**Complete Java Masterclass**By Tim Buchalka

**UI / Shortcuts**

* Type sout and press enter to get ‘System.out.println();’.
* Type psvm and press enter to get ‘**p**ublic **s**tatic **v**oid **m**ain(String[] args) {}’.
* Use Code > Reformat Code to fix code formatting automatically.
* Double LMB the tab to make it full screen.
* Highlight code then press Ctrl+/ to comment it out/in.
* Use Code > Generate (alt + insert) to quickly generate boilerplate code for your classes, e.g. getters, setters, constructors, overridden methods, etc.
* Use View > Tool Windows > TODO (alt+6) to see any ‘// … TODO …’ comments in the code.
* Ctrl+LMB a class/method/etc declaration to see it’s definition, or do it on a definition to see uses of it.
* Code completion is when the IDE suggests entities depending on the context. The **v** refers to a variable, the **p** refers to a parameter, the **f** refers to a field, the **m** refers to a method, the **c** refers to a class, the **I** refers to an interface. The **lock** icon refers to a private variable, the **unlocked lock** icon refers to a public variable, the electric symbol refers to a throwable class or subclass.

**General Language Features**

**Section 4 – Variables, Datatypes and Operators**

To output something to the console: System.out.println(). You can type sout and press enter to generate that quickly.

A **literal** is a fixed value assigned to a datatype within Java, e.g. *5 (int), 10.0 (double), 244L (long), ‘a’ (char), true/false (boolean), “hello” (String), etc*. An **expression** contains literals, variables, operators or method calls. You ignore the datatype, *e.g. int num = 5; 5* is the literal, and *num = 5* is the expression. Expressions have been highlighted, and literals have been bolded:

int score = **100**;  
if (score > **99**) {

System.out.println(**“You got the high score!”**);

score = **0**;

}

**Integers** (*int*) take 4 bytes (32 bits) and can therefore store 232 possible values. Half of these are in the positive range, and half in the negative. 0 is counted as a positive value, hence the positive range is -1 of the negative range. So *int max = 2147483647*, and *int min = -2147483648*.

Literals can contain **underscores** to make them easier to read, e.g. *int max = 2\_147\_483\_647*. The underscores can be played anywhere in the sequence if it’s not in the beginning or end, e.g. *int max = 2\_\_1\_47\_483\_647*.

**Byte** (*byte*) is just 1 byte (8 bits) in size. It can only store values from -128 to 127. There isn’t anything smaller than a byte since a byte is the smallest data that can be fit into memory.

**Short** (*short*) is 2 bytes (16 bits) in size. It can store values from -32768 to 32767.

If the literal value exceeds these limits, then the compiler will give an error. You can cast the value to ‘wrap around’, e.g. *byte num = (byte) 128* (num will be -128), *byte num = (byte) 129* (num will be -127), etc.

**Width** is the size of a datatype in bits, e.g. width of short is 16.

**Long** (long) is 8 bytes (64 bits) in size. To create a long literal you must append L, e.g. *long num = 100L*. You can use lowercase L, but uppercase is easier to read.

In width order: byte < short < int < long. To convert a larger width datatype to a smaller width datatype you will have to cast. So all other types must be manually casted to byte, whereas none of them need to be casted to long as the compiler will automatically do it. Examples: *int num1 = 5*; byte *num2 = (byte) num1*; *long num3 = num1*.

**Float** (float) is 4 bytes in size. To create a float literal, you must append f or F. A float has 7 digits of precision. You can use underscores with floating point values. If you attempt to do calculations with the previous types that include decimals, the decimal/remainder will be disregarded, e.g. *int num = 5/2* will return 2 since .5 is ignored. Float and double keep the remainder.

**Double** (double) is 8 bytes in size. To create a double literal, you must append d or D, or type a decimal value, e.g. *double num = 5d*, *double num = 5.25d*, or *double num = 5.25*. A double has 16 digits of precision. Double calculations tend to be faster than float calculations on modern computers, even though it takes more space. Float is single precision, and double is double precision.

In width order: float < double. As previously stated, larger types must be manually casted to small types. Smaller types automatically cast to larger types.

