double[][]`
- `String[][]`
- `boolean[][]`
- `char[][]`
(PCM) 2D Arrays

An array of arrays!

The two dimensions are “rows” and “columns”
(PCM) 2D Arrays

A slightly more accurate view...

*reference semantics*
2D Array Traversals

```java
for (int i = 0; i < list.length; i++) {
    for (int j = 0; j < list[i].length; j++) {
        // do something with list[i][j]
    }
}
```
# Arrays Utility Class

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
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</thead>
</table>
| Arrays.toString(array);                    | Returns a String representing the array, such as 

"[10, 30, -25, 17]"

| Arrays.fill(array, value);                 | Sets every element to the given value                                                                                                    |
| Arrays.equals(array1, array2);            | Returns true if the two arrays contain the same elements in the same order                                                              |
| Arrays.deepToString(array);               | Returns a String representing the array; if the array contains other arrays as elements, the String represents their contents, and so on. For example, 

"[[99, 151], [30, 5]]"

| Arrays.deepEquals(array1, array2);        | Returns true if the two arrays contain the same elements in the same order; if the array(s) contain other arrays as elements, their contents are tested for equality, and so on. |
Applications of 2D Arrays

• Matrices
  • Useful in various applications requiring complex math!
• Board games
  • (e.g., chess/checkerboard, tic tac toe, sudoku)
• Representing information in a grid or table
  • (e.g., scorekeeping, gradebook)
• Image processing
### matrixAdd

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\[ \begin{array}{c}
  \text{i: 0} \\
  \text{j: 0}
\end{array} \]

\[ \begin{array}{c}
  \text{+} \\
  \rightarrow
\end{array} \]

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\[ i: 0 \]
\[ j: 1 \]

\[ + \]

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<tr>
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<td>91</td>
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\[ 93 \]
\[ 169 \]
# matrixAdd

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\[ \begin{pmatrix} 70 & 73 & 66 & 79 & 39 \\ 91 & 75 & 73 & 99 & 47 \\ 27 & 64 & 21 & 34 & 1 \end{pmatrix} \]

\[ \Rightarrow \]

\[ \begin{pmatrix} 93 & 169 & 84 \\ \vdots & \vdots & \vdots \end{pmatrix} \]
The function `matrixAdd` is demonstrated with two matrices:

**Matrix 1**

<table>
<thead>
<tr>
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</table>

**Matrix 2**

<table>
<thead>
<tr>
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<td>1</td>
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</table>

The operation is performed at position `(i: 0, j: 3)` resulting in:

<table>
<thead>
<tr>
<th>93</th>
<th>169</th>
<th>84</th>
<th>83</th>
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</table>
# matrixAdd

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</tbody>
</table>

\[ \begin{array}{c}
    \text{\( i: 0 \)} \\
    \text{\( j: 4 \)} \\
\end{array} \]

\[ 93 \quad 169 \quad 84 \quad 83 \quad 103 \]

\[ \begin{array}{c}
    70 \quad 73 \quad 66 \quad 79 \quad 39 \\
    91 \quad 75 \quad 73 \quad 99 \quad 47 \\
    27 \quad 64 \quad 21 \quad 34 \quad 1 \\
\end{array} \]
# matrixAdd

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\[ \text{i: 1} \quad \text{j: 0} \]

\[ \begin{array}{cccccc}
70 & 73 & 66 & 79 & 39 & \\
91 & 75 & 73 & 99 & 47 & \\
27 & 64 & 21 & 34 & 1 & \\
\end{array} \]

\[ \begin{array}{cccccc}
93 & 169 & 84 & 83 & 103 & \\
136 & & & & & \\
\end{array} \]
## matrixAdd

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\[ \text{Add: } i = 1, j = 1 \]

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\[ \text{Result: } + \quad \]

