

**Java**

*Introduction*

# History of Java

- Java was originally developed by Sun Microsystems starting in 1991
  - James Gosling
  - Patrick Naughton
  - Chris Warth
  - Ed Frank
  - Mike Sheridan
- This language was initially called ***Oak***
- Renamed ***Java*** in 1995

# What is Java

- A simple, object-oriented, distributed, interpreted, robust, secure, architecture neutral, portable, high-performance, multithreaded, and dynamic language -- **Sun Microsystems**
- **Object-Oriented**
  - No free functions
  - All code belong to some class
  - Classes are in turn arranged in a hierarchy or package structure

# What is Java

- **Distributed**
  - Fully supports IPv4, with structures to support IPv6
  - Includes support for Applets: small programs embedded in HTML documents
- **Interpreted**
  - The program are compiled into Java Virtual Machine (JVM) code called bytecode
  - Each bytecode instruction is translated into machine code at the time of execution

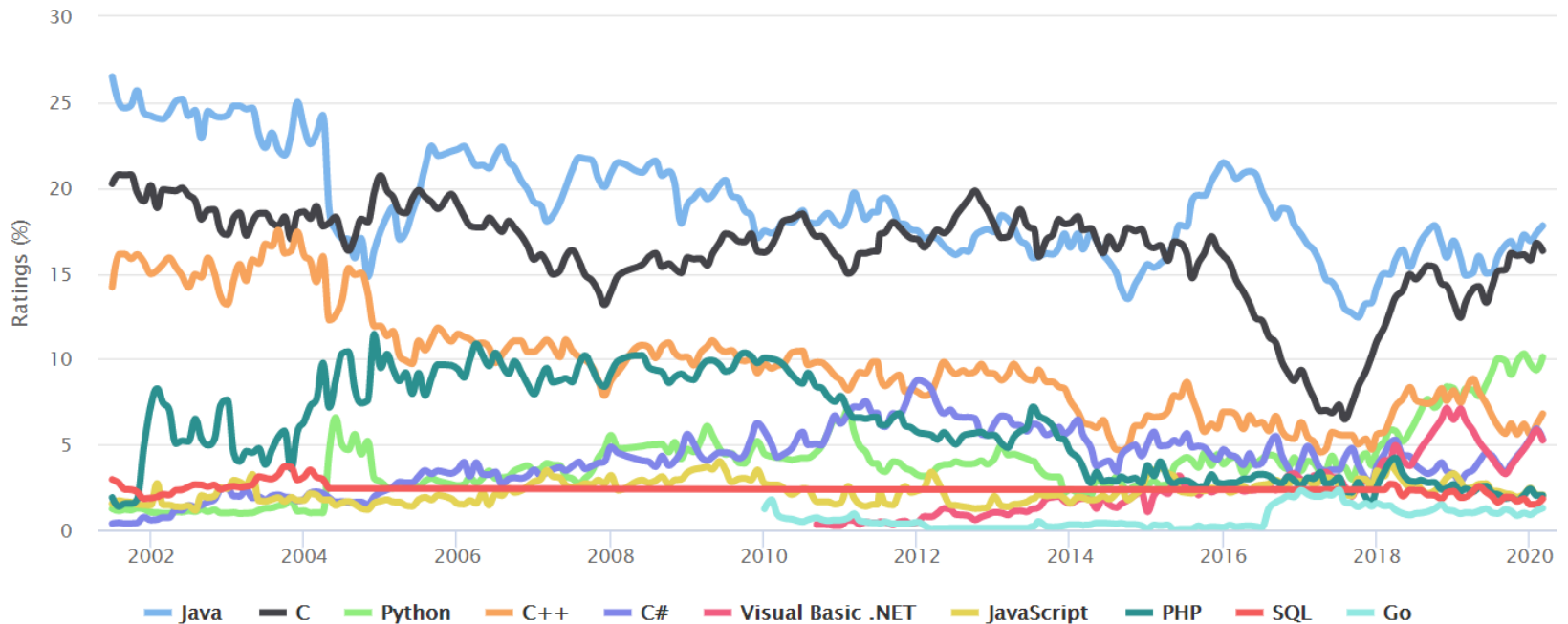
# What is Java

- **Robust**
  - Java is simple – no pointers/stack concerns
  - Exception handling – try/catch/finally series allows for simplified error recovery
  - Strongly typed language – many errors caught during compilation