**Char** (char) takes 2 bytes. It’s used to store a single character such as a letter, number, Unicode character, or escape sequence. Example: *char val = ‘A’*, or *char val = ‘\u00A9’* (Unicode for copyright symbol). The apostrophes define a character literal. Unicode character tables may be useful: <https://unicode-table.com/en/>.

**Boolean** (boolean) takes 1 byte. It stores the state of something, e.g. is it true or false, or *boolean isMale = true*. ‘true’ and ‘false’ are Boolean literals.

All the datatypes covered up to now are primitive types defined within Java. These basic datatypes can be used to create more sophisticated datatypes, such as string. All other datatypes are referred to as a class.

**Strings** (String) takes a variable number of bytes. It is a sequence of characters, so it will take some bytes for each character you type (including spaces), plus more bytes since strings are automatically null terminated. Speech marks are used to define a string literal. Example: *String str = “Hello World”*. Strings support direct concatenation, e.g. *String str = “Hello” + “ world!”*. It can also do this with all primitive types, e.g. *int num = 50; String str = “Hello ” + num*, output: “Hello 50”.

**Operators** can work on 1 (unary), 2 (binary) or 3 (ternary) operands. Unary ops: (post-fix, pre-fix). Binary ops: arithmetic (multiplicative, additive), assignment (=, +=, -=, \*=, /=, %=, &=, ^=, |=, <<=, >>=, >>>=), bitwise (<<, >>, >>>, &, ^, |), logical (&&, ||), relational (comparison, equality). Ternary operator: conditional operator.

When assigning values, you can chain them, e.g. *int a, b, c; a = b = c = 5;*. This is read from right to left and sets all to 5. First c is set to 5, then b is set to c, then a is set to b.

**Relational (comparison, equality) and logical operators** check to see if the two operands match a condition, in which case the output is true, otherwise false. All of them are binary operators except for the not operator, which is unary.

The **conditional operator** checks to see if the condition is true, and returns the first statement, otherwise it returns the other statement, e.g. *(5>4) ? “Yes” : “No”;* returns “Yes”. In general the syntax is *condition ? if\_true : if\_false;*. You can return literals, expressions, statements, etc.

For an if statement to be valid, the expression must evaluate to a boolean. This is why *boolean bool = false; if (bool = true);* compiles, but *int num = 5; if (num = 5);* doesn’t.

**Section 5 – Expressions, Statements, Code Blocks, Methods, etc.**

* There are 53 reserved keywords in Java. Keywords are reserved names defined within Java that carry out specific functionality.
* **Scope** refers to the **block** {} in which a variable is defined. Variables are automatically deleted once they fall out of scope - at the end of the block they were defined in. Variables cannot be accessed outside of their scope.
* **Methods** allow you to type code once and reuse it as needed, thus preventing code duplication. This is ideal because code duplication can lead to an increase in errors since the programmer may forget to make identical changes in the duplicated code.
* **Parameters** are datatypes + variable names expected by a method. **Arguments** are the actual values/objects being supplied to a method call.
* **Procedures** don’t return anything. **Functions** return something. **Methods** are procedures or functions defined within a class.
* **Method overloading** is when a new method is created that has the same name as another method, but has different parameters. The compiler decides which method to call based on the arguments provided.

**Section 6 – Control Flow Statements**

* These change the flow of the code depending on various conditions, e.g. **if statement, switch statement, for loop, while loop, do while loop.**
* If statements are like switch statements. Switch statements can only test one variable, can only test for equality (can be OR’ed), and can only equate constant values. Switch statements should only be used for simple test cases. Examples:

|  |  |
| --- | --- |
| int num = 3; if (num == 1)  System.out.println(“1”);  else if (num == 2 || num == 3)  System.out.println(“2 or 3”);  else  System.out.println(“<1 or >3”); | int num = 3;  switch (num) {  case 1:  System.out.println(“1”);  break;  case 2: case 3:  System.out.println(“2 or 3”);  break;  default:  System.out.println(“<1 or >3”);  break;  } |

* An if statement’s ‘else if’ is equivalent to a switch statement’s ‘case’. An if statement’s ‘else’ is equivalent to a switch statement’s ‘default’.
* You must type break after every case or execution will fall through to the next case, this is how you OR different cases together.
* Switch statements can only switch on byte, short, int, char, their wrapper classes, enum, and String.
* Syntax for an indexed for loop is: *for (init; condition; action) {}*.

