CS1101 Programming and Problem Solving

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Spring 2023

Logistics

- **ZY-7B** and **ZY-8A**on zyBook > Assignments
  - Due: **Wednesday, April 5**, at 11:59pm
- **PA10 – A, B** on zyBook > Chap 11
  - Due: **Thursday, April 6**, at 11:59pm

Start Early!!!

- Midterm Exam 2 Regrade Requests
  - Due: Tuesday, April 11

Parallel Arrays

zyBook Chap 7.5

Parallel Arrays

Parallel arrays are arrays of the **same size** that are used to store **related lists of items**. For example,

- Array for zip codes, `zipCodes`
- Array for the delivery time for a given zip code, `deliveryTimes`
- If `userZipCode` is at `zipCodes[1]`. Then the delivery time for `userZipCode` can be found at `deliveryTimes[1]`

```java
import java.util.Scanner;

public class DeliveryTime {
    // Parallel arrays
    public static final int[] zipCodes = { 37201, 37203, 37205, 37212, 37215 };
    public static final int[] deliveryTimes = { 20, 15, 20, 20, 15 };

    public static void main (String[] args) {
        Scanner scnr = new Scanner(System.in);
        System.out.print("Zipcode: ");
        if (scnr.hasNextInt()) {
            int userZipCode = scnr.nextInt();
            boolean found = false;
            for (int i = 0; i < zipCodes.length && !found; ++i) {
                if (userZipCode == zipCodes[i]) {
                    found = true;
                    System.out.println("Delivery time: " + deliveryTimes[i] + " min.") ;
                }
            }
            if (!found) {
                System.out.println("Sorry, no delivery to that zip code.");
            }
        } else {
            scnr.next();
            System.out.println("Invalid zip code.");
        }
    }
}
```

```
$ java DeliveryTime
Zipcode: 37203
Delivery time: 15 min.
$ java DeliveryTime
Zipcode: 37202
Sorry, no delivery to that zip code.
$ java DeliveryTime
Zipcode: vandy
Invalid zip code.
```

Arrays of Objects

zyBook Chap 7.14

Arrays of Objects

- This lecture covers…
    - Array of Strings
    - Array of Arrays

Array of Strings

We’ve been seeing a String array since the HelloWorld program…

```
public class HelloWorld {
    public static void main(String[] args) {
        System.out.println("Hello World!");
    }
}
```

It is NOT necessary to name the String array as args, just a convention

String[] args – Command-Line Arguments

```java
public class ArgsDemo {
    public static void main(String[] args) {
        System.out.println("Received " + args.length + " arguments.");

        for(int i = 0; i < args.length; ++i){
            System.out.println("args[" + i + "]: " + args[i]);
        }
    }
}
```

```
$ javac ArgsDemo.java
$ java ArgsDemo
Received 0 arguments.

$ java ArgsDemo Hello World
Received 2 arguments.
args[0]: Hello
args[1]: World
```

Lec21 Example:
Token-Based File Processing

```java
import java.io.File;
import java.io.FileNotFoundException;
import java.util.Scanner;

public class CountTokensInFile {
    public static void main (String[] args) throws FileNotFoundException {

        // Set up the scanner to read in from file
        String fileName = "CourseDescription.txt";
        File fileInput = new File(fileName);
        Scanner input = new Scanner(fileInput);

        int countToken = 0, countInt = 0;

        while (input.hasNext()) {
            if (input.hasNextInt()) {
                ++countInt;
            }
            input.next();
            ++countToken;
        }
        input.close(); // Close the scanner
        System.out.println(fileName + " has " + countToken + " tokens, including " +
                           countInt + " integer(s).");
    }
}
```

```
$ javac CountTokensInFile.java
$ java CountTokensInFile
CourseDescription.txt has 80 tokens, including 4 integer(s).
```

