香港中文大學（深圳）
The Chinese University of Hong Kong

(Materials of this lecture are NOT included in the midterm and final exams)

CSC3100 Data Structures
Lecture 2: A brief introduction to Java

Li Jiang
School of Data Science (SDS)
The Chinese University of Hong Kong, Shenzhen

Outline

- Why do we use Java to learn data structures?
- What will we learn and NOT learn about Java?
- Basic knowledge of Java
  - JDK/JVM/JRE
  - Keywords, declaration, expressions, class/object, method, others

Why do we choose Java?

- This course is not just about reading and writing — we need to write codes by implementing data structures and algorithms
- Java is one of the most frequently used programming languages
  - It is one of the easy-to-use programming languages to learn
  - Java is platform-independent, i.e., write once, run anywhere!
- Used for
  - Developing Android Apps
  - Helps you to create Enterprise Software
  - Wide range of mobile applications
  - Scientific computing
  - Big data analytics (e.g., Hadoop and Spark)
  - …
  - Much more!

Java vs C/C++

- Advantages of Java
  - Easier to learn
  - No pointer, safer
  - Automatic memory management, including garbage collection
  - Cross platforms
  - More powerful standard libraries
  - Java and Java-based IDEs are often provided free of charge
  - Often used for research (e.g., Hadoop and Spark)
  - …

What we will learn about Java?

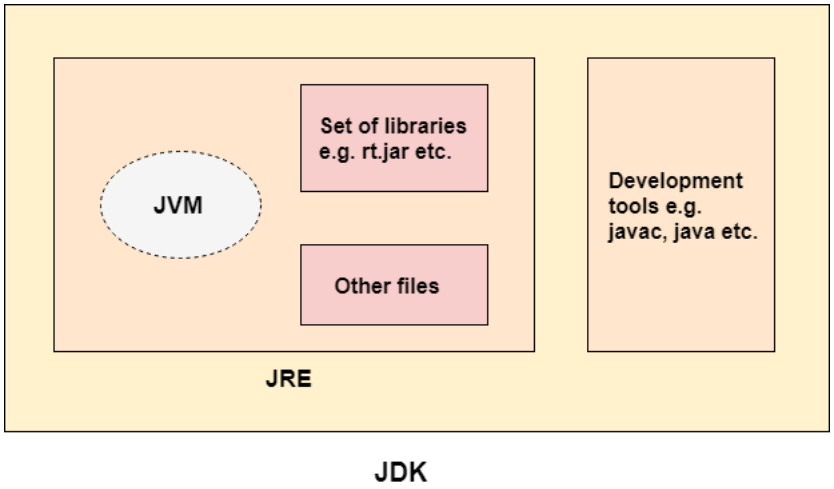
- What will we learn?
  - JDK, JVM, JRE
  - Keywords
  - Simple declarations
  - Statements
  - Classes/objects
  - Methods
  - Exceptions

- What will we NOT learn?
  - Interface
  - Abstract class
  - Inheritance
  - GUI
  - Multi-thread
  - Garbage collection
  - Network communication
  - Web design
  - Android Apps development
  - ...
  - Many others

Only focus on the basic knowledge of Java that is used for implementing the data structures and algorithms in this course!

JDK, JVM, JRE

- Java Development Kit (JDK)
  - A software development environment which is used to develop Java applications and applets
- Java Runtime Environment (JRE)
  - It provides the minimum requirements for executing a Java application; it consists of JVM, core classes, etc.
- JVM (Java Virtual Machine)
  - An abstract machine that doesn't physically exist, a specification that provides a runtime environment in which Java bytecode can be executed



Java is platform-independent, but JVM is platform dependent

OOP (object-oriented programming)

- Everything in Java is an object
  - We organize our software as a combination of different types of objects that incorporate both data and behavior
  - Class "Object" is the root class for **every** derived class in Java

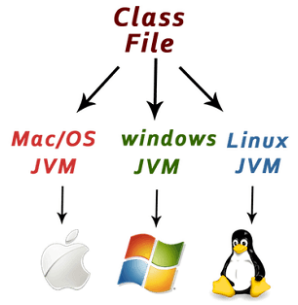
- OOP features:
  - Object
  - Class
  - Inheritance
  - Polymorphism
  - Abstraction
  - Encapsulation

Platform independence

- Java: write once, run anywhere
  - Different from C/C++/…, which are compiled into platform specific machines

- Java is a software platform that runs on top of hardware platforms
  - Runtime environment
  - API (Application Programming Interface)

- Java codes can be executed on Windows, Linux, Mac/OS, etc.
  - Java program is compiled into bytecode
  - The bytecode runs on multiple platforms

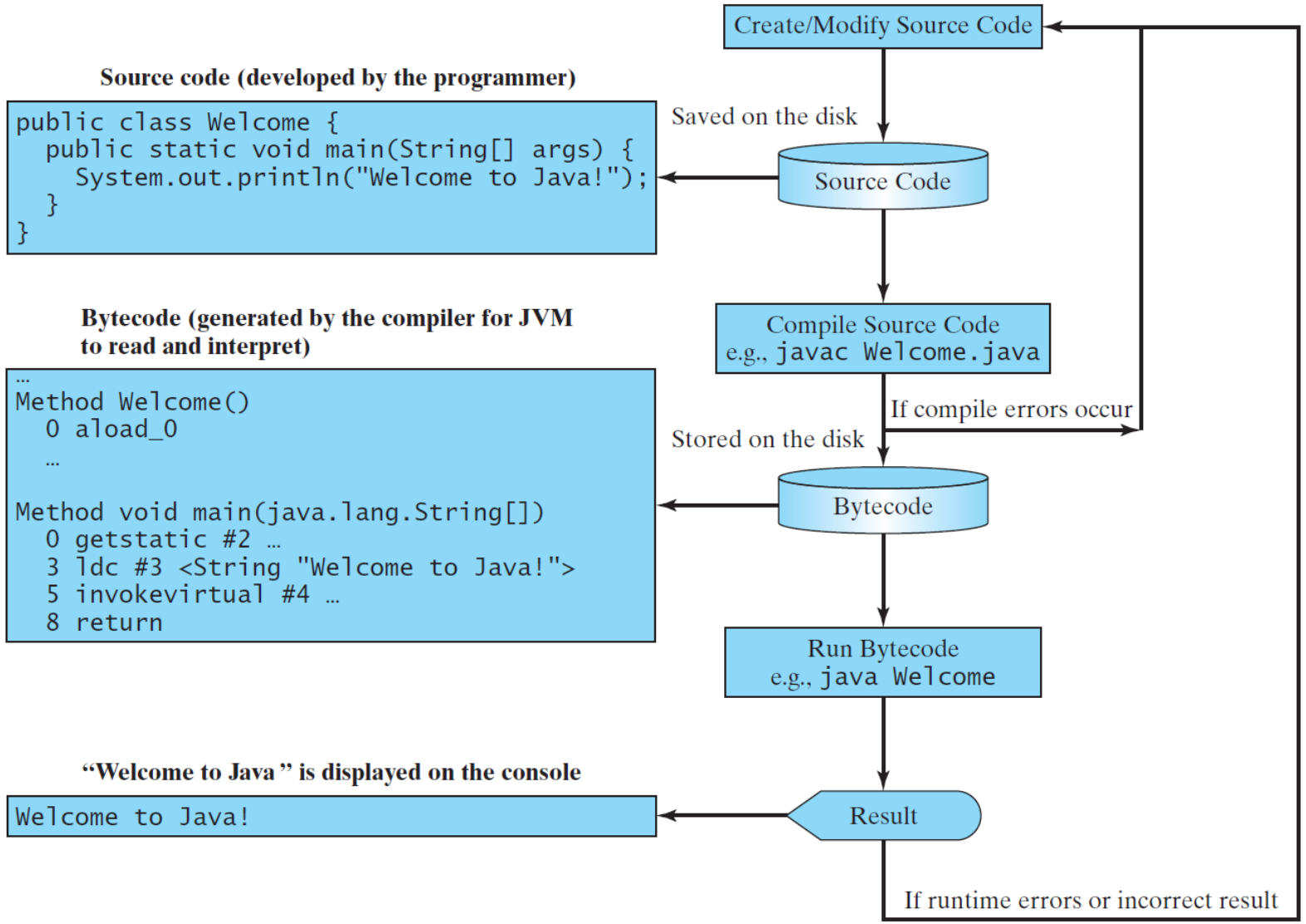


The first Java program

```
1  class Welcome {
2      public static void main(String[] args) {
3          System.out.println("Welcome to Java!");
4      }
5  }
```

- Source codes
  - Declare a class with name
    - class Welcome{…}
  - Declare the main method
    - public static void main(String args[ ]){…}
    - Java main method is the entry point of any java program
  - Print "Welcome to Java!" to the console
    - System.out.println("Welcome to Java!")

