Arrays and Strings

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Arrays

- Array documentation
- Declaration: Brackets can be attached to the *type* or the *variable_name*

```
int[] nums;
int nums[];
```

- Allocation: declaring an array doesn't initialise it, so you first need to allocate it
  - can use the **new** operator, declare an array of <type> values, storing up to <size> elements
  - primitives are initialised to "zero" (**int**: 0, **double**: 0.0, …)
  - objects: initialised to **null**

```
<type>[] var = new <type>[<size>];
```

- can also specify initial values

```
<type>[] var = new <type>[]{element1, element2, ..., elementn};
```

- can use an already declared array to initialise a second,
- second array is an **alias** for the first array; they both refer to same values

```
<type>[] var = new <type>[<size>];
<type>[] var2 = var;
```

- any variable that stores a **non-primitive** value is a **pointer/reference**

Array Methods and Tools

```
int[] nums = new int[10]
int num = nums[0];          // array indexing
int x = intArray[10];       // gives out of bounds error: doesn't cause
    program to crash
int length = nums.length;   // array length is public instance variable
    (NB not usually available)
```

- `Arrays` library

```
import java.util.Arrays;
...
System.out.println(Arrays.toString(nums));      // converting to a
   string
int[] nums = Arrays.copyOf(nums, nums.length);  // create distinct copy
    of an array
Arrays.sort(nums)                               // in-place sort
Arrays.equal(nums, nums2);                      // equality: same
   length + holds same values
```

- Resizing

```
int[] intArray = new int[5];
intArray = new int[intArray.length + 3];
```

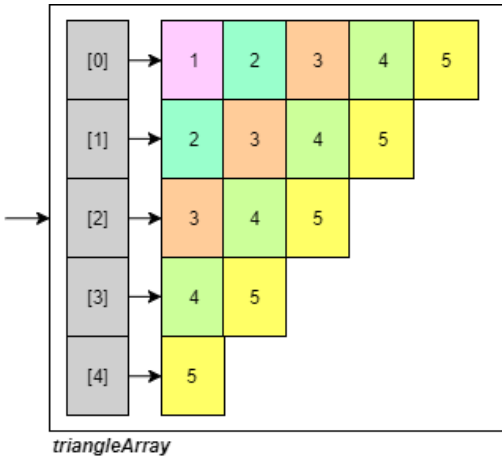
Array Iteration

- **`for each` loop:** can use to access each element of an iterable e.g. array when you are not modifying it

```
for (<type> var : <iterable>) {
    // code block
}
```

Multi-dimensional arrays

```
int[][] triangleArray = {
    {1, 2, 3, 4, 5},
    {2, 3, 4, 5},
    {3, 4, 5},
    {4, 5},
    {5},
};
```



triangleArray

- treated as arrays of arrays
- declaration and initialisation: rectangular 2D array

```
int[][] nums = new int[100][10]; // array with 100 rows and 10 columns,
    each cell initialised to 0
```

- irregular array (e.g. triangular)

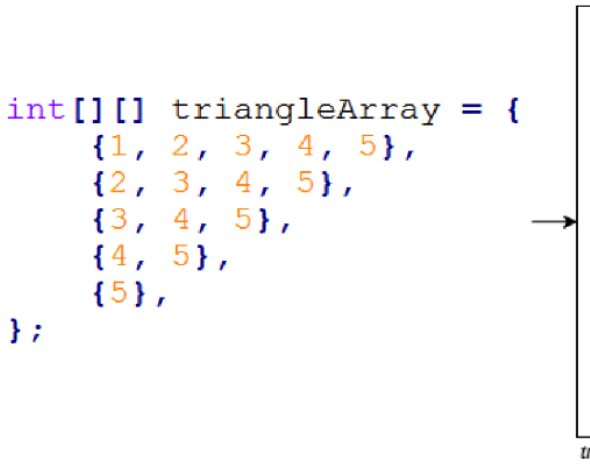
```
int[][] nums = new int[10][];
for (int i = 0; i < nums.length; i++) {
    nums[i] = new int[<length of subarray>];
}
```

```
import java.util.Arrays;

public class Program {
    public static void main(String args[]) {
        final int NUM_ROWS = 5;
        final int MAX_COLS = NUM_ROWS;

        int[][] nums = new int[NUM_ROWS][]; // <- declaration of
           uninitialised 2D array

        for (int i = 0; i < nums.length; i++) {
        nums[i] = new int[NUM_ROWS - i];
    }

        for (int i = 0; i < NUM_ROWS; i++) {
        System.out.println(Arrays.toString(nums[i]));
        }
    }
```