Using Console Input for File Name

```java
import java.io.FileInputStream;
import java.io.FileNotFoundException;
import java.util.Scanner;

public class CountTokensInFile {
    public static void main (String[] args) throws FileNotFoundException {

        // Scanner to read from console
        Scanner console = new Scanner(System.in);
        System.out.print("Enter file name: ");
        String fileName = console.next();

        // Scanner to read from file
        File fileInput = new File(fileName);
        Scanner input = new Scanner(fileInput);

        int countToken = 0, countInt = 0;

        while (input.hasNext()) {
            if (input.hasNextInt()) {
                ++countInt;
            }
            input.next();
            ++countToken;
        }
        input.close(); // Close the scanner for file
        console.close(); // Close the scanner for console for better practice

        System.out.println(fileName + " has " + countToken +
                           " tokens, including " + countInt + " integer(s).");
    }
}
```

```
$ javac CountTokensInFile.java
$ java CountTokensInFile
Enter file name: CourseDescription.txt
CourseDescription.txt has 80 tokens, including 4 integer(s).
```

Using Command Line Arguments for File Name

```java
import java.io.FileInputStream;
import java.io.FileNotFoundException;
import java.util.Scanner;

public class CountTokensInFile {
    public static void main (String[] args) throws FileNotFoundException {
        // Check if the user gave an argument for file name
        if (args.length != 1) {
            System.out.println("Usage: java CountTokensInFile input_filename");
            System.exit(1);
        }
        String fileName = args[0];

        File fileInput = new File(fileName);
        Scanner input = new Scanner(fileInput);

        int countToken = 0, countInt = 0;

        while (input.hasNext()) {
            if (input.hasNextInt()) {
                ++countInt;
            }
            input.next();
            ++countToken;
        }
        input.close(); // Close the scanner

        System.out.println(fileName + " has " + countToken +
                           " tokens, including " + countInt + " integer(s).");
    }
}
```

```
$ javac CountTokensInFile.java
$ java CountTokensInFile
Usage: java CountTokensInFile input_filename
$ java CountTokensInFile CourseDescription.txt
CourseDescription.txt has 80 tokens, including 4 integer(s).
```

Default Value of an Object

Q: What's the output of the following code?

```
import java.util.Arrays;

public class CountLetter {
    public static void main(String[] args) {
        String[] words = new String[5];
        System.out.println(Arrays.toString(words));

        // more code here...
    }
}
```

```
[null, null, null, null, null]
```

null – Default Value of an Object

- A value that shows that the object is referring to nothing

It is legal to…

- **store** null in a variable or array element
    - often as an initial value to be overwritten later
- **print** a null reference
- **ask whether** a variable or array element is null
- **pass** null as a parameter to a method
- **return** null from a method
    - often as an indication of failure, such as a method that searches for an object in a file/array but does not find it

`NullPointerException`

It is NOT legal to **dereference** an object that is `null`

- That is, try to **access** any of **its methods or data** using . (dot) notation

Two-Phase Initialization

- Arrays of objects should use a 2-phase initialization

```java
public class CountLetter {
    public static void main(String[] args) {

        // Phase 1: Initializing the array itself
        String[] words = new String[5];

        // Phase 2: Initializing the object stored into each element of the array
        words[0] = "Hello";
        words[2] = "World";

        // more code here...
    }
}
```

Q: What's wrong with the following code?

```java
/**
 * This program counts the number of letters in each String elements in an array.
 */
public class CountLetter {
    public static void main(String[] args) {
        String[] words = new String[5];
        words[0] = "Hello";
        words[2] = "World";

        // words[1], words[3], and words[4] are null
        int numLetter = 0;
        for (int i = 0; i < words.length; ++i) {
            System.out.println("words[" + i + "]: " +
                               words[i].length() + " letters");
        }
    }
}
```

```
$ javac CountLetter.java
$ java CountLetter
words[0]: 5 letters
Exception in thread "main" java.lang.NullPointerException:
Cannot invoke "String.length()" because "<local1>[<local3>]" is null
        at CountLetter.main(CountLetter.java:14)
```

Avoiding NullPointerException

```java
/**
 * This program counts the number of letters in each String elements in an array.
 */
public class CountLetter {
    public static void main(String[] args) {
        String[] words = new String[5];
        words[0] = "Hello";
        words[2] = "World";

        // words[1], words[3], and words[4] are null
        int numLetter = 0;
        for (int i = 0; i < words.length; ++i) {
            if (words[i] != null) {
                System.out.println("words[" + i + "]: " +
                                   words[i].length() + " letters");
            }
        }
    }
}
```