Running the first Java program



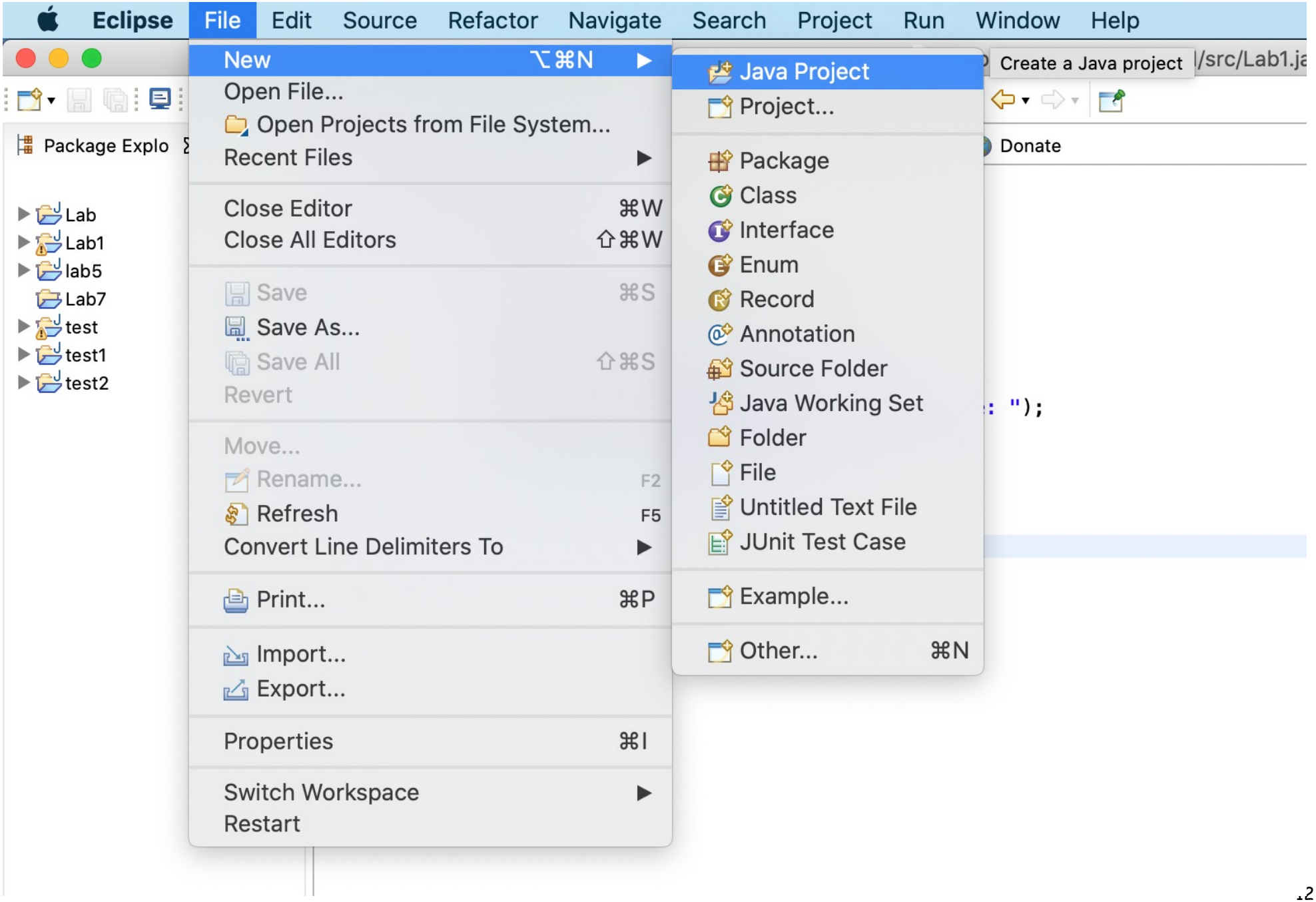
Environment setup

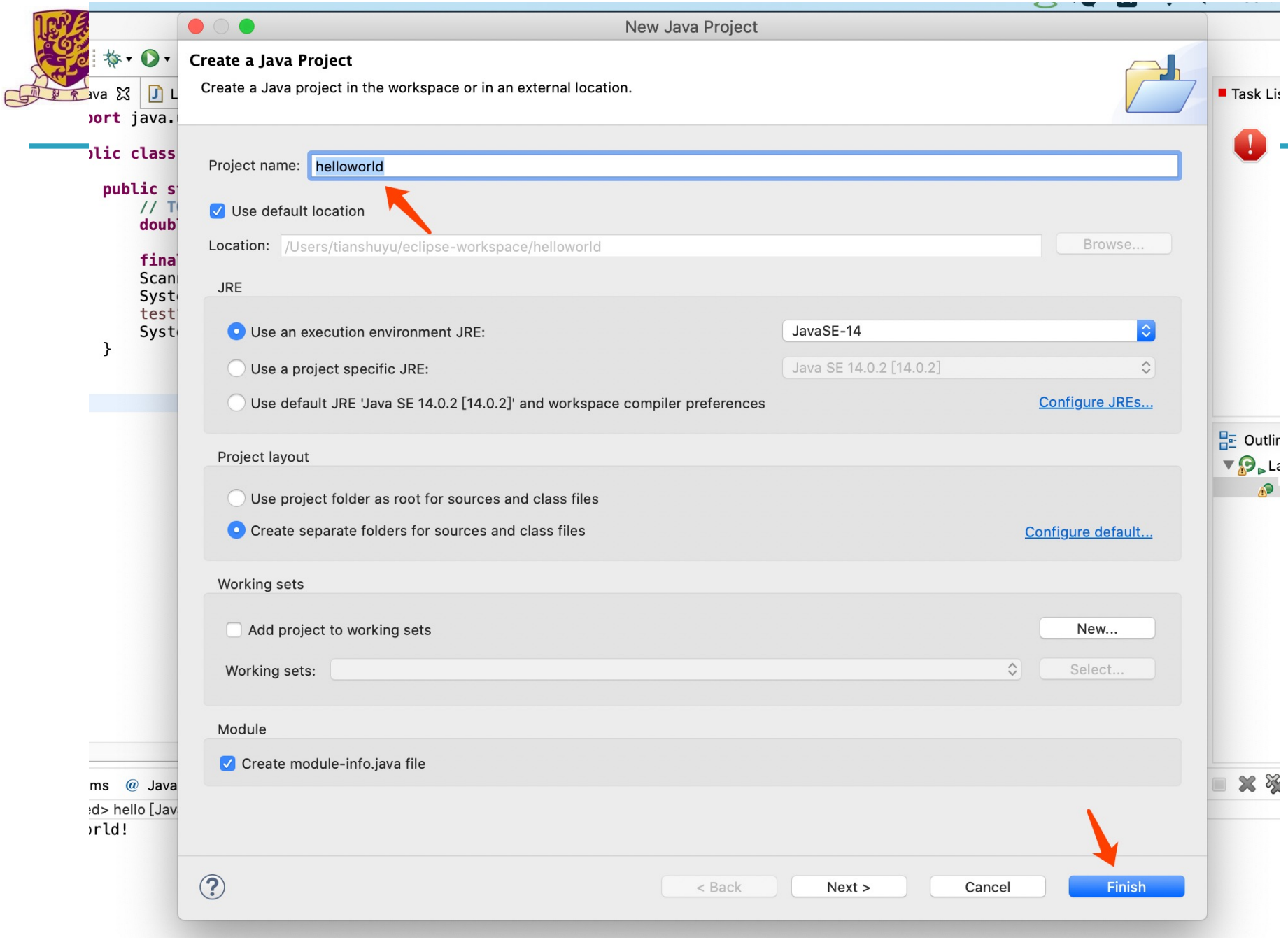
- Install a JDK (Java Development Kit)
  - Install an OpenJDK
    - e.g., Java SE DK 16
  - Set up environment variables:
    - JAVA_HOME: Points to the base of the JDK installation. e.g., "C:\Program Files\Java\jdk___VERSION"
    - PATH: Add "%JAVA_HOME%\bin".
    - Verify installation (e.g., on Mac)

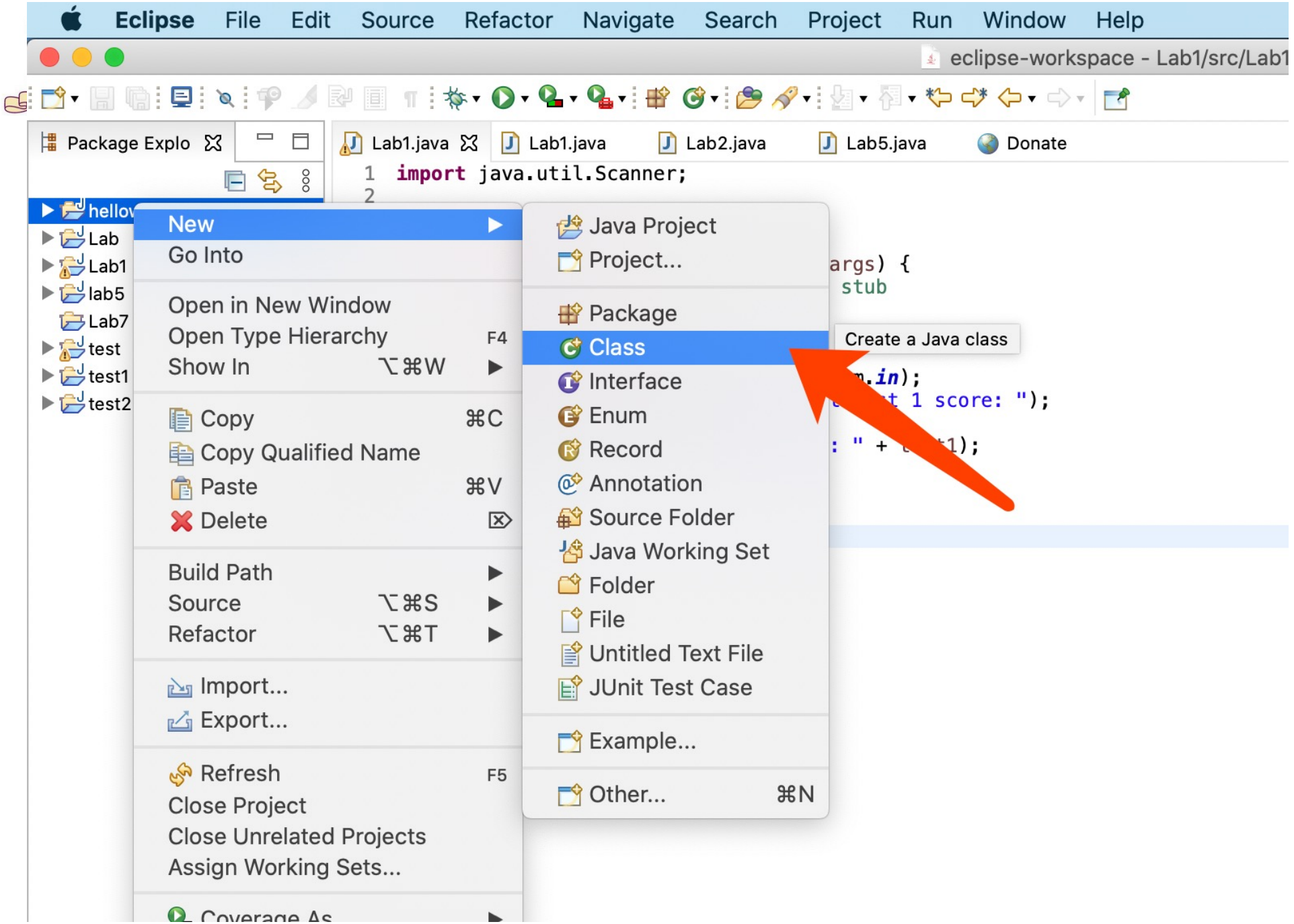
```
(base) TianshudeMacBook-Pro:~ tianshuyu$ java -version
java version "14.0.2" 2020-07-14
Java(TM) SE Runtime Environment (build 14.0.2+12-46)
Java HotSpot(TM) 64-Bit Server VM (build 14.0.2+12-46, mixed mode, sharing)
```

