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Object-Oriented Programming with Java, part I

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19. Methods and copying parameters

Let us focus on a couple of details concerning methods.

In section 15 was an example, in which we tried to change the value of a main program variable inside a method.

```java
public static void main(String[] args) {
    int number = 1;
    addThree();
    System.out.println("Main program variable number holds the value: " + number);
}

public static void addThree() {
    number = number + 3;
}
```

This program of ours does not work. The reason is that the method cannot access the main program variable `number`.

This is because main program variables are not visible to methods. More generally: no method variable is visible to other methods. As the main program `main` is also a method, this constraint holds for the main program as well. The only way to give information to a method is through parameters.

Let us try to fix the above example by passing the main program variable `number` to the method as a parameter.

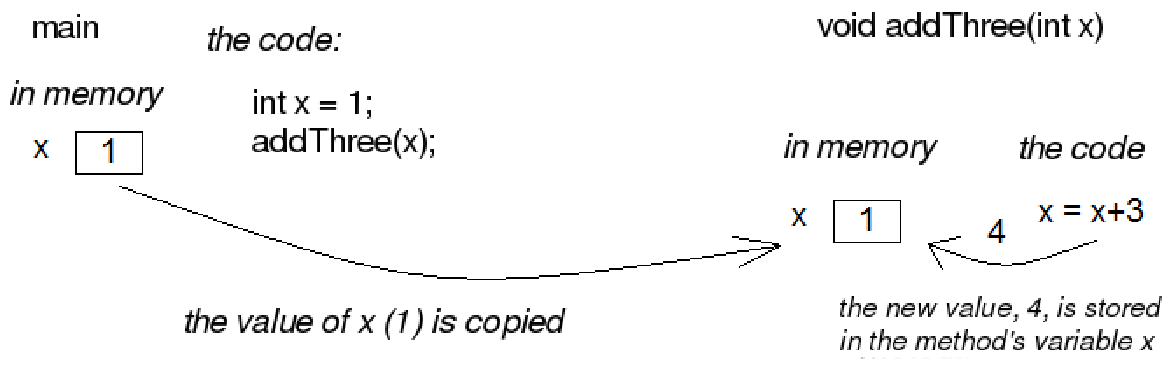
```java
public static void main(String[] args) {
    int number = 1;
    addThree(number);
    System.out.println(number);  // prints 1, the value did not change
}

public static addThree(int number) {
    number = number + 3;
}
```

Still, the program does not function the way we want. The method parameters are different variables than the ones introduced in the main program. In the previous example, the method increments a variable with the same name as the main program variable. The parameter has the same name, but is not the same as the main program variable `number`.

When a parameter is given to a method, the value of the parameter *is copied into a new variable* and that new variable is the one the method uses. In the example above, the variable `number` that was given to the method `addThree` as a parameter, will be copied and then the copy is actually handed out for the method to use. The method uses a copy of the variable from the main program, not the original variable. The main program variable `number` stays unchanged.

We can imagine that the main program method `main` and the method `addThree` both work in their own parts of the computer memory. In the picture below, there is a "box" for the value of the variable `number` of the main method. When the method is called, a new "box" named `number` will be created and the main value of the method variable `number` will be copied into it. In this example, the number is 1. Both variables that are called `number` are separate, therefore when the method `addThree` changes the value of its own variable called `number` it does not affect the variable `number` in the main program.

The picture below will demonstrate what happens.



The method can still naturally pass information to the caller, which happens by using a return value (i.e. using a `return` command to return a variable with a value). We can get the previous example to work by changing the code a little bit:

```java
public static void main(String[] args) {
    int number = 1;
    number = addThreeAndReturn(number);

    System.out.println(number);  // prints 4, because number has the method return value as its value
}

public static int addThreeAndReturn(int number) {
    number = number + 3;

    return number;
}
```

The method still uses the copy of the main program variable `number`. In the main program, we assign the variable `number` the method return value as a new value, so that we can get the change to take effect in the main program. Note that the name of the method variable plays no role here. The code works exactly the same regardless of the variable names. Here follows an example:

```java
public static void main(String[] args) {
    int number = 1;
    number = addThreeAndReturn(number);

    System.out.println(number);
}

public static int addThreeAndReturn(int incremented) {
    incremented = incremented + 3;

    return incremented;
}
```

We have now found out that the parameters in methods are different variables than the variables introduced in the method call. Only the parameter value gets copied from the caller to the method.

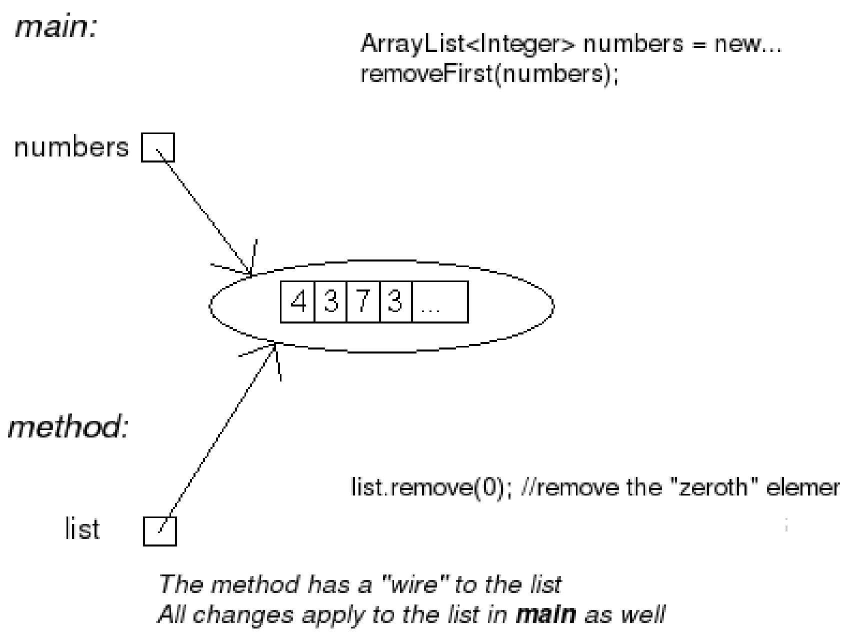
Unfortunately this is not the whole story. If a method gets an `ArrayList` as a parameter, the method sees the original list and all the changes the method makes will take effect everywhere.

```java
public static void removeFirst(ArrayList<Integer> list) {
    list.remove(0); // removes the number from index 0
}
```

```java
public static void main(String[] args) {
    ArrayList<Integer> numbers = new ArrayList<Integer>();
    numbers.add(4);
    numbers.add(3);
    numbers.add(7);
    numbers.add(3);

    System.out.println(numbers); // prints [4,3,7,3]

    removeFirst(numbers);

    System.out.println(numbers); // prints [3,7,3]
}
```

Unlike a parameter of `int` type, a list will not be copied and therefore the method makes changes to the original list given as a parameter.

The picture below will clarify the example. `ArrayList` does not live in an imagined "box" like an `int`. The variable name in the example `numbers` is only a *reference* that refers to the place where the ArrayList is. One way to visualize this is that an `ArrayList` is connected with a wire. The name of the `ArrayList` is a "wire", and the list itself is located "at the other end of the wire". When we give the `ArrayList` to a method as a parameter, we actually give the method a wire. When the method uses its parameter, it finds the original list at the other end of this wire. Actually the main program and the method do have separate wires, but both wires have the same original list at the end of them and all the changes will be made directly to the original list. During and after this week we will find out that many things in Java are "connected with a wire".


main:
ArrayList<Integer> numbers = new...
removeFirst(numbers);
numbers
4 3 7 3 ...
method:
list.remove(0); //remove the "zeroth" elemer
list
The method has a "wire" to the list
All changes apply to the list in main as well

Note that again the parameter name inside the method can be anything. It does not need to be the same as the name in the main program (or other method that calls it). In the example above, the method uses the name `list` but the method caller sees the same list with a different name: `numbers`.

Now, you probably start to wonder why does the value of the parameter get copied and the original variable stay intact when the parameter is of `int` type, but the original list is given to the method when the parameter is of `ArrayList` type? In Java only the values of ***primitive data types*** (which are `int`, `double`, `char`, `boolean` and a couple of others that we have not yet discussed) get copied to the method. When the method parameters are of other types only the *references* are copied to the method. A reference is like a "wire", therefore the method can access the list using it directly. The variables that are not of primitive data types are of ***reference data types*** and are "wired" just like the ArrayList in the previous example. The method is given the wire and the method can access the parameter directly.