When dealing with elements that may be **null**, you ALWAYS check for **null** before any calls

```
$ javac CountLetter.java
$ java CountLetter
words[0]: 5 letters
words[2]: 5 letters
```

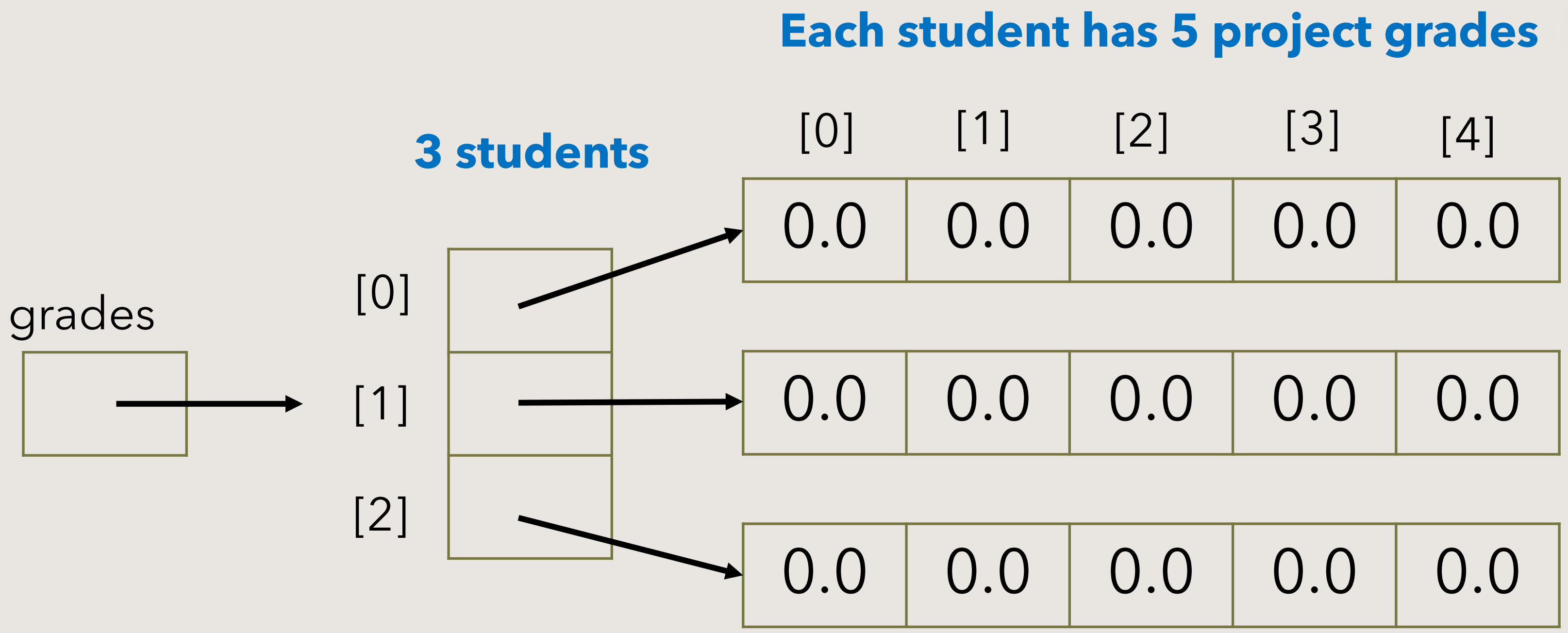
Array of Arrays (Multi-Dimensional Arrays)

- `int` → one integer
- `int[]` → a **one**-dimensional array of integers
- `int[][]` → An array of int arrays
  - **two**-dimensional grid of integers
  - Convention: `[<rows>][<columns>]`
- `int[][][]` …

Example

2-D array storing grades for **three** students, where each student has **five** project grades