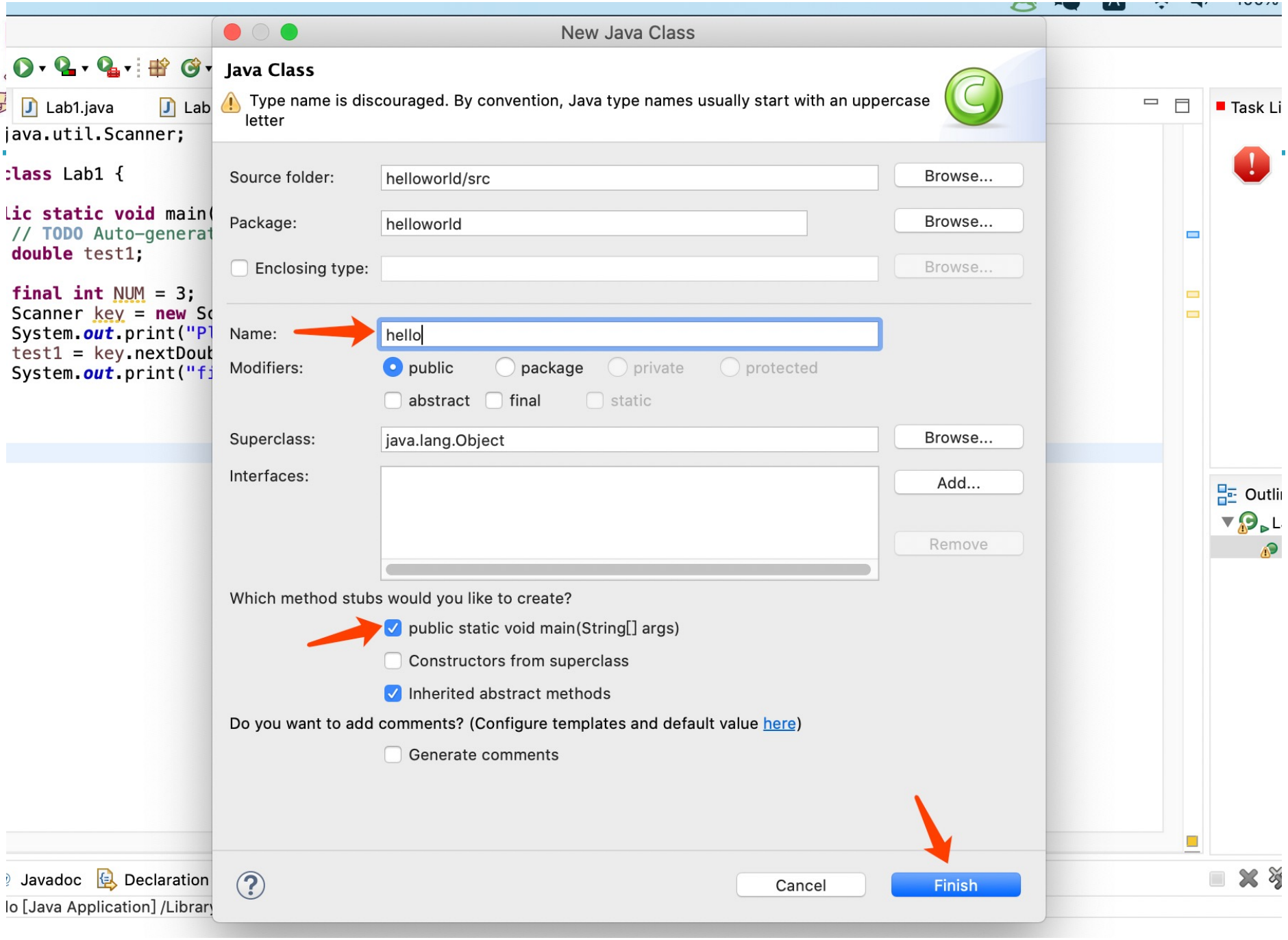
- Install an IDE or editor
  - Eclipse (my personal choice), VS Code, Notepad…

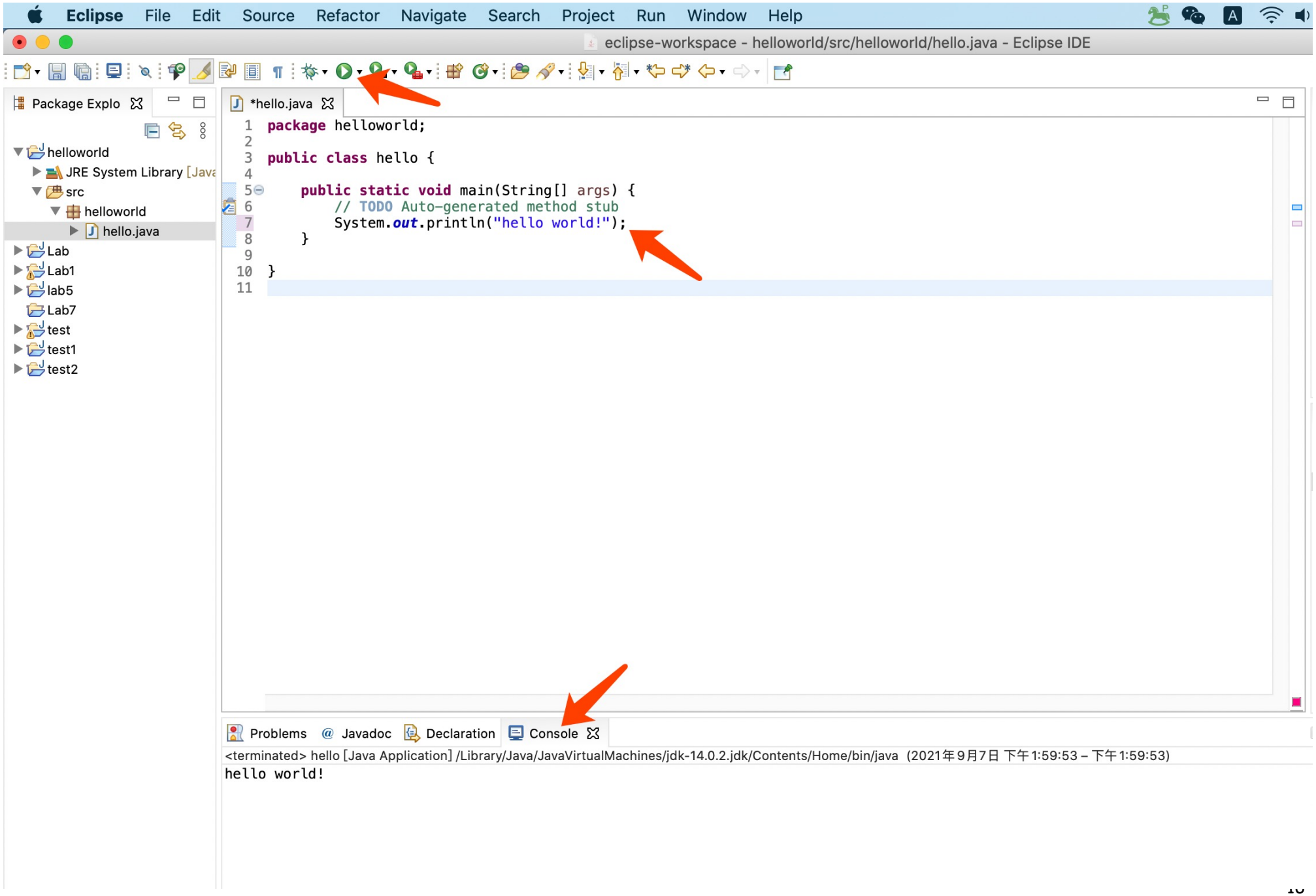
- A concise guide: https://www.runoob.com/java/java-tutorial.html


Eclipse
File
Edit
Source
Refactor
Navigate
Search
Project
Run
Window
Help
New ⌥⌘N
Open File...
Open Projects from File System...
Recent Files
Close Editor ⌘W
Close All Editors ⇧⌘W
Save ⌘S
Save As...
Save All ⇧⌘S
Revert
Move...
Rename... F2
Refresh F5
Convert Line Delimiters To
Print... ⌘P
Import...
Export...
Properties ⌘I
Switch Workspace
Restart
Java Project
Project...
Package
Class
Interface
Enum
Record
Annotation
Source Folder
Java Working Set
Folder
File
Untitled Text File
JUnit Test Case
Example...
Other... ⌘N
Create a Java project
Package Explo
Lab
Lab1
lab5
Lab7
test
test1
test2
Donate


