High Level Programming

Monday 14th January 2008
Time: 14:00 – 16:00

Please answer Question 1 in Section A
and Two Questions in Section B

This is a CLOSED book examination

The use of electronic calculators is NOT permitted
Section A

1. **Compulsory**

   a) Any programming task which can be achieved by using a programming language like JAVA can be accomplished by judicious use of sequence, selection and repetition. Without giving specific examples in JAVA, explain what these three general concepts mean. (4 marks)

   b) Describe and give brief examples of the JAVA statements which can be used to implement the three constructs mentioned in (a). (2 marks)

   c) There is more than one JAVA statement matching each of selection and repetition. Explain the criteria for selecting the most appropriate statement for selection or repetition. (2 marks)

   d) Explain the concept of a 1-dimensional array in JAVA and illustrate how such arrays are declared and constructed, and how their elements are accessed. (2 marks)

   e) What does it mean when a field of a class in JAVA is declared to be static? (2 marks)

   f) What does it mean when a field of a class in JAVA is declared to be final? (2 marks)

   g) What does it mean when a method of a class in JAVA is declared to be final? (2 marks)

   h) What does it mean when a class in JAVA is declared to be final? (2 marks)

   i) What does it mean when a class in JAVA is declared to be abstract? (2 marks)
2.  a) What is probably wrong with the following while statements and why?

i)  while (x = true)
    statement

ii) while (condition1)
    if (condition2)
    statement

iii)  while (condition);
    statement

(4 marks)

b) Which value will be printed by each of the following print statements?

```java
int y = 0;
System.out.println(y = y+1);
System.out.println(y+=1);
System.out.println(++y);
System.out.println(y++);
```

(4 marks)

c) What will be the value for the following variables: (1) fullName1, (2) fullName2, (3) fullName3, after the execution of the program fragment below? Will message “fullName3 == fullName2” be printed? Explain.

```java
public void myFunction ()
{
    String firstName = new String("Rod");
    String secondName = "Stewart";
    String blankChar = " ";
    String fullName1 = firstName + secondName;
    String fullName2 = firstName + blankChar + secondName;
    String fullName3 = new String(fullName2);
    if (fullName3 == fullName2)
    {
        System.out.println("fullName3 == fullName2");
    }
}
```

(4 marks)
d) Explain what the following program fragment does. Which values would be stored in the array after execution of this program fragment considering the following input parameters: \(a = \{10, 10, 10, 10\}, n = 4\)?

\[
\text{public void myFunction (int[]} a, \text{ int n) } \\
\{ \\
\text{ int j; } \\
\text{ for (j = n-1; j >= 0; j--)} \\
\{ \\
\text{ int sum = 0; } \\
\text{ for (int i = 0; i <= j; i++) } \\
\{ \\
\text{ sum = sum + a[i]; } \\
\} \\
\text{ a[j] = sum; } \\
\} \\
\}
\]

(6 marks)

e) What are the types of the following values?

\[
0 \\
"hello" \\
101 \\
-1 \\
true \\
"33" \\
3.1415
\]

(2 marks)
3. a) A small hotel uses software written in JAVA to maintain a list of its current guests. This software includes three functions with the following headings:

    static void enterGuest();
    static void saveGuestList(),
    static void readGuestList(),

These functions respectively allow the hotel to add a new guest to its list, to save the whole guest list to a hard disk, and read the existing list from the hard disk and put it in an array ready for updating.

These three operations are the only ones which are permitted to use or alter the guest list. They can be selected by typing a single character. The software uses a function with heading:

    static char getCommand()

for prompting the user to type a character followed by RETURN, reading lines until a non-empty line is typed, and returning the first character on that line.