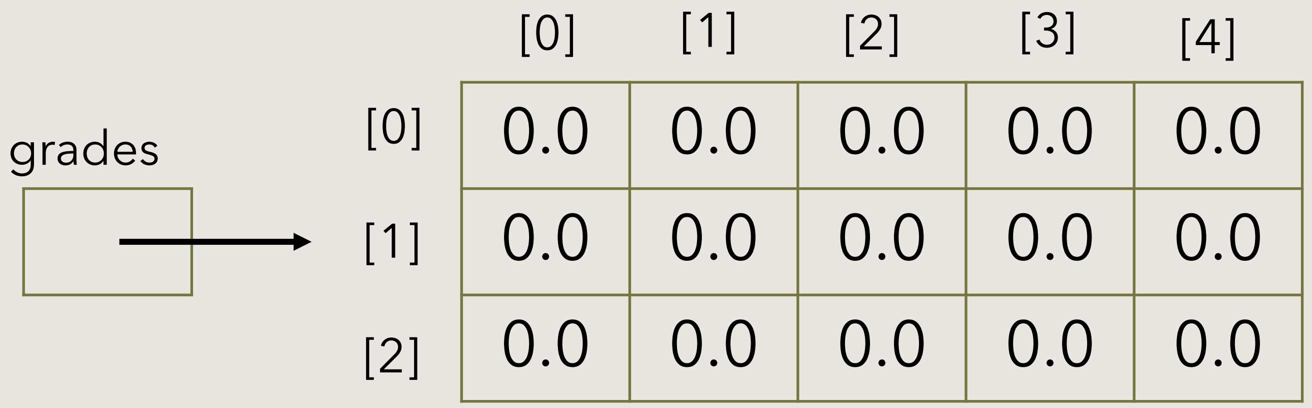
- `double[][] grades = new double[3][5];`



Rectangular/Grid Representation for 2D Array

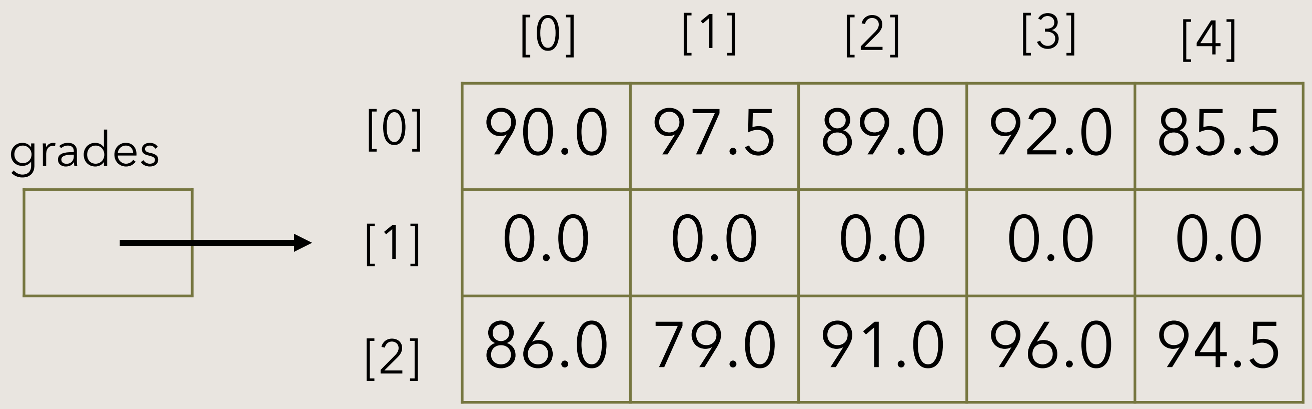
2-D array storing grades for **three** students, where each student has **five** project grades