New Java Project
Create a Java Project
Create a Java project in the workspace or in an external location.
Project name: helloworld
Use default location
Location: /Users/tianshuyu/eclipse-workspace/helloworld
Browse...
JRE
Use an execution environment JRE: JavaSE-14
Use a project specific JRE: Java SE 14.0.2 [14.0.2]
Use default JRE 'Java SE 14.0.2 [14.0.2]' and workspace compiler preferences
Configure JREs...
Project layout
Use project folder as root for sources and class files
Create separate folders for sources and class files
Configure default...
Working sets
Add project to working sets
New...
Working sets:
Select...
Module
Create module-info.java file
< Back
Next >
Cancel
Finish


Eclipse File Edit Source Refactor Navigate Search Project Run Window Help
eclipse-workspace - Lab1/src/Lab1
Package Explo
Lab1.java
Lab1.java
Lab2.java
Lab5.java
Donate
1 import java.util.Scanner;
2
hellov
Lab
Lab1
lab5
Lab7
test
test1
test2
New
Go Into
Open in New Window
Open Type Hierarchy F4
Show In ⌥⌘W
Copy ⌘C
Copy Qualified Name
Paste ⌘V
Delete
Build Path
Source ⌥⌘S
Refactor ⌥⌘T
Import...
Export...
Refresh F5
Close Project
Close Unrelated Projects
Assign Working Sets...
Java Project
Project...
Package
Class
Interface
Enum
Record
Annotation
Source Folder
Java Working Set
Folder
File
Untitled Text File
JUnit Test Case
Example...
Other... ⌘N
Create a Java class
args) {
stub
1 score: ");


New Java Class
Java Class
Type name is discouraged. By convention, Java type names usually start with an uppercase letter
Source folder:
helloworld/src
Browse...
Package:
helloworld
Browse...
Enclosing type:
Browse...
Name:
hello
Modifiers:
public
package
private
protected
abstract
final
static
Superclass:
java.lang.Object
Browse...
Interfaces:
Add...
Remove
Which method stubs would you like to create?
public static void main(String[] args)
Constructors from superclass
Inherited abstract methods
Do you want to add comments? (Configure templates and default value here)
Generate comments
Cancel
Finish
Lab1.java
Javadoc
Declaration
Task Li
Outli


Eclipse File Edit Source Refactor Navigate Search Project Run Window Help
eclipse-workspace - helloworld/src/helloworld/hello.java - Eclipse IDE
Package Explo
helloworld
JRE System Library [Java
src
helloworld
hello.java
Lab
Lab1
lab5
Lab7
test
test1
test2
*hello.java
1 package helloworld;
2
3 public class hello {
4
5 public static void main(String[] args) {
6 // TODO Auto-generated method stub
7 System.out.println("hello world!");
8 }
9
10 }
11
Problems
Javadoc
Declaration
Console
<terminated> hello [Java Application] /Library/Java/JavaVirtualMachines/jdk-14.0.2.jdk/Contents/Home/bin/java (2021年9月7日 下午1:59:53 – 下午1:59:53)
hello world!

(1) Java keywords

- Java keywords (reserved words)
  - Keywords are particular words, which acts as a key to a code
  - Keywords cannot be used as variable or object names

- Keywords of primitive types
  - int: used to declare a variable that can hold a 32-bit signed integer
  - boolean: used to declare a variable as a boolean type (true or false)
  - double: used to declare a variable that can hold a 64-bit floating-point numbers
  - char: used to declare a variable that can hold unsigned 16-bit Unicode characters
  - short: used to declare a variable that can hold a 16-bit integer
  - long: used to declare a variable that can hold a 64-bit integer
  - float: used to declare a variable that can hold a 32-bit floating-point number
  - byte: used to declare a variable that can hold an 8-bit data values

(1) Java keywords

- Keywords of loops
  - for: used to create a for loop (a variable initialization, a boolean expression, and an incrementation)
  - while: used to create a while loop, which tests a boolean expression and executes some statements if the expression is true
  - continue: used to continue the loop; it continues the current flow of the program and skips the remaining code at the specified condition
  - break: used to break loop or switch statement; it breaks the current flow of the program at specified condition
- Keywords of conditions
  - if: Java if keyword tests the condition, and the if block is executed if the condition is true
  - else: used to indicate the alternative branches in an if statement
- Keywords of classes and objects
  - class: used to declare a class
  - new: used to create new objects

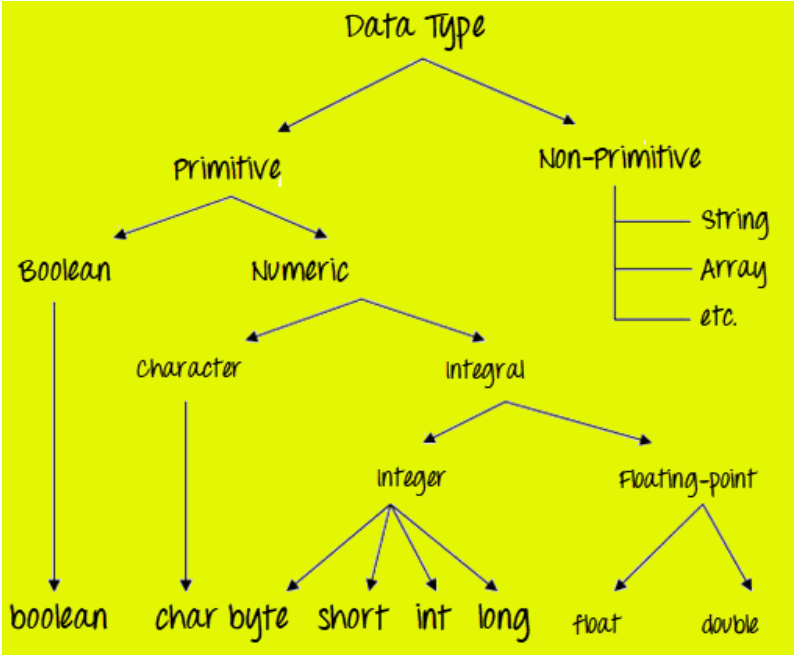
(1) Java keywords

- Keywords of exceptions
  - try: used to start a block of code that will be tested for exceptions, and the try block must be followed by either catch or finally block
  - catch: used to catch the exceptions generated by try statements, and it must be used after the try block only
  - finally: used to create a block of code following a try block; its block always executes whether an exception occurs or not

- Keywords of others
  - import: used to make classes and interfaces available and accessible to the current source code
  - package: used to declare a Java package that includes the classes
  - public: as an access modifier, it is used to indicate that an item is accessible anywhere, and it has the widest scope among all other modifiers
  - return: used to return from a method when its execution is complete
  - null: used to indicate that a reference does not refer to anything. It removes the garbage value

(2) Simple declaration

- Variable in Java is a data container, storing the data values during program execution
- Every variable is assigned a data type which designates the type and quantity of value it can hold
- Variable is a memory location name of the data
- To use variables
  - Variable declaration
  - Variable initialization



(2) Simple declaration

- Variable declaration

```
int m, n;        // Two integer variables
double x, y;     // Two real coordinates
boolean b;       // Either 'true' or 'false'
char ch;         // A character, such as 'P' or '@'
```

type

variable name

semicolon

(2) Simple declaration

- Numeric expressions are written in much the same way as in other languages

```
n = 3 * (5 + 2);
x = y / 3.141592653;
n = m % 8;       // Modulo, i.e. n is now (m mod 8)
b = true;
ch = 'x';
```

- Division operator has two different things:

```
double f;
f = 1 / 3;              // f is now 0.0
f = 1.0 / 3.0;          // f is now 0.33333333...
```

(2) Simple declaration

```
class Guru99 {
    static int a = 1; //static variable
    int data = 99; //instance variable
    void method() {
        int b = 90; //local variable
    }
}
```

- Three types of variables
  - Local variables are declared inside the body of a method
  - Instance variables are defined without STATIC keyword, and they are defined outside a method declaration, i.e., they are object specific
  - Static variables are initialized only once, at the start of the program execution; These variables should be initialized first, before the initialization of any instance variables, i.e., they are Class specific

(2) Simple declaration

- Type conversion (casting)
  - Assign a real value to an integer value: need a cast

```
double radians;
int degrees;
...
degrees = radians * 180 / 3.141592653;          // Error
degrees = (int) (radians * 180 / 3.141592653);  // OK
```

  - Assigning an integer to a real variable does not need casting

(2) Simple declaration

- A string is a sequence of characters, or an array of characters

```
//String is an array of characters
char[] arrSample = {'R', 'O', 'S', 'E'};
String strSample_1 = new String (arrSample);
```

- Use String class to handle strings

```
package codes;
import java.lang.String;

public class StringMethods {

    public static void main(String[] args) {

        String str1 = "Software";
        String str2 = "Testing";
        System.out.println(str1 + str2);
        System.out.println(str1.concat(str2));
    }
}
```

Output:

```
Problems  Javadoc  Declaration  Console
<terminated> StringMethods [Java Application] C:\Program Files\Java\
SoftwareTesting
SoftwareTesting
```

(3) Statements

- Statements can be grouped in blocks using "{ }"
- If and if-else statements

```
if (n == 3)
    x = 3.2;
```

Note:

- There is no `then` keyword
- The condition must be of boolean type and written within parentheses
- Comparison is made using '=='

- Comparison operators: >, <, ==, >=, <=, !=

```
if (x != 0)
    y = 3.0 / x;        // Executed when x is non-zero
else
    y = 1;              // Executed when x is zero
```

(3) Statements

- More about Boolean expressions

and	&&
or	||
not	!

```
int x, y;
boolean b;
...
if ((x <= 9 || y > 3) && !b) {
    b = true;
}
```

- while loop statement: need the stopping criterion

```
// Calculate exp(1). End when the term is less than 0.00001
double sum = 0.0;
double term = 1.0;
int k = 1;
while (term >= 0.00001) {
    sum = sum + term;
    term = term / k;
    k++;                    // Shortcut for 'k = k + 1'
}
```

