1st homework assignment; OPRPP1

In order to solve this homework, you are expected to read (with understanding) chapters 5 and 6 in book. After that you can proceed with this homework. This homework consists of five problems. During the semester we will return to this code, modify it, polish it and use it to implement some very cool stuff. You will have to reuse the code you write here, so write it smart. Be patient and please, don't panic. Breathe deeply. OK, here we go…

Start by creating a blank Maven project: in Eclipse workspace directory create directory `hw01-0000000000` (replace zeros with your JMBAG) and inside setup Maven project `hr.fer.oprpp1.jmbag0000000000:hw01-0000000000` (replace zeros with your JMBAG) and add dependencies needed for junit 5. Import it into Eclipse. Now you can start solving actual problems.

Problem 1.

All of the following classes should be placed in package `hr.fer.oprpp1.custom.collections`.

Define a class `Processor`. It must define a single method:

```
public void process(Object value);
```

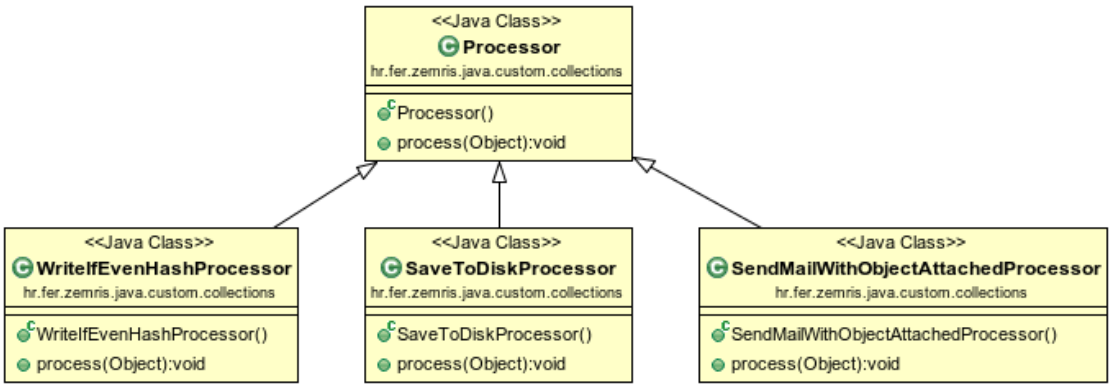
with empty body (its implementation exists but does nothing). What is a `Processor`? The `Processor` is a model of an object capable of performing some operation on the passed object. For this reason, each `Processor` must have the `process(Object value)` method. Class `Processor` here represents an conceptual contract between clients which will have objects to be processed, and each concrete `Processor` which knows how to perform the selected operation. Each concrete `Processor` will be defined as a new class which inherits from the class `Processor`. This is very simple but at the same time powerful idea which allows us to write generic and reusable code. The described code organization paired with the method `forEach(Processor processor)` specified later in text represents the *Strategy Design Pattern*.

As previously explained, the concrete processors are defined as new classes which inherit from `Processor` class. So lets say we which to define a processor which will write message "Got it!" to terminal for each object whose hash code is even number. Such processor would be defined as:

```
package hr.fer.oprpp1.custom.collections;

public class WriteIfEvenHashProcessor extends Processor {

	public void process(Object value) {
		if (value.hashCode() % 2 == 0) {
			System.out.println("Got it!");
		}
	}

}
```

Note: class `Processor` would normally be defined as an abstract class. However, since we haven't talked about abstract classes or interfaces yet, you can not use them so make all classes "normal" classes.

Along with this one, we could define a number of other processors; for example, one which would send the passed object as an attachment via e-mail, one that would store the object into file, etc. This is illustrated in the following figure (ignore packet names).



