



**FACULTY OF COMPUTERS AND INFORMATION,
CAIRO UNIVERSITY**

CS213: Programming II
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First Semester

Problem Sheet 2 – Version 1.0

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Revision History

Version 1.0

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Main Doc

CS213: Object Oriented Programming

Problem Sheet 2 – OOP Modeling and C++ OOP Features



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Objectives

This sheet includes programming problems for training on C++ Revision.

Problems

0. **Minimax.** Given the X-O game we did in the lecture, add to this game:
 - An inherited **ComputerPlayer** class that inherits from **Player** class.
 - The constructor of this player takes an instance of **Board** and decides the best possible move that the computer player should play on this board to maximize the possibility of winning.
 - The computer player implements the *minimax* algorithm where each move that can lead to winning is rewarded and each move that can lead to losing the game is penalized. Read about it.
1. **Function Solver.** Build a set of classes that allow you to build and modify functions at runtime using tools similar to those in the STL <functional> library. We have the following abstract class:

```
class Function
{
public:
    virtual double evaluateAt(double value) = 0;
};
```

This class exports a single function, **evaluateAt**, that accepts a double as a parameter and returns the value of some function evaluated at that point. Write these derived classes of **Function** and test them:

- **SimpleFunction**, whose constructor accepts a regular C++ function or a lambda function that accepts and returns a double and whose **evaluateAt** function returns the value of the stored function evaluated at the parameter.
- The composition of two functions **F** and **G** is defined as **F(G(x))**, i.e. function **F** is applied to the value of **G** applied to **x**. Write a class **CompositionFunction** whose constructor accepts two functions and whose **evaluateAt** returns the composition of the two functions evaluated at **x**.
- The derivative of a function is the slope of the tangent line to that function at a point. The derivative of a function **F** can be approximated as $F'(x) \approx (F(x + \Delta x) - F(x - \Delta x)) / 2\Delta x$ for small values of Δx . Write a class **DerivativeFunction** whose constructor accepts a function and a **double** representing Δx and whose **evaluateAt** approximates the derivative of the stored function using the initial value of Δx .

With these functions, it will be possible to write code like this:

```
double cube (double n) {
    return n * n * n;
}

double second (double d) {
    return d * d - 5 * d - 4;
}

double fun (double d) {
    return d * d - 3 * d - 4;
}
```

```
int main()
{
    SimpleFunction f1
        ([&](double n) ->
            double {return n * n;});
    cout << f1.evaluateAt(5) << endl;

    DerivativeFunction f2(second, 5);
    cout << f2.evaluateAt(5) << endl;

    CompositeFunction f3(fun, cube);
    cout << f3.evaluateAt(5) << endl;

    return 0;
}
```

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2. **Label Generator.** For certain applications, it is useful to be able to generate a series of names that form a sequential pattern, e.g., you may want to number the figures in a report as "**Figure 1**", "**Figure 2**", "**Figure 3**", and so on. You might also need to label points in a geometric diagram, in which case you would want a similar but independent set of labels for points such as "**P0**", "**P1**", "**P2**", and so forth.

Thinking generally, we need a tool or label generator that allows the client to define arbitrary sequences of labels, each of which consists of a prefix string ("**Figure** " or "**P**" for the examples in the preceding paragraph) coupled with an integer used as a sequence number. Because the client may want different sequences to be active simultaneously, it makes sense to define the label generator as an abstract type called **LabelGenerator**. To initialize a new generator, the client provides the prefix string and the initial index as arguments to the **LabelGenerator** constructor. Once the generator has been created, the client can return new labels in the sequence by calling **nextLabel** on the **LabelGenerator**. As an illustration of how the interface works, the main program shown here followed by the output:

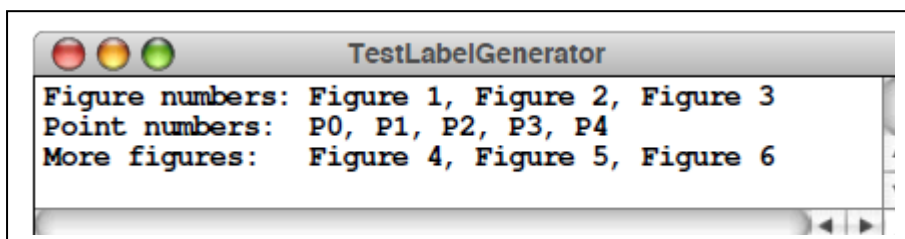
```
int main() {
    LabelGenerator figureNumbers("Figure ", 1);
    LabelGenerator pointNumbers("P", 0);
    cout << "Figure numbers: ";
    for (int i = 0; i < 3; i++) {
        cout << figureNumbers.nextLabel() << ", ";
    }

    cout << endl << "Point numbers: ";
    for (int i = 0; i < 5; i++) {
        cout << pointNumbers.nextLabel() << ", ";
    }

    cout << endl << "More figures: ";
    for (int i = 0; i < 3; i++) {
        cout << figureNumbers.nextLabel() << ", ";
    }

    cout << endl;
    return;
}
```

Separate specifications from
implementation.