(3) Statements

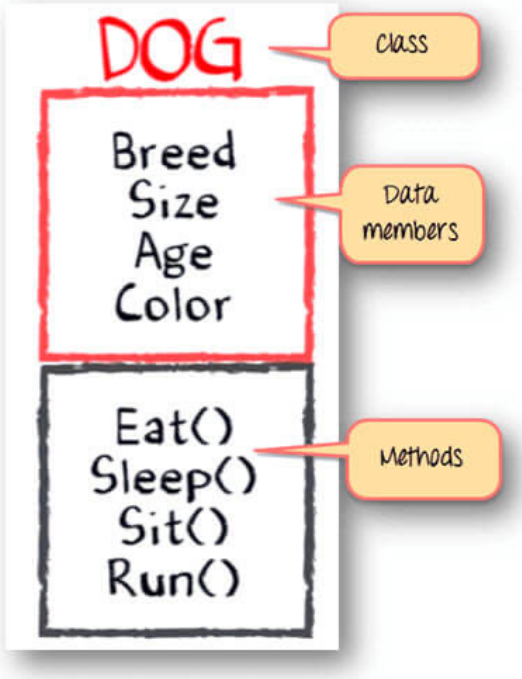
- for loop statement
  - Initial value of value i
  - Stopping criterion of the loop
  - How to change the value of i in each iteration

```
// Calculate 1 + (1/2) + (1/3) + ... + (1/100)
int i;
double sum = 0.0;
for (i = 1; i <= 100; i++) {
    sum = sum + 1.0 / i;
}
```

(4) Class/object

- A class is a blueprint or prototype that defines the variables and the methods (functions) common to all Java objects of a certain kind

- An object is a specimen of a class
  - An object is an instance of a class
  - Software objects are often used to model real-world objects you find in everyday life



(4) Class

- A class declaration contains
  - A set of attributes (called instance variables)
  - A set of functions (called methods in Java)

```
class Turtle {
    private boolean penDown;
    protected int x, y;

    // Declare some more stuff
}
```

- Methods in Java
  - Main methods: public static void main(String [ ] args){…}
  - Constructor methods: public Turtle( ){…}
  - General methods: public void jumpTo(int newX, int newY) {…}

(4) Class

- Java constructor
  - A special method for initializing a newly created object and is called just after the memory is allocated for the object
  - It can be used to initialize the objects to desired values or default values at the time of object creation
  - It is not mandatory to write a constructor for a class
- Rules for creating a java constructor
  - It has the same name as the class
  - It should not return a value (not even void)

(4) Class

- Java method
  - Method name, input parameters, method body, return type

```
class Turtle {
    // Attribute declarations, as above

    public void jumpTo(int newX, int newY) {
        x = newX;
        y = newY;
    }

    public int getX() {
        return x;
    }
}
```

```
public Turtle(int initX, int initY) {
    x = initX;
    y = initY;
    penDown = false;
}
```

(4) Class

Modifier	Class	Package	Subclass	Global
Public	Yes	Yes	Yes	Yes
Protected	Yes	Yes	Yes	No
Default	Yes	Yes	No	No
Private	Yes	No	No	No

- Access modifiers
  - The public keyword is used to declare that something can be accessed from other classes
  - The protected keyword specifies that something can be accessed from within the class and all its subclasses, but not from the outside
  - When we do not mention any access modifier, it is called default access modifier, and the scope of this modifier is limited to the package only
  - The private declaration means that those attributes cannot be accessed outside of the class
    - In general, attributes should be kept private

(4) Class

- In Java, statements can only be written within methods in classes
  - There must be some method which is called by the system when the program starts executing, which is main method

```
01. public class HelloWorld {
02.     public static void main(String[] args){
03.         System.out.println("Hello World!");
04.     }
05. }
```

- Notes
  - static keyword: when the main method is called, it is not associated with an object, but with the class
  - The parameter args: if the Java interpreter is given any more information than the class name, this data is passed on to the main method in this parameter

(4) Class

- The keyword new is used to create an object of a class

```
Turtle t;
t = new Turtle(100, 100);
```

- Calling methods in objects

```
int a = t.getX();
t.jumpTo(300, 200);
```

  - Java has garbage collection, so no need to destroy objects manually

```
public class ConfunDemo3 {
    public static void main(String[] args){
        Person z=new Person("zhangsan",3);
        z.show();
    }
}

class Person{
    private String name;
    private int age;
    public Person(String n,int m){
        name=n;
        age=m;
    }
    //getter
    public String getName(){
        return name;
    }
    public int getAget(){
        return age;
    }
    public void show(){
        System.out.println(name+"\n"+age);
    }
}
```

(5) Exception

- Many things can go wrong during the execution of a program (programmers may introduce faults)
  - E.g., division by zero or calling a method with a null reference

- Throw exceptions
  - E.g., consider a method to read a positive integer from the keyboard; what if the input character is not an integer?

```
public int getNatural() throws IOException {
    char ch;
    while (more input) {
        ch = (read character);
        if (ch < '0' || ch > '9') {
            throw new IOException("bad natural number");
        }
        ...
    }
    ...
}
```

(5) Exception

- Catch exceptions
  - The statement(s) within the try clause are executed as usual, but whenever an exception occurs, the try clause is interrupted and the statements within the corresponding catch clause are executed

```
int m, n;
try {
    n = getNatural();
    m = n * 2; // If an exception is thrown, this is not executed
}
catch (IOException e) {
    // The user entered something wrong. Use 1 as default.
    n = 1;
    m = 2;
}
```

(6) Others

- Print something: writing to the console
  - System.out.print(xxx)
  - System.out.println(xxx)

```
System.out.print("Jag vill bo ");
System.out.println("i en svamp");
System.out.println("Annars får jag kramp");
```

The resulting output is:

```
Jag vill bo i en svamp
Annars får jag kramp
```

Variable values can be printed like this:

```
int a;
a = 6 * 7;
System.out.println("6 * 7 = " + a);
```

(6) Others

- Packages
  - **Package in Java** is a collection of classes, sub-packages, and interfaces
  - It helps organize your classes into a folder structure and make it easy to locate and use them
  - More importantly, it helps improve code reusability

```
import java.awt.*;
```

(6) Others

- Comments
  - Single sentence: two forward slashes //
  - A block of codes: /* xxx */

```
1  import java.util.*;
2
3  /**
4   * This program demonstrates object construction.
5   * @version 1.01 2004-02-19
6   * @author Cay Horstmann
7   */
8  public class ConstructorTest
9  {
10    public static void main(String[] args)
11    {
12       // fill the staff array with three Employee objects
13       Employee[] staff = new Employee[3];
14
15       staff[0] = new Employee("Harry", 40000);
16       staff[1] = new Employee(60000);
17       staff[2] = new Employee();
18
19       // print out information about all Employee objects
20       for (Employee e : staff)
21          System.out.println("name=" + e.getName() + ",id=" + e.getId() + ",salary="
22                + e.getSalary());
23    }
24 }
```

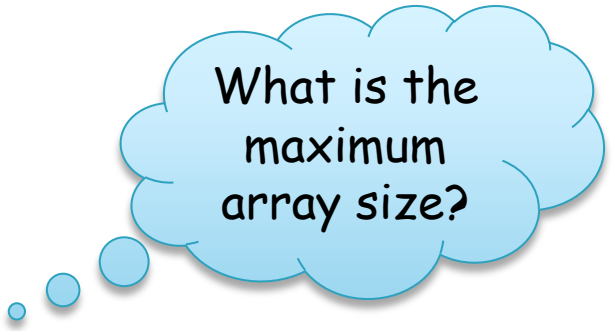
(6) Others

- Array
  - Declaration

```
int[] someInts;       // An integer array
Turtle[] turtleFarm;  // An array of references to Turtles
```

  - Initialization

```
someInts = new int[30];
turtleFarm = new Turtle[100];
```



  - Use arrays: 0 ~ size-1

```
int i;
for (i = 0; i < someInts.length; i = i + 1) {
    someInts[i] = i * i;
}
```

(6) Others

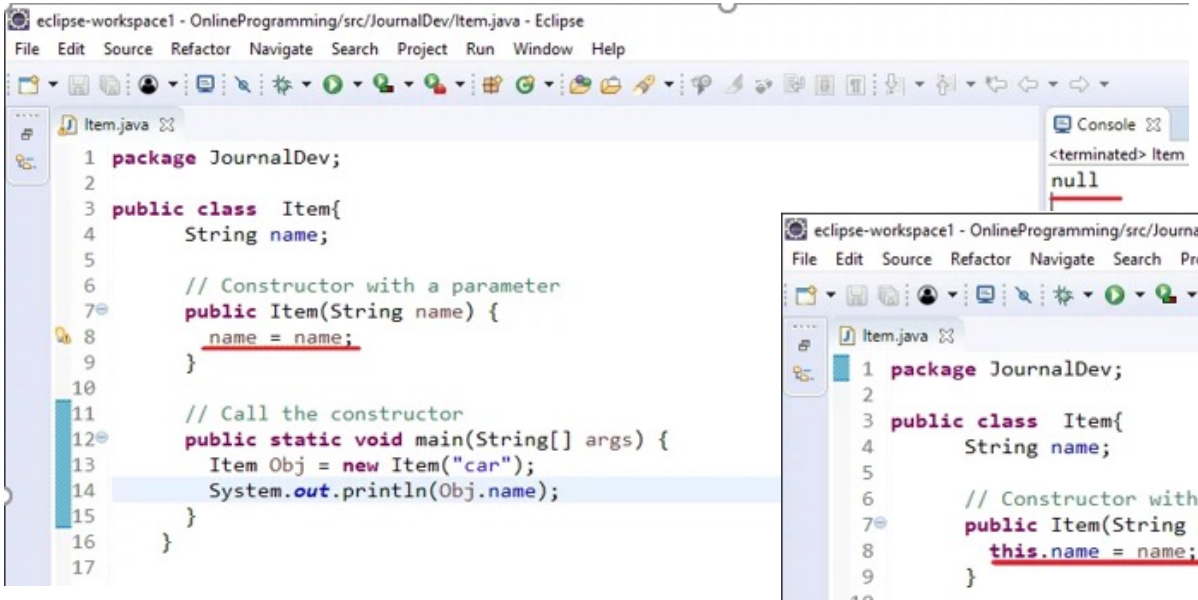
- ArrayList is a data structure that can
  - be stretched to accommodate additional elements within itself
  - shrink back to a smaller size when elements are removed