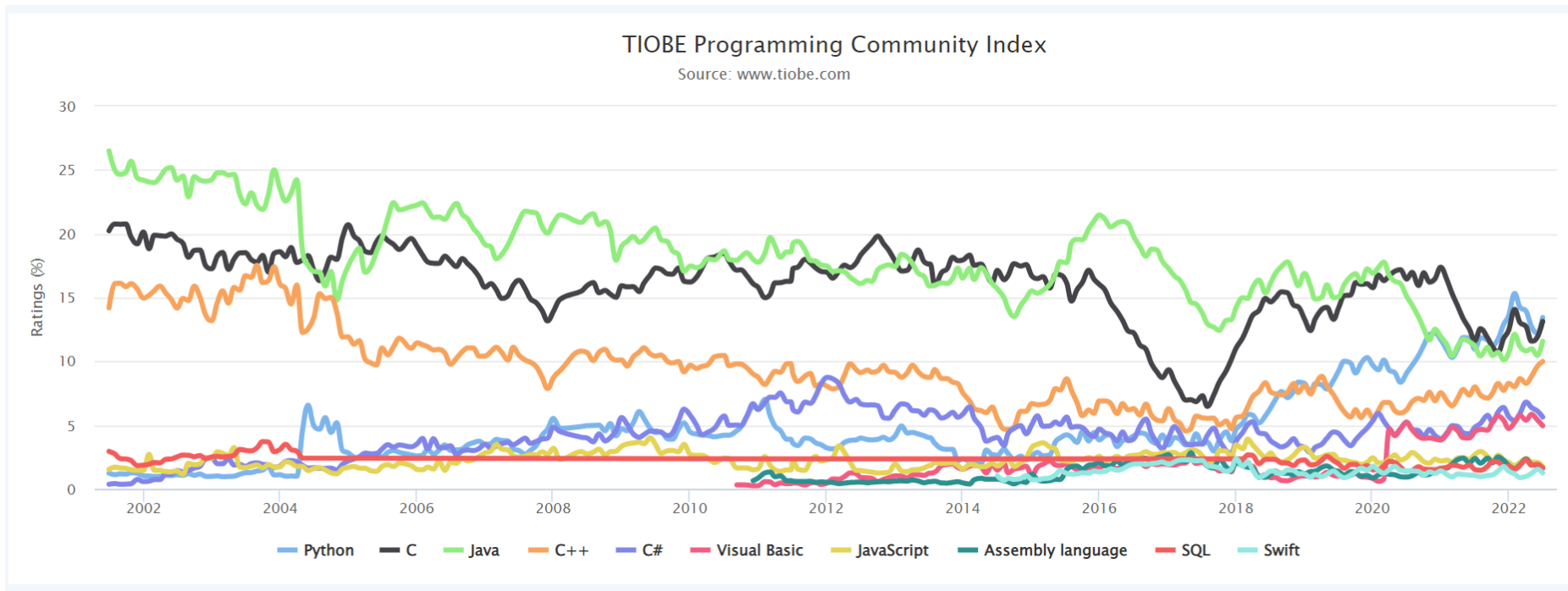
# Java – The Most Popular (2020)

TIOBE Programming Community Index

Source: [www.tiobe.com](http://www.tiobe.com)



