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CS 106A

Handout #64
March 8, 2009

Practice Final Examination #2

Review session: **Sunday, March 14, 7:00–9:00P.M. (Hewlett 201)**

Scheduled finals: **Monday, March 15, 12:15–3:15P.M. (Hewlett 200)**
Friday, March 19, 12:15–3:15P.M. (Hewlett 200)

The answers to this practice final will be posted to the web site on Wednesday. Note that a couple of these problems have since made their way into the text in at least some form, although they were not in the draft at the time at which these problems appeared on a old final.

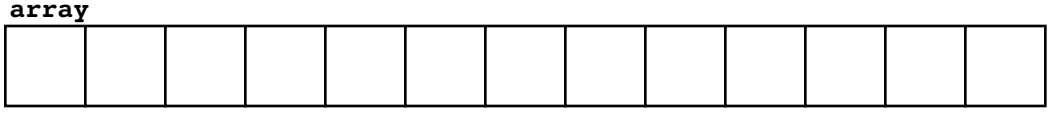
Problem 1—Short answer (10 points)

1a) Trace through the evaluation of the following program and indicate the output it produces.

```
import acm.program.*;

public class Mystery extends ConsoleProgram {

   public void run() {
      int[] array = new int[13];
      for (int i = 1; i <= 12; i++) {
         for (int j = i; j > 0; j--) {
            array[j] += j;
         }
      }
   }

}
```

Work through the method carefully and indicate your answer by filling in the boxes below to show the final contents of **`array`**, just before the **`run`** method returns:

`array`



0 1 2 3 4 5 6 7 8 9 10 11 12

1b) Suppose that you have been assigned to take over a project from another programmer who has just been dismissed for writing buggy code. One of the methods you have been asked to rewrite—which doesn't even compile—looks like this:

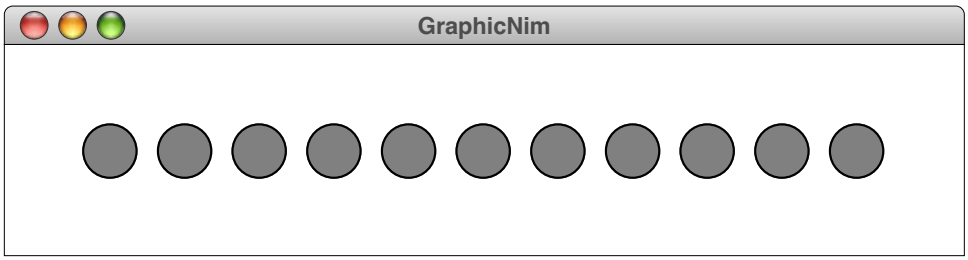
```
/**
 * Returns the acronym of the specified string, which is
 * defined to be a new word formed from the first letter in
 * each separate word contained in the string.  A word is a
 * consecutive string of letters.  For example, calling
 *
 *    acronym("self-contained underwater breathing apparatus")
 *
 * should return the string "scuba".
 */
  private String acronym(String str) {
     boolean inWord = false;
     for (int i = 0; i < str.length(); i++) {
        char ch = str.charAt(i);
        if (ch.isLetter()) {
           if (!inWord) result += ch;
        } else {
           inWord = false;
        }
     }
     return result;
  }
```

Unfortunately, the code—short as it is—contains several bugs. Circle the bugs in the implementation and write a short sentence explaining the precise nature of each problem you identify.

