Project 5— Implementation of LRU/FIFO Paging Algorithms -**100 points**

(**Due date: 12/1/2010/Wednesday Midnight at Moodle**)

Your name:	Date:

====================How To Submit—Read Carefully, Pease!!============

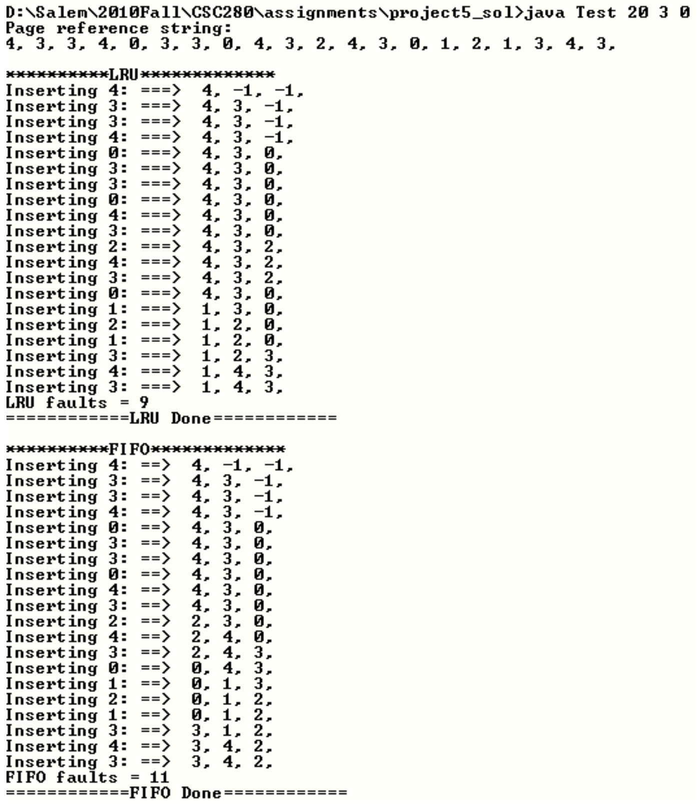
1. Create a directory "**project5_YourLastName**" (you must use this format for the directory name for this project; **Use Your Last Name.**
2. When having finished your project, copy **all the source files (*.java)** to these subdirectories, respectively—you should keep this folders clean: ***only source code*** files included.
3. **A "readme" file is required** for the project write-up that tells how to compile/run the programs and result screenshots … *keep this readme simple*!
4. Compress directory "**project5_YourLastName**" and its contents into a **zip** or **rar** file with same name.
5. Submit the compressed file at Moodle.
6. **Penalty** for NOT following these submission instructions (10% ~100%).

In Chapter 9 (Virtual Memory), we introduced several algorithms on page replacement in virtual memory management, among which are FIFO (First-In, First-Out) and LRU (Least-Recently-Used). In this project, we will write a Java program that implements FIFO and LRU.

- Design and implement two ***subclasses*** of *ReplacementAlgorithm*—LRU and FIFO—that extend *ReplacementAlgorithm* class (available from this project zipped file and in the following).
    1. Each of these two classes will implement the ***insert***() method, one class using the LRU page-replacement algorithm and other using the FIFO algorithm.
- There are two classes available to test your algorithm:
    1. *PageGenerator*—a class that generates page-reference strings with page numbers ranging from 0 to 4. The size of the reference string is passed to the PageGenerator constructor. Once a PageGenerator object is constructed, the **getReferenceString**() method returns the reference string as an array of intergers.
    2. *Test*—used to test your FIFO and LRU implementations of the ReplacementAlgorithm abstract class. Testing is invoked with the following command:
        - **java Test <reference string size> <# of page frames> <#--to indicate which reference string will be used: 1—the sample one; 0—randomly generated one>**
- Apply the random page-reference string to each algorithm, and record the number of page faults incurred by each algorithm and page frame list (see the screenshots).
- Assume that **demand paging** is used.
- **Required for this programming project:**
    1. The two classes: **LRU and FIFO,** each of which must be **extended** from class *ReplacementAlgorithm!!!!!!*
    2. **You must use the *Test* class to test your algorithms.**
    3. **The output must include:**

   - **The reference string you have generated/used for the testing of the algorithms.**
   - **The number of page faults.**
   - **The page frames.**
   - (see the sample screenshots).
4. Using the following reference string and **3** as the number of page frames to test the algorithms you have implemented:
   - **{7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1}.**
   - This string is included in the Test class.
   - You must use the command **"java Test 20 3 1"** to run the program and get the output.
   - Take a screenshot for the output.
5. Using several randomly generated reference strings (with sizes from **25 to 50** and page frame numbers from **2 to 7**) to test the algorithms you have implemented:
   - You may use class *PageGenerator*.
   - You may use the command like **"java Test 30 3 0"** to run the program and get the output.
   - After several runs of your program, take one screenshot of a typical output.
6. Your code should be compact and clean:
   - There are tons of examples for implementing FIFO and LRU—you may use them. But you need to *modify them to fit into* this project (i.e., the creation of subclasses of *ReplacementAlgorithm*).
   - Group discussion and cooperation is encouraged but your submission/code should be **100%** of your own work!—using different variables names, replacing with different selection/loop statements, changing the order of some statements….will **NOT** be tolerated and both (or more getting involved) will get 0 and be reported to the department and college.