Lets assume now that we have an array of objects. We can create an instance of selected processor an send each object to it for processing, as illustrated in code bellow. In order to change the operation which is applied to each object (write message, e-mail it or save it), all we must modify is the line which chooses the concrete `Processor` class.

```
public static void main(String[] args) {
	Object[] data = new Object[] {
			Integer.valueOf(20),
			Integer.valueOf(25),
			"Ivana",
			"Stjepan",
			"B",
			Integer.valueOf(30),
			Boolean.valueOf(false)
	};

	Processor p = new WriteIfEvenHashProcessor();

	for(int i = 0; i < data.length; i++) {
		p.process(data[i]);
	}
}
```

Note: as part of this homework you should create class `Processor` as required. Classes `WriteIfEvenHashProcessor`, `SaveToDiskProcessor` and `SendMailWithObjectAttachedProcessor` were mentioned just for illustration.

Define a class `Collection` which represents some general collection of objects. This class should provide only a protected default constructor. Class `Collection` must provide following public methods.

`boolean isEmpty();` Returns `true` if collection contains no objects and `false` otherwise. Implement it here to determine result by utilizing method `size()`.
`int size();` Returns the number of currently stored objects in this collections. Implement it here to always return 0.
`void add(Object value);` Adds the given object into this collection. Implement it here to do nothing.
`boolean contains(Object value);` Returns `true` only if the collection contains given `value`, as determined by `equals` method. Implement it here to always return `false`. It is OK to ask if collection contains `null`.
`boolean remove(Object value);`

Returns `true` only if the collection contains given `value` as determined by `equals` method and removes one occurrence of it (in this class it is not specified which one). Implement it here to always return `false`.
`Object[] toArray();` Allocates new array with size equals to the size of this collections, fills it with collection content and returns the array. This method never returns `null`. Implement it here to throw `UnsupportedOperationException`.
`void forEach(Processor processor);` Method calls `processor.process(.)` for each element of this collection. The order in which elements will be sent is undefined in this class. Implement it here as an empty method.
`void addAll(Collection other);` Method adds into the current collection all elements from the given collection. This other collection remains unchanged. Implement it here to define a local processor class (read about *Local classes* in book) whose method `process` will add each item into the current collection by calling method `add`, and then call `forEach` on the other collection with this processor as argument. You must define this new class directly in the method `addAll` (such classes are called local classes).
`void clear();` Removes all elements from this collection. Implement it here as an empty method.

Since this class does not actually have any storage capabilities, you will not be able to test it yet.

Problem 2.

Write an implementation of resizable array-backed collection of objects denoted as `ArrayIndexedCollection` which extends class `Collection` from previous problem.
Put it also in package `hr.fer.oprpp1.custom.collections`. Each instance of this class should manage two *private* variables:

- `size` – current size of collection (number of elements actually stored in `elements` array),
- `elements` – an array of object references which length determines its current capacity (obviously, at any time size can not be greater than array length).

General contract of this collection is: duplicate elements **are allowed**; storage of `null` references **is not allowed**.

You should provide *four* public constructors. The default constructor should create an instance with `capacity` set to 16 (this also means that constructor should preallocate the `elements` array of that size). The second constructor should have a single integer parameter: `initialCapacity` and should set the `capacity` to that value, as well as preallocate the `elements` array of that size. If initial capacity is less then 1, an `IllegalArgumentException` should be thrown.

Other two constructors are variation of the previous two, but they accept additional parameter (as first argument): a non-null reference to some other `Collection` which elements are copied into this newly constructed collection; if the `initialCapacity` is smaller than the size of the given collection, the size of the given collection should be used for `elements` array preallocation. If the given collection is `null`, a `NullPointerException` should be thrown.

Please implement the simpler constructors so that they delegate the construction process to the more complex constructors (read section “Delegiranje zadaće konstrukcije objekta” in book, chapter 5). You are also free to add private constructor(s) if this can lead to better code.

This class should override empty method definitions inherited from the `Collection` class with an appropriate implementation.

This class should also have all of the methods given below. Please note that some methods are copied from the previous problem but have better specified behavior.

`void add(Object value);` Adds the given object into this collection (reference is added into first empty place in the `elements` array; if the `elements` array is full, it should be reallocated *by doubling* its size). The method should refuse to add `null` as element by throwing the appropriate exception (`NullPointerException`). What is the average complexity of this method?
`Object get(int index);` Returns the object that is stored in backing array at position `index`. Valid indexes are 0 to `size`-1. If `index` is invalid, the implementation should throw the appropriate exception (`IndexOutOfBoundsException`). What is the average complexity of this method?
`void clear();` Removes all elements from the collection. The allocated array is left at current capacity. Do not just set size to 0; write `null` references into the backing array so that objects which became unreferenced become eligible for garbage collection. Do not allocate new array.

