

CS2030 Programming Methodology II  
Semester 1 2023/2024

30 & 31 August 2023

Problem Set #1

**Abstraction and Encapsulation**

1. Study the following classes P and Q:

```
1:  class P {
2:      private final int x;
3:
4:      P(int x) {
5:          this.x = x;
6:      }
7:
8:      P foo() {
9:          P newP = new P(this.x + 1);
10:         return newP;
11:     }
12:
13:     P bar(P p) {
14:         p.x = p.x + 1;
15:         return p;
16:     }
17: }
18:
19: class Q {
20:     P baz(P p) {
21:         return new P(p.x + 1);
22:     }
23: }
```

- (a) Which line(s) above violate the **final** modifier of property **x** in class **P**?
- (b) Which line(s) above violate the **private** modifier of property **x** in class **P**? Relate your observation to the concept of an “abstraction barrier”.

2. A sample use of the **Pair** class is shown below:

```
jshell> Pair<Double,Double> pair = new Pair<Double,Double>(1.0, 2.0)
pair ==> (1.0, 2.0)

jshell> pair.first()
$.. ==> 1.0

jshell> pair.second()
$.. ==> 2.0
```

Now consider the following definition of a `Vector2D` class:

```
class Vector2D {
    private final Pair<Double, Double> pair;

    Vector2D(double x, double y) {
        this.pair = new Pair<Double, Double>(x, y);
    }

    private double x() {
        return this.pair.first();
    }

    private double y() {
        return this.pair.second();
    }

    Vector2D add(Vector2D v) {
        Vector2D newVector = new Vector2D(
            this.x() + v.x(),
            this.y() + v.y());
        // line A
        return newVector;
    }

    public String toString() {
        return "(" + this.x() + ", " + this.y() + ")";
    }
}
```

- (a) Do the `x()` and `y()` methods violate the *Tell-Don't-Ask* principle? How about `first()` and `second()` in the `Pair` class?
- (b) Suppose that the following is executed in `JShell`:

```
new Vector2D(1.0, 1.0).add(new Vector2D(2.0, 2.0))
```

Show the content of the stack and the heap when the execution reaches the line labelled A above. Label your variables and the values they hold clearly. You can use arrows to indicate object references.

3. The most effective way to get acquainted with Object Oriented Programming is to look at everyday objects around us, and try to model them. In this exercise, we shall be modeling a book.

A book comprises of some pages of words (we ignore pictures for now). When reading a book, one can flip from one page to the next, flip a page back, or go to a specified page. Each page of a book comprises several lines of text.

Here's an example of page 8 from the Dr. Seuss' "One fish, two fish, red fish, blue fish".

```
Yes. Some are red. And some are blue.  
Some are sad.  
And some are glad.  
--- Page 8 ---
```

Here are some specifications of how a **Book** object should behave.

- **Book::nextPage() : Book**  
Advances the book by one page. Turning the next page beyond the last page remains at the last page.
- **Book::prevPage() : Book**  
Turns the page back by one page. Turning the page back from the first page remains at the first page.
- **Book::gotoPage(int pageNumber) : Book**  
Turns to the page specified by **pageNumber**. If **pageNumber** is not a valid page number, then remain with the current page.

The user (or client) of a **Book** object will only make use of the above methods to read a book. Once a book is created, it's contents will not change. You are free to represent a **Page** as appropriate; just implement the **Book** constructor accordingly.

Design and test your program, bearing in mind the following Object-Oriented design considerations.

- Identify the **objects** in the problem statement.
- **OO Principle #1: Abstraction** — identify the relevant **data** and **functionality** of each object.
- **OO Principle #2: Encapsulation** — **package** data/functionality into each object and utilize **information-hiding** techniques to prevent client access.
- Maintain an **abstraction barrier** between the client and the implementor.
- Application of the **Tell-Don't-Ask** principle.
- Making use of **immutable** objects for ease of testing.

Write JShell tests to test your program.