|  |  |
| --- | --- |
| for (int i = 0; i < 5; i++) {  System.out.println(i);  } | for (int i = 0, j = 5; i < 5; i++, j--) {  System.out.println(i + " " + j);  } |

* By convention, simple variables are used to track the index, e.g. *int i, int j, int k, …*
* *String.format("First: %d Second: %.2f Third: %c", 5, 10.0, 'c')*, will output “First: 5 Second: 10.00 Third: c”. The % notation refers to the corresponding argument, e.g. the first % refers to the first argument etc.
* Nested if statements are more efficient than sequential if statements, if the sequential if statement depends on code executed in the former if statement. Example:

|  |  |
| --- | --- |
| int primes = 0;  for (int i = 1; i < 20; i++) {  if (isPrime(i)) {  System.out.println(i);  primes++;  }    if (primes >= 3)  break;  }  } | int primes = 0;  for (int i = 1; i < 20; i++) {  if (isPrime(i)) {  System.out.println(i);  primes++;  if (primes >= 3)  break;  }  } |

The code on the left checks two conditions every time, while the code on the right checks two conditions sometimes.

* For loops are ideal for looping a certain number of times. While loops are ideal for looping until a certain condition is met. Do while loops are the same as while loops, but run at least once since the condition is checked after the loop.
* You can use the **break** keyword to exit a loop if a condition is met, or you can use the **continue** keyword to start the next iteration of the loop.

**Section 7 – OOP Part 1: Classes, Constructors, and Inheritance**

* It’s a naming convention to start classes with a capital letter (upper CamelCase), and to make it a noun. Methods use lower camelCase and are verbs. Classes should be created in their own files with the same name as the class.
* Each section in the package name refers to another subfolder. If the package name is “com.cjm.ms” and the new class is created in a file called car, then it will be stored as “ProjectPath/com/cjm/ms/car.java”.
* **Public** is an **access modifier**, as is **private**, **default** and **protected**. Public gives unrestricted access to the class. Private means the class can only be accessed from within. Default means the class can only be access by classes within the same package. Protected means the class is accessible within the package, or from another package through inheritance. Most of the time you will use public. You can remove the access modifier, but this is equivalent to default.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Can be accessed from: | Inside the class. | Current package only. | Any package w/ inheritance. | Anywhere. |
| public | x | x | x | x |
| protected | x | x | x |  |
| default/none | x | x |  |  |
| private | x |  |  |  |

* A class is a blueprint for an object you will create. They are used to model real world problems.
* Variables defined at class scope are referred to as member variables or fields. They also require an access modifier. Unlike with class access specifier you will tend to mark these private for encapsulation. The idea is to prevent accidental misuse of what your class was designed for by hiding data from external access. In other words it can only be access from within the class.
* The fields within a class represent the **state** of the class at runtime since they are the only entities which can be changed. The methods represent the **behaviour** of the class.
* Typing “*Car car;*” will create a reference variable. Typing “*new Car();*” will create a Car object in memory. To point the reference to the object, type “*Car car = new Car();*”. To have a reference point to nothing use **null**, e.g. “*Car car = null;*”.
* Variables with primitive datatypes and reference variables exists in **stack memory**, while objects exist in **heap memory**. The stack is cleared when execution reaches the end of a code block. If no references point to an object then the **garbage collector** will delete the object at an undetermined time.
* **Setter methods**, or setters, are used to set fields from outside of the class.
* When referring to a field with a method that has the same name as a local variable, use the **this** keyword to specify the field. Otherwise the compiler will assume you want the local variable.
* **Getter methods**, or getters, are used to retrieve a field from outside of the class.
* You use setters and getters to put logic in between the user of your class and them setting/getting fields. Even if you do not need to put any logic in between you should still follow this practice as in the future you may need to add logic. The benefit of this is that if you decide to add something in the future, users of your class will not need to change all of their code to accommodate your new setters/getters.
* An example of adding logic is input validation. You may want to check what input the user is sending before assigning it to the field. There is also verification, exception handling, logging, etc.
* You can either initialise an object using setters or, more preferably, a constructor. Java creates a default constructor automatically if no custom constructor is defined. A default constructor does not take any arguments because it has no parameters, e.g. “*Car car = new Car();*” will use a default constructor. If none are defined implicitly or explicitly, this will result in a compilation error. A constructor is syntactically similar to a method, except that it has no return type and runs automatically when a class is instantiated.
* Constructors can call one another, or other methods, which may be ideal for code reuse. There is debate, but using other methods/setters is not recommended in the constructor. Other methods cannot call a constructor since they are special methods that only run when the class is instantiated.
* Classes should carry out specific functionality rather than trying to do everything. You can **extends** the functionality of a class by using **inheritance**. The simpler class is called the **superclass** while the more complex class using inheritance is called the **subclass**. Inheritance represents an **is-a** relationship.
* The superclass should only contain functionality that will be common to all subclasses. Example: you can have a superclass called Animal, that may be subclassed by Dog, Cat, etc. Animal should contain state/behaviour that is applicable to all shapes, while Dog and Cat will contain state/behaviour specific to them.
* ‘this.’ is used to access fields and methods within the current class. ‘super.’ is used to access fields and methods within superclasses. These cannot used by static blocks/methods. ‘this()’ is used to call constructors within the current class. ‘super()’ is used to call constructors within the superclass. The constructor calls can only be made from other constructors and must be the first statement.
* Access modifier result:

|  |  |  |  |
| --- | --- | --- | --- |
| Can be accessed from: | Inside the class. | Derived classes. | Outside the class. |
| public | x | x | x |
| protected | x | x |  |
| private | x |  |  |

* The subclass can **override** methods from the superclass. Thus the subclass’ version of the method is called instead of the superclass’ version. You can do this to run specific functionality in the subclass, or to extend functionality from the superclass’ version you can use *super.methodname(…)*. Example: Animal may contain the eat method since it applies to all animals, but a dog might eat differently to a cat and so they can both override Animal.eat(…) to provide their own definition/functionality. If they have some common aspects in the way they eat then that common functionality can be defined in Animal.eat(…) and the dog or cat can use super.eat(…) to run that functionality before running their own.
* When overriding a method you must use the same method name, parameter types, and return type.
* You can call superclass versions of methods without using the super keyword as long as there is nothing else with that name in scope. This is recommended because if you later override a method in your subclass, it will automatically use that version of the method instead.
* All classes subclass the **Object** class. When you create a new class without using the extends keyword, it implicitly extends from Object. You can also type *extends Object* to make it explicit, but it is not required.
* A **class** is a blueprint that defines state and behaviour for a datatype. An **instance** of a class is created using the new keyword, or you can say that using the new keyword instantiates a class. Instances of a class exist in heap memory as **objects**. **Reference** variables point to an object.

**Section 8 – OOP Part 2: Composition, Encapsulation, and Polymorphism**

* While inheritance represents is-a relationships, **composition** represents **has-a** relationships. Example: A dog is an animal, a square is a shape, a car is a vehicle, etc. Example: A dog has a heart, a square has an edge, a car has an engine, etc. To use composition make one class a field in another class.
* Java can only use single inheritance to prevent over-complicating code. Thus composition is another way to extend classes.
* You can instantiate a class directly in a method call if it won’t be used anywhere else.
* **Encapsulation** is used for data hiding and to protect the inner workings of a class. This ensures that a class follows it’s defined behaviour and protects your design. It also allows you to rename fields without affecting dependant classes. It also allows you to introduce logic before returning the field the user of the class sets/gets. Encapsulation is achieved through access modifiers, and getters and setters.
* You can create multiple classes within one file, but it is usually not recommended since it can make your code confusing and unorganised. It is usually only done if the class will not be reused anywhere else in the code. A public class must exist within its own file.
* Use *Math.random()* to return a double literal from 0 <= x < 1.
* **Polymorphism** (many forms) allows entities with the same name to act like something else. There is **static polymorphism** which refers to method overloading, and **dynamic polymorphism** which refers to method overriding. The former is called static because the appropriate method to call is decided at compile time. The latter is called dynamic because it is decided at runtime.
* Dynamic polymorphism allows references of one class to point to an instance of a derived class at runtime. Example: *Animal animal1 = new Animal()*, and *Animal animal2 = new Dog()* are both valid assuming Dog is a subclass of Animal. If you call a method within animal1, e.g. *animal1.eat()* it will call *Animal.eat()*. If you call *animal2.eat()* it will still call *Animal.eat()*. If you first override *Animl.eat()* within Dog, then calling *animal2.eat()* will call *Dog.eat().* This allows you to feed all your different types of animals in one loop rather than having to treat each animal differently.
* The fact to note is that a reference for one datatype can point to an instantiation of any of its subclasses. You will only be able to use methods defined in that type, or methods that have been overridden from that type. For example, an Object reference can point to any object in memory since they all inherit from this class. However, you will only be able to call methods declared in Object.
* Call *getClass().getSimpleName()* to get the name of the class without having to type it. This method is defined within the Object class. It doesn’t display the name of the static class, but rather the dynamic class.