`void insert(Object value, int position);` **Inserts** (does not overwrite) the given `value` at the given `position` in array (observe that before actual insertion elements at `position` and at greater positions must be shifted one place toward the end, so that an empty place is created at `position`). The legal positions are 0 to `size` (both are included). If `position` is invalid, an appropriate exception should be thrown (`IndexOutOfBoundsException`). Except the difference in position at witch the given object will be inserted, everything else should be in conformance with the method `add`. What is the average complexity of this method?
`int indexOf(Object value);` Searches the collection and returns the index of the first occurrence of the given `value` or -1 if the `value` is not found. Argument can be `null` and the result must be that this element is not found (since the collection can not contain `null`). The equality should be determined using the `equals` method. What is the average complexity of this method?
`void remove(int index);` Removes element at specified `index` from collection. Element that was previously at location `index+1` after this operation is on location `index`, etc. Legal indexes are `0` to `size-1`. In case of invalid index throw an appropriate exception (`IndexOutOfBoundsException`). Please note that the method `remove(Object value)` specified in class `Collection` and this method are two different methods which perform different operations.

You are expected to write junit tests for all public constructors and for all methods described in the previous table.

Problem 3.

Write an implementation of linked list-backed collection of objects denoted as `LinkedListIndexedCollection` which extends class `Collection` from previous problem.
Put it also in package `hr.fer.oprpp1.custom.collections`.
This class should define private static class `ListNode` with pointers to `previous` and `next` list node and additional reference for `value` storage.

Each instance of this class should manage three *private* variables:

- `size` – current size of collection (number of elements actually stored; number of nodes in list),
- `first` – reference to the first node of the linked list,
- `last` – reference to the last node of the linked list.

General contract of this collection is: duplicate elements **are allowed** (each of those element will be held in different list node); storage of `null` references **is not allowed**.

You should provide *two* constructors. The default constructor should create an empty collection with `first=last=null`. The second constructor should have a single parameter: reference to some other `Collection` whose elements are copied into this newly constructed collection.

This class should override empty method definitions inherited from `Collection` class with appropriate implementation.

This class should also have all of the methods given below. Please note that some methods are copied from the previous problem but have better specified behavior.

`void add(Object value);` Adds the given object into this collection at the end of collection; newly added element becomes the element at the biggest index. Implement it with complexity O(1). The method should refuse to add `null` as element by throwing the appropriate exception (`NullPointerException`).
`Object get(int index);` Returns the object that is stored in linked list at position `index`. Valid indexes are 0 to `size`-1. If `index` is invalid, the implementation should throw the appropriate exception (`IndexOutOfBoundsException`). Implement this method so that it never has the complexity greater than *n*/2+1.
`void clear();` Removes all elements from the collection. Collection “forgets” about current linked list.
`void insert(Object value, int position);` **Inserts** (does not overwrite) the given `value` at the given `position` in linked-list. Elements starting from this position are shifted one position. The legal positions are 0 to `size`. If `position` is invalid, an appropriate exception should be thrown. Except the difference in position at witch the given object will be inserted, everything else should be in conformance with the method `add`. What is the average complexity of this method?
`int indexOf(Object value);` Searches the collection and returns the index of the first occurrence of the given `value` or -1 if the `value` is not found. `null` is valid argument. The equality should be determined using the `equals` method. What is the average complexity of this method?
`void remove(int index);` Removes element at specified `index` from collection. Element that was previously at location `index+1` after this operation is on location `index`, etc. Legal indexes are `0` to `size-1`. In case of invalid index throw an appropriate exception (and document it!).