Problem 2—Using the `acm.graphics` library (15 points)

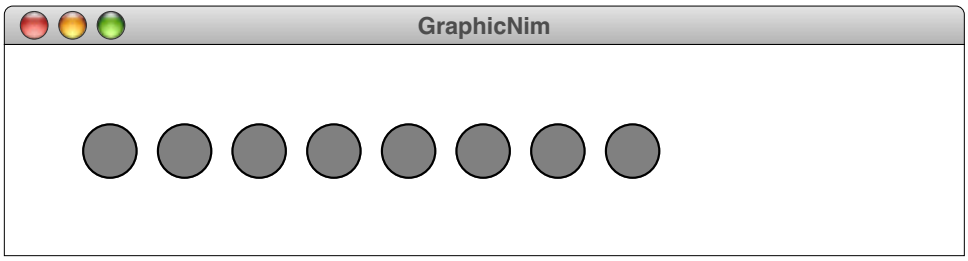
Back before we had a graphics library, one of the early assignments in CS 106A was to write a program that played a simple game called Nim. In the simplest version of the game, two players start with a pile of 11 coins on the table between them. The players then take turns removing 1, 2, or 3 coins from the pile. The player who is forced to take the last coin loses. In the old days, the point of this assignment was to figure out a strategy for winning the game. With our modern attachment to fancier user interfaces, however, it is just as easy to focus on the problem of representing the game graphically on the screen.

Your job in this problem is to complete the implementation of the program that appears on the following page, which is responsible for displaying the coins and handling the user interaction. You should think about the task as consisting of two parts. The first part of this problem is to create a graphical display in which you have a line of coins arranged horizontally on the screen, like this:

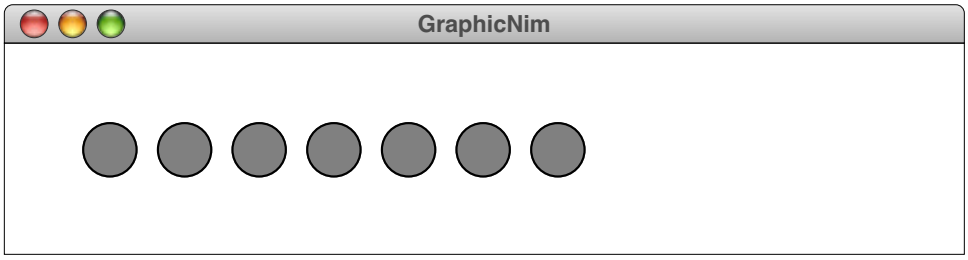


In constructing your display, you should make use of the named constants—**`N_COINS`**, **`COIN_SIZE`**, and **`COIN_SEP`**—that appear at the top of the program framework. You should also make sure that each coin is filled in **`GRAY`** and outlined in **`BLACK`**. The line of coins should be centered both horizontally and vertically in the window.

The second part of the problem consists of making it possible to take coins away. Add the necessary code so that if the user clicks the mouse in one of the last three coins in the row, those coins disappear. For example, if the user clicked on the third coin from the right end, the program should respond by removing the last three coins from the display, like this:



If the user then clicked on the rightmost coin, only that coin should go away:



If the mouse click does not occur inside a coin or if the coin is not one of the last three in the row, that click should simply be ignored.

In order to solve this problem, you will need to store the **GOval** objects in some kind of data structure that allows you to keep track of their order. Given the fact that you need to take coins away, an **ArrayList** seems perfect for the job. When a mouse click occurs, your program needs to find the object at that mouse location (if any) and see whether it is one of the last three elements in the **ArrayList**. If so, your program should remove that element and any following elements from both the **ArrayList** and the window.

Solution to problem 2:

```
public class GraphicNim extends GraphicsProgram {

   public static final int N_COINS = 11;   /* Number of coins     */
   public static final int COIN_SIZE = 25; /* Diameter of a coin  */
   public static final int COIN_SEP = 10;  /* Space between coins */

   . . . You fill in the run method and any other methods you need . . .

}
```

Problem 3—Strings (15 points)

In Dan Brown's best-selling novel *The Da Vinci Code,* the first clue in a long chain of puzzles is a cryptic message left by the dying curator of the Louvre. Two of the lines of that message are

O, Draconian devil!
Oh, lame saint!