Exercise 70: Combining ArrayLists

Create the method `public static void combine(ArrayList<Integer> first, ArrayList<Integer> second)` that inserts the items in a list called `second` to a list called `first`. The order of the items can be anything and the same item can appear in the list more than once. An example on using the method:

```
ArrayList<Integer> list1 = new ArrayList<Integer>();
ArrayList<Integer> list2 = new ArrayList<Integer>();

list1.add(4);
list1.add(3);

list2.add(5);
list2.add(10);
list2.add(7);

combine(list1, list2);

System.out.println(list1); // prints [4, 3, 5, 10, 7]

System.out.println(list2); // prints [5, 10, 7]
```

We can use the method `addAll` provided by the ArrayList class to add one list in another list. The list gets the other list, whose items are to be added, as a parameter.

Exercise 71: Smart combining

Create the method `smartCombine` that works like the previous `combine` method except that numbers can be on the list only once. This means that the method adds a new number to the list only if the list does not already contain that number. You might find the method `contains` from the ArrayList class useful. You can use that method to check if a number is in the list.

20. Instructions on code-writing and problem solving

Two of the leading software developers, *Martin Fowler* and *Kent Beck* have said in the book *Refactoring: Improving the Design of Existing Code* that:

- Fowler: *"Any fool can write code that a computer can understand. Good programmers write code that humans can understand."*
- Beck: *"I'm not a great programmer, I'm just good a programmer with great habits."*

[Update: previously both quotes were credited to Kent Beck. Our thanks go to Esko Luontola for pointing out this mistake]:

We are now taking the first steps towards becoming good programmers.

20.1 Well indented and "breathing" code

Let us take a look at a code that first adds numbers to a list and then prints the items fo the list. Then all instances of a certain number are removed from the list and the list gets printed.

First, we write the code badly and without indentations:

```
public static void main(String[] args) {
ArrayList<Integer> numbers = new ArrayList<Integer>();
numbers.add(4);
numbers.add(3);
numbers.add(7);
numbers.add(3);
System.out.println("The numbers in the beginning:");
for (int number : numbers) {
System.out.println(number);
}
while (numbers.contains(Integer.valueOf(3))) {
numbers.remove(Integer.valueOf(3));
}
System.out.println("The numbers after removal:");
for (int number : numbers) {
System.out.println(number);
}
```

Even though the unindented code works, it is unpleasant to read. Let us indent the code (you can get NetBeans to auto-indent your code by pressing Alt+Shift+F) and separate logical parts with line breaks:

```
public static void main(String[] args) {
    ArrayList<Integer> numbers = new ArrayList<Integer>();
    numbers.add(4);
    numbers.add(3);
    numbers.add(7);
    numbers.add(3);

    System.out.println("The numbers in the beginning:");

    // here we print numbers
    for (int number : numbers) {
        System.out.println(number);
    }

    // checks if the list contains the number 3
    while (numbers.contains(Integer.valueOf(3))) {
        numbers.remove(Integer.valueOf(3));  // if yes, it is removed
    }
    // we use a while structure to get all the threes removed!

    System.out.println("The numbers after removal:");

     // here we print numbers
    for (int number : numbers) {
        System.out.println(number);
    }
}
```

Now, the code starts to make sense. For example, the printing and the number removal are two logical parts, therefore they are separated with line breaks. The code is *airy* and reading the code is much more pleasant.

There are even comments in the code to help the reader understand what happens and where!

20.2 Getting rid of copy-paste with methods

What could be called the Original sin of a programmer is to create copy-paste code. This means using the same code in multiple places by copy-pasting it around the source code. In our example, the printing of the list is done twice. The code that handles the printing part should be separated as its own method. Then the printing method should be called from the main program:

```
public static void main(String[] args) {
    ArrayList<Integer> numbers = new ArrayList<Integer>();
    numbers.add(4);
    numbers.add(3);
    numbers.add(7);
    numbers.add(3);

    System.out.println("The numbers in the beginning:");

    // here we print numbers
    print(numbers);

    while (numbers.contains(Integer.valueOf(3))) {
        numbers.remove(Integer.valueOf(3));
    }

    System.out.println("The numbers after removal:");

    // here we print numbers
    print(numbers);
}

public static void print(ArrayList<Integer> numbers) {
    for (int number : numbers) {
        System.out.println( number );
    }
}
```

20.3 Slicing separate tasks into methods with descriptive names

Now, the code has become even more easy to read. A distinctively separate entity, the printing of the list is now a method that is easy to understand. By defining a new method the readability of the main program has improved. Pay attention to the descriptive name of the method: the name describes exactly what the method does. Next, we can remove the advising comments *here we print numbers* , because the name of the method speaks for itself.

There is still room for improvements in writing the program. The main program still looks a bit messy, since there is an "unaesthetic" code line that directly manipulates the list, in between the neat method calls. Let us turn that unaesthetic piece of code into a method:

```
public static void main(String[] args) {
    ArrayList<Integer> numbers = new ArrayList<Integer>();
    numbers.add(4);
    numbers.add(3);
    numbers.add(7);
    numbers.add(3);

    System.out.println("The numbers in the beginning:");
    print(numbers);

    remove(numbers, 3);

    System.out.println("The numbers after removal:");
    print(numbers);
}

public static void print(ArrayList<Integer> numbers) {
    for (int number : numbers) {
        System.out.println( number );
    }
}
```

```
public static void remove(ArrayList<Integer> numbers, int removed) {
    while (numbers.contains(Integer.valueOf(removed))) {
        numbers.remove(Integer.valueOf(removed));
    }
}
```

In the example above, we created a new descriptively named method out of a separate logical entity, i.e. removing all the instances of a certain number. The resulting main program is now very understandable - almost like natural language. Both methods are very simple and easy to understand as well.

Kent Beck might be proud of what we have accomplished! The code is easy to understand, easy to modify and does not include any copy-paste.

21. Object-oriented programming

Before we begin, here is a small introduction to object-oriented programming.

In procedural programming - which is the way of programming we have been studying so far - a program is divided in to smaller parts, methods. A method works as a separate part of a program and it can be called from anywhere in the program. When a method is called, execution of the program moves to the beginning of the called method. After the execution of the method is done, the program will continue from where the method was called.

In object oriented programming, just like in procedural programming, we attempt to divide a program into smaller parts. In object-oriented programming the small parts are objects. Each separate object has its own individual responsibility; an object contains a related group of information and functionality. Object-oriented programs consist of multiple objects which together define how the program works.

21.1 Object

We have already used many of the ready-made objects in Java. For example, `ArrayLists` are objects. Each separate list consists of information related to it; that is, *the state of the object*. Functionality is also contained in the ArrayList objects: the methods by which the state of the object can be altered. As an example, there are two ArrayList objects in the following piece of code, `cities` and `countries` :

```
public static void main(String[] args) {
    ArrayList<String> cities = new ArrayList<String>();
    ArrayList<String> countries = new ArrayList<String>();

    countries.add("Finland");
    countries.add("Germany");
    countries.add("Netherlands");

    cities.add("Berliini");
    cities.add("Nijmegen");
    cities.add("Turku");
    cities.add("Helsinki");

    System.out.println("number of countries " + countries.size() );
    System.out.println("number of cities " + cities.size() );
}
```

Both the `countries` object and the `cities` object live a life of their own. The state of each is not related to the state of the other. For example, the state of the `countries` object consists of the Strings "Finland", "Germany" and "Netherlands" that are in the list, probably also the information of how many countries are in the list.

When doing a method call related to an object (for example, `countries.add("Finland");`), the name of the object whose method is being called goes to the left side of the period sign (dot), and to the right side goes the name of the method itself. When asking how many Strings the `countries` list contains, we call countries.size(). We are calling the method `size` of the object `countries`. What the method returns depends on the state of the object in question, other objects do not affect the execution of the method in any way.

We have used the command `new` many times already. For example, creation of a list (`ArrayList`) and creation of a reader (`Scanner`) have been done using the command `new`. The reason is that both of these are *classes* from which the object is created. In Java, objects are always created with `new`, except in a few cases.

One of the cases where you do not always need to use `new` is in the construction of Strings. The familiar way to create a String is actually an abbreviated way of using `new`. A String can also be created with new just like any other object:

```
String text = "some text";       // abbreviated way of creating a String
String anotherText = new String("more text");
```

Cases in which ready-made parts of Java call `new` out of sight of the programmer also exist.

21.2 Class

It is clear that all objects are not similar to one another. For example, `ArrayList` objects differ drastically from `String` objects. All `ArrayList`s have the same methods `add`, `contains`, `remove`, `size`, ... and respectively all `String` objects have the same methods (`substring`, `length`, `charAt`, ...). Arraylist and String objects do not have the same methods because they are different types of objects.

The type of a certain group of objects is called a **class**. `ArrayList` is a class, as are `String`, `Scanner`, and so forth. Objects, on the other hand, are *instances* of classes.

Objects of the same class all have the same methods and a similar state. For example, the state of an `ArrayList` object consists of elements inserted to the list while the state of a `String` object consists of a string of characters.