Example of usage for problems 1, 2 and 3 (you will have to `import java.util.Arrays;`):

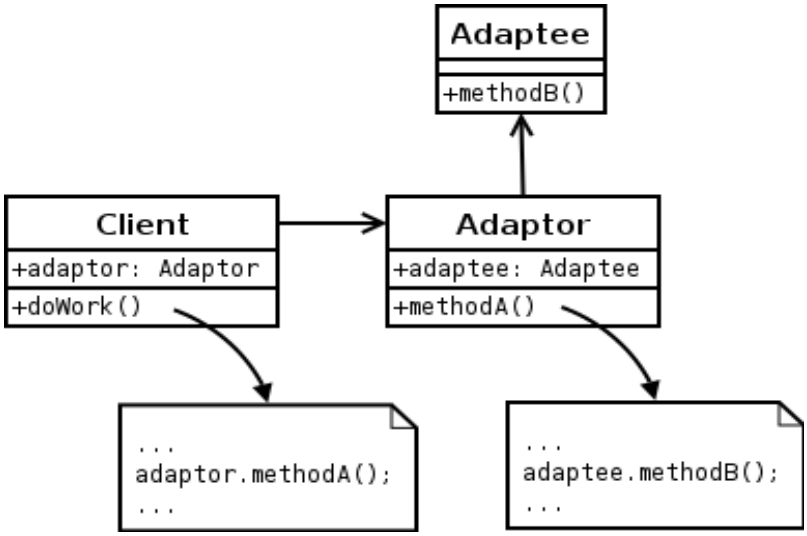
```
ArrayIndexedCollection col = new ArrayIndexedCollection(2);
col.add(Integer.valueOf(20));
col.add("New York");
col.add("San Francisco");  // here the internal array is reallocated to 4
System.out.println(col.contains("New York")); // writes: true
col.remove(1); // removes "New York"; shifts "San Francisco" to position 1
System.out.println(col.get(1)); // writes: "San Francisco"
System.out.println(col.size()); // writes: 2
col.add("Los Angeles");

LinkedListIndexedCollection col2 = new LinkedListIndexedCollection(col);

// This is local class representing a Processor which writes objects to System.out
class P extends Processor {
  public void process(Object o) {
    System.out.println(o);
  }
};

System.out.println("col elements:");
col.forEach(new P());

System.out.println("col elements again:");
System.out.println(Arrays.toString(col.toArray()));

System.out.println("col2 elements:");
col2.forEach(new P());

System.out.println("col2 elements again:");
System.out.println(Arrays.toString(col2.toArray()));

System.out.println(col.contains(col2.get(1))); // true
System.out.println(col2.contains(col.get(1))); // true

col.remove(Integer.valueOf(20)); // removes 20 from collection (at position 0).
```

In order to solve this, consult lecture presentation, chapters 5 and 6 in book as well as the *Lesson: Exception* from the official *Java Tutorial* (see: http://docs.oracle.com/javase/tutorial/essential/exceptions/).

You are expected to write junit tests for all public constructors and for all methods described in the previous table.

Problem 4.

Soon we will need an implementation of the *stack*-like collection. The collection `ArrayIndexedCollection` you already implemented could be used for that purpose; however, the interface (in a sense how users interact with it) of that collection is inappropriate. If the collection is a stack, you would expect it to have methods such as `push`, `pop` and `peek`, and not `insert`, `add` etc. which can be confusing for user. There is well known design pattern that can be employed to solve this mismatch: *Adapter pattern*[1] which is illustrated in the following figure.



In this case the *Adaptee* is the `ArrayIndexedCollection` class with its methods `add`, `insert` etc. It is the class with "wrong" interface toward the user. Your task will be to write `ObjectStack` class (it is top level class – it does not extends `Collection` class we defined previously) that is the *Adaptor* in used design pattern (place the class in the package from previous problem). This class must provide to user the methods which are natural for a stack and hide everything else. The `ObjectStack` class should provide the following methods:

`boolean isEmpty();` – same as `ArrayIndexedCollection.isEmpty()`

`int size();` – same as `ArrayIndexedCollection.size()`

`void push(Object value);` – pushes given value on the stack. `null` value must not be allowed to be placed on stack.

`Object pop();` – removes last value pushed on stack from stack and returns it. If the stack is empty when method `pop` is called, the method should throw `EmptyStackException`. This exception *is not part* of JRE libraries; you should provide an implementation of `EmptyStackException` class (put the class in the same package as all of collections you implemented and let it inherit from `RuntimeException`).