- `double[][] grades = new double[3][5];`



Access 2D Array Elements

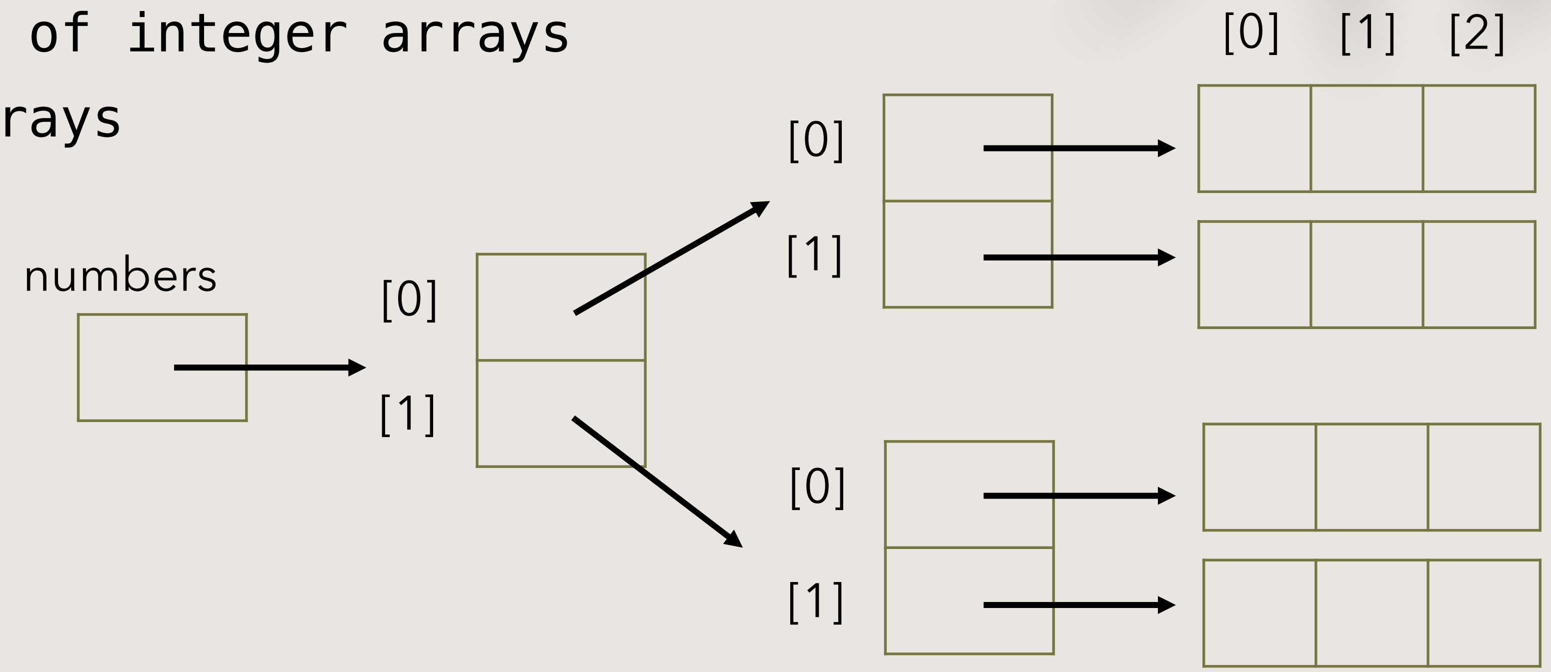
- `grades` → the entire 2-d array
- `grades[1]` → the entire row 1 **// [0.0, 0.0, 0.0, 0.0, 0.0]**
- `grades[0][0]` → element at row 0, column 0 **// 90.0**
- `grades[2][3]` **// 96.0**
- `grades[2][4]` **// 94.5**



	[0]	[1]	[2]	[3]	[4]
[0]	90.0	97.5	89.0	92.0	85.5
[1]	0.0	0.0	0.0	0.0	0.0
[2]	86.0	79.0	91.0	96.0	94.5