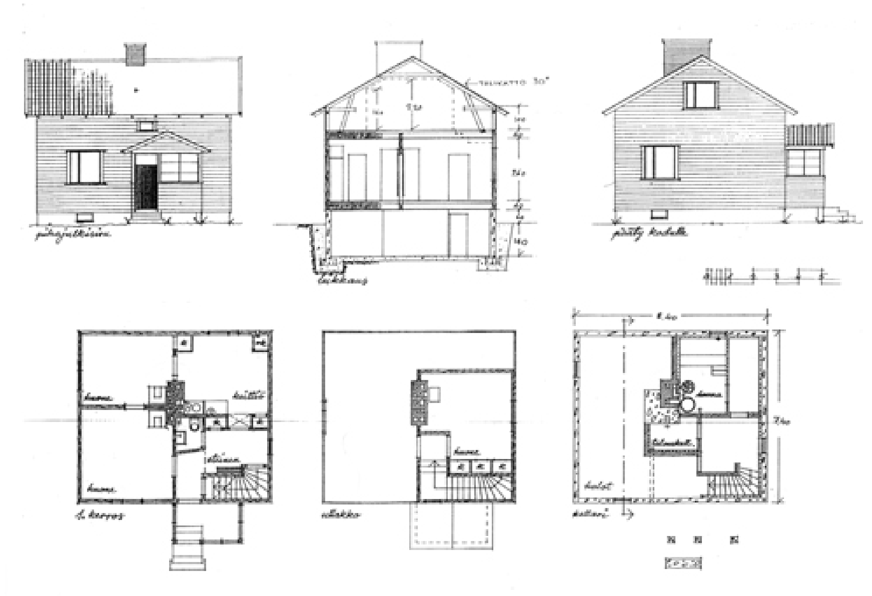
21.3 A class and its objects

A **class defines** what kind of objects it has:

- **what methods the objects have**
- **what the state of the objects are, or in other words, what kind of attributes the objects have**

A class describes the "blueprint" of the objects that are made out of it (are instances of it).

Lets take an analogy from the world outside of computers: the blueprints of a house. The blueprints define how the building is to be built and in that way dictate the shape and size of it. The blueprints are the class, they define the general characteristics of the objects created out of that class:



Individual objects, the houses in our analogy, are made from that same blueprint. They are instances of the same class. The state of individual objects, the attributes, can vary (color of walls, building material of the roof, doors, windowsills, etc...). Here is one instance of a House object:

An object is always created from its class by calling the method - the *constructor* - that creates the object with the command `new`. For example, a new instance is created from the class Scanner by calling `new Scanner(..)`:

```
Scanner reader = new Scanner(System.in);
```

Constructors take parameters the way any other method does.

Exercise 72: Accounts

You are handed a ready-made class `Account` along with your exercise files. The object of the class `Account` represents a bank account that has a balance (meaning some amount of money). The accounts are used as follows:

```
Account bartosAccount = new Account("Barto's account",100.00);
Account bartosSwissAccount = new Account("Barto's account in Switzerland",1000000.00);

System.out.println("Initial state");
System.out.println(bartosAccount);
System.out.println(bartosSwissAccount);
```

```
bartosAccount.withdrawal(20);
System.out.println("Barto's account balance is now: "+bartosAccount.balance());
bartosSwissAccount.deposit(200);
System.out.println("Barto's Swiss account balance is now: "+bartosSwissAccount.balance());

System.out.println("Final state");
System.out.println(bartosAccount);
System.out.println(bartosSwissAccount);
```

Exercise 72.1: Your first account

Note: there is a different exercise template for each of the sub-exercises. For this exercise use the template 072.1

Create a program that creates an account with the balance of 100.0, deposits 20.0 and prints the account. **Note!** do all the steps described in the exercise exactly in the described order!

Exercise 72.2: Your first money transfer

Note: there is a different exercise template for each of the sub-exercises. For this exercise use the template 072.2

Create a program that:

- Creates an account named `"Matt's account"` with the balance of 1000
- Creates an account named `"My account"` with the balance of 0
- Withdraws 100.0 from Matt's account
- Deposits 100.0 to My account
- Prints both accounts

Exercise 72.3: Money transfers

Note: there is a different exercise template for each of the sub-exercises. For this exercise use the template 072.3

In the above program, you made a money transfer from one person to another. Let us next create a method that does the same!

Create the method `public static void transfer(Account from, Account to, double howMuch)` in the given program body. The method transfers money from one account to another. You do not need to check that the `from` account has enough balance.

After completing the above, make sure that your `main` method does the following:

- Creates an account `"A"` with the balance of 100.0
- Creates an account `"B"` with the balance of 0.0
- Creates an account `"C"` with the balance of 0.0
- Transfers 50.0 from account A to account B
- Transfers 25.0 from account B to account C

21.4 Defining your own class - object variables

A class is defined to serve some meaningful whole. Often a "meaningful whole" represents something from the real world. If a computer program needs to handle personal data it could be sensible to define a separate class `Person` which then holds methods and attributes related to an individual.

Let us go ahead and assume that we have a project frame with an empty main program:

```
public class Main {

    public static void main(String[] args) {
    }

}
```

We will create a new class in our project. In NetBeans, this can be done in *projects* on the left, from the right click menu select *new*, *java class*. We will name the class in the dialog that pops up.

Just as with variables and methods, the name of the class should always be as descriptive as possible. Sometimes as a project progresses a class might transform into something different in order meet the programmer's needs. In situations like this, it is possible to rename your class with ease (see the NetBeans guide).

Let us create a class named `Person`. The class will exist in its own `Person.java` file. Since the main program is in its own file the program now consists of two files in total. At first the class will be empty:

```
public class Person {

}
```

The class has to define what methods and attributes the objects created from the class will have. Let us decide that each person has a name and an age. It feels natural to represent the name as a String and the age as an integer. Let us add this to our schematics:

```
public class Person {
    private String name;
    private int age;
}
```

Above, we defined that all instances created from the `Person` class have a name and an age. Defining attributes is done in a quite similar fashion as with normal variables. In this case though, there is the keyword `private` in front. This keyword means that `name` and `age` will not show outside of the object, but are instead hidden within it. Hiding things within an object is called *encapsulation*.

Variables defined within a class are called *object variables*, *object fields* or *object attributes*. A beloved child has many names.

So, we have defined the schematics -- the class -- for the person object. All person objects have the variables `name` and `age`. The 'state' of the objects is determined by the values that have been set to its variables.

21.5 Defining your own class - constructor, or "formatting the state"

When an object is created its starting state is defined at the same time. Self-defined objects are created for the most part in the same way as ready-made objects (`ArrayList` objects for example) are created. Objects are created with the `new` command. When creating an object it would be handy to be able to set the values of some of the variables of that object.

```
    public static void main(String[] args) {
        Person bob = new Person("Bob");
        // ...
    }
```

This can be achieved by defining the method that creates the object, *the constructor*. The constructor for the `Person` class that creates a new `Person` object has been defined in the following example. In the constructor, the person that is being created gets 0 as her age and her name is received from the parameter of the constructor.

```
public class Person {
    private String name;
    private int age;

    public Person(String initialName) {
        this.age = 0;
        this.name = initialName;
    }
}
```

The constructor always has the same name as the class. In the code above, the class is `Person` and the constructor is `public Person(String initialName)`. The value the constructor receives as a parameter is in parentheses after the name of the constructor. You can imagine the constructor as a method that Java runs when an object is created with the command `new Person("Bob");` Whenever an object is created from a class, the constructor of that class is called.

A few notes: within the constructor there is a command `this.age = 0`. Through it, we set a value for this particular object; we define the internal variable age of "this" object. Another command we use is `this.name = initialName;`. Again, we give the internal variable called name the String that is defined in the constructor. The variables `age` and `name` are automatically visible in the constructor and elsewhere in the object. They are referred to with the `this` prefix. Due to the `private` modifier, the variables cannot be seen from outside the object.

One more thing: if the programmer does not create a constructor for her class, Java will automatically create a default constructor for it. A default constructor is a constructor that does nothing. So, if you for some reason do not need a constructor you do not need to write one.

21.6 Class definition - methods

We already know how to create and initialize objects. However, objects are useless if they cannot do anything. Therefore, objects should have methods. Let us add to the `Person` class a method that prints the object on the screen:

```
public class Person {
    private String name;
    private int age;

    public Person(String nameAtStart) {
        this.age = 0;
        this.name = nameAtStart;
    }

    public void printPerson() {
        System.out.println(this.name + ", age " + this.age + " years");
    }
}
```

As seen above, the method is written within the class. The method name is prefixed with `public void` since it is assumed that users of the object should be capable of using the method and the method should not return anything. With objects the keyword `static` is not used in method definitions. Next week, we will clarify the reason behind that.