# Java – Top Three (2022)



# Java – The Most Popular (2002-2020)

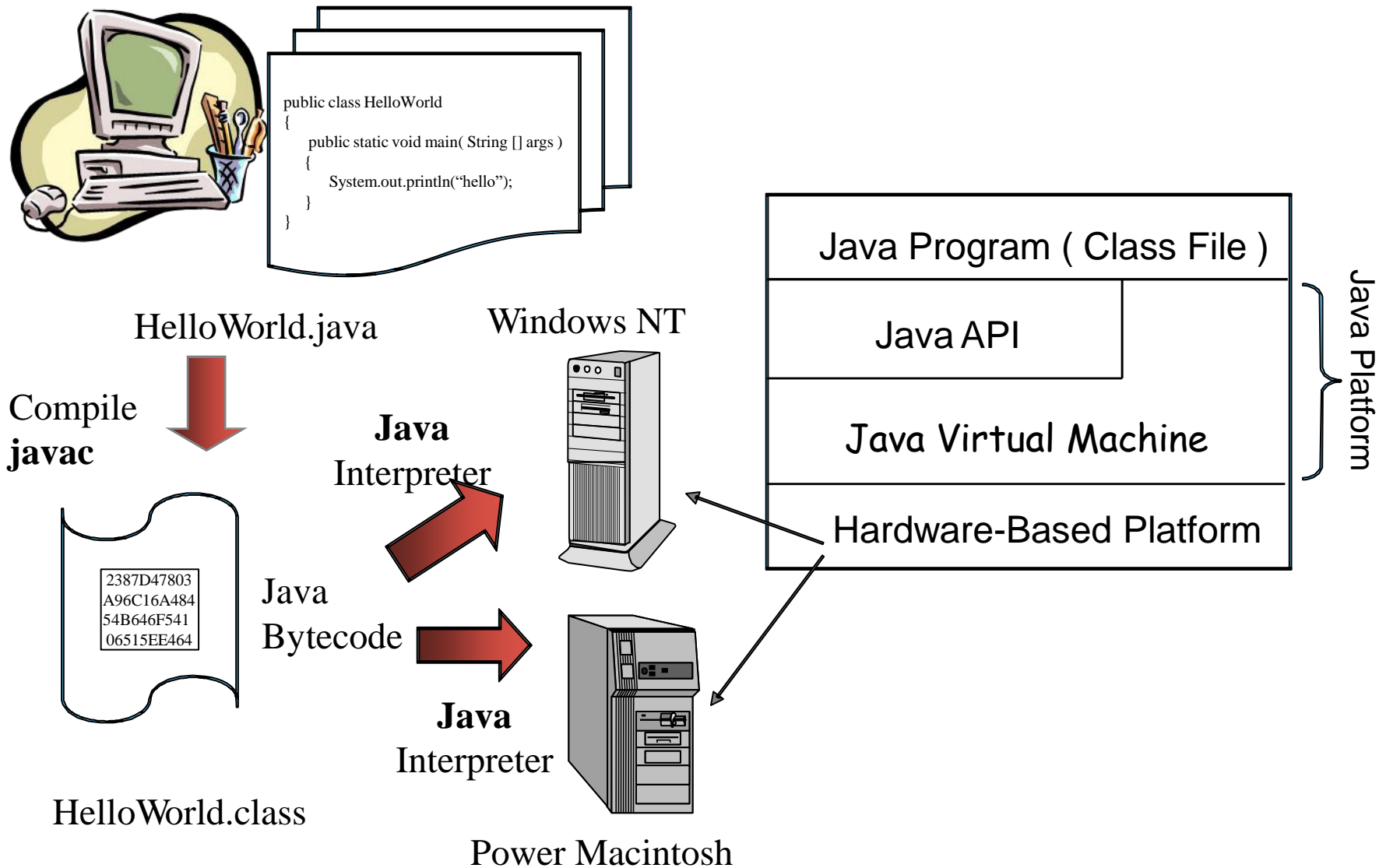
| Programming Language | 2022 | 2017 | 2012 | 2007 | 2002 | 1997 | 1992 | 1987 |
|----------------------|------|------|------|------|------|------|------|------|
| Python               | 1    | 5    | 8    | 7    | 12   | 28   | -    | -    |
| C                    | 2    | 2    | 2    | 2    | 2    | 1    | 1    | 1    |
| Java                 | 3    | 1    | 1    | 1    | 1    | 13   | -    | -    |
| C++                  | 4    | 3    | 3    | 3    | 3    | 2    | 2    | 5    |
| C#                   | 5    | 4    | 4    | 8    | 18   | -    | -    | -    |
| Visual Basic         | 6    | 15   | -    | -    | -    | -    | -    | -    |
| JavaScript           | 7    | 8    | 10   | 9    | 9    | 20   | -    | -    |
| Assembly language    | 8    | 10   | -    | -    | -    | -    | -    | -    |
| SQL                  | 9    | -    | -    | -    | 7    | -    | -    | -    |
| PHP                  | 10   | 7    | 6    | 5    | 6    | -    | -    | -    |



# Java Editions

- Java 2 Platform, Standard Edition (J2SE)
  - Used for developing desktop-based applications and networking applications
- Java 2 Platform, Enterprise Edition (J2EE)
  - Used for developing large-scale, distributed networking applications and web-based applications
- Java 2 Platform, Micro Edition (J2ME)
  - Used for developing applications for small memory-constrained devices, such as cell phones, pagers and PDAs

# Java platform



Power Macintosh

# Java Development Environment

- Edit
  - Create/edit the source code
- Compile
  - Compile the source code
- Load
  - Load the compiled code
- Verify
  - Check against security restrictions
- Execute
  - Execute the compiled