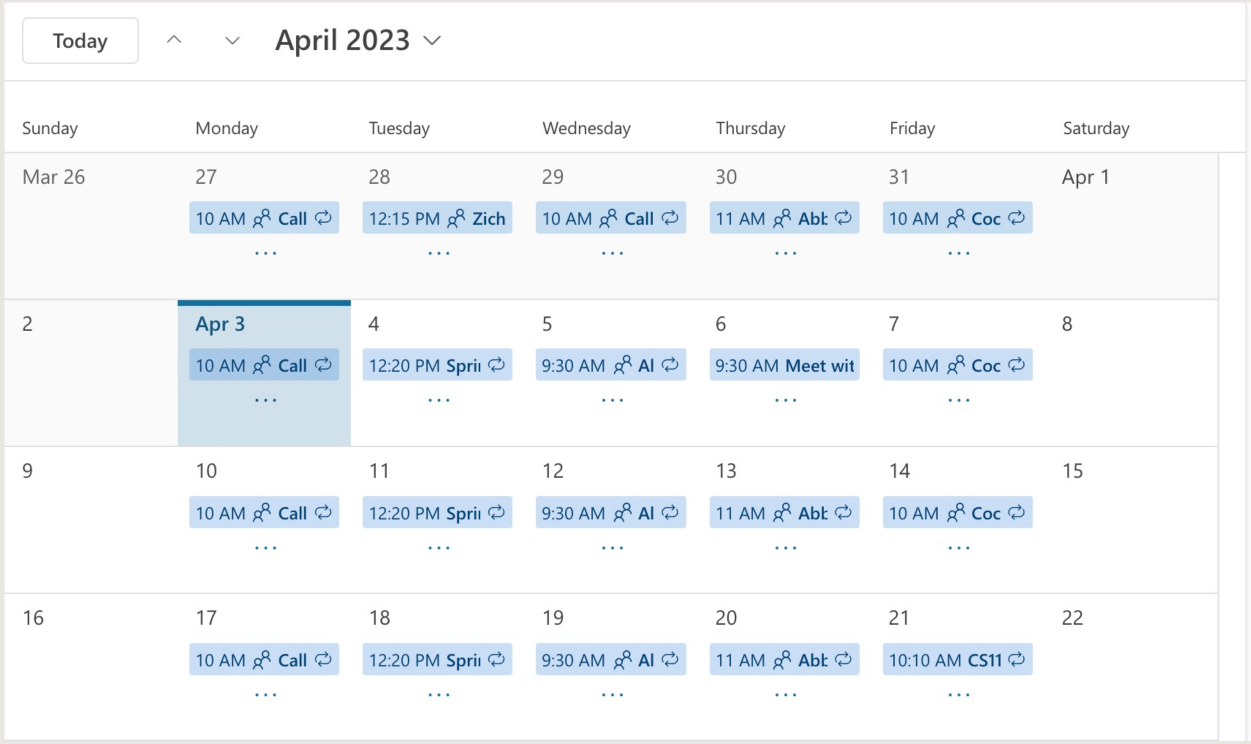
Multi-dimensional Arrays

- Three-dimensional arrays
  - For example
  - `int[][][] numbers = new int[2][2][3];`
    - `Array of arrays of integer arrays`
    - `Array of 2-d arrays`



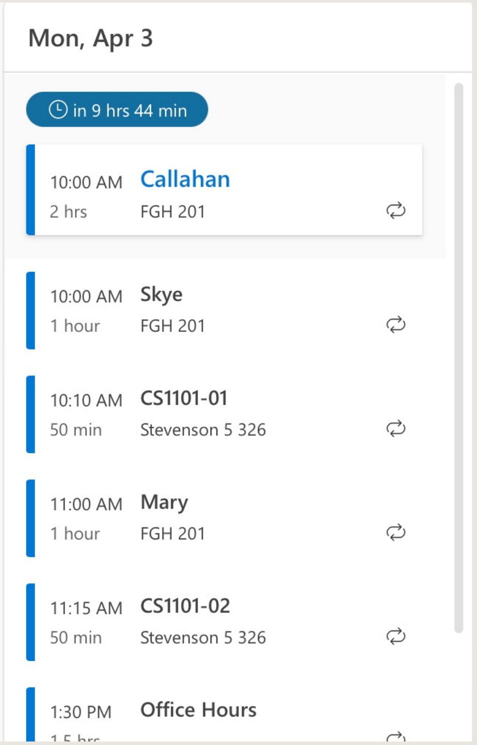
Daily Life 3D Array Examples

1st Dimension: 4 Weeks
2nd Dimension: 7 Days in each week
3rd Dimension: X Tasks in each day