Inside the method `printPerson`, there is a single line of code that uses the object variables `name` and `age`. The prefix `this` is used to emphasize that we are referring to the name and age of *this* object. All the object variables are visible from all the methods of the object.

Let us create three persons and ask them to print themselves:

```
public class Main {

    public static void main(String[] args) {
        Person pekka = new Person("Pekka");
        Person brian = new Person("Brian");
        Person martin = new Person("Martin");

        pekka.printPerson();
        brian.printPerson();
        martin.printPerson();
    }
}
```

The output is:

```
Pekka, age 0 years
Brian, age 0 years
Martin, age 0 years
```

Exercise 73: Product

Create a class `Product` that represents a product sold in a webshop. A product has a price, amount and name.

A new class can be created as follows: Point at the project *073.Product* in the *projects* tab and click the right mouse button. Then select *new* and *java class*. When a dialog opens, give the class the name `Product`.

The class should have:

- A constructor `public Product(String nameAtStart, double priceAtStart, int amountAtStart)`
- A method `public void printProduct()` that prints a product in the following form:

  ```
  Banana, price 1.1, amount 13
  ```

21.7 More methods

Let us create a method that can be used to increase the age of a person by one:

```
public class Person {
    // ...

    public void becomeOlder() {
        this.age++;;    // same as this.age = this.age + 1;
    }
}
```

As expected, the method is written inside the class `Person`. The method increases the value of object variable `age` by one.

Let us call the method and see what happens:

```
public class Main {

    public static void main(String[] args) {
        Person pekka = new Person("Pekka");
        Person andrew = new Person("Andrew");

        pekka.printPerson();
        andrew.printPerson();

        System.out.println("");

        pekka.becomeOlder();
        pekka.becomeOlder();

        pekka.printPerson();
        andrew.printPerson();
    }
}
```

Output:

```
Pekka, age 0 years
Andrew, age 0 years

Pekka, age 2 years
Andrew, age 0 years
```

When born, both objects have age 0 due to the line `this.age = 0;` in the constructor. The method `becomeOlder` of object `pekka` is called twice. As the output shows, this causes the age of pekka to increase by two. It should be noted that when the method `becomeOlder` is called in the object `pekka`, the other object `andrew` is not touched at all and he remains at age 0. The state of an object is independent of the other objects!

Also, the object methods can return a value to the caller of the method. Let us define a method that can be used to ask for the age of a person:

```
public class Person {
    // ...

    public int getAge() {
        return this.age;
    }
}
```

Now the `void` in the method definition is replaced with `int` since the value the method returns has the type integer. The following example demonstrates, how the value returned by a method can be used:

```
public class Main {

    public static void main(String[] args) {
        Person pekka = new Person("Pekka");
        Person andrew = new Person("Andrew");

        pekka.becomeOlder();
        pekka.becomeOlder();

        andrew.becomeOlder();

        System.out.println( "Age of Pekka: "+pekka.getAge() );
        System.out.println( "Age of Andrew: "+andrew.getAge() );

        int total = pekka.getAge() + andrew.getAge();

        System.out.println( "Pekka and Andrew total of "+total+ " years old" );
    }
}
```

Output:

```
Age of Pekka: 2
Age of Andrew: 1

Pekka and Andrew total of 3 years old
```

Exercise 74: Multiplier

Implement the class `Multiplier` that has:

- a constructor `public Multiplier(int number)`.
- a method `public int multiply(int otherNumber)` that returns `otherNumber` multiplied by `number` (i.e., the constructor parameter).

Example of usage:

```
Multiplier threeMultiplier = new Multiplier(3);
System.out.println("threeMultiplier.multiply(2): " + threeMultiplier.multiply(2));

Multiplier fourMultiplier = new Multiplier(4);
System.out.println("fourMultiplier.multiply(2): " + fourMultiplier.multiply(2));

System.out.println("threeMultiplier.multiply(1): " + threeMultiplier.multiply(1));
System.out.println("fourMultiplier.multiply(1): " + fourMultiplier.multiply(1));
```

Output

```
threeMultiplier.multiply(2): 6
fourMultiplier.multiply(2): 8
threeMultiplier.multiply(1): 3
fourMultiplier.multiply(1): 4
```

Exercise 75: Decreasing counter

The starting point of this exercise is a partially implemented class `DecreasingCounter`:

```
public class DecreasingCounter {
    private int value;   // object variable that remembers the value of the counter
    public DecreasingCounter(int valueAtStart) {
        this.value = valueAtStart;
    }

    public void printValue() {
        System.out.println("value: " + this.value);
    }

    public void decrease() {
        // write here the code that decrements the value of counter by one
    }

    // and here the rest of the methods
}
```

The counter can be used as follows:

```
public class Main {
    public static void main(String[] args) {
        DecreasingCounter counter = new DecreasingCounter(10);

        counter.printValue();

        counter.decrease();
        counter.printValue();

        counter.decrease();
        counter.printValue();
    }
}
```

Output should be:

```
value: 10
value: 9
value: 8
```

The constructor of `DecreasingCounter` receives as parameter the initial value of the counter. In the example, the constructor parameter is `10`, which is then set to the object variable `this.value`. The value of the counter can be printed with the method `printValue()`. The method `decrease()` should decrease the value of the counter by one.

Exercise 75.1: Implementing method decrease()

Implement the method `decrease()` so that when called, the object variable `this.value` is decreased by one. When this is done, your program should work as the example above.

Exercise 75.2: Value remains positive

Change your implementation of the method `decrease()` so that the value of the counter will not drop below zero. If the method is called when the value is zero, nothing should happen:

```
public class Main {
    public static void main(String[] args) {
        DecreasingCounter counter = new DecreasingCounter(2);

        counter.printValue();

        counter.decrease();
        counter.printValue();

        counter.decrease();
        counter.printValue();
        counter.decrease();
        counter.printValue();
    }
}
```

Output should be:

```
value: 2
value: 1
value: 0
value: 0
```

Exercise 75.3: Counter reset

Implement the method `public void reset()` that sets the value of the counter to zero. Example of usage:

```
public class Main {
    public static void main(String[] args) {
        DecreasingCounter counter = new DecreasingCounter(100);

        counter.printValue();

        counter.reset();
        counter.printValue();

        counter.decrease();
        counter.printValue();
    }
}
```

Output:

```
value: 100
value: 0
value: 0
```

Exercise 75.4: Back to initial value

Implement the method `public void setInitial()`, which returns the counter to its initial value:

```
public class Main {
    public static void main(String[] args) {
        DecreasingCounter counter = new DecreasingCounter(100);

        counter.printValue();

        counter.decrease();
        counter.printValue();

        counter.decrease();
        counter.printValue();

        counter.reset();
        counter.printValue();

        counter.setInitial();
        counter.printValue();
    }
}
```

Output:

```
value: 100
value: 99
value: 98
value: 0
value: 100
```

Hint: add to the class a new object variable that remembers the initial value of the counter

Exercise 76: Menu

In this assignment, we will implement a class `Menu` that holds information about meals that are available in a cafeteria.

Our starting point is the following class skeleton:

```java
import java.util.ArrayList;

public class Menu {

    private ArrayList<String> meals;

    public Menu() {
        this.meals = new ArrayList<String>();
    }

    // Implement the methods here
}
```

Menu objects store the information of meals using an object variable of type ArrayList<String>

Exercise 76.1: Adding a meal to menu

Implement the method `public void addMeal(String meal)` that adds a new meal to the list `this.meals` of a Menu object. If the meal is already in the list, it should not be added.

Exercise 76.2: Printing the menu

Implement the method `public void printMeals()` that prints the meals in a menu. As an example, the output after three additions could be:

```
Hamburger
Fish'n'Chips
Sauerkraut
```

Exercise 76.3: Clearing a menu

Implement the method `public void clearMenu()` that clears a menu. After calling this method, the menu should be empty. Class `ArrayList` has a method that is useful here. Within your method body write `meals.` and see how NetBeans helps you by showing the available methods.

