NATIONAL UNIVERSITY OF SINGAPORE

SCHOOL OF COMPUTING
EXAMINATION FOR CS1020
Semester 1: AY2013/14

CS1020 – Data Structures and Algorithms I

Nov 2013 Time allowed: 2 hours

Matriculation number: | | | | | | | | | |

INSTRUCTIONS TO CANDIDATES

1. This examination paper consists of **EIGHTEEN (18)** questions and comprises **THIRTEEN (13)** printed pages.
2. This is a **CLOSED BOOK** examination. You are NOT allowed to refer to any material during the exam.
3. Fill in your **Matriculation Number** above clearly with a pen.
4. Answer all questions.
5. For MCQs (Q1 to Q12), use the OCR form provided. Shade and write down your matriculation number on the OCR form. You must use 2B pencil to shade/write on the OCR form.
6. For short questions (Q13 to Q18), write your answers in the space provided. You may use pencil to write your answers.
7. You must submit both the OCR form and this document. It is your responsibility to ensure that you have submitted both to the invigilator at the end of the examination.

EXAMINER'S USE ONLY			
Section / Question	**Possible**	**Marks**	**Check**
A. MCQs 1-12	**36**		
B. Q 13	**6**		
B. Q 14	**12**		
B. Q 15	**12**		
B. Q 16	**12**		
B. Q 17	**13**		
B. Q 18	**9**		
Total	**100**		

SECTION B (7 Short Questions: 64 Marks)

13. Given the following function where n is an integer,

$$f(n) = \begin{cases} f(n-1) + n - 1 & \text{if } n > 1 \\ 0 & \text{if } n = 1 \end{cases}$$

In trying to implement the function iteratively, a student makes some mistakes. Help him to correct all the mistakes in his codes. You should have the same number of statements as the codes provided. (6 marks)

Wrong implementation

```
float calculate(n) {
    int result = 0;
    for (i = 2; i < n; i+=2)
        result = result + (i – 1);
    return result;
}
```

your correction

14a. Given the following array,

32	41	12	27	49	87	55	62	38	74
0	1	2	3	4	5	6	7	8	9

If we apply Insertion Sort, Selection Sort and the improved version of Bubble Sort to the array, what will be the content of the array after 3 passes of the respective sorting process?
(6 marks)

Insertion Sort

0	1	2	3	4	5	6	7	8	9

Selection Sort

0	1	2	3	4	5	6	7	8	9

Improved Bubble Sort

0	1	2	3	4	5	6	7	8	9

14b. A community club has many members. The youngest is 5 years old and the oldest 98. They are organizing some activities for different age groups and hence they would like to sort the members according to their age. Propose an efficient sorting algorithm to do the job for the club. Take note that the member list is already sorted alphabetically according to their names. Your algorithm should ensure that in the age groups, the names are still sorted alphabetically. (5 marks)

What is the complexity of your sorting algorithm? (1 mark)

15. Given an unsorted array of integers, design algorithms to transform the array such that the integers are replaced by the nearest bigger integer on their right. If there is no bigger integer on its right, the integer remains the same. For example, the following array of integers

2	1	4	5	3	6	7	9	4	8

should become

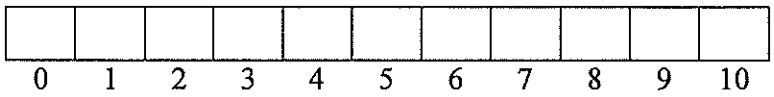
4	4	5	6	6	7	9	9	8	8

a) Create an $O(n^2)$ algorithm (4 marks)

b) Create an O(n) algorithm (8 marks)

16. Perform the following operations to the hash tables below with the respective hash functions and collision resolution methods. Also answer the question at the end of each part.

a. insert 52, insert 73, insert 29, insert 47, insert 31, insert 91, delete 29, insert 84.
Hash function H(key) = key % 11, Use linear probing to resolve collision. (2 marks)

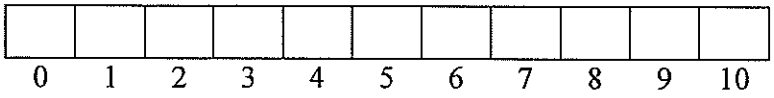


How many probes are needed when you insert 84? (1 mark)

b. insert 56, insert 73, insert 29, insert 47, insert 31, insert 95, delete 29, insert 82.
Hash function H(key) = key % 13. Use Quadratic probing to resolve collision. (2 marks)