Today April 2023

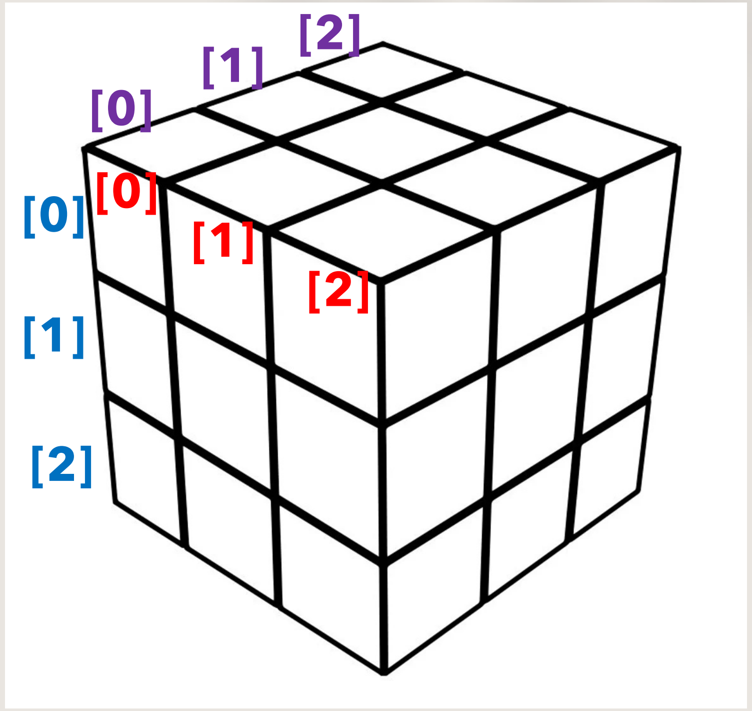
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Mar 26	27 10 AM Call ...	28 12:15 PM Zich ...	29 10 AM Call ...	30 11 AM Abt ...	31 10 AM Coc ...	Apr 1
2	Apr 3 10 AM Call ...	4 12:20 PM Sprii ...	5 9:30 AM Al ...	6 9:30 AM Meet wit ...	7 10 AM Coc ...	8
9	10 10 AM Call ...	11 12:20 PM Sprii ...	12 9:30 AM Al ...	13 11 AM Abt ...	14 10 AM Coc ...	15
16	17 10 AM Call ...	18 12:20 PM Sprii ...	19 9:30 AM Al ...	20 11 AM Abt ...	21 10:10 AM CS11 ...	22



Mon, Apr 3

in 9 hrs 44 min

10:00 AM	Callahan	
2 hrs	FGH 201	
10:00 AM	Skye	
1 hour	FGH 201	
10:10 AM	CS1101-01	
50 min	Stevenson 5 326	
11:00 AM	Mary	
1 hour	FGH 201	
11:15 AM	CS1101-02	
50 min	Stevenson 5 326	
1:30 PM	Office Hours	
1.5 hrs		