21.8 The Person class grows

Let us get back to work on the `Person` class. The current version of the class looks like this:

```
public class Person {
    private String name;
    private int age;

    public Person(String initialName) {
        this.age = 0;
        this.name = initialName;
    }

    public void printPerson() {
        System.out.println(this.name + ", age " + this.age + " years");
    }

    public void becomeOlder() {
        this.age = this.age + 1;
    }
}
```

Let us create a method for person that can figure out if a person is an adult. The method returns a boolean -- either `true` or `false`:

```
public class Person {
    // ...

    public boolean isAdult(){
        if ( this.age < 18 ) {
            return false;
        }

        return true;
    }

   /*
      note that the method could also be written like this:

      public boolean isAdult(){
        return this.age >= 18;
      }
   */
}
```

Let us test it:

```
    public static void main(String[] args) {
        Person bob = new Person("Bob");
        Person andy = new Person("Andy");

        int i = 0;
        while ( i < 30 ) {
            bob.becomeOlder();
            i++;
        }

        andy.becomeOlder();

        System.out.println("");

        if ( andy.isAdult() ) {
            System.out.print("adult: ");
            andy.printPerson();
        } else {
            System.out.print("minor: ");
            andy.printPerson();
        }

        if ( bob.isAdult() ) {
            System.out.print("adult: ");
            bob.printPerson();
        } else {
            System.out.print("minor: ");
            bob.printPerson();
        }
    }
```

```
minor: Andy, age 1 years
adult: bob, age 30 years
```

Let us tune up the solution a little further. Now, a person can only be printed in a manner where in addition to the name, the age also gets printed. In some cases, we might only want to print the name of the object. Let us tailor a method for this purpose:

```
public class Person {
    // ...

    public String getName() {
        return this.name;
    }
}
```

The method `getName` returns the object variable `name` to its caller. The name of the method might seem a little odd (or not). In Java, it is considered the 'correct' way to name an object-variable-returning method in this manner; as `getVariableName`. Methods like these are often called 'getters'.

Let us edit the main program to use the new 'getter':

```
    public static void main(String[] args) {
        Person bob = new Person("bob");
        Person andy = new Person("andy");

        int i = 0;
        while ( i < 30 ) {
            bob.becomeOlder();
            i++;
        }

        andy.becomeOlder();

        System.out.println("");

        if ( andy.isAdult() ) {
            System.out.println( andy.getName() + " is an adult" );
        } else {
            System.out.println( andy.getName() + " is a minor" );
        }

        if ( bob.isAdult() ) {
            System.out.println( bob.getName() + " is an adult" );
        } else {
            System.out.println( bob.getName() + " is a minor" );
        }
    }
```

The print is starting to look pretty clean:

```
andy is a minor
bob is an adult
```

21.9 toString

We have been guilty of bad programming style; we have created a method that prints an object, `printPerson`. The recommended way of doing this is by defining a method that returns a "character string representation" of the object. In Java, a method returning a String representation is called `toString`. Let us define this method for person:

```
public class Person {
    // ...

    public String toString() {
        return this.name + ", age " + this.age + " years";
    }
}
```

The method `toString` works just like `printPerson`, but instead of printing it the method returns the string representation. The call to the method can be used for printing it if necessary.

The method is used in a slightly surprising way:

```
    public static void main(String[] args) {
        Person bob = new Person("Bob");
        Person andy = new Person("Andy");

        int i = 0;
        while ( i < 30 ) {
            bob.becomeOlder();
            i++;
        }

        andy.becomeOlder();

        System.out.println( andy ); // same as System.out.println( andy.toString() );
        System.out.println( bob ); // same as System.out.println( bob.toString() );
    }
```

The principle is that the `system.out.println` method requests the string representation of an object and then prints it. The returned string representation of the `toString` method does not have to be written, as Java adds it automatically. When the programmer writes:

```
        System.out.println( andy );
```

Java completes the call during runtime to the format:

```
        System.out.println( andy.toString() );
```

What happens is that the object is asked for its string representation. The string representation the object is returned and is printed normally with the `system.out.println` command.

We can get rid of the obsolete `printObject` method.

Exercise 77: Lyyra-card

The University of Helsinki students use a so-called Lyyra cards to pay for their meals in student cafeterias. In this assignment, we implement the class `LyyraCard` that simulates the Lyyra card.

Exercise 77.1: Class skeleton

Start by adding the class `LyyraCard` to your project.

Then implement the `LyyraCard` constructor that gets the starting balance of the card as parameter. The card saves the balance in the object variable `balance`. Implement also the `toString` method that returns a string of the form "The card has X euros".

The skeleton of class `LyyraCard` looks like this:

```
public class LyyraCard {
    private double balance;

    public LyyraCard(double balanceAtStart) {
        // write code here
    }

    public String toString() {
        // write code here
    }
}
```

The following main program can be used to test the program:

```
public class Main {
    public static void main(String[] args) {
        LyyraCard card = new LyyraCard(50);
        System.out.println(card);
    }
}
```

The output should be:

```
The card has 50.0 euros
```

Exercise 77.2: Paying with card

Implement the following methods to `LyyraCard`:

```
public void payEconomical() {
    // write code here
}

public void payGourmet() {
    // write code here
}
```

Method `payEconomical` should decrease the balance by 2.50 euros and method `payGourmet` by 4.00 euros.

The following main program can be used to test the program:

```
public class Main {
    public static void main(String[] args) {
        LyyraCard card = new LyyraCard(50);
        System.out.println(card);

        card.payEconomical();
        System.out.println(card);

        card.payGourmet();
        card.payEconomical();
        System.out.println(card);
    }
}
```

The output should be:

```
The card has 50.0 euros
The card has 47.5 euros
The card has 41.0 euros
```

Exercise 77.3: Balance nonnegative

Change methods `payEconomical` and `payGourmet` so that if there is not enought money, the balance does not change.

The following main program can be used to test the program:

```
public class Main {
    public static void main(String[] args) {
        LyyraCard card = new LyyraCard(5);
        System.out.println(card);

        card.payGourmet();
        System.out.println(card);

        card.payGourmet();
        System.out.println(card);
    }
}
```

The output should be:

```
The card has 5.0 euros
The card has 1.0 euros
The card has 1.0 euros
```

Above, the second call `payGourmet` does not alter the balance since there is not enough money on the card for a gourmet lunch.

Exercise 77.4: Loading money to card

Add the `LyyraCard` the following method:

```
public void loadMoney(double amount) {
    // write code here
}
```

The method should increase the balance of the card by the given amount. However, the maximum balance on a card is 150 euros. In case the balance after loading money would be more than that, it should be truncated to 150 euros.

The following main program can be used to test the program:

```
public class Main {
    public static void main(String[] args) {
        LyyraCard card = new LyyraCard(10);
        System.out.println(card);
        card.loadMoney(15);
        System.out.println(card);

        card.loadMoney(10);
        System.out.println(card);

        card.loadMoney(200);
        System.out.println(card);
    }
}
```

The output should be:

```
The card has 10.0 euros
The card has 25.0 euros
The card has 35.0 euros
The card has 150.0 euros
```

Exercise 77.5: Loading a negative amount

Change the method `loadMoney` so that the balance of the card does not change if the amount to load is negative.

The following main program can be used to test the program:

```
public class Main {
    public static void main(String[] args) {
        LyyraCard card = new LyyraCard(10);
        System.out.println("Pekka: " + card);
        card.loadMoney(-15);
        System.out.println("Pekka: " + card);
    }
}
```

The output should be:

```
Pekka: The card has 10.0 euros
Pekka: The card has 10.0 euros
```

Exercise 77.6: Multiple cards

Write a main method that does the following:

- Creates a LyyraCard for Pekka with initial balance of 20 euros
- Creates a LyyraCard for Brian with initial balance of 30 euros
- Pekka buys gourmet lunch
- Brian buys economical lunch
- cards are printed (both on their own row, starting with the name of the card owner)
- Pekka loads 20 euros
- Brian buys gourmet lunch
- cards are printed (both on their own row, starting with the name of the card owner)
- Pekka buys economical lunch
- Pekka buys economical lunch
- Brian loads 50 euros
- cards are printed (both on their own row, starting with the name of the card owner)

The main skeleton is as follows:

```
public class Main {
    public static void main(String[] args) {
        LyyraCard cardPekka = new LyyraCard(20);
        LyyraCard cardBrian = new LyyraCard(30);

        // write code here
    }
}
```

The output should be:

```
Pekka: The card has 16.0 euros
Brian: The card has 27.5 euros
Pekka: The card has 36.0 euros
Brian: The card has 23.5 euros
Pekka: The card has 31.0 euros
Brian: The card has 73.5 euros
```

21.10 More methods

Let us continue with the class `Person`. We would be interested in knowing the body mass index of a person. To calculate the index, we need to know the height and weight of the person. We add for both height and weight object variables and methods that can be used to assign the variables a value. When this is in place, we add a method that calculates the body mass index.

Here is the class `Person` after the changes (only the parts affected by the change are shown):

```
public class Person {
    private String name;
    private int age;
    private int weight;
    private int height;

    public Person(String initialName) {
        this.age = 0;
        this.name = initialName;
        this.weight = 0;
        this.height = 0;
    }

    public void setHeight(int newHeight) {
        this.height = newHeight;
    }

    public void setWeight(int newWeight) {
        this.weight = newWeight;
    }

    public double bodyMassIndex(){
        double heightDividedByHundred = this.height / 100.0;
        return this.weight / ( heightDividedByHundred * heightDividedByHundred );
    }

    // ...
}
```

We added object variables `height` and `weight`, and methods `setHeight` and `setWeight` that can be used to give values to the variables. In naming the methods, we follow the Java convention to call a method that just sets a new value to a variable `setVariableName`. This type of methods are usually called *setter methods*.