`Object peek();` – similar as `pop`; returns last element placed on stack but does not delete it from stack. Handle an empty stack as described in `pop` method.

`void clear();` – removes all elements from stack.

1 Please see: http://en.wikipedia.org/wiki/Adapter_pattern

The goal that `ObjectStack` should provide for it users appropriate interface but at the same time avoid code duplication will be accomplished by using *delegation* (remember this term). Each `ObjectStack` instance will create and manage its own private instance of `ArrayIndexedCollection` and use it for actual element storage. This way, the methods of `ObjectStack` will be the methods user expects to exist in stack, and those methods will implement its functionality by calling (i.e. delegating) methods of its internal collection of type `ArrayIndexedCollection`. The fact that our implementation of stack internally uses an instance of `ArrayIndexedCollection` is an implementation detail of which the final user is unaware. Additional benefit of this approach is the fact that actual implementation of element storage can be changed at any time (for example, we can decide to use `LinkedListIndexedCollection`) and without any consequences for clients of our stack class: we will not have to adjust or modify any of these clients – they are isolated from this change.

The methods `push` and `pop` should be implemented so that they have *o*(1) average complexity (except when the underlying array in used collection is reallocated).

Now create class `StackDemo` in subpackage `demo`. This should be command-line application which accepts a single command-line argument: expression which should be evaluated. Expression must be in postfix representation. When starting program from console, you will enclose whole expression into quotation marks, so that your program always gets just one argument (`args.length` should be `1` and the `args[0]` should be the whole expression).

Example 1: “8 2 /” means apply / on 8 and 2, so 8/2=4.
Example 2: “-1 8 2 / +” means apply / on 8 and 2, so 8/2=4, then apply + on -1 and 4, so the result is 3.

In expressions, you can assume that everything is separated by one (or more) spaces.
Each operator takes two preceding numbers and replaces them with operation result. You must support only +, -, /, * and % (remainder of integer division). All operators work with and produce integer results. So it is expected that 3/2=1. The calculation process can be solved by using the stack you just developed. Split the expression by spaces, and then do the following:

```
stack = empty
for each element of expression
    if element is number, push it on stack and continue
    else pop two elements from stack, perform operation and push result back on stack
end for
if stack size different from 1, write error
else syso stack.pop()
```

Ensure that you terminate the evaluation if user tries to divide by zero (write appropriate message to user; do not dump a stack trace on user). Also, if expression is invalid, write appropriate message to user.

Usage example:

```
D:\java> java -cp . hr.fer.oprpp1.custom.collections.demo.StackDemo "8 -2 / -1 *"
Expression evaluates to 4.
```

Please observe: the whole argument is enclosed in quotes so that it is given to your program as a single argument. It is your responsibility to split it.

Please note. You can consult with your peers and exchange ideas about this homework *before* you start actual coding (but in that case don't forget: `diskusija.txt`). Once you open you IDE and start coding, consultations with others (except with me) will be regarded as cheating. You can not use any of preexisting code or libraries for this homework (whether it is yours old code or someones else). Additionally, for this homework you can not use any of Java Collection Framework classes which represent collections or its derivatives (its OK to use Arrays class if you find it suitable). Document your code!

All source files must be written using UTF-8 encoding. All classes, methods and fields (public, private or otherwise) must have appropriate javadoc.

You must write junit tests for problem 2 and problem 3; be aware that both implementations share a lot of functionality, so think about how to organize tests in a way that won't have a lot of redundancies. Junit tests for other problems are encouraged but not mandatory.

Important: when exporting project as ZIP-archive, from this homework on, ensure that the archive in its root contains `pom.xml` and `src`. In order to get such archive, in export wizard only select `pom.xml` file and `src` directory, and check "`Create only selected directories`". Once again: ZIP-archive must not contain a top level project folder which then contains `pom.xml` and `src`!

When your homework is done, pack it in zip archive with name `hw01-0000000000.zip` (replace zeros with your JMBAG). Upload this archive to Ferko before the deadline. Do not forget to lock your upload or upload will not be accepted.