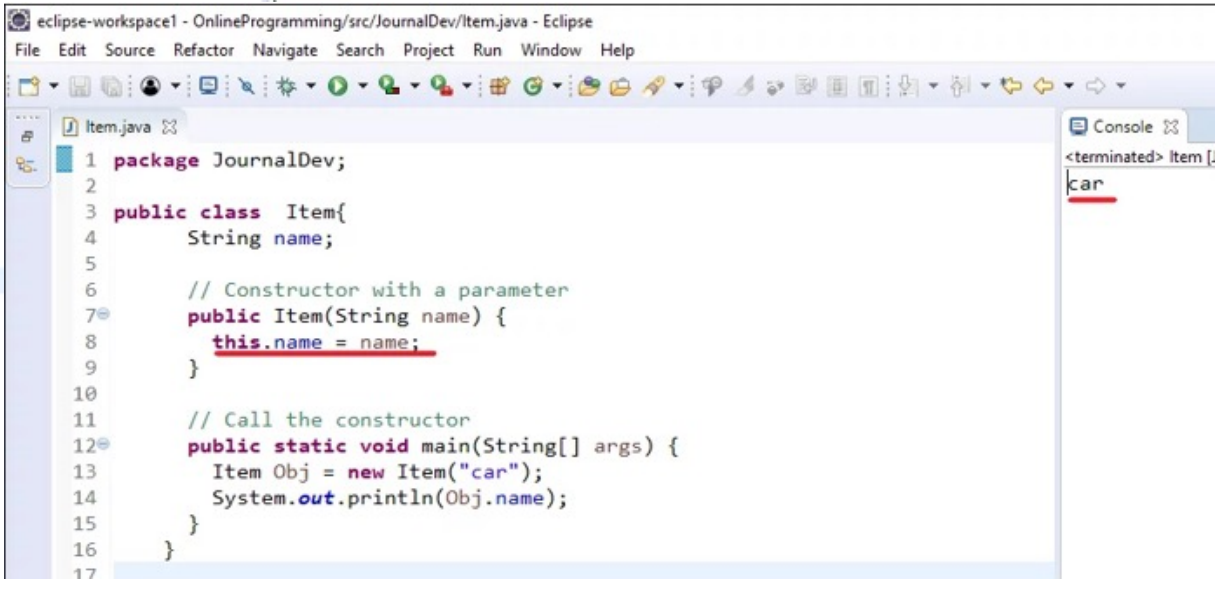
```
ArrayList<Object> a = new ArrayList<Object>();
add(Object o);
remove(Object o);
```

- Notes
  - A key data structure for handling dynamic behaviors of elements
  - When the number of elements is larger than its initial size, it creates another larger interval array and then copied the existing elements to the new interval array
  - Although it provides more flexibility, it often take more space cost than an array

(6) Others

- Keyword "this"
  - **this** keyword in Java is a reference variable that refers to the current object of a method or a constructor
  - The main purpose of using this keyword is to remove the confusion between class attributes and parameters that have same names





(6) Others

eclipse-workspace - CSC3100/src/javaIO/MyIOClass.java - Eclipse

Package Explorer

- CSC3100
  - JRE System Library [JavaSE-
  - src
    - javaIO
      - MyIOClass.java

MyIOClass.java

```
1  package javaIO;
2  import java.io.BufferedReader;
7
8  public class MyIOClass {
9
10     public static void main(String[] args) {
11         String inFilePath = "/Users/yxfang/Documents/eclipse-workspace/inputInfo";
12         String outFilePath  = "/Users/yxfang/Desktop/eclipse-workspace/outputInfo";
13         try {
14             FileReader fileReader = new FileReader(inFilePath);
15             BufferedReader stdin = new BufferedReader(fileReader);
16
17             FileWriter fileWriter = new FileWriter(outFilePath);
18             BufferedWriter stdout = new BufferedWriter(fileWriter);
19
20             String line = null;
21             while((line = stdin.readLine()) != null) {
22                 String s[ ] = line.split(" ");
23                 int a = Integer.parseInt(s[0]);
24                 int b = Integer.parseInt(s[1]);
25
26                 int sum = a + b;
27                 String sumStr = String.valueOf(sum);
28                 stdout.write(sumStr);
29                 stdout.newLine();
30             }
31
32             stdout.flush();
33             stdout.close();
34             stdin.close();
35         }catch(IOException e) {
36             System.out.println("something wrong");
37             e.printStackTrace();
38             System.exit(0);
39         }
40     }
41
42 }
```

inputInfo

```
1 1 3
2 2 4
3 5 6
4
```

outputInfo

```
1 4
2 6
3 11
4
```

Problems Javadoc Declaration Console

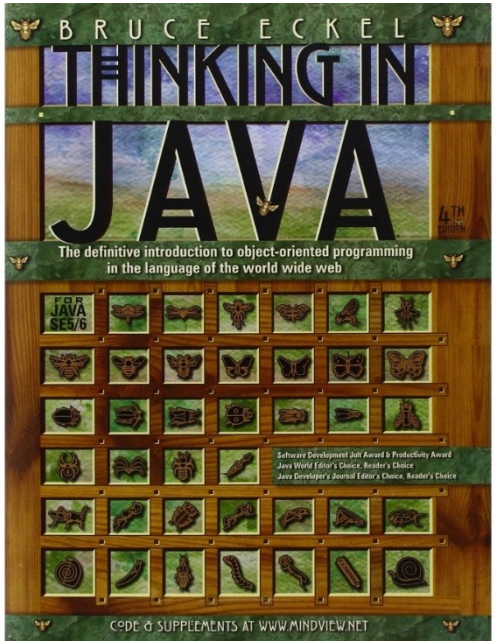
<terminated> MyIOClass [Java Application] /Library/Java/JavaVirtualMachines/jdk1.8.0_151.jdk/Contents/Home/bin/java (2021年6月4日 下午3:06:24)

javaIO.MyIOClass.java - CSC3100/src

More information

- Shortcut keys in IDE
  - E.g., in Eclipse IDE, to import packages automatically, we can use shortcut key: "Shit" + "Ctrl" + "o"

- More online materials
  - https://www.guru99.com/java-tutorial.html
  - https://fileadmin.cs.lth.se/cs/Education/EDA040/common/java21.pdf
  - Book: Think in Java



Materials for self-learning

Example: Fibonacci Series

- In Fibonacci series, next number is the sum of previous two numbers.
  - 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55 etc.
  - The first two numbers of Fibonacci series are 0 and 1.

- Two ways to write the Fibonacci series program:
  - Fibonacci Series without using **recursion**
  - Fibonacci Series using recursion

- We will see
  - Defining variables
  - Loop
  - Recursion

```java
class FibonacciExample1
{
    public static void main(String args[])
    {
        int n1 = 0, n2 = 1, n3, i, count = 10;
        System.out.print(n1 + " " + n2); //printing 0 and 1

        for(i = 2; i < count; ++i) //loop starts from 2 because 0 and 1 are already printed
        {
            n3 = n1 + n2;
            System.out.print(" " + n3);
            n1 = n2;
            n2 = n3;
        }

    }
}
```

```java
class FibonacciExample2
{
    static int n1 = 0, n2 = 1, n3 = 0;
    static void printFibonacci(int count)
    {
        if(count > 0)
        {
            n3 = n1 + n2;
            n1 = n2;
            n2 = n3;
            System.out.print(" " + n3);
            printFibonacci(count - 1);
        }
    }
    public static void main(String args[])
    {
        int count = 10;
        System.out.print(n1 + " " + n2); //printing 0 and 1
        printFibonacci(count - 2); //n-2 because 2 numbers are already printed
    }
}
```

Example: Greatest Common Diviser

- Given two numbers, find the greatest common diviser (GCD)
  - for example, GCD of 15 and 20 is 5; GCD of 7 and 5 is 1.
- Algorithm 1
  - iterate from the smaller number given to 1
- Algorithm 2 (Euclid's Algorithm)
  - if we subtract the smaller number from the larger number, the GCD doesn't change
  - when the smaller number exactly divides the larger number, the smaller number is the GCD of the two given numbers.

```
3 public class gcd1 {
4     static int gcdByBruteForce(int n1, int n2) {
5         int gcd = 1;
6         for (int i = 1; i <= n1 && i <= n2; i++) {
7             if (n1 % i == 0 && n2 % i == 0) {
8                 gcd = i;
9             }
0         }
1         return gcd;
2     }
3     public static void main(String[] args) {
4         // TODO Auto-generated method stub
5         int a = 15, b = 5;
6         int g = gcdByBruteForce(a, b);
7         System.out.println("GCD of " + a + " and " + b + " is: " + g);
8     }
9
0 }
```

```java
public class gcd2 {
    static int gcdByEuclidsAlgorithm(int n1, int n2) {
        if (n2 == 0) {
            return n1;
        }
        return gcdByEuclidsAlgorithm(n2, n1 % n2);
    }
    public static void main(String[] args) {
        // TODO Auto-generated method stub
        int a = 15, b = 5;
        int g = gcdByEuclidsAlgorithm(a, b);
        System.out.println("GCD of " + a + " and " + b + " is: " + g);
    }

}
```