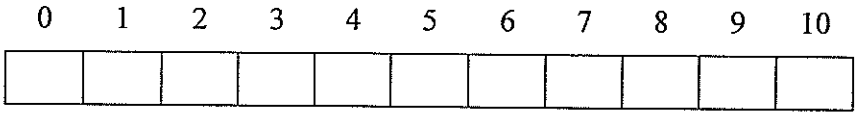
What is the probe sequence when you insert 82? (1 mark)

c. insert 56, insert 73, insert 39, insert 47, insert 31, insert 99, insert 82.
Hash function H(key) = key % 11, using G(key) = 9 – key % 9 as secondary hash function to resolve collision. (2 marks)



What can you conclude about the hash function for the given set of keys? (1 marks)

d. insert 56, insert 78, insert 23, insert 45, insert 34, insert 95, insert 89.
Hash function H(key) = key % 11, separate chaining to resolve collision. (2 marks)



If the load factor is 5, what must be done after the integer 89 is added? (1 marks)

17a. Write a recursive method that tests whether an array, A, is sorted in ascending order. The header of the method is given. (4 marks)

```
public static boolean sorted (int [] A, int l, int r) {



}
```

What is the complexity of your algorithm? (1 mark)

17b. Assume that we have the usual ListNode class with getter methods getValue() and getNext() which return the value in the node and the next pointer of the node respectively. Given a linear linkedlist which stores integers with a head pointer, write a RECURSIVE method to determine whether there are more even numbers or odd numbers or the same in the list. Return "Even" or "Odd" or "Same" accordingly. (6 marks)

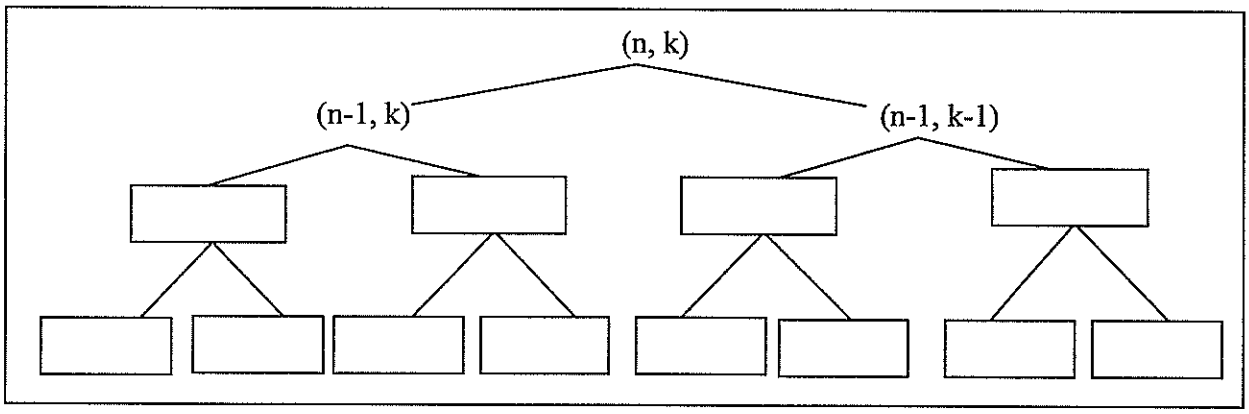
Given that the ListNode head points to the linkedlist created, write the statements to call the method in 17a and print the result returned by the method. (2 marks)

```
public static void main (String [] args) {
    ListNode head = createList();   // createList() creates the linked list

    // write your statements to call your method in 17a and then print the result.
```

18. The nchoosek algorithm is given below. A partial recursive tree of the algorithm is also given. Complete the next two levels of the recursive tree. (3 marks)

```
int nchoosek(int [] arr, int n, int k) {
    if (n == k) return 1;
    if (k == 0) return 1;
    return nchoosek(arr, n-1, k) + nchoosek(arr, n-1, k-1);
}
```



What is the maximum level of the tree? (3 marks)

What is the worst case complexity of the algorithm? Give you answer in Big-O. (3 marks)

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