COMP 250

Lecture 4

Java Programming Overview

Compiler, JRE, JDK, IDE

Debugging

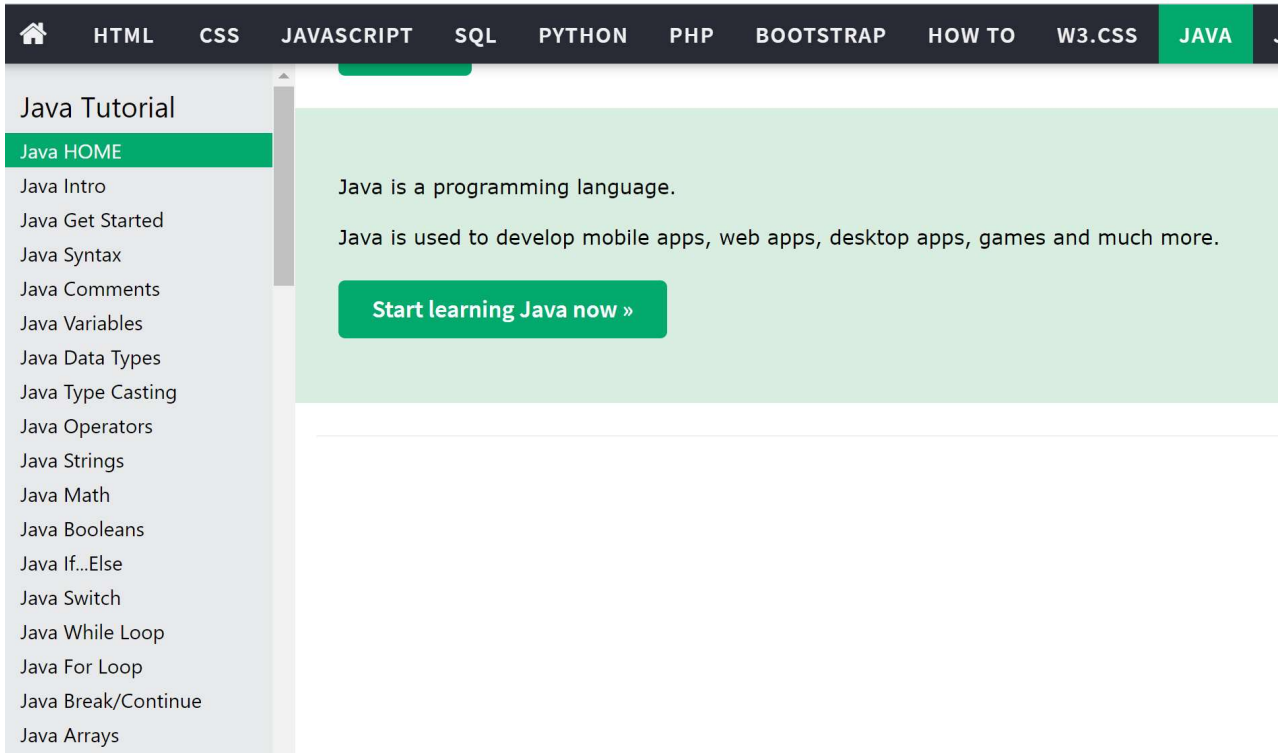
Java documentation (API)

Packages

Fri. Jan. 14, 2022

TODO (Done?): learn basic Java syntax

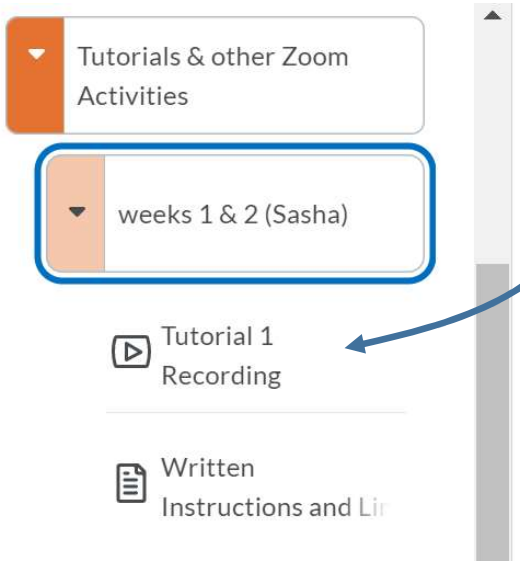
https://www.w3schools.com/java/default.asp



By today, you should have covered all the basics.

I am *not* expecting you to have mastered these topics by now. That will come with practice...

Yesterday's Tutorial



weeks 1 & 2 (Sasha)

This folder contains various materials put together by T.A. Sasha to get you started with coding in Java. It includes:

- **Installation Guide for JDK and IDE** videos
  - For Windows https://youtu.be/X6b5-RjbXKE
  - For Mac https://youtu.be/X6b5-RjbXKE
- **Sasha's tutorial from Thursday Jan. 13 (zoom recording)** in which he covered:
  - IDE + Tech Setup
  - Expectations for assignments, quizzes, exam
  - How to download and start assignments with Ed / MyCourses / IntelliJ
  - How run tests in your IDE

Brief History of Java

- Java (1995) shares similar syntax to C (1970's) and C++ (1980's).

- Like C++, Java is object oriented. ASIDE: Java is *easier to use* than C++ :
  Java does not require memory management, and pointers are hidden.

- Java was used in early web browsers to run "Java applets".
  Modern web browsers now use JavaScript (unrelated to Java), but Java remains a commonly used language in industry.

- Java was written James Gosling ("Dr Java") at Sun Microsystems.
  Sun was acquired by Oracle (2010). Oracle now maintains/improves Java.

Java Programs

A Java program (“application”) is a Java class that has a main method.

I am not expecting you to understand the code below yet. We will starting talking about classes next week.

```
public class HelloWorld {

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

}
```

Levels of Programming Languages

- High Level (e.g. C, C++, **Java**, Python,... and hundreds more)
- Assembly language (human readable version of machine code)
- Machine code (binary code that controls the circuits of a computer)

In COMP 273 and ECSE 324, you will learn MIPS assembly language and machine code.

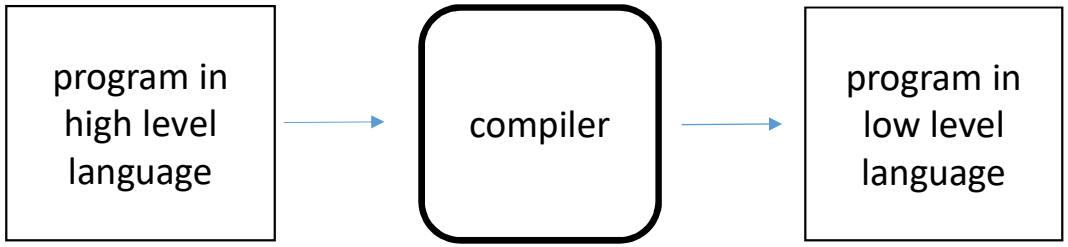
ASIDE Example: MIPS Assembly Language

The code below is part of a MIPS assembly language program in COMP 273. Each of the instructions is encoded in 32 bits which provide data and control information for a MIPS CPU (hardware).