# Phase 1: Creating a Program

- Any text editor or Java IDE (Integrated Development Environment) can be used to develop Java programs
- Java source-code file names must end with the ***.java*** extension
- Some popular Java IDEs are
  - IntelliJ
  - NetBeans
  - Eclipse

# Phase 2: Compiling a Java Program

- ***javac Welcome.java***
  - Searches the file in the current directory
  - Compiles the source file
  - Transforms the Java source code into bytecodes
  - Places the bytecodes in a file named **Welcome.class**

# Bytecodes \*

- They are not machine language binary code
- They are independent of any particular microprocessor or hardware platform
- They are platform-independent instructions
- Another entity (interpreter) is required to convert the bytecodes into machine codes that the underlying microprocessor understands
- This is the job of the **JVM** (Java Virtual Machine)

# JVM (Java Virtual Machine) \*

- It is a part of the JDK and the foundation of the Java platform
- It can be installed separately or with JDK
- A virtual machine (VM) is a software application that simulates a computer, but hides the underlying operating system and hardware from the programs that interact with the VM
- It is the JVM that makes Java a portable language

# JVM (Java Virtual Machine) \*

- The same bytecodes can be executed on any platform containing a compatible JVM
- The JVM is invoked by the java command
  - *java Welcome*
- It searches the class Welcome in the current directory and executes the main method of class Welcome
- It issues an error if it cannot find the class Welcome or if class Welcome does not contain a method called main with proper signature



# Phase 3: Loading a Program \*

- One of the components of the JVM is the class loader
- The class loader takes the .class files containing the programs bytecodes and transfers them to RAM
- The class loader also loads any of the .class files provided by Java that our program uses

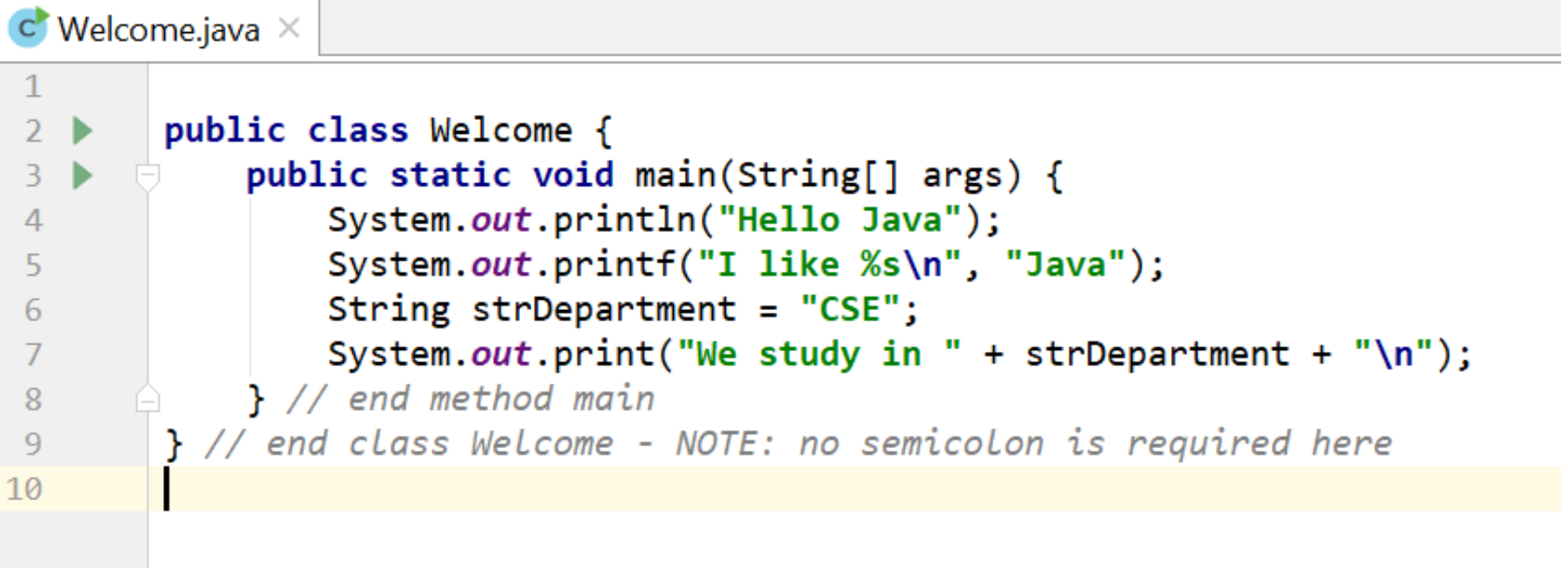
# Phase 4: Bytecode Verification \*

- Another component of the JVM is the bytecode verifier
- Its job is to ensure that bytecodes are valid and do not violate Java's security restrictions
- This feature helps to prevent Java programs arriving over the network from damaging our system

