

**Data Structures & Algorithms (DSA)**

Year 2 (2016/17), Semester 4

## SCHOOL OF INFOCOMM TECHNOLOGY

Diploma in Information Technology

Diploma in Information Security & Forensics

**COMMON TEST**

Date: 14 December 2016 (Wed)

Time: 8:30 AM – 10:00 AM

INSTRUCTIONS TO CANDIDATES:

1. Write your Student Number, Name, Seat Number and Module Group CLEARLY in the boxes provided above.
2. This paper consists of 16 pages including this cover page. Check carefully to make sure your set is complete.
3. There are **5** questions in this paper. Answer ALL questions.
4. You are allowed to use the additional workspace provided from page 15 to page 16. State the question number clearly.
5. Computer laptops/notebooks, language translators and calculators are NOT allowed.

**GRADE**

There are 5 questions. Answer **ALL** questions (100 marks).

Question 1 (20 marks)

The specification of a pointer-based List ADT is given in Figure 1:

|  |
| --- |
| typedef int ItemType;  class **List**  {  private:  struct Node  {  string item; // item  Node \*next; // pointer pointing to next node  };  Node \*firstNode; // pointer to the first node  int size; // number of elements in the list    public:  //constructor  **List();**    // add a new item to the back of the list (append)  // pre : none  // post: new item is added to the back of the list  // size of list is increased by 1  **bool add(ItemType item);**    // add a new item at a specified position in the list  // pre : 1 <= index <= size  // post: new item is added to the specified position in  // the list and size of list is increased by 1  **bool add(int index, ItemType item);**    // remove an item at a specified position in the list  // pre: 1 <= index <= size  // post: item is removed from specified position in list  // size of list is decreased by 1  **void remove(int index);**    // get an item at a specified position of the list  // pre : 1 <= index <= size  // post: none  // return the item in the specified index of the list  **ItemType get(int index);**    // check and return the size of the list  // pre : none  // post: none  **int getLength();**  // replace the item in the specified index in the list  // pre : 1 <= index <= size  // post: item in the specified index is replaced  **void replace(int index, ItemType item);**  // reverse the items in the list  // pre : none  // post: items in the list is in reverse order  **void reverse();**  }; |

Figure 1: Specification of a pointer-based List ADT

1. Implement the ***reverse()*** function for the List ADT.

(8 marks)

|  |
| --- |
| ***Answer:***    **void List::reverse()**  **{**  **Node \* prevNode = NULL;**  **Node \* currentNode = firstNode;**  **Node \* nextNode = newNode;**  **While ( current != NULL )**  **{**  **nextNode = currentNode->next;**  **currentNode->next = prevNode;**  **prevNode = currentNode;**  **currentNode = nextNode;**  **}**  **// when the while-loop has finished executing.**  **firstNode = prevNode;**  **}** |

Question 1 (cont.)

1. A list, markList, is being created using the List ADT in (a) to store the marks of the students in a class. Write the statement for each step such that when executed will produce the content in the markList shown in Figure 1(b).

|  |  |
| --- | --- |
| Statements | Content in markList |
| markList.add(75); | 75 |
| markList.add(50); | 75, 50 |
| marklist.add(2,90); | 75, 90, 50 |
| markList.add(60); | 75, 90, 50, 60 |
| Marklist.remove(3); | 75, 90, 60 |
| Marklist.replace(1,70); | 70, 90, 60 |
| For int (i = 1; i <= markList.getLength(); i++)  {  markList[i] += 5;  markList.replace(i,markList[i]);  } | 75, 95, 65 |

Figure 1(b): Execution of Operations on markList

(8 marks)

1. What is the time-complexity of the ADT List function below?

**bool add(ItemType item);**

Discuss how the time-complexity of the function can be improved.

(4 marks)

|  |
| --- |
| ***Answer:***  The time complexity of the function is big O(n);    The time complexity of the function can be improved if I declare a global variable pointer that points the lastNode of the linkedList. This is to allow the addition function to only have a time complexity of Big O(1) since the function does not have to loop to find the lastNode and point the lastNode to the new Node that has been creates; |

**Question 2 (23 Marks)**

(a) Show clearly the contents of the required stack when the following postfix expression is evaluated.

2 3 + 2 ^ 6 3 / 5 \* -

|  |  |  |
| --- | --- | --- |
| **Next character** | **Stack**  Stack Bottom Stack Top | **Evaluation** |
| 2 | 2 |  |
| 3 | 3  2 |  |
| + |  | 2 + 3 |
| 2 | 2  5 |  |
| ^ |  | 5 ^ 2 |
| 6 | 6  25 |  |
| 3 | 3  6  25 |  |
| / | 2  25 | 6 / 3 |
| 5 | 5  2  25 |  |
| \* | 10  25 | 2 \* 5 |
| - | 15 | 25 - 10 |
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(10 marks)

Question 2 (cont.)