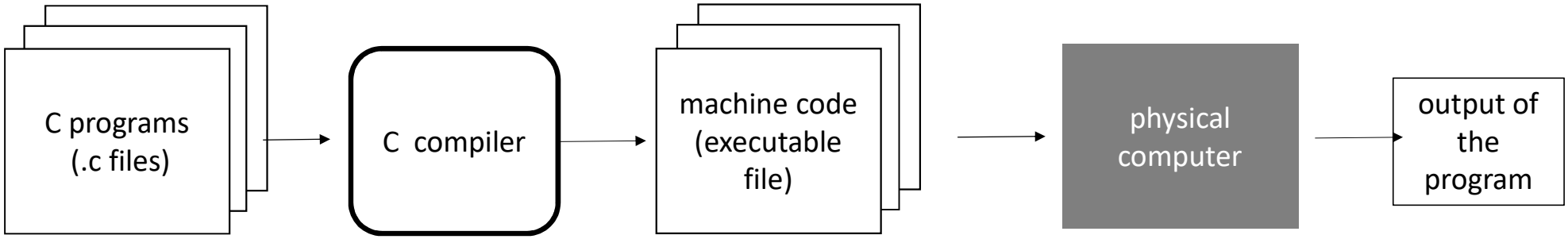
```
addi $sp,$sp,-8       # else , make space for 2 items on the stack
sw $ra, 4($sp)        # store return address on stack
sw $a0, 0($sp)        # store argument n on stack
                      # (will need it to calculate returned value)

addi $a0, $a0, -1     # compute argument for next call: n = n-1
jal sumton            # jump and link to sumton (recursive)

lw $ra, 4($sp)        # load the return address
lw $a0, 0($sp)        # load n from the stack
addi $sp, $sp, 8      # change the stack pointer

add $v0, $a0, $v0     # add current argument n to $v0

jr $ra                # return to parent
```

Compiler

A compiler is a program that translates a higher level language into a lower level language.



Running a C Program (or Fortran, …)

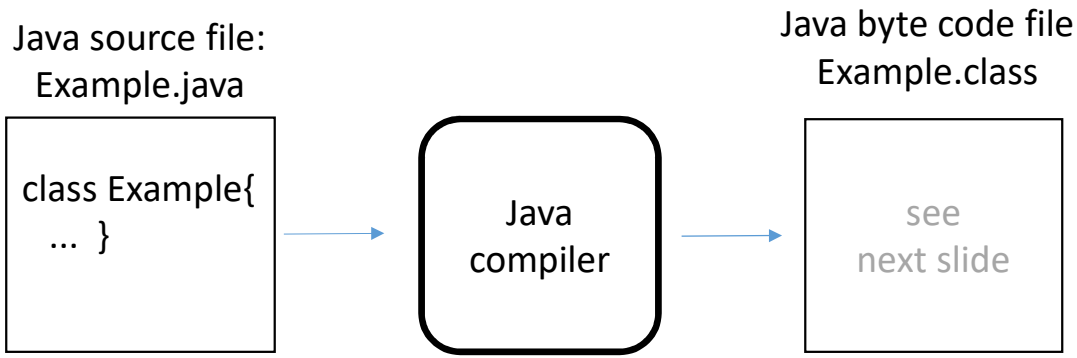


With C, there is an intermediate step of "object files" which I am leaving out for simplicity.

The physical computer only understands the machine code.

Java Compiler (source → byte code)

A Java compiler is a program that translates a Java source file into a Java class file. The latter is *byte code*.



Source Code

file Example.**java**

```
class Example {

  public static int sumToN(int n){
        int sum = 0;
        for (int k=0; k < n; k++){
            sum = sum + k;
        }
        return sum;
   }
}
```

Byte Code

Example.**class**

```
0: iconst_0
1: istore_1
2: iconst_0
3: istore_2
4: iload_2
5: iload_0
6: if_icmpge 19
9: iload_1
10: iload_2
11: iadd
12: istore_1
13: iinc 2, 1
16: goto 4
19: iload_1
20: ireturn
```

ASIDE: this slide is for your interest only !

What I'm showing here is like assembly language which you'll learn in COMP 273. *It is a human readable version of Java byte code.* The actual byte code is a sequence of coded bytes.

The numbers on left are byte indices where instruction starts (like a line number).

iconst_n, istore_n, iload_n are standard instructions that each have own code word. (Each code word is a byte.)

See here for the Java byte codes (the "instruction set").

Compiler Errors

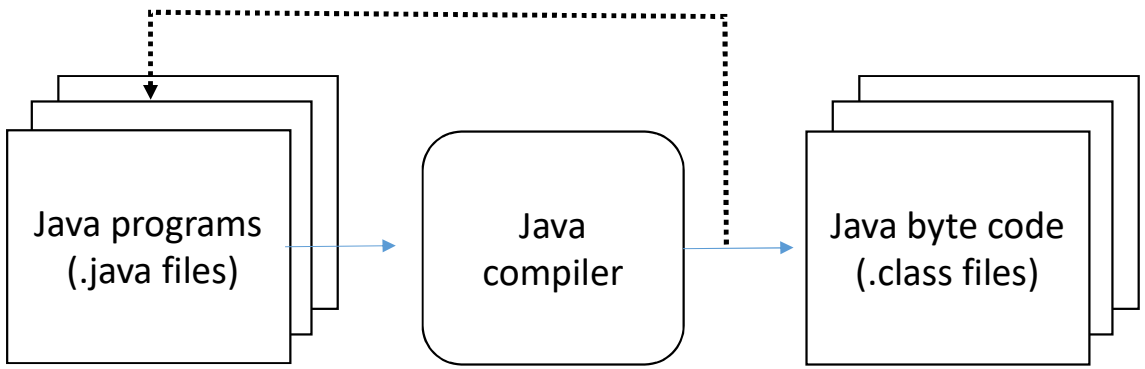
Java has strict rules for syntax. If a program has *invalid syntax*, then the compiler reports an error.

- did the programmer misspell or forget to declare a variable?
  ("cannot resolve symbol")
- did the programmer forget a semicolon or bracket ?
  ("expecting ;")
- are the types compatible ?
  - e.g. `int j = 1.0;`

If there is a compiler error (a.k.a. "syntax error") then the compiler does not produce a class file.

Compiler Errors

If there is a **compiler/syntax error**, then the compiler does not produce a .class file. You need to edit your code.



ASIDE: Compilers, Grace Hopper, WICS

High level languages and hence compilers were invented very earlier in CS.

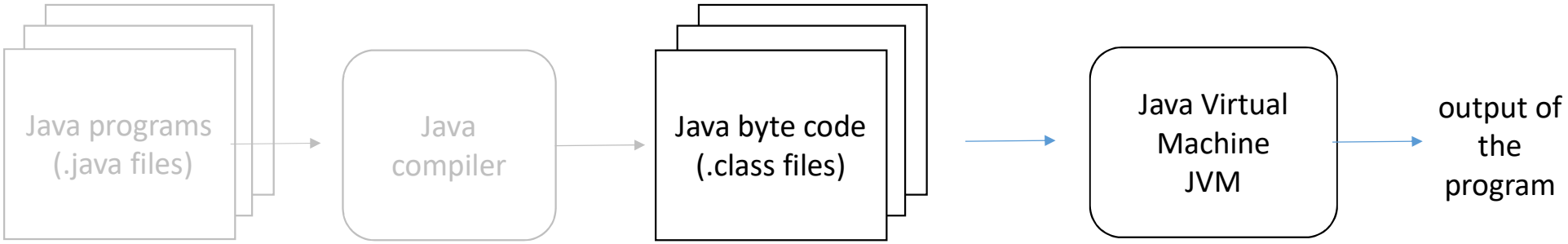
One of the pioneers (1950s) was Grace Hopper.