The new methods in use:

```
public static void main(String[] args) {
    Person matti = new Person("Matti");
    Person john = new Person("John");

    matti.setHeight(180);
    matti.setWeight(86);

    john.setHeight(175);
    john.setWeight(64);

    System.out.println(matti.getName() + ", body mass index: " + matti.bodyMassIndex());
    System.out.println(john.getName() + ", body mass index: " + john.bodyMassIndex());
}
```

The output:

```
Matti, body mass index: on 26.54320987654321
John, body mass index: on 20.897959183673468
```

21.11 Object variable and parameter with identical name

Above, the method `setHeight` assigns the object variable `height` the value of the parameter `newHeight`:

```
public void setHeight(int newHeight) {
    this.height = newHeight;
}
```

The parameter could also be named identically with the object variable:

```
public void setHeight(int height) {
    this.height = height;
}
```

Now, the name `height` means the parameter *height* and the identically named object variable is referred to as `this.height`. The following would not work since the object variable *height* is not at all referred to in the code:

```
public void setHeight(int height) {
    // DOES NOT WORK!
    height = height;
    // this just assigns the value of the parameter to the parameter itself
}
```

21.12 Contolling the number of decimals when printing a float

The number of decimals in the last output was far too high, two decimals would be enough. One technique to control how a float number is printed is to use the command `String.format`.

If `value` is a float number, the command `String.value( "%.2f", value )` returns a string where the value is rounded to contain 2 decimals. The number between dot and f defines the amount of decimals shown.

After changing the code, we have the following:

```
System.out.println(matti.getName() + ", body mass index: " + String.format( "%.2f", matti.bodyMassIndex()));
System.out.println(john.getName() + ", body mass index: " + String.format( "%.2f", john.bodyMassIndex()));
```

The output is:

```
Matti,  body mass index: 26,54
John,  body mass index: 20,90
```

The method `String.format` is not the most flexible way provided by Java for formatting float values, but it is simple to use and suits our purposes here well.

Exercise 78: Clock using a counter

We start by implementing a class `BoundedCounter` and then use counter objects to implement a clock.

Exercise 78.1: BoundedCounter

Implement class `BoundedCounter` with the following functionality:

- A counter has an object variable that remembers the *value* of the counter. The value is within the range 0..upperBound
- In the beginning the value is 0.
- The upper bound of the value is defined by the constructor parameter.
- The method `next` increments the value of the counter. If the value would be more that the upper limit, it wraps around and becomes zero.
- The method `toString` returns a string representation of the counter value.

The skeleton of the class is as follows:

```
public class BoundedCounter {
    private int value;
    private int upperLimit;

    public BoundedCounter(int upperLimit) {
        // write code here
    }

    public void next() {
        // write code here
    }

    public String toString() {
        // write code here
    }
}
```

Note: you cannot return an integer value directly from the method toString since the method should return a string. Integer variable `value` can be turned into a string by prefixing it with an empty string: `"" + value`.

A main program that uses the counter:

```
public class Main {
    public static void main(String[] args) {
        BoundedCounter counter = new BoundedCounter(4);
        System.out.println("Value at start: " + counter );

        int i = 0;
        while ( i < 10) {
            counter.next();
            System.out.println("Value: " + counter );
            i++;
        }
    }
}
```

In the constructor, an upper limit of 4 is given to the new counter object. Now, the value of the counter should be within the range 0...4. Note how the method `next` increases the value until it hits the upper limit and becomes zero again:

```
Value at start: 0
Value: 1
Value: 2
Value: 3
Value: 4
Value: 0
Value: 1
Value: 2
Value: 3
Value: 4
Value: 0
```

Exercise 78.2: Printing the initial zero

Imrove `toString` so that if the value of the counter is less than 10, it prefixes the value with 0. If the value of the counter is e.g. 3, toString should produce "03". If the value is at least 10, e.g. 12, the returned string would be "12".

A main program that demonstrates the desired functionality of the improved toString.

```
public class Main {
    public static void main(String[] args) {
        BoundedCounter counter = new BoundedCounter(14);
        System.out.println("Value at start: " + counter );

        int i = 0;
        while ( i < 16){
            counter.next();
            System.out.println("value: " + counter );
            i++;
        }
    }
}
```

```
value at start: 00
value: 01
value: 02
value: 03
value: 04
value: 05
value: 06
value: 07
value: 08
value: 09
value: 10
value: 11
value: 12
value: 13
value: 14
value: 00
```

```
value: 01
```

Exercise 78.3: The first version of the clock

With two counter objects it possible for us to build a simple clock. Hours can be represented by a counter with upper bound 23 and minutes by a counter with upper bound 59. As we all know, when minutes wrap around from 59 to 0, hours advance by one.

First you should implement the method `getValue` for the counters in the class:

```
public int getValue() {
    // write here code that returns the value
}
```

Then implement the clock in your main method in the following style:

```
public class Main {
    public static void main(String[] args) {
        BoundedCounter minutes = new BoundedCounter(59);
        BoundedCounter hours = new BoundedCounter(23);

        int i = 0;
        while ( i < 121 ) {
            System.out.println( hours + ":" + minutes);   // the current time printed
            // advance minutes
            // if minutes become zero, advance hours
            i++;
        }
    }
}
```

The output should be:

```
00:00
00:01
...
00:59
01:00
01:01
01:02
...
01:59
02:00
```

Exercise 78.4: The second version of the clock

Firstly implement the method `setValue` to the class `BoundedCounter`. The method should set the value of the parameter to the counter unless the parameter is less than zero or larger than the upper bound. In those cases, the method does not have any effect.

Then add a seconds counter to your clock. The clock should now be as follows:

```
public class Main {
    public static void main(String[] args)  {
        Scanner reader = new Scanner(System.in);
        BoundedCounter seconds = new BoundedCounter(59);
        BoundedCounter minutes = new BoundedCounter(59);
        BoundedCounter hours = new BoundedCounter(23);

        System.out.print("seconds: ");
        int s = // read the initial value of seconds from the user
        System.out.print("minutes: ");
        int m = // read the initial value of minutes from the user
        System.out.print("hours: ");
        int h = // read the initial value of hours from the user

        seconds.setValue(s);
        minutes.setValue(m);
        hours.setValue(h);

        int i = 0;
        while ( i < 121 ) {
            // like in previous but seconds taken into account

            i++;
        }

    }
}
```

Ensure that all works as expected when starting e.g. with time *23:59:50*.

The output should be:

```
seconds: 50
minutes: 59
hours: 23
23:59:50
23:59:51
23:59:52
...
```

Bonus: eternal clock (exercise not assessed with TMC!)

Before you start, submit the exercise for assesment.

Change your main as follows:

```
public class Main {
    public static void main(String[] args) throws Exception {
        BoundedCounter seconds = new BoundedCounter(59);
        BoundedCounter minutes = new BoundedCounter(59);
        BoundedCounter hours = new BoundedCounter(23);

        seconds.setValue(50);
        minutes.setValue(59);
        hours.setValue(23);

        while ( true ) {
            System.out.println( hours + ":" + minutes + ":" + seconds );
            Thread.sleep(1000);
            // put here the logic to advance your clock by one second
        }
    }
}
```

Now, the clock goes on forever and the value is updated as it should be, once in a second. The clock estimates the duration of a second with the command `Thread.sleep(1000);` The parameter in the command is the time to sleep in milliseconds. In order to use the sleep command, you should do an addition to the definition of main: `public static void main(String[] args) throws Exception {`

You can end the eternal clock by pressing the red box in the NetBeans console (i.e. the area in NB where the output of programs gets printed).

Important notes regarding the use of objects. You should definately read these.

Object-oriented programming is mostly about turning concepts into their own entities, or in other words forming abstractions. One might think that it is pointless to create an object that only holds one number in it, and that the same could be achieved with simple `int` variables. This is not the case. If a clock consists of just 3 int variables that are then increased, the program loses some human readability. It becomes more difficult to "see" what the program is about. Earlier in the material we mentioned the advice of the renown programmer Kent Beck: *"Any fool can write code that a computer can understand. Good programmers write code that humans can understand"*, since the hand of a clock is its own clearly definable concept, it is a good idea to create it an own class - `BoundedCounter` - for the sake of human readability.

Turning a concept into a class of its own is a good idea for a lot of reasons. Firstly, some details (i.e. when the counter makes a full round) can be hidden inside the class (*abstracted*). Instead of writing an if-clause and an assignment operation, it is enough that the user of the counter calls the descriptively named method `next()`. In addition to clocks, the created counter might be good for being used as a building block for other projects too, so a class made from a clear concept can be very versatile. Another huge advantage we gain by writing code this way, is that when the details of the mechanics are hidden, they can be changed if need be.

