CS_171 Introduction to Computing II - May/June 2006

(Attempt 2 questions out of 3)

All programming questions refer to the programming language Java.

Question 1.

(a.) The following Java program, which computes the area of the four walls in a room, is not complete. Add an implementation of the method `computeWallspace`.

```
public class Wallspace{
  public static void main(String[] args) {
   double length = 5.4;
   double width = 3.6;
   double height = 2.8;
   double wallspace =  computeWallspace(length,width,height);
   System.out.println("The wallspace is  "+ wallspace +" sqms.")
   }
}
```

[3 marks]

(b.) What will be printed by the following program fragment?

```
int[] a = {1,3,5,7};
for (int i = 0; i < a.length; i++){
   a[i]++;
   System.out.print(a[i]+" ");
}
```

Does the result change if the body of the for loop is replaced by

```
t=a[i]++;
System.out.print(t+" ");
```

Explain your answer.

[3 marks]

(c.) Write a method that takes as parameters a string and an array of strings, and counts how often the string occurs in the array.

[4 marks]

(Question continues on the next page)

(d.) We want a recursive method that takes a string as parameter and returns its reverse string, this is to say, if the input to the method is `"hello"`, then the method should return `"olleh"`.

Plan first, step by step, a recursive solution, and then give an implementation.

[5 marks]

(e.) What is the difference between passing an argument by value and passing an argument by reference? Give an example for each case.

[4 marks]

(f.)
- i) You want to make use of a Java Library method which may throw a checked/unchecked exception. Which possibilities do you have to deal with it? What is the difference between a checked and an unchecked exception?
- ii) You want to write a method that throws an exception when the value of a variable becomes negative. What code should you use?
- iii) What is the difference between the keywords `throws` and `throw`?

[6 marks]

Question 2.

(a.)
- i) What do we understand by the runtime of an algorithm?
- ii) How many comparisons does an optimal algorithm need to make in the worst case to decide whether all elements in a given array of length 100 are different? Briefly describe how the algorithm you have in mind works.
- iii) How does the result of ii) change if we, in addition, know that the input is a sorted array?
- iv) Give tight upper bounds (in terms of Big$O$) for the runtimes of the algorithms used in ii) and iii).

[8 marks]

(b.)
- i) What do we understand by a computational problem? Formulate the sorting problem as a computational problem.
- ii) Briefly explain how `quicksort` works by means of the example:

$$5, 3, 7, 4, 2, 1, 8, 6.$$

- iii) Name three sorting algorithms and comment on their worst case runtime. Which of them are divide-and-conquer algorithms?

[7 marks]

(c.)
- i) What do we know about a function, once we know it is in $O(n^2)$?
- ii) Show that $3n^2 + 4n + 10$ is in $O(n^2)$.
- iii) Is $n \log n$ in $O(n^2)$?

[5 marks]

(d.) Given an array of n integers, the 2-sum problem is to find a pair of integers whose sum is closest to zero. Describe an $O(n \log n)$ algorithm for the problem.

[5 marks]

Question 3.

(a.) Assume you want to implement a new data structure and can use either a representation as an array or as a list. What are the advantages/disadvantages of these two representations?

[7 marks]

(b.) Consider the following (partial) implementations of a stack, the first using an array implementation, the second using a list implementation.

Implementation of a stack using an array:

```
public class Stack{
   private Object[] s = new Object[1];
   private int N = 0;

   public void push(object anItem){
     if (N >= s.length){
        Object[] dup = new Object[2*N];
        for (int i = 0; i<N; i++)
           dup[i]=s[i];
        s=dup;
     }
   s[N++] = anItem;
   }
}
```

Implementation of a stack using a list:

```
public class Stack{
  private List s = null;
  public void push(Object item){
     s = new List(item, s);
  }
```

where we refer to the following implementation of a list:

```
public class List{
  Object item;
  List next;
  public List(Object item, List next){
    this.item = item;
    this.next = next;
  }
}
```

Add the following methods to both implementations:

- `isEmpty`, which checks whether or not the stack is empty,
- `pop`, which 'pops' the topmost element, and
- `height`, which returns the height of the stack.

[10 marks]

(c.) Specify a queue by naming its main operations and explain what each of the operations is supposed to do.

[3 marks]

(d.) Briefly describe how binary search (on an array) works. What is the recurrence for the runtime of the binary search algorithm? How can it be solved?

[5 marks]