**Section 9 - Arrays, Java inbuilt lists, autoboxing and unboxing**

* Regular variables store a single value. **Arrays** can hold multiple values of the same type. You can make an array of any type. Example: *int var = 5* stores a single value, and *int[] values = {5, 7, 9}* stores multiple. Arrays use a zero-based index, e.g. first element (5) is 0, second element (7) is 1, third element (9) is 2, etc. Trying to access the fourth element in this case will throw an ArrayIndexOutOfBoundsException.
* There are a few ways to initialise an array: *int[] arr1 = {5, 5, 9}*; *int[] arr2 = new int[]{5, 5, 9}*; *int[] arr3 = new int[3]; arr3[0] = arr3[1] = 5; arr3[2] = 9;*.
* The length of the array during initialisation can be a literal or an expression.
* You can use a for loop to go through an array, or use a for each loop if you don’t care about the index. Use arr.length to determine how many iterations to run the indexed loop for as opposed to hardcoding it.
* To get **input** from the user, use the Scanner class: *Scanner sc = new Scanner(System.in)*. Then call one of it’s many methods to store a value: *int val = sc.nextInt()*.
* Since arrays have a fixed length it isn’t simple to add another value. You must create a new array that’s larger than the old array, then copy the original array to the new array, and then add the values that you originally intended to add. This is because arrays occupy contiguous memory. So each of the elements appear next to each other in memory as they do in the array. This allows for fast random access but makes it slow at resizing.
* Alternatively, a **list** has a dynamic size and makes it easy to add another value. This is because the list contains nodes that point to the next node in memory. So the data is stored randomly in memory. This means that to get the 5th value you must go through the first four nodes. This makes it slow for random access, but fast for resizing. A **doubly linked list** has a previous node and a next node.
* To create an ArrayList you can either use *ArrayList<String> list = new ArrayList<String>()*, or *List<String> list = new ArrayList<String>()*. The latter is recommended since you’re coding to the interface which makes use of polymorphic concepts. You can remove the second <String> from either since the compiler can use the first one to determine that it must be the same.
* Arrays and lists are examples of **collections**. Collections in general store multiple values, but with different rules. Arrays and lists are **ordered collections**, meaning that the order of insertion is kept. List is an interface that’s implemented by many different types of list subclasses. The most common of which is ArrayList.
* An ArrayList works like a resizable array, while a LinkedList works like list.
* You cannot access collections elements directly and must use getters/setters and other methods for manipulation. Example: *ArrayList.get(), ArrayList.set(), ArrayList.remove(), ArrayList.contains(),* etc.
* When using methods such as *remove()* or *contains()*, you must make sure that the argument you pass is a reference to the same object in memory, or that the class overrides the *equals()* method. Otherwise the operation will fail as the *List* implementation has no way of knowing if the elements match.
* To create a copy of an array use *Arrays.copyOf()*. To create a copy of an ArrayList use *ArrayList.addAll()* or just pass an existing ArrayList into the constructor of the new ArrayList. An ArrayList can be converted to a built-in array using *ArrayList.toArray()*.
* Although you can do ‘ArrayList<String>...’ you can’t do it with primitive types ‘ArrayList<int>…’. You must use wrapper classes for the primitive types. For int this is Integer. **Autoboxing** is when you convert a primitive type to its **wrapper class**. **Unboxing** is the opposite.
* **Value type** and **reference type** refers to two types of variables in Java. A value type is a variable with a primitive datatype. A reference type is a variable with a non-primitive datatype.
* Both value types and reference types exist in stack memory and are deleted when execution reaches the end of their code block.
* Reference types point to objects created in heap memory. Objects are created in heap memory every time the new keyword is used. When the number of references pointing to an object in heap memory is 0, the garbage collector will delete that object. This is done non-deterministically.
* When assigning one variable to another or when passing variables as arguments, a copy of the variable is created, so changing the new variable doesn’t affect the old variable. Variables are passed by value in Java. When assigning one reference type to another, they both point to the same location in heap memory, so changing the object through one reference is the same thing is changing it through the other.
* **Iterator** can be used to transverse collections. Methods: hasNext(), next(), remove(). **ListIterator** can do much more. Methods: add(), hasNext(), hasPrevious(), next(), nextIndex(), previous(), previousIndex(), remove(), set(). A for each loop is syntactic sugar for iterators when traversing a collection, but if you’re going to add/remove elements while traversing the list you need iterators.
* An Iterator works like a list, while a ListIterator works like a doubly linked list.
* When you call ListIterator.next() and then switch to ListIterator.previous(), it will actually return the same element because of the way the cursor/position works. You must call it twice to actually return the previous element. This happens anytime you change direction, so calling ListIterator.previous() then ListIterator.next() will have the same result. This is because a ListIterator doesn’t have an index, but just has references to the next and previous nodes. This is why it’s said to sit in between two nodes.
* A **side effect** is when calling a method changes the object in such a way that calling the method again returns a different result, e.g. iter.next(). Side effects should generally be avoided.
* If you try to use a ListIterator after changing add/removing elements from the original list, you will get a ConcurrentModificationException. So either only use ListIterator to set/remove elements to the original list, or create a new ListIterator after making changes to the original list.