Annual events for women in computer science:

- Grace Hopper Celebration of Women in Computing
- ACM ***Canadian*** Celebration of Women in Computing

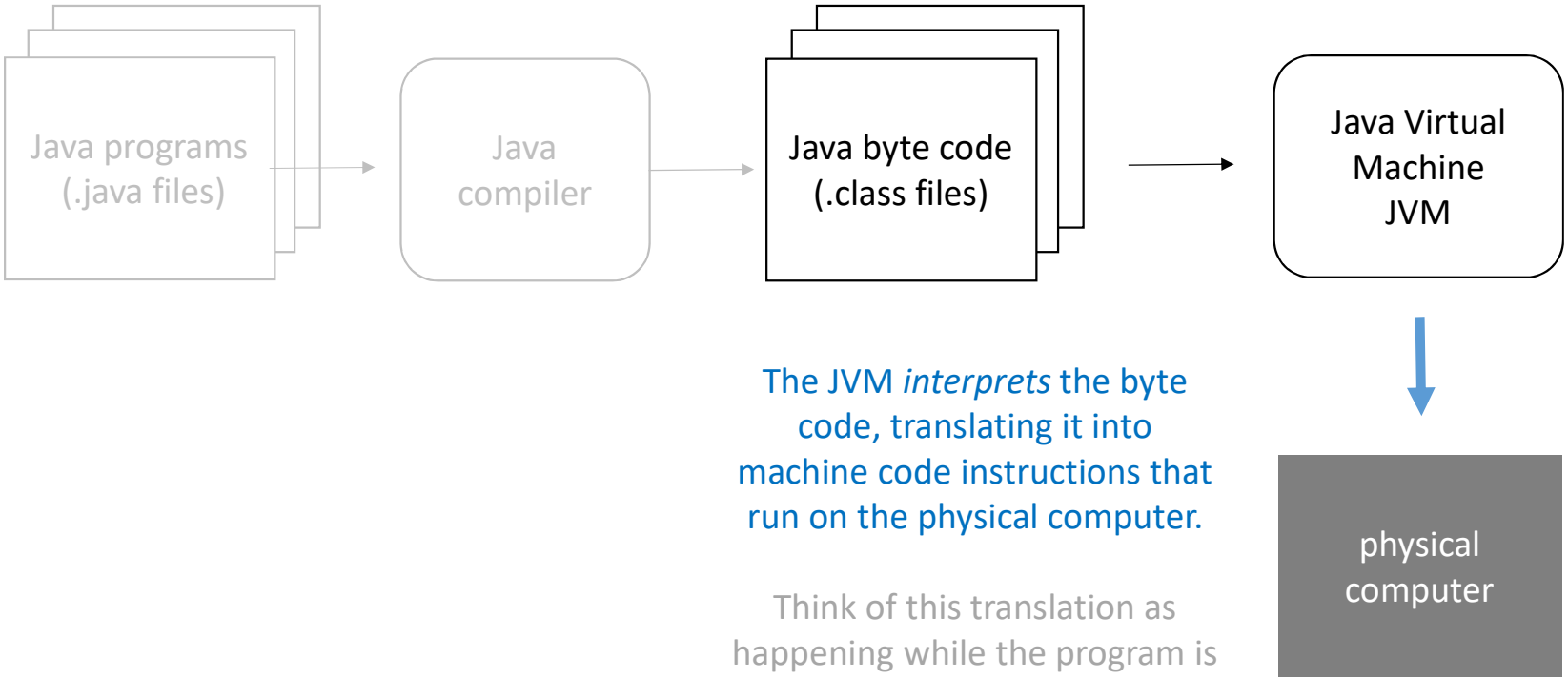
  Many women McGill CS students go to latter conference: see McGill Women in CS (WICS)

Running a Java Program

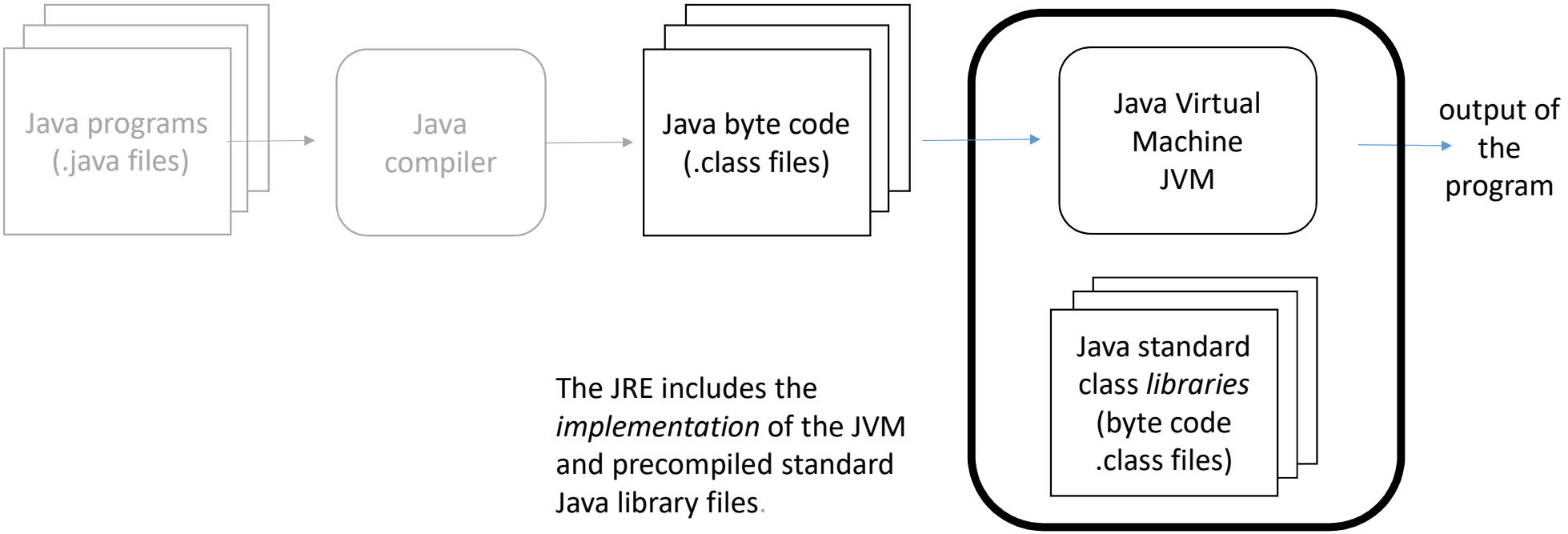


The JVM is a program that runs on your computer. The JVM *simulates* a specialized Java computer (i.e. "virtual machine").

Running a Java Program



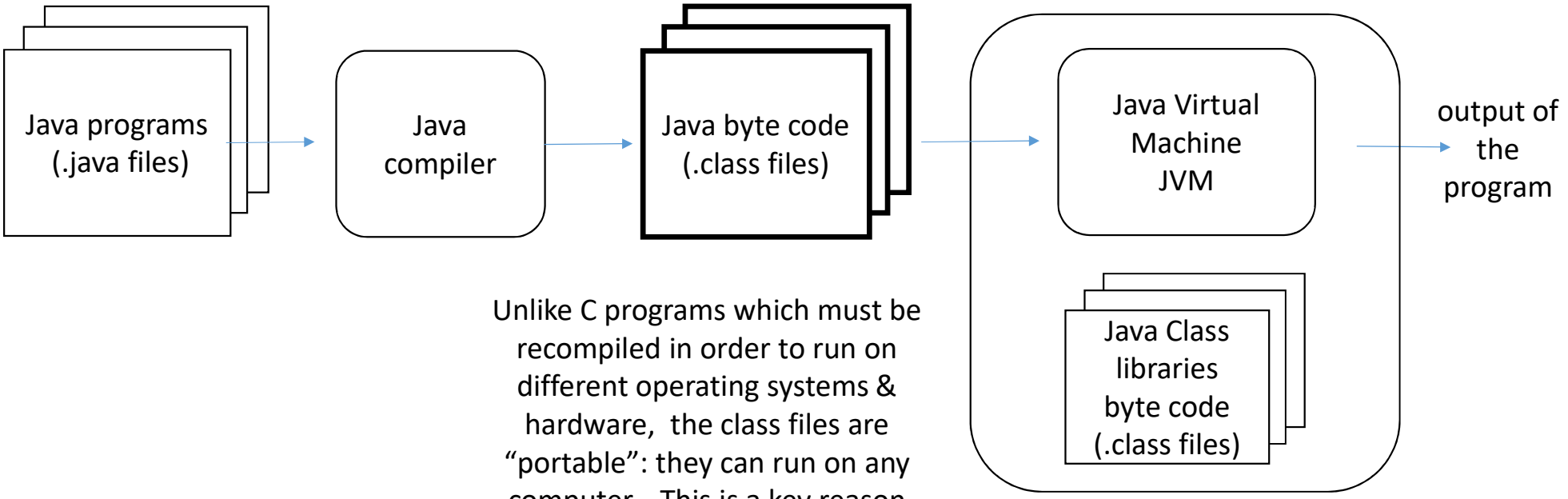
Java *Runtime* Environment (JRE)



The JRE includes the *implementation* of the JVM and precompiled standard Java library files.