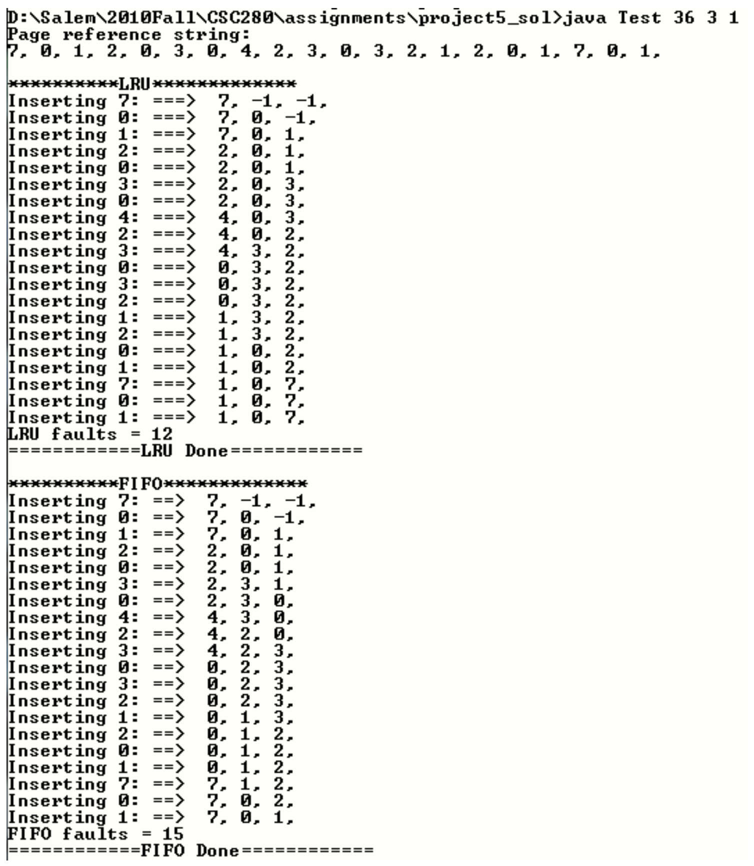
Sample screenshots:



```
D:\Salem\2010Fall\CSC280\assignments\project5_sol>java Test 20 3 0
Page reference string:
4, 3, 3, 4, 0, 3, 3, 0, 4, 3, 2, 4, 3, 0, 1, 2, 1, 3, 4, 3,

**********LRU*************
Inserting 4: ===>  4, -1, -1,
Inserting 3: ===>  4, 3, -1,
Inserting 3: ===>  4, 3, -1,
Inserting 4: ===>  4, 3, -1,
Inserting 0: ===>  4, 3, 0,
Inserting 3: ===>  4, 3, 0,
Inserting 3: ===>  4, 3, 0,
Inserting 0: ===>  4, 3, 0,
Inserting 4: ===>  4, 3, 0,
Inserting 3: ===>  4, 3, 0,
Inserting 2: ===>  4, 3, 2,
Inserting 4: ===>  4, 3, 2,
Inserting 3: ===>  4, 3, 2,
Inserting 0: ===>  4, 3, 0,
Inserting 1: ===>  1, 3, 0,
Inserting 2: ===>  1, 2, 0,
Inserting 1: ===>  1, 2, 0,
Inserting 3: ===>  1, 2, 3,
Inserting 4: ===>  1, 4, 3,
Inserting 3: ===>  1, 4, 3,
LRU faults = 9
===========LRU Done===========

**********FIFO*************
Inserting 4: ==>  4, -1, -1,
Inserting 3: ==>  4, 3, -1,
Inserting 3: ==>  4, 3, -1,
Inserting 4: ==>  4, 3, -1,
Inserting 0: ==>  4, 3, 0,
Inserting 3: ==>  4, 3, 0,
Inserting 3: ==>  4, 3, 0,
Inserting 0: ==>  4, 3, 0,
Inserting 4: ==>  4, 3, 0,
Inserting 3: ==>  4, 3, 0,
Inserting 2: ==>  2, 3, 0,
Inserting 4: ==>  2, 4, 0,
Inserting 3: ==>  2, 4, 3,
Inserting 0: ==>  0, 4, 3,
Inserting 1: ==>  0, 1, 3,
Inserting 2: ==>  0, 1, 2,
Inserting 1: ==>  0, 1, 2,
Inserting 3: ==>  3, 1, 2,
Inserting 4: ==>  3, 4, 2,
Inserting 3: ==>  3, 4, 2,
FIFO faults = 11
===========FIFO Done===========
```



```
D:\Salem\2010Fall\CSC280\assignments\project5_sol>java Test 36 3 1
Page reference string:
7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1,

**********LRU*************
Inserting 7: ===>  7, -1, -1,
Inserting 0: ===>  7, 0, -1,
Inserting 1: ===>  7, 0, 1,
Inserting 2: ===>  2, 0, 1,
Inserting 0: ===>  2, 0, 1,
Inserting 3: ===>  2, 0, 3,
Inserting 0: ===>  2, 0, 3,
Inserting 4: ===>  4, 0, 3,
Inserting 2: ===>  4, 0, 2,
Inserting 3: ===>  4, 3, 2,
Inserting 0: ===>  0, 3, 2,
Inserting 3: ===>  0, 3, 2,
Inserting 2: ===>  0, 3, 2,
Inserting 1: ===>  1, 3, 2,
Inserting 2: ===>  1, 3, 2,
Inserting 0: ===>  1, 0, 2,
Inserting 1: ===>  1, 0, 2,
Inserting 7: ===>  1, 0, 7,
Inserting 0: ===>  1, 0, 7,
Inserting 1: ===>  1, 0, 7,
LRU faults = 12
===========LRU Done===========

**********FIFO*************
Inserting 7: ==>  7, -1, -1,
Inserting 0: ==>  7, 0, -1,
Inserting 1: ==>  7, 0, 1,
Inserting 2: ==>  2, 0, 1,
Inserting 0: ==>  2, 0, 1,
Inserting 3: ==>  2, 3, 1,
Inserting 0: ==>  2, 3, 0,
Inserting 4: ==>  4, 3, 0,
Inserting 2: ==>  4, 2, 0,
Inserting 3: ==>  4, 2, 3,
Inserting 0: ==>  0, 2, 3,
Inserting 3: ==>  0, 2, 3,
Inserting 2: ==>  0, 2, 3,
Inserting 1: ==>  0, 1, 3,
Inserting 2: ==>  0, 1, 2,
Inserting 0: ==>  0, 1, 2,
Inserting 1: ==>  0, 1, 2,
Inserting 7: ==>  7, 1, 2,
Inserting 0: ==>  7, 0, 2,
Inserting 1: ==>  7, 0, 1,
FIFO faults = 15
===========FIFO Done===========
```