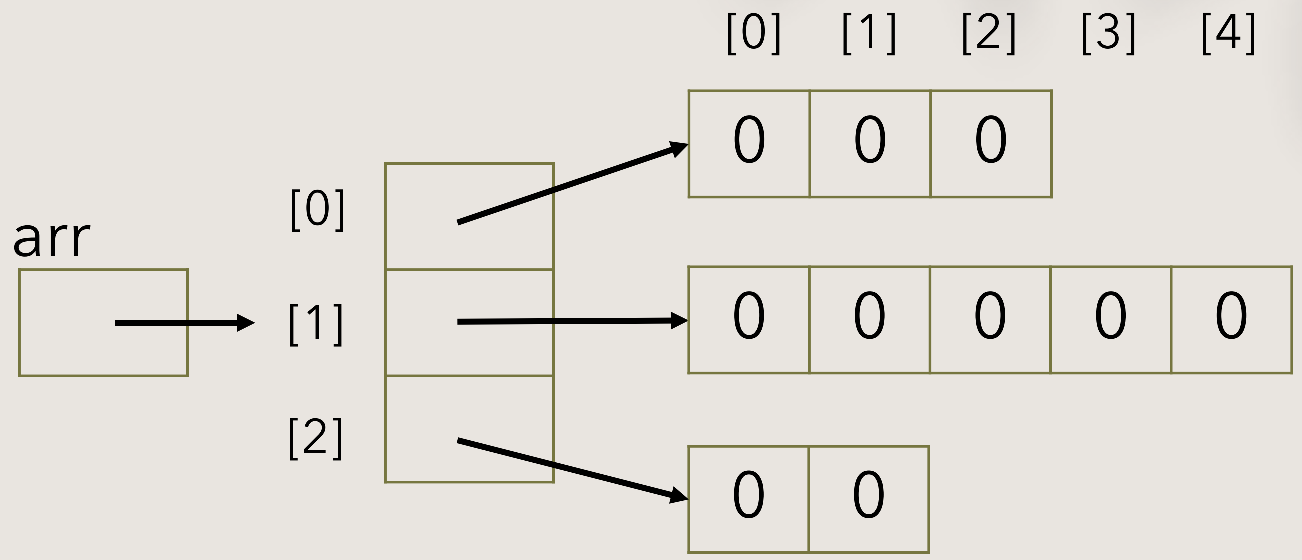
Generalizing Multi-dimensional Arrays

- Multi-dimensional arrays
  - Consistency on what you consider each array of arrays to be
  - Comments to remind you (and others) what each dimension is–program context!

Jagged Arrays

- An array of arrays of varying lengths
  - First, construct the first-dimension array (the "rows"). Then, construct the array for each row.

```
int[][] arr = new int[3][];
arr[0] = new int[3];
arr[1] = new int[5];
arr[2] = new int[2];
```



Coding Practice

MultiplicationTable

JAVA File

Complete the **MultiplicationTable** program that contains methods that create multiplication tables with a given number of rows and columns and prints them.

```
public class MultiplicationTable {

    public static void main(String[] args) {
        System.out.println();
        int[][] smallTable = createMultiplicationTable(3);
        printMultiplicationTable(smallTable);

        System.out.println();
        int[][] largeTable = createMultiplicationTable(10);
        printMultiplicationTable(largeTable);
    }

    //Create and return a multiplication table witn n rows and n columns
    public static int[][] createMultiplicationTable(int n) {
        // TODO: Add code here
    }

    //Print multiplication table using %4d to print each value
    public static void printMultiplicationTable(int[][] table) {
        // TODO: Add code here
    }
}
```

```
$ java MultiplicationTable

   1   2   3
   2   4   6
   3   6   9

   1   2   3   4   5   6   7   8   9  10
   2   4   6   8  10  12  14  16  18  20
   3   6   9  12  15  18  21  24  27  30
   4   8  12  16  20  24  28  32  36  40
   5  10  15  20  25  30  35  40  45  50
   6  12  18  24  30  36  42  48  54  60
   7  14  21  28  35  42  49  56  63  70
   8  16  24  32  40  48  56  64  72  80
   9  18  27  36  45  54  63  72  81  90
  10  20  30  40  50  60  70  80  90 100
```

Sample Solution

```java
public class MultiplicationTable {
    public static void main(String[] args) {
        System.out.println();
        int[][] smallTable = createMultiplicationTable(3);
        printMultiplicationTable(smallTable);

        System.out.println();
        int[][] largeTable = createMultiplicationTable(10);
        printMultiplicationTable(largeTable);
    }

    public static int[][] createMultiplicationTable(int n) {
        int[][] multTable = new int[n][n];
        for (int row = 0; row < multTable.length; ++row) {
            for (int col = 0; col < multTable[row].length; ++col) {
                multTable[row][col] = (row + 1) * (col + 1);
            }
        }

        return multTable;
    }

    public static void printMultiplicationTable(int[][] table) {
        for (int row = 0; row < table.length; ++row) {
            for (int col = 0; col < table[row].length; ++col) {
                System.out.printf("%4d", table[row][col]);
            }
            System.out.println("");
        }
    }
}
```