Now inherit from this class a new class called **FileLabelGenerator** which has an extra attribute that is a file name with lines of captions of labels to use in generation. This will override method **nextLabel** to take the next label from the file and added it to the generated label that you by calling the parent's **nextLabel**. So, the following code run and produce the following output:

```
FileLabelGenerator figureLabels ("Figure ", 1, "labels.txt");
cout << "Figure labels: \n";
for (int i = 0; i < 3; i++) {
    cout << figureLabels.nextLabel() << endl;
}
```

Figure 1 Sign vs Cosine Functions.
Figure 2 Sigmoid Function.
Figure 3

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3. **Document Similarity.** Document similarity measures are very important in the field of information retrieval and search engines. They are measures that tell us how similar to documents are in terms of their word content. They can be used to find similar documents or to find how close a document is to a query on a search engine. There are many of such measures. In this problem, you will develop:

- Define a class called **StringSet** that will store a set of C++ strings. Use an array or a vector to store the strings. Create a constructor that takes a file name and loads the words in it (ignoring punctuation and turning text to lower case). Write another constructor that takes a string and loads it and breaks it to tokens. Write member functions to add a string to the set, remove a string from the set, clear the entire set, return the number of strings in the set, and output all strings in the set. Overload the **+** operator to return the union of two **StringSet** objects. Overload the ***** operator so that it returns the intersection of two **StringSet** objects. Write a program to test all functions.
- Add a member function that computes the similarity between the current **StringSet** and an input parameter of type **StringSet**. Similarity is measured by *binary cosine coefficient*. The coefficient is a value between 0 and 1, where 1 indicates that the query (or document) is very similar to the document and 0 indicates that the query has no keywords in common with the document. This approach treats each document as a set of words. For example, given the following sample document:

“Chocolate ice cream, chocolate milk, and chocolate bars are delicious.”

This document would be parsed into keywords where case is ignored and punctuation discarded and turned into the set containing the words {chocolate, ice, cream, milk, and, bars, are, delicious}. An identical process is performed on the query to turn it into a set of strings. Once we have a query **Q** represented as a set of words and a document **D** represented as a set of words (each word counts once even if repeated in document multiple times), the similarity between **Q** and **D** is computed by:

$$\text{Sim} = \frac{|Q \cap D|}{\sqrt{|Q|} \sqrt{|D|}} \quad \text{The size of set of common words} / (\text{sqrt size of } D * \text{sqrt size of } Q)$$

Write a program to test the classes and run sample queries on sample documents.

4. **Task Manager.** Write your task manager to see running processes on operating system (OS). A program is an executable file stored on hard disk. A process is a program running in the memory by OS. A process has a name, Process ID (PID) and memory usage and other info depending on the OS as shown for Linux and Windows. On windows, get the running processes in the command line with **tasklist** command.

Create a class to represent process, create a class that represents list of running processes. Add functions to fill it with processes information and to allow displaying the processes as in the picture below (1) sorted by name, (2) sorted by PID and sorted by memory use. Add a function that gets the list of processes from OS and loads the process list. Write a program to test your classes.

```
chrome.exe      10100  Running  marius.bancila  227756  32-bit
cmd.exe         512    Running  SYSTEM          48      64-bit
explorer.exe    7108   Running  marius.bancila  29529   64-bit
skype.exe       22456  Suspended marius.bancila  656     64-bit
```

```
Image Name      PID Session Name      Session#      Mem Usage
=====
System Idle Process  0 Services      0             8 K
System            4 Services      0            24 K
Registry          96 Services      0          10,792 K
smss.exe          416 Services      0            284 K
```



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5. **Game of Life.** (See <https://playgameoflife.com/>) Write a program that implements the *Game of Life* cellular automaton proposed by *John Horton Conway*. The universe of this game is a grid of square cells that could have one of two states: **dead** or **alive**. Every cell interacts with its adjacent neighbors, with the following transactions occurring on every step:
- Any live cell with fewer than two live neighbors dies, as if caused by underpopulation
 - Any live cell with two or three live neighbors lives on to the next generation
 - Any live cell with more than three live neighbors dies, as if by overpopulation
 - Any dead cell with exactly three live neighbors becomes a live cell, as if by reproduction

The status of the game on each iteration should be displayed on the console, and for convenience, you should pick a reasonable size, such as 20 rows x 50 columns or 30 x 30 columns or 20 x 20.

Implement a class called **Universe** with these functions (add more if needed):

- **initialize(...)** generates a starting layout
- **reset(...)** sets all the cells as dead.
- **count_neighbors(...)** returns the number of alive neighbors.
- **next_generation(...)** produces a new state of the game based on the transition rules.
- **display(...)** shows the game status on the console (It is better to erase screen and rewrite, and NO it is console, no graphics is needed)
- **run(...)** to start the game for a certain number of runs.