# Phase 5: Execution

- Now the actual execution of the program begins
- Bytecodes are converted to machine language suitable for the underlying OS and hardware
- Java programs go through two compilation phases
  - Source code -> Bytecodes
  - Bytecodes -> Machine language

# Editing a Java Program



```
1  
2 ▶ public class Welcome {  
3 ▶   public static void main(String[] args) {  
4     System.out.println("Hello Java");  
5     System.out.printf("I like %s\n", "Java");  
6     String strDepartment = "CSE";  
7     System.out.print("We study in " + strDepartment + "\n");  
8   } // end method main  
9 } // end class Welcome - NOTE: no semicolon is required here  
10
```

# Examining Welcome.java

- A Java source file can contain multiple classes, but only one class can be a public class
- Typically, Java classes are grouped into packages (similar to namespaces in C++)
- A public class is accessible across packages
- The source file name must match the name of the public class defined in the file with the .java extension

# Examining Welcome.java

- In Java, there is no provision to declare a class, and then define the member functions outside the class
- Body of every member function of a class (called method in Java) must be written when the method is declared
- Java methods can be written in any order in the source file
- A method defined earlier in the source file can call a method defined later

# Examining Welcome.java

- ***public static void main(String[] args)***
  - **main** is the starting point of every Java application
  - **public** is used to make the method accessible by all
  - **static** is used to make main a static method of class Welcome. Static methods can be called without using any object; just using the class name. JVM call main using the **ClassName.methodName** (*Welcome.main*) notation
  - **void** means main does not return anything
  - **String args[ ]** represents an array of String objects that holds the command line arguments passed to the application. *Where is the length of args array?*

# Examining Welcome.java

- Think of JVM as a outside Java entity who tries to access the main method of class Welcome
  - main must be declared as a public member of class Welcome
- JVM wants to access main without creating an object of class Welcome
  - main must be declared as static
- JVM wants to pass an array of String objects containing the command line arguments
  - main must take an array of String as parameter



# Examining Welcome.java

- ***System.out.println()***
  - Used to print a line of text followed by a new line
  - **System** is a class inside the Java API
  - **out** is a public static member of class System
  - **out** is an object of another class of the Java API
  - **out** represents the standard output (similar to stdout or cout)
  - **println** is a public method of the class of which out is an object

# Examining Welcome.java

- **System.out.print()** is similar to **System.out.println()**, but does not print a new line automatically
- **System.out.printf()** is used to print formatted output like printf() in C
- In Java, characters enclosed by double quotes ("") represents a String object, where String is a class of the Java API
- We can use the plus operator (+) to concatenate multiple String objects and create a new String object

# Compiling a Java Program

- Place the .java file in the bin directory of your Java installation
  - ***C:\Program Files\Java\jdk-17.0.4\bin***
- Open a command prompt window and go to the bin directory
- Execute the following command
  - ***javac Welcome.java***
- If the source code is ok, then javac (the Java compiler) will produce a file called Welcome.class in the current directory

# Compiling a Java Program

- If the source file contains multiple classes then javac will produce separate .class files for each class
- Every compiled class in Java will have their own .class file
- .class files contain the bytecodes of each class
- So, a .class file in Java contains the bytecodes of a single class only

# Executing a Java Program

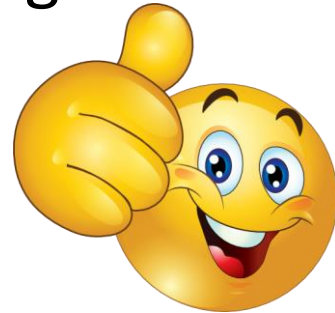
- After successful compilation execute the following command
  - *java Welcome*
  - *Note that we have omitted the .class extension here*
- The JVM will look for the class file *Welcome.class* and search for a *public static void main(String args[])* method inside the class
- If the JVM finds the above two, it will execute the body of the main method, otherwise it will generate an error and will exit immediately

# Another Java Program

```
A.java x
1 public class A {
2     private int a;
3
4     public A()
5     {
6         this.a = 0;
7     }
8
9     public void setA(int a)
10    {
11        this.a = a;
12    }
13
14    public int getA()
15    {
16        return this.a;
17    }
18
19    public static void main(String args[])
20    {
21        A ob;
22        ob=new A();
23        ob.setA(10);
24        System.out.println(ob.getA());
25    }
26 }
27 }
```