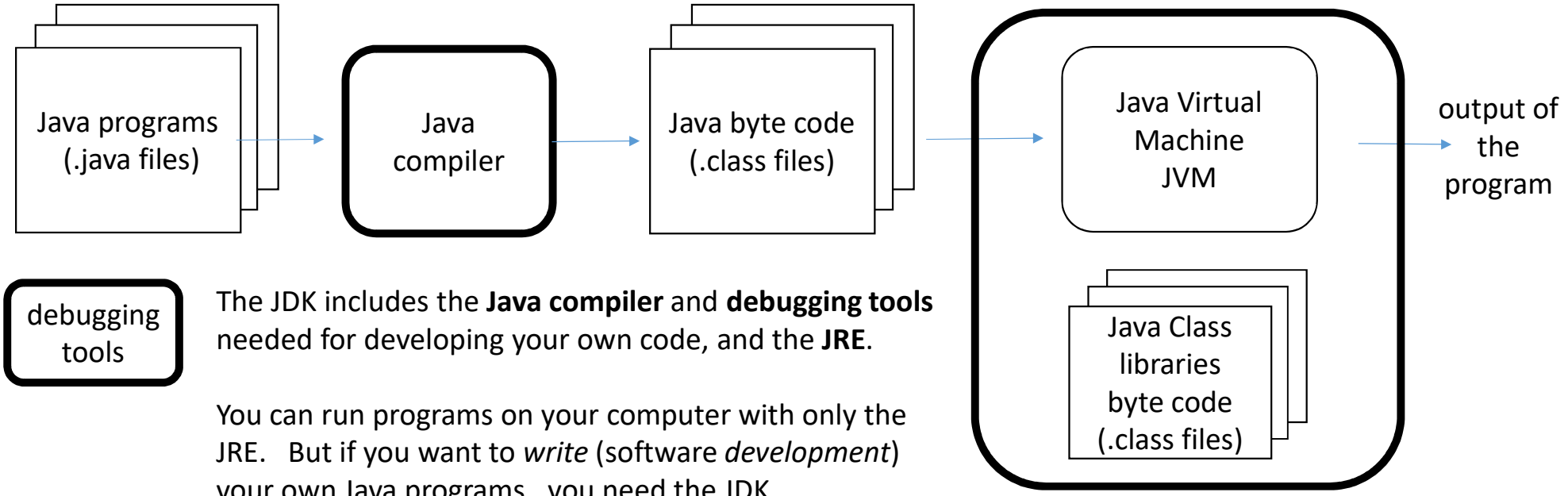
It will be specific to your operating system & computer hardware.

“Portability”



Unlike C programs which must be recompiled in order to run on different operating systems & hardware, the class files are “portable”: they can run on any computer. This is a key reason why Java has been so popular.

Java *Development* Kit (JDK)



debugging tools

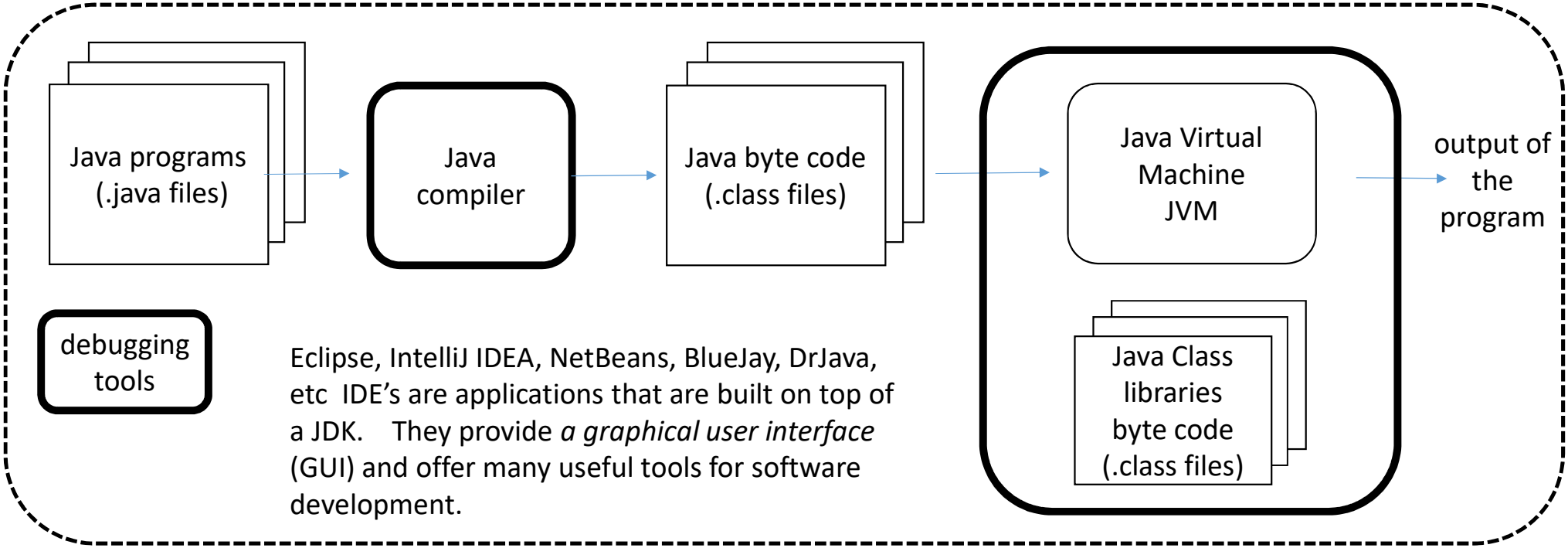
The JDK includes the **Java compiler** and **debugging tools** needed for developing your own code, and the **JRE**.

You can run programs on your computer with only the JRE. But if you want to *write* (software *development*) your own Java programs, you need the JDK.