PageGenerator class code:

```
public class PageGenerator
{
   private static final int DEFAULT_SIZE = 100;
   private static final int RANGE = 4;

  int[] referenceString;

   public PageGenerator() {
      this(DEFAULT_SIZE);
   }

   public PageGenerator(int count) {
      if (count < 0)
         throw new IllegalArgumentException();

      java.util.Random generator = new java.util.Random();
      referenceString = new int[count];

      for (int i = 0; i < count; i++){
         referenceString[i] = generator.nextInt(RANGE + 1);
      }
   }

   public int[] getReferenceString() {
      return referenceString;
   }
}
```

ReplacementAlgorithm class code:

```
public abstract class ReplacementAlgorithm
{
   // the number of page faults
   protected int pageFaultCount;

   // the number of physical page frame
   protected int pageFrameCount;

   /**
    * @param pageFrameCount - the number of physical page frames
    */
   public ReplacementAlgorithm(int pageFrameCount) {
      if (pageFrameCount < 0)
         throw new IllegalArgumentException();

      this.pageFrameCount = pageFrameCount;
      pageFaultCount = 0;
   }

   /**
    * @return - the number of page faults that occurred.
    */
   public int getPageFaultCount() {
      return pageFaultCount;
   }

   /**
    * @param int pageNumber - the page number to be inserted
    */
   public abstract void insert(int pageNumber);
}
```

Test class code:

```
public class Test
{
   public static void main(String[] args) {
      PageGenerator ref = new PageGenerator(new Integer(args[0]).intValue());

      int[] referenceString = {7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1};

      if ( (new Integer (args[2]).intValue() ) == 0 )
         referenceString = ref.getReferenceString();

      System.out.println("Page reference string:");
      for (int i = 0; i < referenceString.length; i++)
          System.out.printf("%d, ", referenceString[i]);
      System.out.println("\n");


      /** Use either the FIFO or LRU algorithms */
      ReplacementAlgorithm fifo = new FIFO(new Integer(args[1]).intValue());
      ReplacementAlgorithm lru = new LRU(new Integer(args[1]).intValue());

      // output a message when inserting a page
      System.out.println("*********LRU************");
      for (int i = 0; i < referenceString.length; i++) {
         lru.insert(referenceString[i]);
      }

      // report the total number of page faults
      System.out.println("LRU faults = " + lru.getPageFaultCount());
      System.out.println("============LRU Done============");

      System.out.println();

      // output a message when inserting a page
      System.out.println("*********FIFO************");
      for (int i = 0; i < referenceString.length; i++) {
         fifo.insert(referenceString[i]);
      }

      // report the total number of page faults
      System.out.println("FIFO faults = " + fifo.getPageFaultCount());
      System.out.println("============FIFO Done============");

   }
}
```