Professor Robert Langdon (the hero of the book, who is played by Tom Hanks in the movie version) soon recognizes that these lines are **anagrams**—pairs of strings that contain exactly the same letters even if those letters are rearranged—for

Leonardo da Vinci
The Mona Lisa

Your job in this problem is to write a predicate method

```
public boolean isAnagram(String s1, String s2)
```

that takes two strings and returns **`true`** if they contain exactly the same alphabetic characters, even though those characters may appear in any order. Thus, your method should return **`true`** for each of the following calls:

```
isAnagram("O, Draconian devil!", "Leonardo da Vinci")
isAnagram("Oh, lame saint!", "The Mona Lisa")
isAnagram("ALGORITHMICALLY", "logarithmically")
isAnagram("Doctor Who", "Torchwood")
```

These examples illustrate two important requirements for the **`isAnagram`** method:

- The implementation should look only at letters (i.e., characters for which the **`Character.isLetter`** method returns **`true`**), ignoring any extraneous spaces and punctuation marks thrown in along the way.
- The implementation should ignore the case of the letters in both strings.

There are many different algorithmic strategies you could use to decide whether two strings contain the same alphabetic characters. If you're having trouble coming up with a strategy, you should note that two strings are anagrams if and only if they would generate the same letter-frequency table, as discussed in the lecture on arrays.

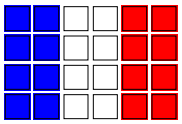
Problem 4—Arrays (10 points)

Write a method

```
private GImage doubleImage(GImage oldImage)
```

that takes an existing **`GImage`** and returns a new **`GImage`** that is twice as large in each dimension as the original. Each pixel in the old image should be mapped into the new image as a 2 × 2 square in the new image where each of the pixels in that square matches the original one.

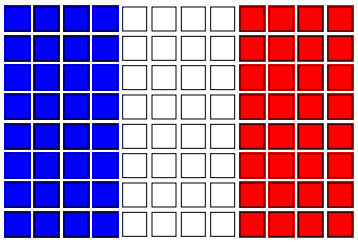
As an example, suppose that you have a **`GImage`** from the file **`TinyFrenchFlag.gif`** that looks like this, where the diagram has been expanded so that you can see the individual pixels, each of which appears as a small outlined square:



This 6 × 4 rectangle has two columns of blue pixels, two columns of white pixels, and two columns of red pixels. Calling

```
GImage biggerFlag = doubleImage(new GImage("TinyFrenchFlag.gif"));
```

should create a new image with the following 12 × 8 pixel array:



The blue pixel in the upper left corner of the original has become a square of four blue pixels, the pixel to its right has become the next 2 × 2 square of blue pixels, and so on.

Keep in mind that your goal is to write an implementation of **`doubleImage`** that works with any **`GImage`** and not just the flag image used in this example.

Problem 5—Building graphical user interfaces (15 points)

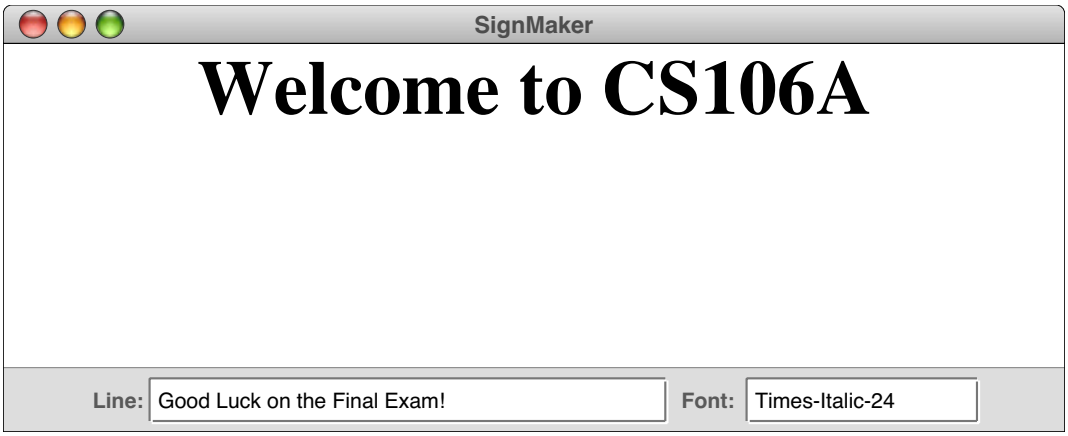
In this problem, your task is to implement a simple graphical user interface for creating simple signs, each of which consists of lines of centered text displayed in different fonts. When you start the **`SignMaker`** program, the user interface looks like this:

You can then add a line to the display by entering text in the field marked Line, as follows:

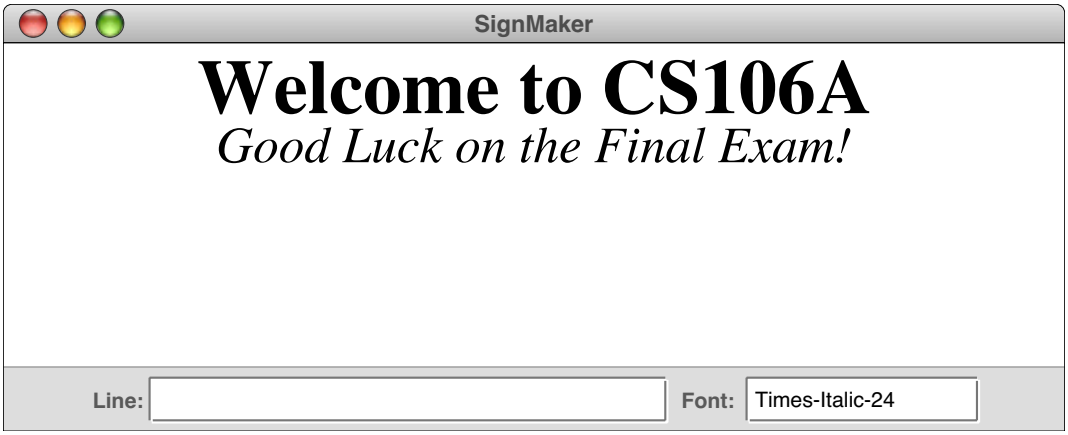
Hitting ENTER should add a new **`GLabel`** to the graphics display containing the text in the field. That **`GLabel`** should be centered in the window and set in the font shown in the Font text field. The first label you add should be positioned so that its baseline is the font height below the top of the window. The first line therefore is set in Times-Bold-36 and appears very close to the top of the window, like this:

Note that hitting ENTER also clears the text field in the control strip making it easier for the user to enter the next line of the sign.

The user can change the font of each line by typing a new font name in the Font field. For example, if the user wanted to add a second line to the message is a smaller, italic font, that user could do so by changing the contents of the Font field to Times-Italic-24 and then typing in the new message, like this:



Hitting ENTER at this point would add a new centered **`GLabel`** below the first one. The distance to the next baseline from the previous one should be the height of the new label you're adding. The final contents of the graphics window therefore look like this:



As you write this problem, you should keep the following points in mind:

- The horizontal sizes of the two **`JTextField`** interactors are given by the following constants, which you may assume are already defined:

```
private static final int CHARS_IN_LINE_FIELD = 30;
private static final int CHARS_IN_FONT_FIELD = 15;
```

- This problem asks you to build a very simple sign-making application that offers no opportunity to change the text that's already on the screen. Given that this is a practice final rather than an actual one, however, you could give yourself more practice by adding more interesting behavior as an extension.

Problem 6—Using Java collections (15 points)

In recent years, the globalization of the world economy has put increasing pressure on software developers to make their programs operate in a wide variety of languages. That process used to be called *internationalization,* but is now more often referred to (perhaps somewhat paradoxically) as *localization*. In particular, the menus and buttons that you use in a program should appear in a language that the user knows.