You can compile from command line with

```
> javac  Example.java
> java   Example
```

Integrated Development Environment (IDE)



Eclipse, IntelliJ IDEA, NetBeans, BlueJay, DrJava, etc IDE's are applications that are built on top of a JDK. They provide *a graphical user interface* (GUI) and offer many useful tools for software development.

physical computer

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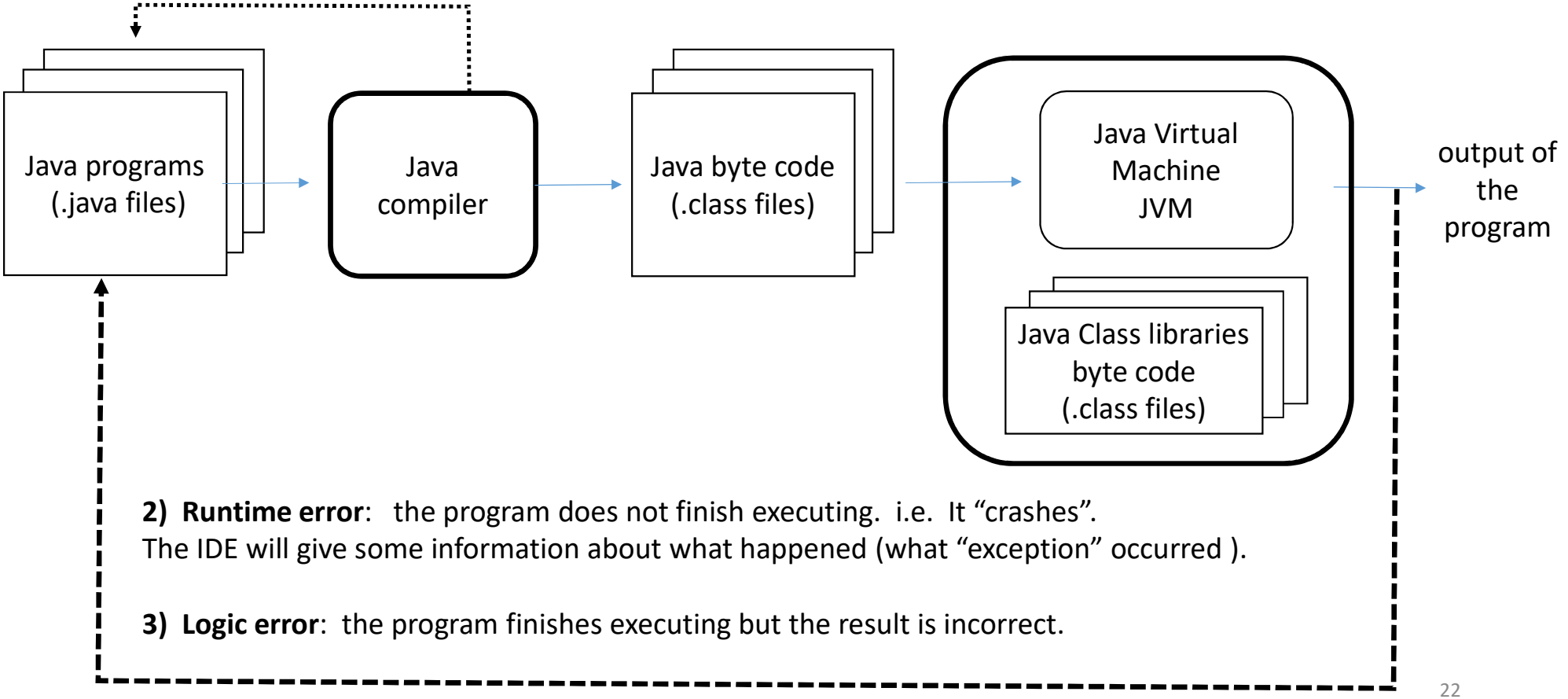
Debugging: 3 kinds of error

1) compiler/syntax error
(discussed earlier)



2) Runtime error: the program does not finish executing. i.e. It "crashes".
The IDE will give some information about what happened (what "exception" occurred).

3) Logic error: the program finishes executing but the result is incorrect.

Runtime errors: Java “Exceptions”

Examples

- ArrayIndexOutOfBoundsException

```
double[] x = {7.0, 2.3, 5.0};

System.out.println( x[3] );
```

Exception in thread "main" java.lang.ArrayIndexOutOfBoundsException: Index 3 out of bounds for length 3

- NullPointerException

We will discuss this next week. We need reference types next week.

Debug Mode (Eclipse demo)

- set breakpoint
- execute a single statement at a time
- step over/into methods
- display variable values
- modify variables
- ...

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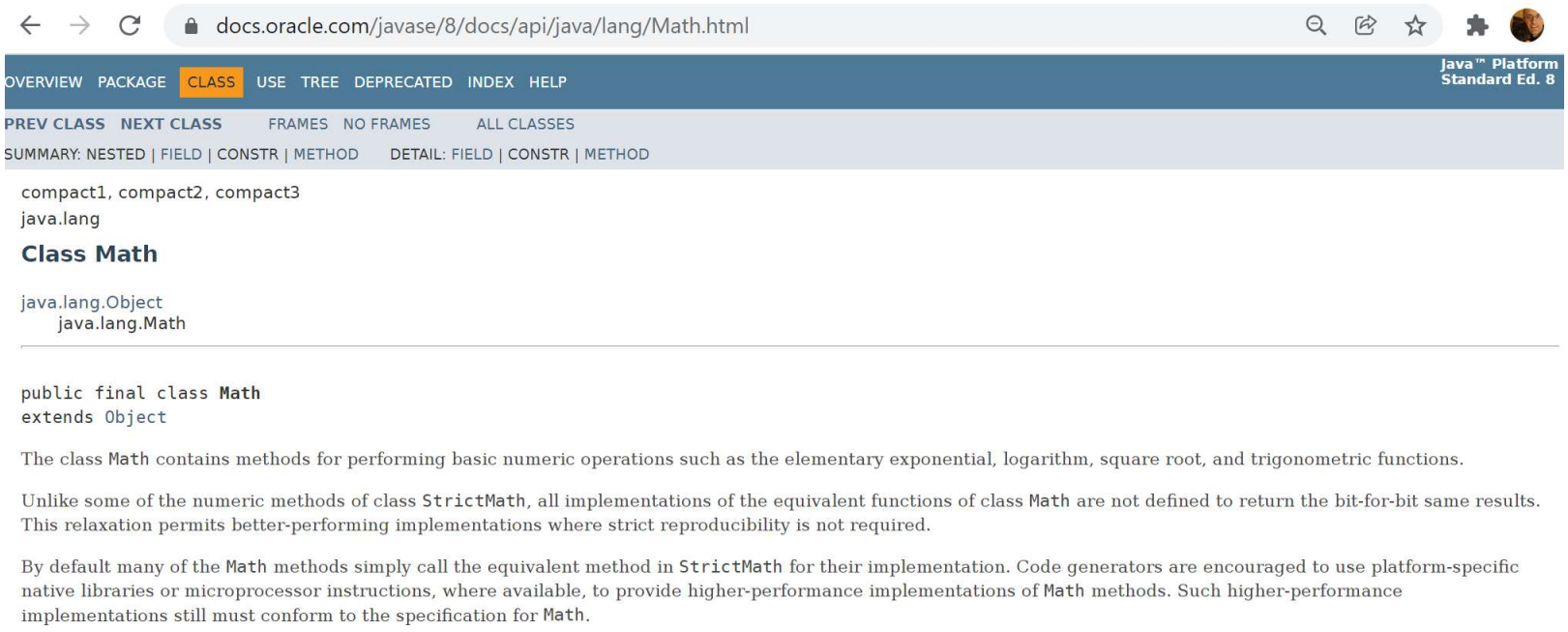
Java Documentation (part of JDK)

The **Java Application Programming Interface (API)** defines all classes in the standard library. You can find the complete list via here. e.g. Math library



Method Summary

Methods

Modifier and Type	Method and Description
`static double`	**`abs`**`(double a)` Returns the absolute value of a `double` value.
`static float`	**`abs`**`(float a)` Returns the absolute value of a `float` value.
`static int`	**`abs`**`(int a)` Returns the absolute value of an `int` value.
`static long`	**`abs`**`(long a)` Returns the absolute value of a `long` value.
`static double`	**`acos`**`(double a)` Returns the arc cosine of a value; the returned angle is in the range 0.0 through *pi*.
`static double`	**`asin`**`(double a)` Returns the arc sine of a value; the returned angle is in the range -*pi*/2 through *pi*/2.
`static double`	**`atan`**`(double a)` Returns the arc tangent of a value; the returned angle is in the range -*pi*/2 through *pi*/2.
`static double`	**`atan2`**`(double y, double x)` Returns the angle *theta* from the conversion of rectangular coordinates (x, y) to polar coordinates (r, *theta*).
`static double`	**`cbrt`**`(double a)` Returns the cube root of a `double` value.
`static double`	**`ceil`**`(double a)` Returns the smallest (closest to negative infinity) `double` value that is greater than or equal to the argument and is e
`static double`	**`copySign`**`(double magnitude, double sign)` Returns the first floating-point argument with the sign of the second floating-point argument.
`static float`	**`copySign`**`(float magnitude, float sign)` Returns the first floating-point argument with the sign of the second floating-point argument.
`static double`	**`cos`**`(double a)` Returns the trigonometric cosine of an angle.
`static double`	**`cosh`**`(double x)` Returns the hyperbolic cosine of a `double` value.
`static double`	**`exp`**`(double a)`

Sample entry

`static double` `abs(double a)`

Returns the absolute value of a double value.