- Write a Java static method `computeDoublePowers` that accepts an integer `n` and returns an

array of **double**s of that size. Your method should then fill that array with increasing powers of 2 (starting from 1.0)

```
import java.lang.Math;
// ...
public static double[] computeDoublePowers(int n) {
    double[] nums = new double[n];
    for (int i = 0; i < n; i++) {
        arr[0] = Math.pow(2, i);
    }
    return nums;
}
```



- Write a program that can generate the following 2D array:

```
public class IrregularArray {
    public static void main(String[] args) {
        final int HEIGHT = 5;
        final int MAX_WIDTH = HEIGHT;
        int[][] triangleArray = new int[HEIGHT][];
        for (int i = 0; i < HEIGHT; i++) {
            triangleArray[i] = new int[MAX_WIDTH - i];
            for (int j = 0; j < MAX_WIDTH - i; j++) {
                triangleArray[i][j] = j+i+ 1;
            }
        }
    }
}
```

Arrays of Objects

- arrays can also be used to store objects, but when you initialise the array it doesn't create the objects

```java
// CircleArray.java
class CircleArray {
    Circle[] circleArray = new Circle[3];
    // create circle objects, store in array
    for (int i = 0; i < circleArray.length; i++) {
        circleArray[i] = new Circle(i, i, i+2);
    }
}
```

Strings

- `String`s are a class imported by default in Java
- cannot use single quotes for Java `String`s

Basic string operations

```java
String s = "Hello";
s.length();             // returns length of s (5)
s.toUpperCase();        // returns "HELLO"
s.toLowerCase();        // returns "hello"
s.split(" ");           // split by space character
```

e.g. What does this output?

```java
String s = "Hello World";
s.toUpperCase();    // "HELLO WORLD"
s.replace("e", "i");// "Hillo World"
s.substring(0,2);   // "He"
s += " FIVE";       // s = "Hello World FIVE"
System.out.println(s);  // "Hello World FIVE"
```

Substrings

```java
String substr = "el";
s.contains(substr);         // indicates if substr found in s
s.indexOf(substr);          // indicates index of first instance of
    substring; else -1
s.substring(arg1, arg2);    // slice of string with indices [arg1, arg2
     - 1]
```

String concatenation

- Java has + operator overloaded for string concatenation

```
System.out.println("1 + 1 = " + 1 + 1);
// "1 + 1 = 11"
System.out.println("1 + 1 = " + (1 + 1));
// "1 + 1 = 2"
```

String equality and references

```
public class Program {
    public static void main(String[] args) {
        // 1. Two string literals
        System.out.println("Hello" == "Hello"); // true

        // 2. One literal, one variable
        String s0 = "Hello";
        System.out.println(s0 == "Hello");      // true

        // 3. Two variables, given the same literal value
        String s1 = "Hello";
        String s2 = "Hello";
        System.out.println(s1 == s2);           // true

        // 4. Two variables, with one creating a new "object"
        String s3 = "Hello";
        String s4 = new String("Hello");
        System.out.println(s3 == s4);           // false
    }
}
```

- Java is built on **references** which act like pointers
- when you explicitly write a `String` (e.g. “Hello”) it is effectively treated as a constant (string literal*) and stored separate to dynamic memory
  - this constant is only created once, in e.g. 1-3, the string is the same, irrespective of which variable it is in
- e.g. 4 creates a `new String`, which Java puts on the *heap* (dynamic memory)
  - `s3` is now pointing at different address than `s4`
- == applied to objects is actually comparing *address* of reference
- for string comparison, use `String.equals()`

String Modification

- strings are **immutable**: once created they cannot be modified
- all string methods return a string which you can then assign to a variable