Your task in this problem is to write a definition for a class called **Localizer** designed to help with the localization process. The constructor for the class has the form

```
public Localizer(String filename)
```

The constructor creates a new **Localizer** object and initializes it by reading the contents of the data file. The data file consists of an English word, followed by any number of lines of the form

xx=*translation*

where *xx* is a standardized two-letter language code, such as **de** for German, **es** for Spanish, and **fr** for French. Part of such a data file, therefore, might look like this:

Localizations.txt

```
Cancel
de=Abbrechen
es=Cancelar
fr=Annuler
Close
de=Schließen
es=Cerrar
fr=Fermer
OK
fr=Approuver
Open
de=Öffnen
es=Abrir
fr=Ouvrir
```

This file tells us, for example, that the English word **Cancel** should be rendered in German as **Abbrechen**, in Spanish as **Ayudar**, and in French as **Annuler**.

Beyond the constructor, the only public method you need to define for **Localizer** is

```
public String localize(String word, String language)
```

which returns the English word passed as the first parameter translated into the language indicated by the two-letter language code passed as the second parameter. For example, assuming that you had initialized a variable **myLocalizer** by calling

```
Localizer myLocalizer = new Localizer("Localizations.txt");
```

you could then call

```
myLocalizer.localize("Open", "de");
```

and expect it to return the string **"Öffnen"**. If no entry appears in the table for a particular word, **localize** should return the English word unchanged. Thus, **OK** becomes **Approuver** in French, but would remain as **OK** in Spanish or German.

As you write your answer to this problem, here are a few points to keep in mind:

- You can determine when a new entry starts in the data file by checking for a line without an equal sign. As long as an equal sign appears, what you have is a new translation for the most recent English word into a new language.
- For this problem, you don't have to work about distinctions between uppercase and lowercase letters and may assume that the word passed to **`localize`** appears exactly as it does in the data file.
- The data file shown on the previous page is just a small example; your program must be general enough to work with a much larger file. You may not assume that there are only three languages or, worse yet, only four words.
- You don't have to do anything special for the characters in other languages that are not part of standard English, such as the **`ö`** and **`ß`** that appear in this data file. They're just characters in the expanded Unicode set that Java uses.
- It may help you solve this problem if you observe that it is the *combination* of an English word and a language code that has a unique translation. Thus, although there are several different translations of the word **`Close`** in the localizer and German translations of many words, there is only one entry for the combination **`Close+de`**.

Problem 7—Essay: Extensions to the assignments (10 points)

In many ways, the assignment that offers the greatest opportunities for extension is the Breakout game from Assignment #3. For this problem, imagine that you are trying to create a "Super Breakout" in which multiple balls can be in play at the same time.

Here is how you would like your new program to work. In the initial layout of bricks at the top of the screen, a random collection of bricks (a different set each time) are designated **superbricks** and are marked on the display by having a black border instead of being solidly colored throughout. Superbricks are relatively rare; as you lay them out, each brick has a 5% chance of being a superbrick. One possible initial configuration with four superbricks appears at the left side of Figure 3 at the bottom of the page.

The game proceeds exactly as it did before until the ball hits a superbrick, at which point the program fires off another ball just as it did at the beginning of the turn. The diagram at the right of Figure 3 shows the situation shortly after the ball has collided with the cyan superbrick in the second row. There are now two balls in play. In each time step of the game, both balls move, bounce off the walls and the paddle, and collide with bricks (and possibly each other). The number of balls increases as you hit more superbricks, and decreases when a ball falls off the bottom. The current turn, however, ends only when there are no balls remaining on the board.

Discuss the changes that would be necessary in the Breakout implementation to implement this extension to the game. Keep in mind that this is an essay question, and you should not feel compelled to write any actual code unless you feel that doing so is the best way to convey your ideas. You should, however, explain as clearly as you can what parts of the program will need to change and what data structures you would need to add to the program to implement this feature.

Figure 3. Scenes from Super Breakout