It specifies the **name** of the method and the **parameters (number and type).**
The name + types of each parameter define the *method's signature*.

The return type and other modifiers `(static)` are also specificed

There is also a detailed description of what the method does.

abs

```
public static double abs(double a)
```

Returns the absolute value of a double value. If the argument is not negative, the argument is returned. If the ar
- If the argument is positive zero or negative zero, the result is positive zero.
- If the argument is infinite, the result is positive infinity.
- If the argument is NaN, the result is NaN.

In other words, the result is the same as the value of the expression:

```
Double.longBitsToDouble((Double.doubleToLongBits(a)<<1)>>>1)
```

Parameters:

a - the argument whose absolute value is to be determined

Returns:

the absolute value of the argument.

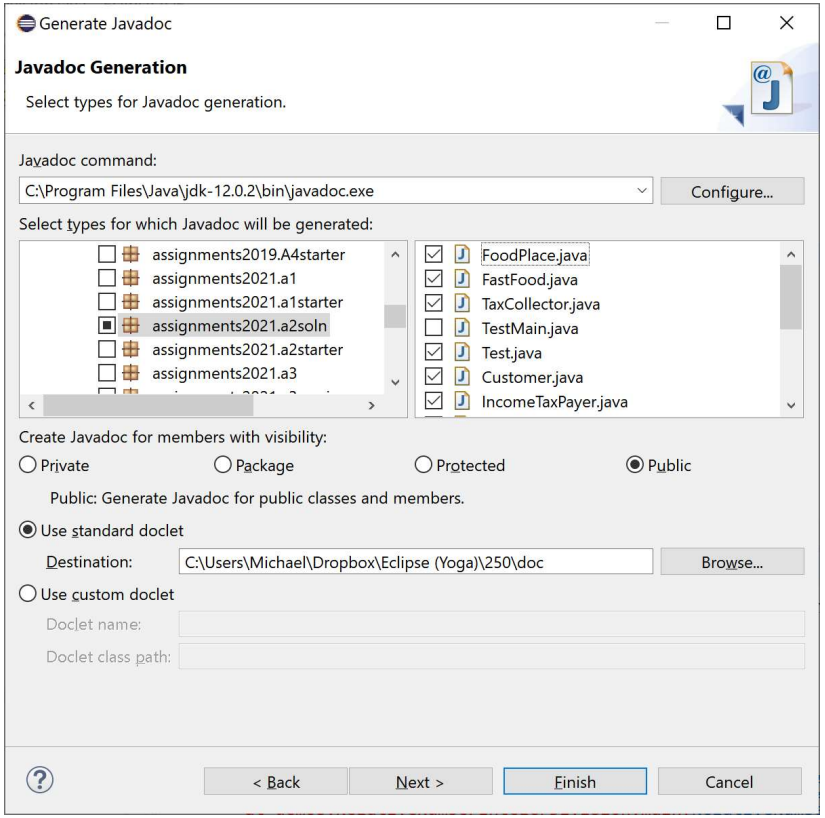
ASIDE: Javadoc

If you are doing *software development* as part of a team, then you may be asked to make documentation for the Java classes that you write and that will be used by others.

Javadoc is a tool for creating a class API in form of an html file. The API is nicely formatted when displayed in a browser.

- In Eclipse, **File > Export**
- Expand **Java,** select **Javadoc.** Then click **Next**.

Javadoc is not necessary for COMP 250.



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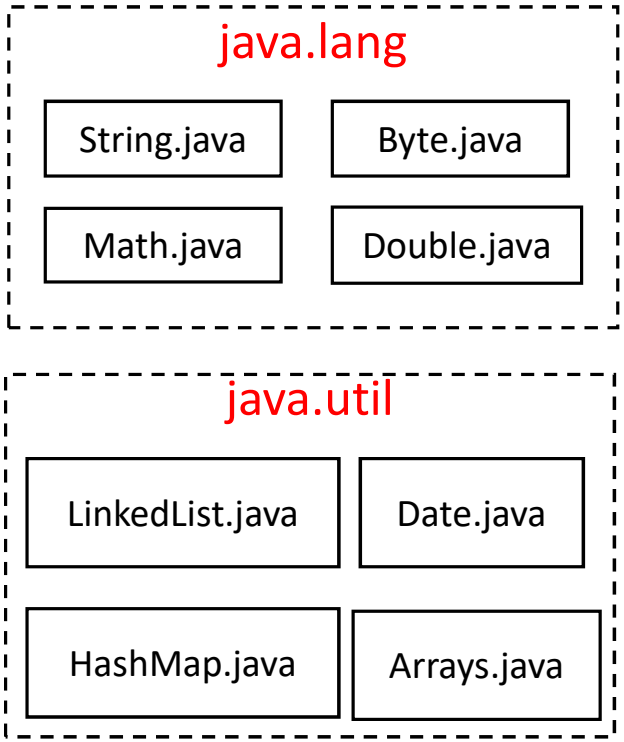
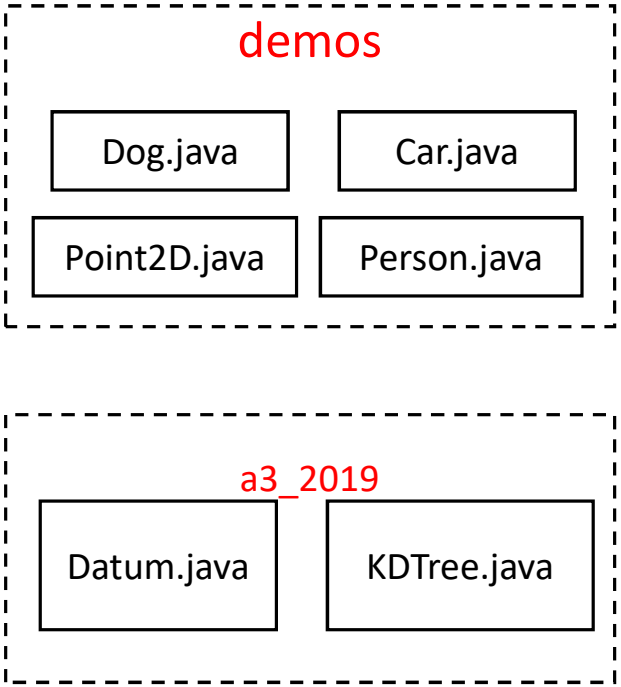
Packages

A package is a set of classes. The two on left are examples from the standard Java library. The two on right are examples of my own packages.





We put a package statement at the first line of our class definition file.
This says which package the class belongs to.