(b) A stack is normally used in the translation of ***an infix expression to its postfix form***. Show clearly, step-by-step, the contents of the stack and contents of the postfix expression for each step of the translation of infix to postfix expression below.ab

(a + b) ^ c - d / (e \* f)

|  |  |  |
| --- | --- | --- |
| **Next character** | **Postfix Expression** | **Operator Stack** |
| ( |  | ( |
| a | a |  |
| + |  | +  ( |
| b | ab |  |
| ) | ab |  |
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(13 marks)

**Question 3 (17 Marks)**

(a) An array-based queue, aQueue, is capable of holding 7 integers. The queue is implemented such that for every dequeue operation, the remaining items will be moved forward by one position. Show the contents of the array at //A when the code is executed.

for (int i=1; i<=7; i++)

aQueue.enqueue(i);

for (int i=1; i<=3; i++)

{ int item;

aQueue.dequeue(item);

aQueue.enqueue(item);

aQueue.dequeue();

//A

}

(9 marks)

***Answer:***

When i = 1

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| index | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| contents |  |  |  |  |  |  |  |

front index: \_\_\_\_\_ back index: \_\_\_\_\_\_

0

When i = 2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| index | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| contents |  |  |  |  |  |  |  |

front index: \_\_\_\_\_ back index: \_\_\_\_\_\_

0

When i = 3

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| index | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| contents |  |  |  |  |  |  |  |

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Question 3 (cont.)

(b) An array-based **circular** queue, bQueue, is capable of holding 4 strings. The queue is implemented as follows:

class Queue

{

private:

string items[4];

int front;

int back;

int count;

public:

…

}

The queue operations shown below are to be executed. What are the values of the variables front and back of the queue at the points A, B, C and D ?

Figure 3(b) shows the contents of bQueue before these operations are executed.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| index | 0 | 1 | 2 | 3 |
| contents | "a" | "b" | "c" | "d" |

Figure 3(b): Contents of circular queue, bQueue

(8 marks)

***Answer:***

bQueue.dequeue();

bQueue.dequeue();

bQueue.dequeue(); //A front : \_\_\_\_\_\_ back : \_\_\_\_\_\_

bQueue.enqueue("a");

bQueue.enqueue("b");

bQueue.enqueue("c"); //B front : \_\_\_\_\_\_ back : \_\_\_\_\_\_

bQueue.dequeue();

bQueue.getFront(); //C front : \_\_\_\_\_\_ back : \_\_\_\_\_\_

bQueue.enqueue("d");

bQueue.dequeue(); //D front : \_\_\_\_\_\_ back : \_\_\_\_\_\_

**Question 4 (20 Marks)**

(a) Write a ***recursive*** function that finds the sum of integers between 2 given integer values.

(8 marks)

***Answer:***

*// find sum of integers between 2 integers, start and*

*// end, inclusive*

*// return result of sum of integers*

**int findSum(int start, int end)**

**{**

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**}**

Question 4 (cont.)

(b) Consider the following recursive function puzzle() in Figure 4(b):

int puzzle (int n)

{

if (n == 1)

return 1;

if (n % 2 == 0)

return puzzle (n/2);

else

return puzzle(3\*n+1);

}

Figure 4(b) – *A Recursive Function*

Describe ***2 potential problems*** that can occur for the above function.

(6 marks)

|  |
| --- |
| ***Answer:***  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

Question 4 (cont.)

(c) A ***recursive*** version of a function is shown below:

bool isSomething(int p, i)

{

if (i ==p)

return true;

if (p%i == 0)

return false;

return isSomething(p, i+1);

}

Figure 4(b) – *A Recursive Function*

Convert the isSomething() function to an ***Iterative***function.

(6 marks)

|  |
| --- |
| ***Answer:***  **bool isSomethingIterative(int p, int i)**  **{**  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  } |

**Question 5 (20 Marks)**

(a) Write an iterative binary search method, **binarySearch()**, to search for a given number in an array. The method returns the array index if the number is found or -1 if it is not found.

(10 marks)

***Answer***:

int binarySearch(int array[], int n, int target)  
{  
 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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}

(b) A sorted array of integer numbers is given below.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 25 | 36 | 48 | 52 | 60 | 68 | 75 | 88 | 92 | 98 |

What is the total number of comparisons for searching the number 88 in the given array using the binary search algorithm?

(2 marks)

|  |
| --- |
| ***Answer***: |

Question 5 (cont.)

(c) Explain why the binary search algorithm cannot be applied in the following scenarios:

I unsorted array of integers

II linked list of integers

(8 marks)

|  |
| --- |
| ***Answer:***  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

**ADDITIONAL WORKSPACE**

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**– End of Paper –**