# Examining A.java

- The variable of a class type is called a reference
  - *ob* is a reference to A object
- Declaring a class reference is not enough, we have to use `new` to create an object
- Every Java object has to be instantiated using keyword **new**
- We access a public member of a class using the dot operator (`.`)
  - Dot (`.`) is the only member access operator in Java
  - Java does not have `->`, `&` and `*`



# Primitive (built-in) Data types

- Integers
  - **byte**      **8-bit integer (new)**
  - short      16-bit integer
  - int      32-bit signed integer
  - long      64-bit signed integer
- Real Numbers
  - float      32-bit floating-point number
  - double      64-bit floating-point number
- Other types
  - **char**      **16-bit, Unicode 2.1 character**
  - boolean      true or false, *false is not 0 in Java*



# Boolean Type

```
Boolean.java x
1  ▶ public class Boolean {
2  ▶  ▶ public static void main(String[] args) {
3      int a = 10;
4      if (a > 0) // if (a) will give compilation error
5      {
6          System.out.println("Inside If");
7      }
8      boolean b = false;
9      if (b)
10     {
11         System.out.println("Inside If");
12     }
13     else
14     {
15         System.out.println("Inside Else");
16     }
17 }
18 }
19 |
```

# Non-primitive Data types

- The non-primitive data types in java are
  - Objects
  - Array
- Non-primitive types are also called reference types

```
public class Box {  
    int L, W, H;  
  
    Box(int l, int w, int h)  
    {  
        L = l;  
        W = w;  
        H = h;  
    }  
  
    public static void main(String[] args)  
    {  
        Box p; // p is a reference pointing to null  
        p = new Box( l: 1, w: 2, h: 3); // now the actual object is created  
    }  
}
```

# Primitive vs. Non-primitive type

- Primitive types are handled by value – the actual primitive values are stored in variable and passed to methods

```
int x = 10;
```

```
public MyPrimitive(int x) { }
```

- Non-primitive data types (objects and arrays) are handled by reference – the reference is stored in variable and passed to methods

```
Box b = new Box(1,2,3);
```

```
public MyNonPrimitive(Box x) { }
```

# Primitive vs. Non-primitive type

- Primitive types are handled by value
  - There is no easy way to swap two primitive integers in Java
  - No method like **void swap(int \*x, int \*y)**
  - Can only be done using object or array
- But do we actually need a method to swap?
  - **x += (y - (y = x))** does the same in a single statement

# Java References

- Java references are used to point to Java objects created by new
- Java objects are **always** passed **by reference** to other functions, ***never by value***
- Java references act as pointers but does not allow pointer arithmetic
- We cannot read the value of a reference and hence cannot find the address of a Java object
- We cannot take the address of a Java reference

# Java References

- We can make a Java reference point to a new object
  - By copying one reference to another  
*ClassName ref2 = ref1; // Here ref1 is declared earlier*
  - By creating a new object and assign it to the reference  
*ClassName ref1 = new ClassName();*
- We cannot place arbitrary values to a reference except the special value **null** which means that the reference is pointing to nothing
  - ClassName ref1 = 100; // compiler error*
  - ClassName ref2 = null; // no problem*

# Java References

```
Box.java x
1 public class Box {
2     int L, W, H;
3
4     Box(int l, int w, int h)
5     {
6         L = l;
7         W = w;
8         H = h;
9     }
10
11    public static void main(String[] args)
12    {
13        Box b1; // b1 refers to null
14        Box b2; // b2 refers to null
15        b1 = new Box( l: 8, w: 5, h: 7); // b1 refers to new object (8, 5, 7)
16        b2 = b1; // b2 refers to b1, so both refers (8, 5, 7)
17        b1 = new Box( l: 3, w: 9, h: 2); // b1 refers to new object (3, 9, 2)
18        b1 = b2; // b1 refers to b2, what happens to object (3, 9, 2)
19    }
20 }
21
```

# Java version, IDE, and Textbook

- We will follow Java SE 17 (LTS), latest release - 17.0.4
  - <https://www.oracle.com/java/technologies/downloads/#java17>
- We will use IntelliJ IDEA Community version
  - <https://www.jetbrains.com/idea/download/>
- Books
  - Java: The Complete Reference, 12<sup>th</sup> Edition by Herbert Schildt
  - Effective Java, 3<sup>rd</sup> edition by Joshua Bloch (for future)