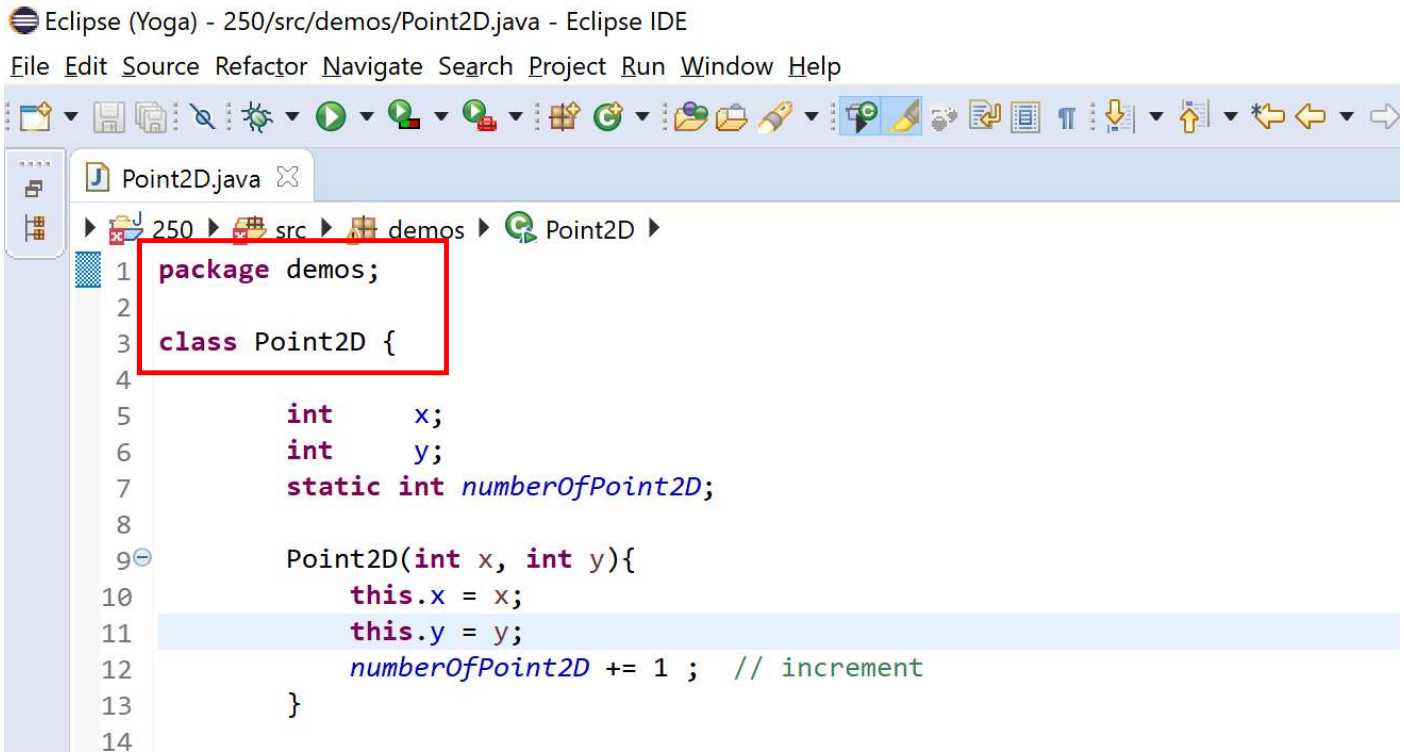
[DEMO THIS IN ECLIPSE]

Point2D.java

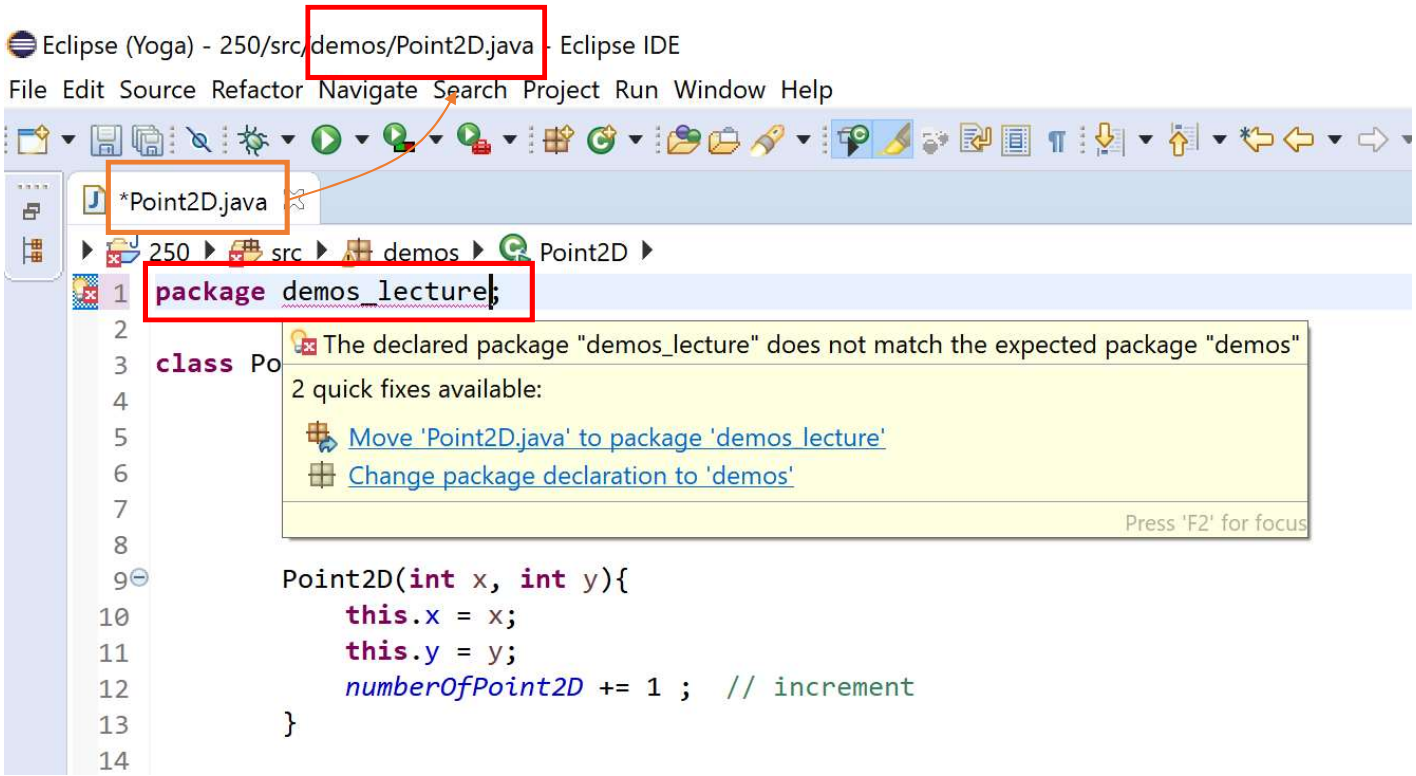
```
package demos;

class Point2D{
            :
}
```

Example (Eclipse)



Example (Eclipse)