Example: Prime Numbers

- Verify prime number in Java: Prime number is a number that is greater than 1 and divided by 1 or itself only. For example, 2, 3, 5, 7, 11, 13, 17.... are the prime numbers.

```java
public class PrimeExample
{
    public static void main(String args[])
    {
        int i, m = 0, flag = 0;
        int n = 3; //it is the number to be checked
        m = n / 2;
        if(n == 0 || n == 1)
        {
            System.out.println(n + " is not prime number");
        }
        else
        {
            for(i = 2; i <= m; i++)
            {
                if(n % i == 0)
                {
                    System.out.println(n + " is not prime number");
                    flag = 1;
                    break;
                }
            }
            if(flag == 0)
            {
                System.out.println(n + " is prime number");
            }
        }//end of else
    }
}
```

Example: Palindrome

- A palindrome number is a number that is same after reverse.
  - 545, 151, 34543, 343, 171, 48984 are the palindrome numbers.
- Algorithm
  - Get the number to check for palindrome
  - Hold the number in temporary variable
  - Reverse the number
  - Compare the temporary number with reversed number
  - If both numbers are same, print "palindrome number"
  - Else print "not palindrome number"

```java
class PalindromeExample
{
    public static void main(String args[])
    {
        int r, sum = 0, temp;
        int n = 454; //It is the number variable to be checked for palindrome

        temp = n;
        while(n > 0)
        {
            r = n % 10; //getting remainder
            sum = (sum * 10) + r;
            n = n / 10;
        }
        if(temp == sum)
            System.out.println("palindrome number ");
        else
            System.out.println("not palindrome");
    }
}
```

```
palindrome  number
```

```java
import java.util.*;
class PalindromeExample2
{
    public static void main(String args[])
    {
        String original, reverse = ""; // Objects of String class
        Scanner in = new Scanner(System.in);
        System.out.println("Enter a string/number to check if it is a palindrome");
        original = in.nextLine();
        int length = original.length();
        for ( int i = length - 1; i >= 0; i-- )
            reverse = reverse + original.charAt(i);
        if (original.equals(reverse))
            System.out.println("Entered string/number is a palindrome.");
        else
            System.out.println("Entered string/number isn't a palindrome.");
    }
}
```

Example: Object

- The object is a basic building block of an OOPs language. We cannot execute any Java program without creating an object.

- Five ways to create an object in Java.
  - Using new Keyword: the most popular way to create an object or instance of the class. When we create an instance of the class by using the new keyword, it allocates memory for the newly created **object** and also returns the **reference** of that object to that memory. The new keyword is also used to create an array.
  - Using clone() method
  - Using newInstance() method of the Class class
  - Using newInstance() method of the Constructor class
  - Using Deserialization

Object vs. Class

No.	Object	Class
1)	Object is an **instance** of a class.	Class is a **blueprint or template** from which objects are created.
2)	Object is a **real world entity** such as pen, laptop, mobile, bed, keyboard, mouse, chair etc.	Class is a **group of similar objects**.
3)	Object is a **physical** entity.	Class is a **logical** entity.
4)	Object is created through **new keyword** mainly e.g. Student s1=new Student();	Class is declared using **class keyword** e.g. class Student{}
5)	Object is created **many times** as per requirement.	Class is declared **once**.
6)	Object **allocates memory when it is created**.	Class **doesn't allocated memory when it is created**.
7)	There are **many ways to create object** in java such as new keyword, newInstance() method, clone() method, factory method and deserialization.	There is only **one way to define class** in java using class keyword.

```java
public class CreateObjectExample1
{
    void show()
    {
        System.out.println("Welcome to javaTpoint");
    }
    public static void main(String[] args)
    {
        //creating an object using new keyword
        CreateObjectExample1 obj = new CreateObjectExample1();
        //invoking method using the object
        obj.show();
    }
}
```

Example: Printing ASCII value

- ASCII: American Standard Code for Information Interchange.
  - A 7-bit character set contains 128 (0 to 127) characters.
  - It represents the numerical value of a character.
  - Example: ASCII value of A is 65

- Two ways to print ASCII value:
  - Assigning a Variable to the int Variable
  - Using **Type-Casting**

```java
public class PrintAsciiValueExample1
{
    public static void main(String[] args)
    {
        // character whose ASCII value to be found
        char ch1 = 'a';
        char ch2 = 'b';
        // variable that stores the integer value of the character
        int asciivalue1 = ch1;
        int asciivalue2 = ch2;
        System.out.println("The ASCII value of " + ch1 + " is: " + asciivalue1);
        System.out.println("The ASCII value of " + ch2 + " is: " + asciivalue2);
    }
}
```

```
The ASCII value of a is: 97
The ASCII value of b is: 98
```

```java
public class PrintAsciiValueExample2
{
    public static void main(String[] String)
    {
        int ch1 = 'a';
        int ch2 = 'b';
        System.out.println("The ASCII value of a is: " + ch1);
        System.out.println("The ASCII value of b is: " + ch2);
    }
}
```

```
The ASCII value of a is: 97
The ASCII value of b is: 98
```

Example: Count Characters

- Iterate through the string and count the characters.
  - STEP 1: START
  - STEP 2: DEFINE String *string = "The best of both worlds".*
  - STEP 3: SET *count =0.*
  - STEP 4: SET *i=0.* REPEAT STEP 5 to STEP 6 as long as *i<string.length*
  - STEP 5: IF *(string.charAt(i)!= ' ')* then *count =count +1.*
  - STEP 6: *i=i+1*
  - STEP 7: PRINT *count.*
  - STEP 8: END

```java
public class CountCharacter
{
    public static void main(String[] args)
    {
        String string = "The best of both worlds";
        int count = 0;

        //Counts each character except space
        for(int i = 0; i < string.length(); i++)
        {
            if(string.charAt(i) != ' ')
                count++;
        }

        //Displays the total number of characters present in the given string
        System.out.println("Total number of characters in a string: " + count);
    }
}
```

```
Total number of characters in a string: 19
```

Example: Count Punctuation Characters

- Algorithm
  - Define a string or read from the user.
  - Declare a variable to count the number of punctuations and initialized it with 0.
  - Match each character with the punctuation marks (!, . , ' , - , " , ? , ;). If any character in the string is matched, increase the count variable by 1.
  - Print the count variable that gives the total number of punctuations.

```java
public class CountPunctuation
{
    public static void main (String args[])
    {
        //Stores the count of punctuation marks
        int count = 0;
        String str = "He said, 'The mailman loves you.' I heard it with my own ears.";
        for (int i = 0; i < str.length(); i++)
        {
            //Checks whether given character is punctuation mark
            if(str.charAt(i) == '!' || str.charAt(i) == ',' || str.charAt(i) == ';' || str.
              charAt(i) == '.' ||  str.charAt(i) == '?' || str.charAt(i) == '-' ||
                    str.charAt(i) == '\'' || str.charAt(i) == '\"' || str.charAt(i) == ':')
            {
                count++;
            }
        }
        System.out.println("The number of punctuations exists in the string is: " + count);
    }
}
```

```
The number of punctuations exists in the string is: 5
```

Example: Replace Characters

- Replace lower-case characters in a string to upper-case and vice versa.
  - STEP 1: START
  - STEP 2: DEFINE a string *str = "Great Power"*.
  - STEP 3: DEFINE *newstr* as StringBuffer object .
  - STEP 4: SET *i=0*. REPEAT STEP 5 to STEP 6 as long as *i<str.length()*.
  - STEP 5: IF lower-case character encountered then CONVERT in upper-case. ELSEIF upper-case character encountered then CONVERT in lower-case.
  - STEP 6: *i=i+1*
  - STEP 7: PRINT *newstr*.
  - STEP 8: END

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

        String str1 = "Great Power";
        StringBuffer newStr = new StringBuffer(str1);

        for(int i = 0; i < str1.length(); i++)
        {

            //Checks for lower case character
            if(Character.isLowerCase(str1.charAt(i)))
            {
                //Convert it into upper case using toUpperCase() function
                newStr.setCharAt(i, Character.toUpperCase(str1.charAt(i)));
            }
            //Checks for upper case character
            else if(Character.isUpperCase(str1.charAt(i)))
            {
                //Convert it into upper case using toLowerCase() function
                newStr.setCharAt(i, Character.toLowerCase(str1.charAt(i)));
            }
        }
        System.out.println("String after case conversion : " + newStr);
    }
}
```

```
String after case conversion: gREAT pOWER
```

Example: check rotation of a string

- Check whether string 2 is a rotation of string 1: Concatenate string 1 with string 1. If string 2 is present in concatenated string then, string 2 is rotation of string 1.
  - STEP 1: START
  - STEP 2: DEFINE String *str1 = "abcde"*, *str2 = "deabc"*
  - STEP 3: IF length of *str1* not equals to *str2* then PRINT *"No"* else go to STEP 4
  - STEP 4: CONCATENATE *str1* with *str1*.
  - STEP 5: IF *str2* present in *str1* then PRINT "Yes" else PRINT "No".
  - STEP 6: END

```java
public class StringRotation
{
    public static void main(String[] args)
    {
        String str1 = "abcde", str2 = "deabc";

        if(str1.length() != str2.length())
        {
            System.out.println("Second string is not a rotation of first string");
        }
        else
        {
            //Concatenate str1 with str1 and store it in str1
            str1 = str1.concat(str1);
            //Check whether str2 is present in str1
            if(str1.indexOf(str2) != -1)
                System.out.println("Second string is a rotation of first string");
            else
                System.out.println("Second string is not a rotation of first string");
        }
    }
}
```