We established that a clock contains three hands, it consists of three concepts. Actually the clock itself is a concept too and next week we will make the class Clock. Then, we can create distinct Clock objects. Clock will be an object which functionality is based on "simpler" objects, the hands. This is the grand idea of object-oriented programming: a program is built out of small, clearly defined co-operating objects.

Now, we will take some careful first steps in the object world. Towards the end of the course, objects will start to come to you naturally and the idea of *programs being built out of small, well defined, co-operating pieces* - which at this point might feel incomprehensible - will become something you will take for granted.

21.13 Calling other methods within an object

Objects can also call its own methods. Let us assume we would like to include body mass index in the string representation of the person objects. Instead of calculating the body mass index in the toString method, a better idea is to call the method `bodyMassIndex` from the `toString` method:

```
public String toString() {
    return this.name + ", age " + this.age + " years, my body mass index is " + this.bodyMassIndex();
}
```

As can be seen, an object can call its own method by prefixing the method name with `this` and dot. The this is not necessary, so also the following works:

```
public String toString() {
    return this.name + ", age " + this.age + " years, my body mass index is " + bodyMassIndex();
}
```

Now it is time to continue practising programming.

Exercise 79: NumberStatistics

Exercise 79.1: Amount of numbers

Implement class `NumberStatistics` with the following methods:

- `addNumber` adds a new number to the statistics
- `amountOfNumbers` tells us how many numbers have been added to the statistics

Note that the class *should not store* the added numbers. At this stage, it is enough to remember how many added numbers there are, i.e. how many times the method `addNumber` has been called.

The class skeleton:

```
public class NumberStatistics {
    private int amountOfNumbers;

    public NumberStatistics() {
        // initialize here the object variable amountOfNumbers
    }

    public void addNumber(int number) {
        // code here
    }

    public int amountOfNumbers() {
        // code here
    }
}
```

A usage example:

```
public class Main {
   public static void main(String[] args) {
      NumberStatistics stats = new NumberStatistics();
      stats.addNumber(3);
      stats.addNumber(5);
      stats.addNumber(1);
      stats.addNumber(2);
      System.out.println("Amount: " + stats.amountOfNumbers());
    }
}
```

The output should be:

```
Amount: 4
```

Exercise 79.2: sum and average

Add the following methods to the class:

- `sum` returns the sum of the added numbers (if no numbers added, the sum is 0)
- `average` returns the average of the added numbers (if no numbers added, the average is 0)

The class skeleton now:

```
public class NumberStatistics {
    private int amountOfNumbers;
    private int sum;

    public NumberStatistics() {
        // initialize here the object variable amountOfNumbers
    }
    public void addNumber(int number) {
        // code here
    }

    public int amountOfNumbers() {
        // code here
    }

    public int sum() {
        // code here
    }

    public double average() {
        // code here
    }
}
```

A usage example:

```
public class Main {
    public static void main(String[] args) {
        NumberStatistics stats = new NumberStatistics();
        stats.addNumber(3);
        stats.addNumber(5);
        stats.addNumber(1);
        stats.addNumber(2);
        System.out.println("Amount: " + stats.amountOfNumbers());
        System.out.println("sum: " + stats.sum());
        System.out.println("average: " + stats.average());
    }
}
```

The output should be:

```
Amount: 4
sum: 11
average: 2.75
```

Exercise 79.3: Asking for numbers from the user

Create a program that asks the user to input numbers of type integer. When the user gives -1, the program stops and prints the sum of the given numbers (excluding the -1).

Note: you should not make any changes to class NumberStatistics!

The program should use a `NumberStatistics` object to calculate the sum.

```
Type numbers:
4
2
5
4
-1
sum: 15
```

Exercise 79.4: Many sums

Change your program so that it also calculates the sum of even and odd numbers in the user input (again -1 excluded).

NOTE: define in your program *three* `NumberStatistics` objects. The first is used to track the sum of all the numbers. The second takes care of even numbers and the third the odd numbers. Remember also that you should not make any changes to class NumberStatistics!

The tests does not work if you do not create the objects in the order mentioned above!!

The program should work as follows:

```
Type numbers:
4
2
5
2
-1
sum: 13
sum of even: 8
sum of odd: 5
```

22. Randomness

When programming, you may occasionally need to simulate random events. Situations such as the unpredictability of weather, or surprising moves on the AI's part in a computer game can often be simulated with random number generators, running on a computer. In Java, there is a ready-made class `Random`, which you can use in the following way:

```java
import java.util.Random;

public class Randomizing {
    public static void main(String[] args) {
        Random randomizer = new Random(); // creates a random number generator
        int i = 0;

        while (i < 10) {
            // Generates and prints out a new random number on each round of the loop
            System.out.println(randomizer.nextInt(10));
            i++;
        }
    }
}
```

In the code above, you first create an instance of the class `Random` with the keyword `new` -- exactly as when creating objects implementing other classes. An object of type Random has the method `nextInt` that can be given an integer value as parameter. The method returns a random integer within the range *0..(the integer given as parameter- 1)*.

The printout of this program could be as follows:

```
2
2
4
3
4
5
6
0
7
8
```

We will need floating point numbers, for example when dealing with probability calculations. In computing, probabilities are usually calculated with numbers within the range [0..1]. An object of the class Random can return random floating point numbers with the method `nextDouble`. Let us consider the following probabilities of weather conditions:

- Sleet with the probability 0.1 (10%)
- Snow with the probability 0.3 (30%)
- Sunny with the probability 0.6 (60%)

Using the estimates above, let us create a weather forecaster.

```
import java.util.ArrayList;
import java.util.Random;

public class WeatherForecaster {
    private Random random;

    public WeatherForecaster() {
        this.random = new Random();
    }

    public String forecastWeather() {
        double probability = this.random.nextDouble();

        if (probability <= 0.1) {
            return "Sleet";
        } else if (probability <= 0.4) { // 0.1 + 0.3
            return "Snow";
        } else { // the rest, 1.0 - 0.4 = 0.6
            return "Sunny";
        }
    }

    public int forecastTemperature() {
        return (int) ( 4 * this.random.nextGaussian() - 3 );
    }
}
```

The method `forecastTemperature` is interesting in many ways. Within this method, we are calling the method `this.random.nextGaussian()`, just like any other time we have called a method in the previous examples. Interestingly, this method of the class Random returns a value from the *normal distribution* (if you have no interest in the different varieties of random figures, that's okay!).

```
public int forecastTemperature() {
    return (int) ( 4 * this.random.nextGaussian() - 3 );
}
```

In the expression above, interesting is the section `(int)`. This part of the expression changes the bracketed floating point number into an integer value. A corresponding method transforms integer values into floating point numbers: `(double) integer`. This is called an *explicit type conversion*.

Let us create a class with a main method that uses the class `WeatherForecaster`.

```
public class Program {

    public static void main(String[] args) {
        WeatherForecaster forecaster = new WeatherForecaster();

        // Use a list to help you organise things
        ArrayList<String> days = new ArrayList<String>();
        Collections.addAll(days, "Mon", "Tue", "Wed", "Thu", "Fri", "Sat", "Sun");

        System.out.println("Weather forecast for the next week:");
        for(String day : days) {
            String weatherForecast = forecaster.forecastWeather();
            int temperatureForecast = forecaster.forecastTemperature();
            System.out.println(day + ": " + weatherForecast + " " + temperatureForecast + " degrees.");
        }
    }
}
```

The printout from this program could be as follows:

```
Weather forecast for the next week:
Mon: Snow 1 degrees.
Tue: Snow 1 degrees.
Wed: Sunny -2 degrees.
Thu: Sunny 0 degrees.
Fri: Snow -3 degrees.
Sat: Snow -3 degrees.
Sun: Sunny -5 degrees.
```

Exercise 80: Rolling the dice

In the template is class `Dice` that has the following functionality:

- The constructor `Dice(int numberOfSides)` creates a new dice object that has the amount of sides defined by the argument.
- The method `roll` tells the result of a roll (which depends on the number of its sides)

The frame of the program is as follows:

```
import java.util.Random;

public class Dice {
    private Random random;
    private int numberOfSides;

    public Dice(int numberOfSides){
        this.numberOfSides = numberofSides;
        random = new Random();

    }

    public int roll() {
          // we'll get a random number in the range 1-numberOfSides<
    }
}
```

Expand the class `Dice` so that with each roll the dice returns a random number between `1...number of sides`. Here is a main program that tests the dice:

```
public class Program {
    public static void main(String[] args) {
        Dice dice = new Dice(6);

        int i = 0;
        while ( i < 10 ) {
            System.out.println( dice.roll() );
            i++;
        }
    }
}
```