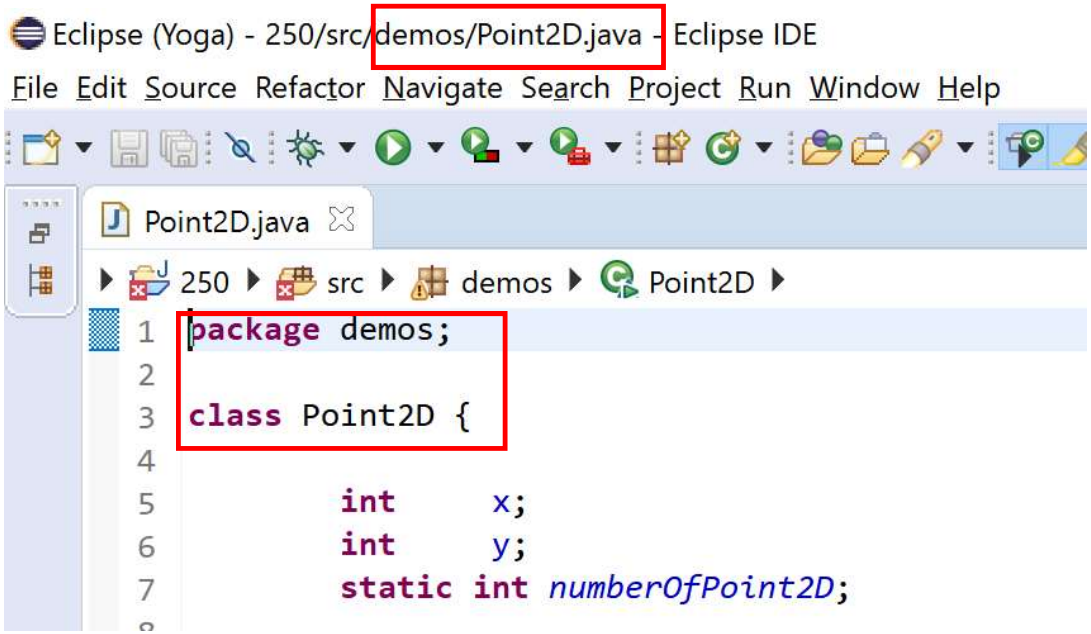


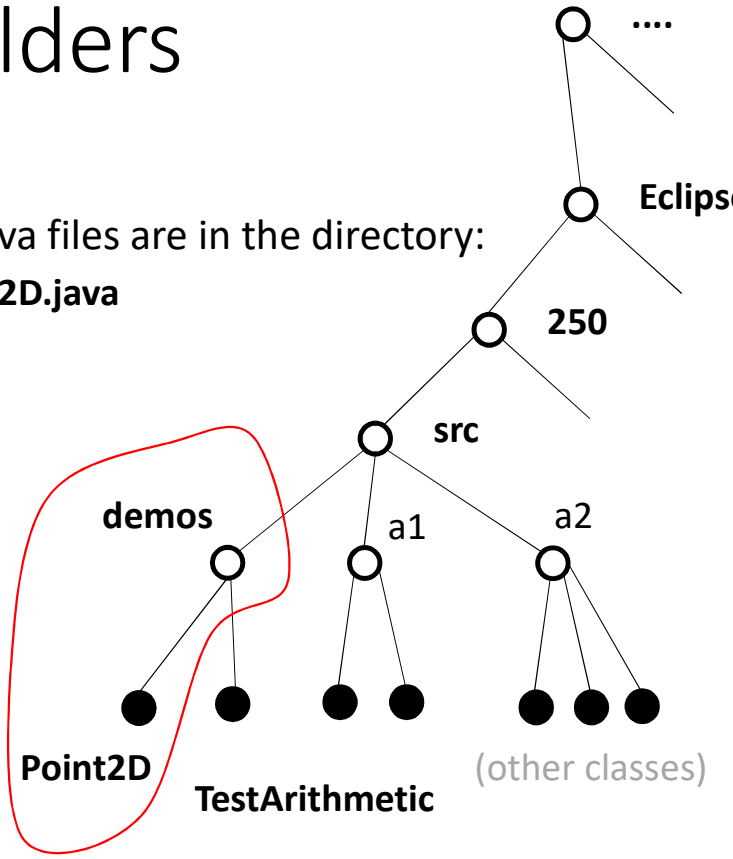
Packages and File folders

Packages are organized as folders on your computer file system.

In this Eclipse example, there is a project name (“250”) and the .java files are in the directory:

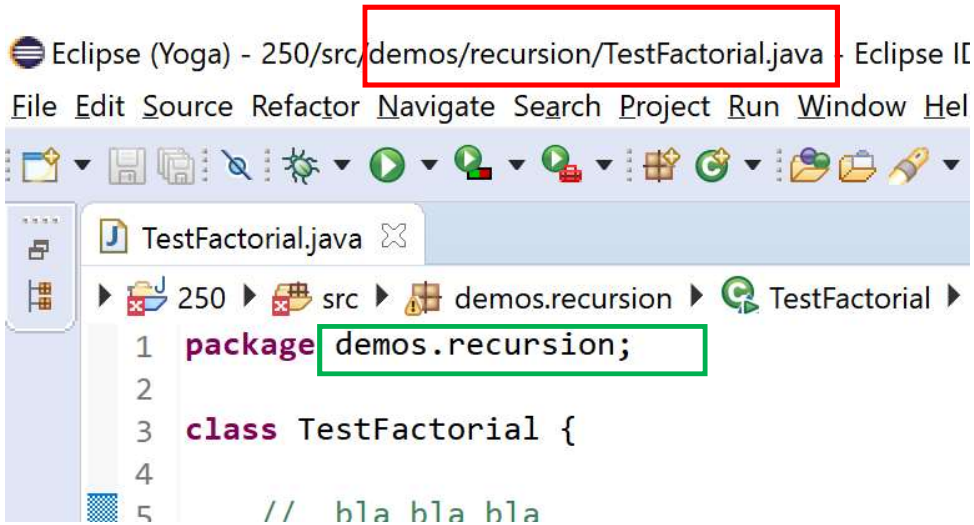
C:\Users\MichaelLanger\Dropbox**Eclipse\250\src\demos\Point2D.java**

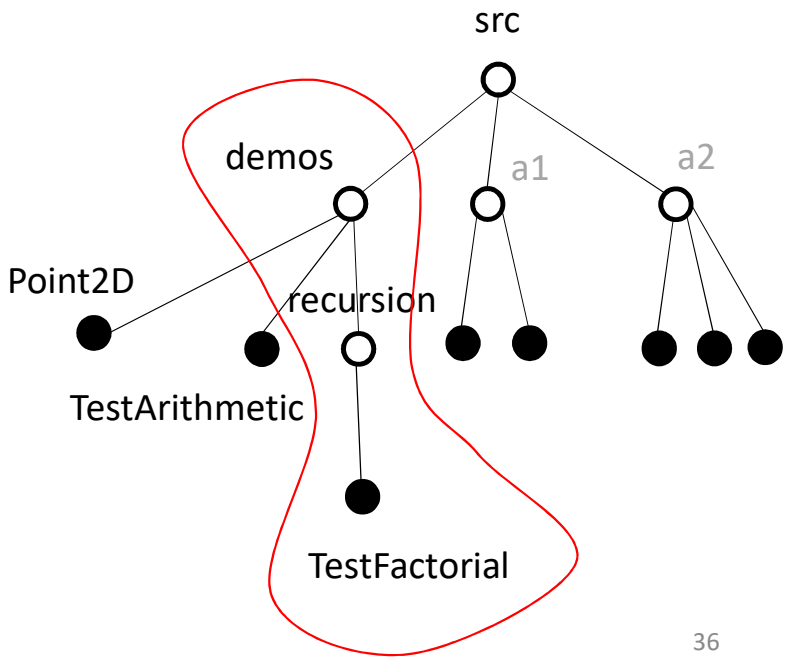




You can have *packages within packages*, corresponding to file folders within file folders.
e.g. C:\Users\YourName\Dropbox\Eclipse\250\src\demos\recursion\TestFactorial.java

The package name matches the folder path.
On the file system, subfolders are indicated with a "slash".
In the package name, a "dot" is used.





Packages and File Folders

250/src/ contains source code e.g. TestArithmetic.java

250/bin/ contains Java byte code e.g. TestArithmetic.class

For more information on packages and file folders, see here.

Coming up…

Lectures

Mon. Jan 17 arrays

Wed. Jan. 19 objects & classes 1:
(wrapper classes, strings)

Fri. Jan. 21 objects & classes 2

Homework (TODO)

- w3schools Tutorial (done)
- Install either Eclipse or IntelliJ. (done)
- Simple coding exercises (posted soon)

Assignment 1 to be posted Fri. Jan. 28 (2 weeks).