**Section 10 - Inner classes, abstract classes, and interfaces**

* An **interface** ensures common behaviour between different classes. The classes must implement the interface and provide definitions for declared methods.
* It is convention to start interfaces with an ‘I’, e.g. IAnimal, IVehicle, etc.
* Classes are defined using the class keyword. Interfaces are defined using the interface keyword.
* They can only contain public fields, public method signatures, or private defined methods.
* Interface methods are public by default.
* Use the **implements** keyword after a class declaration to implement an interface. All public methods must be given a definition, or if the class is abstract then it is optional. You can use code generation to speed this up. A class can only ‘extends’ one class, but implement many interfaces.
* Interfaces can’t be instantiated, but a reference variable for an interface can make use of polymorphism to instantiate classes that implement the interface, e.g. *ITelephone timsPhone = new DeskPhone()*.
* This is why you should always code to the interface as the resulting code isn’t specific to a single class, e.g. use *List<String> str = new ArrayList<>()* instead of *ArrayList<String> str = new ArrayList<>()*. This way you could change *str* to other lists and reuse code, e.g. *str = new LinkedList<>()*.
* **Inner class** refers to a class defined within a class. It can also be called a nested class. There are four types. **Outer class** refers to the class that contains the inner class. You can create an inner interface.
* Inner classes make sense to use when the inner class won’t be used anywhere else in the program, e.g. a Gear class will only need to be used to by a GearBox class so it can be an inner class.
* **Non-static inner class** (or just inner class) are defined within classes, but outside of methods. They can access all fields and methods defined in the outer class including private entities. To access a field defined within the outer class that’s also defined within the inner class use *Gearbox.this.gearNumber*. The inner class field is **shadowing** the declaration of the outer class field. Avoid shadowing declarations as it reduces code quality. To access a public inner class from outside the outer class use dot notation, e.g. *Gearbox mcLaren = new Gearbox(6); Gearbox.Gear first = mcLaren.new Gear(1, 12.3);*.
* **Static inner class** is the same as a non-static inner class except that it uses the static keyword in the declaration. This means that the inner class belongs to the outer class, rather than an instance of the outer class. To access a public static inner class from outside the outer class use dot notation, e.g. *Gearbox.Gear first = new Gearbox.Gear(1, 12.3)*.
* **Local class** is a class that is defined within a method.
* **Anonymous class**