The output could look something like this:

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

Exercise 81: Password randomizer

Your assignment is to expand the class `PasswordRandomizer` that has the following functionality:

- The constructor `PasswordRandomizer` creates a new object, which uses the given password length.
- The method `createPassword` returns a new password, which consists of symbols a-z and is of the length given as a parameter to the constructor

The frame of the class is as follows:

```
import java.util.Random;

public class PasswordRandomizer {
    // Define the variables here

    public PasswordRandomizer(int length) {
        // Format the variable here
    }

    public String createPassword() {
      // Write the code here which returns the new password
    }
}
```

In the following is a program that uses a PasswordRandomizer object:

```
public
class Program {
    public static void main(String[] args) {
        PasswordRandomizer randomizer = new PasswordRandomizer(13);
        System.out.println("Password: " + randomizer.createPassword());
        System.out.println("Password: " + randomizer.createPassword());
        System.out.println("Password: " + randomizer.createPassword());
        System.out.println("Password: " + randomizer.createPassword());
    }
}
```

The output could look something like this:

```
Password: mcllsoompezvs
Password: urcxboisknkme
Password: dzaccatonjcqu
Password: bpqmedlbqaopq
```

Tip 1: this is how you turn the integer `number` into a character:

```
int number = 17;
char symbol = "abcdefghijklmnopqrstuvwxyz".charAt(number);
```

Tip 2: The tip in assignment 58 might be useful in this one too.

Exercise 82: Lottery

Your assignment is to expand the class `LotteryNumbers`, which draws the lottery numbers of the week. The numbers of the week consist of 7 different numbers between 1 and 39. The class has the following functionality:

- the constructor `LotteryNumbers` creates a new LotteryNumbers object, which contains the new drawn numbers
- the method `numbers` returns the drawn numbers of this draw
- the method `drawNumbers` draws new numbers
- the method `containsNumber` reveals if the number is among the drawn numbers

The frame of the class is as follows:

```
import java.util.ArrayList;
import java.util.Random;

public class LotteryNumbers {
    private ArrayList<Integert> numbers;

    public LotteryNumbers() {
        // We'll format a list for the numbers
        this.numbers = new ArrayList<Integert>();
        // Draw numbers as LotteryNumbers is created
        this.drawNumbers();
    }

    public ArrayList<Integert> numbers() {
        return this.numbers;
    }

    public void drawNumbers() {
        // Write the number drawing here using the method containsNumber()
    }

    public boolean containsNumber(int number) {
        // Test here if the number is already among the drawn numbers
    }
}
```

The following main program comes with the template:

```
import java.util.ArrayList;

public class Program {
    public static void main(String[] args) {
        LotteryNumbers lotteryNumbers = new LotteryNumbers();
        ArrayList<Integert> numbers = lotteryNumbers.numbers();

        System.out.println("Lottery numbers:");
        for (int number : numbers) {
            System.out.print(number + " ");
        }
        System.out.println("");
    }
}
```

The program can print lines like these:

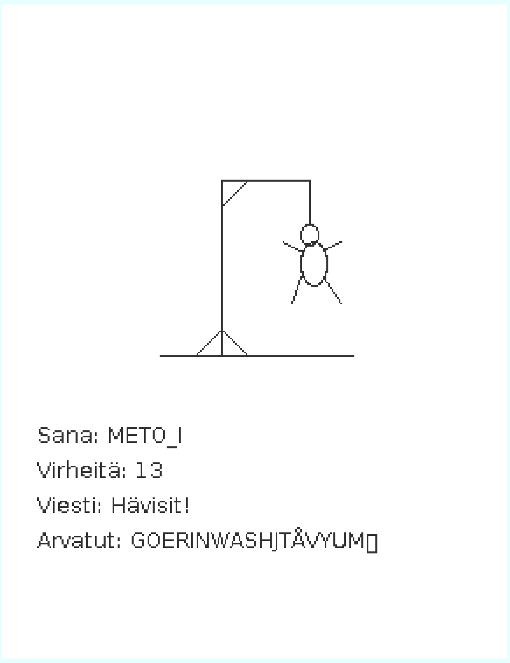
```
Lottery numbers:
3 5 10 14 15 27 37
```

```
Lottery numbers:
2 9 11 18 23 32 34
```

Note! a number can be in one set of numbers only once (per draw of course).

Exercise 83: Game logic for Hangman

Your Finnish friend designed a Hangman game that looks like the following:



Sana: METO_I
Virheitä: 13
Viesti: Hävisit!
Arvatut: GOERINWASHJTÅVYUM▯

Your friend has programmed the user interface and also a skeleton for the game logic. Now, she asks you to finish the remaining pieces of the game logic.

The Finnish words *sana*, *virheitä*, *viesti*, *hävisit* and *arvatut (kirjaimet)* translate into *word*, *(number of) faults*, *message*, *you lost* and *guessed (letters)* respectively.

Amongst other stuff, with TMC you get the following skeleton for the class `HangmanLogic`

```java
public class HangmanLogic {

    private String word;
    private String guessedLetters;
    private int numberOfFaults;

    public HangmanLogic(String word) {
        this.word = word.toUpperCase();
        this.guessedLetters = "";
        this.numberOfFaults = 0;
    }

    public int numberOfFaults() {
        return this.numberOfFaults;
    }

    public String guessedLetters() {
        return this.guessedLetters;
    }

    public int losingFaultAmount() {
        return 12;
    }

    public void guessLetter(String letter) {
        // program here the functionality for making a guess

        // if the letter has already been guessed, nothing happens

        // it the word does not contains the guessed letter, the number of faults increases
        // the letter is added among the already guessed letters
    }

    public String hiddenWord() {
        // program here the functionality for building the hidden word

        // create the hidden word by iterating through this.word letter by letter
        // if the letter in turn is within the guessed words, put it in the hidden word
        // if the letter is not among the guessed ones, replace it with _ in the hidden word

        // return the hidden word at the end

        return "";
    }
}
```

In this assignment, *you should only touch class `HangmanLogic` and implement the functionality of the methods `guessLetter(String letter)` and `hiddenWord()`.*

Testing the code

The TMC project includes *two* classes that help you with testing. The class `Main` starts the graphical version of the game. The class `TestProgram` can be used to test the class `HangmanLogic`.

Exercise 83.1: Guessing a letter

Touch only the method `guessLetter(String letter)` in this assignment!

When a user guesses a letter, the user interface calls method `guessLetter` which is supposed to take care of action related to guessing a letter. First, it should check if the letter has already been guessed. In that case, the method does not do anything.

The method increases the number of faults (`this.numberOfFaults`) if the word (`this.word`) does not contain the guessed letter. Then the letter is added among the already guessed letters (the object variable `this.guessedLetters`).

An example of how the method `guessLetter` should work:

```
HangmanLogic l = new HangmanLogic("kissa");
System.out.println("guessing: A, D, S, F, D");
l.guessLetter("A");   // correct
l.guessLetter("D");   // wrong
l.guessLetter("S");   // correct
l.guessLetter("F");   // wrong
l.guessLetter("D");   // This should not have any effect on the number of faults since D was already guessed
System.out.println("guessed letters: "+l.guessedLetters());
System.out.println("number of faults: "+l.numberOfFaults());
```

```
guessing: A, D, S, F, D
guessed letters: ADSF
```

```
number of faults: 2
```

Exercise 83.2: Creating the hidden word

The Hangman user interface shows a hidden version of the word to the user. In the above figure, the hidden word is METO_I. All the letters that the user has already guessed are shown in the hidden word but the rest of the letters are replaced with underscores. In this part of the assignment, you should complete the method `hiddenWord` of Hangman logic that takes care of building the hidden word for the user interface.

Commands `while`, `charAt` and `contains` might be useful here. Note that a single char can be made into a string as follows:

```java
char c = 'a';
String aString = "" + c;
```

An example of how the method works:

```java
HangmanLogic l = new HangmanLogic("kissa");
System.out.println("word is: "+l.hiddenWord());

System.out.println("guessing: A, D, S, F, D");
l.guessLetter("A");
l.guessLetter("D");
l.guessLetter("S");
l.guessLetter("F");
l.guessLetter("D");
System.out.println("guessed letters: "+l.guessedLetters());
System.out.println("number of faults: "+l.numberOfFaults());
System.out.println("word now: "+l.hiddenWord());
```

```
word is: _____
guessing: A, D, S, F, D
guessed letters: ADSF
number of faults: 2
word now: __SSA
```

Now, you can test the game by using class `Main`. You can change the guessed word by changing the constructor parameter of the game logic:

```java
HangmanLogic logic = new HangmanLogic("parameter");
HangmanUI game = new HangmanUI(logic);
game.start();
```

The game is played with the keyboard. You can end the game by pressing x in the upper left corner of the game window.

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