```
Second string is a rotation of first string
```

Example: file handling (I/O)

- The File class is an abstract representation of file and directory pathname.
  - A pathname can be either absolute or relative.
- The File class have methods for working with directories and files:
  - creating new directories or files
  - deleting and renaming directories or files
  - listing the contents of a directory, etc.
- VERY USEFUL IN THIS CLASS

https://www.javatpoint.com/java-file-class

Modifier and Type	Method	Description
static File	createTempFile(String prefix, String suffix)	It creates an empty file in the default temporary-file directory, using the given prefix and suffix to generate its name.
boolean	createNewFile()	It atomically creates a new, empty file named by this abstract pathname if and only if a file with this name does not yet exist.
boolean	canWrite()	It tests whether the application can modify the file denoted by this abstract pathname.String[]
boolean	canExecute()	It tests whether the application can execute the file denoted by this abstract pathname.
boolean	canRead()	It tests whether the application can read the file denoted by this abstract pathname.
boolean	isAbsolute()	It tests whether this abstract pathname is absolute.
boolean	isDirectory()	It tests whether the file denoted by this abstract pathname is a directory.
boolean	isFile()	It tests whether the file denoted by this abstract pathname is a normal file.
String	getName()	It returns the name of the file or directory denoted by this abstract pathname.
String	getParent()	It returns the pathname string of this abstract pathname's parent, or null if this pathname does not name a parent directory.
Path	toPath()	It returns a java.nio.file.Path object constructed from the this abstract path.
URI	toURI()	It constructs a file: URI that represents this abstract pathname.
File[]	listFiles()	It returns an array of abstract pathnames denoting the files in the directory denoted by this abstract pathname
long	getFreeSpace()	It returns the number of unallocated bytes in the partition named by this abstract path name.
String[]	list(FilenameFilter filter)	It returns an array of strings naming the files and directories in the directory denoted by this abstract pathname that satisfy the specified filter.
boolean	mkdir()	It creates the directory named by this abstract pathname.

```java
import java.io.*;
public class FileDemo
{
    public static void main(String[] args)
    {

        try
        {
            File file = new File("javaFile123.txt");
            if (file.createNewFile())
            {
                System.out.println("New File is created!");
            }
            else
            {
                System.out.println("File already exists.");
            }
        }
        catch (IOException e)
        {
            e.printStackTrace();
        }

    }
}
```

```
New File is created!
```

```java
import java.io.*;
public class FileDemo2
{
    public static void main(String[] args)
    {

        String path = "";
        boolean bool = false;
        try
        {
            // createing  new files
            File file  = new File("testFile1.txt");
            file.createNewFile();
            System.out.println(file);
            // createing new canonical from file object
            File file2 = file.getCanonicalFile();
            // returns true if the file exists
            System.out.println(file2);
            bool = file2.exists();
            // returns absolute pathname
            path = file2.getAbsolutePath();
            System.out.println(bool);
            // if file exists
            if (bool)
            {
                // prints
                System.out.print(path + " Exists? " + bool);
            }
        }
        catch (Exception e)
        {
            // if any error occurs
            e.printStackTrace();
        }
    }
}
```

```
testFile1.txt
/home/Work/Project/File/testFile1.txt
true
/home/Work/Project/File/testFile1.txt Exists? true
```

```java
import java.io.*;
public class FileExample
{
    public static void main(String[] args)
    {
        File f = new File("/Users/sonoojaiswal/Documents");
        String filenames[] = f.list();
        for(String filename : filenames)
        {
            System.out.println(filename);
        }
    }
}
```

```
"info.properties"
"info.properties".rtf
.DS_Store
.localized
Alok news
apache-tomcat-9.0.0.M19
apache-tomcat-9.0.0.M19.tar
bestreturn_org.rtf
BIODATA.pages
BIODATA.pdf
BIODATA.png
struts2jars.zip
workspace
```

```java
import java.io.*;
public class FileExample
{
    public static void main(String[] args)
    {
        File dir = new File("/Users/Documents");
        File files[] = dir.listFiles();
        for(File file : files)
        {
            System.out.println(file.getName() + " Can Write: " + file.canWrite() + "Is Hidden: "
                + file.isHidden() + " Length: " + file.length() + " bytes");
        }
    }
}
```

```
"info.properties" Can Write: true Is Hidden: false Length: 15 bytes
"info.properties".rtf Can Write: true Is Hidden: false Length: 385 bytes
.DS_Store Can Write: true Is Hidden: true Length: 36868 bytes
.localized Can Write: true Is Hidden: true Length: 0 bytes
Alok news Can Write: true Is Hidden: false Length: 850 bytes
apache-tomcat-9.0.0.M19 Can Write: true Is Hidden: false Length: 476 bytes
apache-tomcat-9.0.0.M19.tar Can Write: true Is Hidden: false Length: 13711360 bytes
bestreturn_org.rtf Can Write: true Is Hidden: false Length: 389 bytes
BIODATA.pages Can Write: true Is Hidden: false Length: 707985 bytes
BIODATA.pdf Can Write: true Is Hidden: false Length: 69681 bytes
BIODATA.png Can Write: true Is Hidden: false Length: 282125 bytes
workspace Can Write: true Is Hidden: false Length: 1972 bytes
```

Example: fileinputstream & fileoutputstream

- Java FileInputStream class obtains input bytes from a file.
  - used for reading byte-oriented data (streams of raw bytes) such as image, audio etc.
  - can also read character-stream data.
  - For reading streams of characters, it is preferred to use FileReader.

- FileOutputStream write primitives values into a file.
  - Write byte-oriented and character-oriented data.
  - For character-oriented data, it is preferred to use FileWriter.

https://www.javatpoint.com/java-fileinputstream-class
https://www.javatpoint.com/java-fileoutputstream-class

Java FileInputStream class methods

Method	Description
int available()	It is used to return the estimated number of bytes that can be read from the input stream.
int read()	It is used to read the byte of data from the input stream.
int read(byte[] b)	It is used to read up to **b.length** bytes of data from the input stream.
int read(byte[] b, int off, int len)	It is used to read up to **len** bytes of data from the input stream.
long skip(long x)	It is used to skip over and discards x bytes of data from the input stream.
FileChannel getChannel()	It is used to return the unique FileChannel object associated with the file input stream.
FileDescriptor getFD()	It is used to return the FileDescriptor object.
protected void finalize()	It is used to ensure that the close method is call when there is no more reference to the file input stream.
void close()	It is used to closes the stream.

```java
import java.io.FileInputStream;
public class DataStreamExample
{
    public static void main(String args[])
    {
        try
        {
            FileInputStream fin = new FileInputStream("D:\\testout.txt");
            int i = fin.read();
            System.out.print((char)i);

            fin.close();
        }
        catch(Exception e)
        {
            System.out.println(e);
        }
    }
}
```

Note: Before running the code, a text file named as "**testout.txt**" is required to be created. In this file, we are having following content:

```
Welcome to javatpoint.
```

After executing the above program, you will get a single character from the file which is 87 (in byte form). To see the text, you need to convert it into character.

Output:

```
W
```

```java
import java.io.FileInputStream;
public class DataStreamExample
{
    public static void main(String args[])
    {
        try
        {
            FileInputStream fin = new FileInputStream("D:\\testout.txt");
            int i = 0;
            while((i = fin.read()) != -1)
            {
                System.out.print((char)i);
            }
            fin.close();
        }
        catch(Exception e)
        {
            System.out.println(e);
        }
    }
}
```

```
Welcome to javaTpoint
```

FileOutputStream class methods

Method	Description
protected void finalize()	It is used to clean up the connection with the file output stream.
void write(byte[] ary)	It is used to write **ary.length** bytes from the byte array to the file output stream.
void write(byte[] ary, int off, int len)	It is used to write **len** bytes from the byte array starting at offset **off** to the file output stream.
void write(int b)	It is used to write the specified byte to the file output stream.
FileChannel getChannel()	It is used to return the file channel object associated with the file output stream.
FileDescriptor getFD()	It is used to return the file descriptor associated with the stream.
void close()	It is used to closes the file output stream.

```java
import java.io.FileOutputStream;
public class FileOutputStreamExample
{
    public static void main(String args[])
    {
        try
        {
            FileOutputStream fout = new FileOutputStream("D:\\testout.txt");
            fout.write(65);
            fout.close();
            System.out.println("success...");
        }
        catch(Exception e)
        {
            System.out.println(e);
        }
    }
}
```

```
Success...
```

The content of a text file **testout.txt** is set with the data **A**.

testout.txt

```
A
```

```java
import java.io.FileOutputStream;
public class FileOutputStreamExample
{
    public static void main(String args[])
    {
        try
        {
            FileOutputStream fout = new FileOutputStream("D:\\testout.txt");
            String s = "Welcome to javaTpoint.";
            byte b[] = s.getBytes(); //converting string into byte array
            fout.write(b);
            fout.close();
            System.out.println("success...");
        }
        catch(Exception e)
        {
            System.out.println(e);
        }
    }
}
```

```
Success...
```

The content of a text file **testout.txt** is set with the data **Welcome to javaTpoint.**

testout.txt

```
Welcome to javaTpoint.
```

Example: filereader & filewriter

- Both FileReader and FileWriter classes are character-oriented (for text file)
  - FileReader is used to read data from the file.
  - It returns data in byte format like FileInputStream class.
  - FileWriter is used to write character-oriented data to a file.
  - Unlike FileOutputStream class, no need to convert string into byte array.

```java
import java.io.FileReader;
public class FileReaderExample
{
    public static void main(String args[])throws Exception
    {
        FileReader fr = new FileReader("D:\\testout.txt");
        int i;
        while((i = fr.read()) != -1)
            System.out.print((char)i);
        fr.close();
    }
}
```

Here, we are assuming that you have following data in "testout.txt" file:

```
Welcome to javaTpoint.
```

Output:

```
Welcome to javaTpoint.
```

```java
import java.io.FileWriter;
public class FileWriterExample
{
    public static void main(String args[])
    {
        try
        {
            FileWriter fw = new FileWriter("D:\\testout.txt");
            fw.write("Welcome to javaTpoint.");
            fw.close();
        }
        catch(Exception e)
        {
            System.out.println(e);
        }
        System.out.println("Success...");
    }
}
```