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matrixAdd

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</table>

\[ 
\begin{array}{ccccc}
23 & 96 & 18 & 4 & 64 \\
45 & 40 & 18 & 44 & 34 \\
92 & 13 & 77 & 71 & 12 \\
\end{array} 
\]

\[ 
\begin{array}{ccccc}
70 & 73 & 66 & 79 & 39 \\
91 & 75 & 73 & 99 & 47 \\
27 & 64 & 21 & 34 & 1 \\
\end{array} 
\]

\[ 
\begin{array}{cccc}
93 & 169 & 84 & 83 & 103 \\
136 & 115 & 91 &  \ \\
\end{array} 
\]
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\[ i: 1 \]
\[ j: 3 \]

\[ \begin{array}{cccc}
93 & 169 & 84 & 83 \\
136 & 115 & 91 & 143 \\
\end{array} \]

\[ \begin{array}{cccc}
70 & 73 & 66 & 79 \\
91 & 75 & 73 & 99 \\
27 & 64 & 21 & 34 \\
\end{array} \]
matrixAdd

\[
\begin{array}{cccc}
23 & 96 & 18 & 4 \\
45 & 40 & 18 & 44 \\
92 & 13 & 77 & 71 \\
\end{array}
\]

\[
\begin{array}{cccc}
64 & 34 & 12 & \\
\end{array}
\]

\[
\begin{array}{cccc}
70 & 73 & 66 & 79 \\
91 & 75 & 73 & 99 \\
27 & 64 & 21 & 34 \\
\end{array}
\]

\[
\begin{array}{cccc}
39 & & & \\
47 & & & \\
1 & & & \\
\end{array}
\]

\[
\begin{array}{cccc}
\text{i: 1} & \text{j: 4} & & \\
\end{array}
\]

\[
\begin{array}{cccc}
93 & 169 & 84 & 83 \\
136 & 115 & 91 & 143 \\
& & & 81 \\
\end{array}
\]
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| i: 2            | j: 1            |                 |                 |                 |
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+-----------------+-----------------+-----------------+-----------------+-----------------+
| 93 | 169 | 84 | 83 | 103 |
| 136 | 115 | 91 | 143 | 81 |
| 119 | 77 |          |          |          |

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\[ \begin{array}{cccc}
93 & 169 & 84 & 83 & 103 \\
136 & 115 & 91 & 143 & 81 \\
119 & 77 & 98 &   &   \\
\end{array} \]

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\[ j: 3 \]

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  91 & 75 & 73 & 99 \\
  27 & 64 & 21 & 34 \\
\end{array} \]

\[ \begin{array}{cccc}
  93 & 169 & 84 & 83 \\
  136 & 115 & 91 & 143 \\
  119 & 77 & 98 & 105 \\
\end{array} \]
# matrixAdd

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</table>
(2D)ays Above Average: `readData()`

How many days' data would you like to input? 3

Next day's data:
- Temperature in Seattle? 44
- Temperature in Tacoma? 40
- Temperature in Bothell? 43

Next day's data:
- Temperature in Seattle? 42
- Temperature in Tacoma? 40
- Temperature in Bothell? 44

Next day's data:
- Temperature in Seattle? 42
- Temperature in Tacoma? 41
- Temperature in Bothell? 43

...
(2D)ays Above Average: `readData()`

How many days' data would you like to input? **3**

Next day's data:
- Temperature in Seattle? **44**
- Temperature in Tacoma? **40**
- Temperature in Bothell? **43**

Next day's data:
- Temperature in Seattle? **42**
- Temperature in Tacoma? **40**
- Temperature in Bothell? **44**

Next day's data:
- Temperature in Seattle? **42**
- Temperature in Tacoma? **41**
- Temperature in Bothell? **43**

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(2D)ays Above Average: `readData()`

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(2D)ays Above Average: `computeAverages()`

How many days' data would you like to input? 3

... The average values for each location were 
[42.666666666666664, 40.333333333333336, 43.333333333333336]

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Average of Seattle temperatures 
\[
\frac{44 + 42 + 42}{3}
\]

\[
42.667, 40.333, 43.333
\]