Write down a JAVA statement which obtains the next command, stores it in a variable

    char command

and then executes an appropriate command, i.e.

    if the character is 'e' it will execute enterGuest()
    if the character is 's' it will execute saveGuestList()
    if the character is 'r' it will execute readGuestList()  (5 marks)

b) What alternative statement could you have used? Which of the two alternatives is better and why? (3 marks)

c) Why is the result of the following program “0”? What must be done to this program to produce a more precise answer?

    public void myFunction ()
    {
        System.out.println("result = "+(1/3));
    }  (2 marks)
d) Complete the program fragment below, to compute the total sum and average of five integer numbers.

```java
public void myFunction ()
{
    int[] myArray = new int[5];
    // Declare and construct your variables
    BufferedReader in =
    new BufferedReader(new InputStreamReader(System.in));
    try
    {
        // Ask user for inputs
        // Store inputs in array myArray
        // Calculate sum
    }
    catch (Exception e)
    {
        System.out.println("Usage: Input each number on a " +
        "separate line terminated by ENTER");
        return;
    }
    // Calculate average
    // Print results to user
}
```

(6 marks)

e) The following program reads a list of five numbers stored in an array and counts the number of 3's and 7's in the data. What results will be printed, and if any is wrong, why?

```java
public void myFunction ()
{
    int[] myArray = {3, 7, 10, 7, 3};
    int index;
    int threeCount = 0;
    int sevenCount = 0;
    for (index = 1; index <= 4; index++)
    {
        if (myArray[index] == 3)
            threeCount++;
        if (myArray[index] == 7)
            sevenCount++;
    }
    System.out.println("threeCount = " + threeCount);
    System.out.println("sevenCount = " + sevenCount);
}
```

(4 marks)
4. a) Object orientation in JAVA is achieved by means of classes. Objects are obtained by instantiating classes. Illustrate this by giving the declaration of a class called Aircraft with two public fields, String name and int noOfEngines, together with a public constructor to create a new Aircraft with given values for these fields and a method with the heading public String toString() which generates an appropriate representation containing these values.

[You need not include the class in a package.] (4 marks)

b) An essential feature of object orientation is inheritance. Illustrate this by means of a class FlyingBoat which extends Aircraft and has an extra public field, int length, to record the length when floating. You should include a public constructor to create a new FlyingBoat with given name, noOfEngines and length, and give it a toString method which includes the additional information. (4 marks)

c) Arguably, fields should be made private, and methods should be provided, as appropriate, to access and update them. Explain the reason which is usually given for this. (4 marks)

d) Using the examples above, explain what is meant by constructor chaining. (4 marks)

e) In JAVA, all methods are said to be virtual. Explain what this means.

Consider the following object:

Aircraft ac1 = new FlyingBoat("Pacific Delight", 4, 60); 

What is the value of ac1.toString()? Explain your answer. (4 marks)
5. a) Explain the notion of recursion. Give an example by writing a recursive method with the heading

```
static int fact (int n)
```

which, for non-negative arguments, \( n \), returns factorial \( n \), the product of the natural numbers from 1 to \( n \), or 1 when \( n \) is 0. Explain how your solution ensures that the recursion is well-founded, and show why this is important.

Why are recursive solutions sometimes inefficient? To what extent does this criticism apply to your implementation of \texttt{fact}? (5 marks)

b) Explain what it means for a method to be tail-recursive. Why is this form of recursion often preferred over other forms of recursion? Develop a tail-recursive version of \texttt{fact} which uses an accumulating parameter to store partial results. (3 marks)

c) How will your methods behave if they are given a negative argument? If you were to modify your methods to indicate an error in such a situation, how would you do it? (2 marks)

d) We wish to write a method with the heading

```
public static boolean isItThere(int key, int [] a, int low, int high)
```

which returns \texttt{true} if any of the elements of \( a \) between indices \( \text{low} \) and \( \text{high} \) inclusive is equal to \( \text{key} \), and \texttt{false} otherwise. The idea is that, if \( \text{mid} \) is the middle point between \( \text{low} \) and \( \text{high} \), the value is there if it is in either the section \( \text{low} \) to \( \text{mid} \) inclusive, or the section \( (\text{mid}+1) \) to \( \text{high} \) inclusive, and these are each just recursive calls to \texttt{isItThere}. Of course there is no point dividing a section containing only 1 element, and then that element must be compared with \( \text{key} \). You may assume that \( \text{low} \) is less than or equal to \( \text{high} \).

Write the body of the method \texttt{isItThere} in full. (5 marks)

e) Without giving the details of a proof, explain what has to be proved to show that your method will always terminate and return the correct result. (3 marks)

f) How could you improve the efficiency of \texttt{isItThere} if the elements of \( a \) were sorted into ascending order? (2 marks)

\textbf{END OF EXAMINATION}