

**Prince Sultan University**  
**CCIS - Department of Computer Science**

**Major Exam 1**  
**Term 241**

**Course title: Data Structures and Algorithms**

**Course Code: CS 210**

**Exam date: 30/09/2024**

**Exam Time: 50**  
minutes

**Student Name:**

**Student ID:**

**Circle Instructor Name:**

**Dr. Syed Umar Amin**

**Dr. Basit Qureshi**

**Circle Section Time:**

**9AM**

**10AM**

**11AM**

Question Number	CLO	Question points	Score
Question 1	CLO 1	6	
Question 2	CLO 3	6	
Question 3	CLO 4	3	
<b>Total out of</b>		<b>15</b>	

**Instructions:**

- This exam contains three questions with multiple parts.
- Time allowed: 50 minutes
- Closed Book, Closed Notes.
- Use of Calculators and / or computing devices / smartphones etc is strictly prohibited.
- Answer the problems on the exam sheets only. No additional attachments would be accepted.
- If you need extra space use the back of a page.
- When the “time is over” is called, it is students’ responsibility to submit his exam to the invigilator. Submitting completed exam 3 minutes after the “time is over” will incur a penalty of **5 points**.
- Do **NOT** use the erasable pens

**Few gentle reminders:**

- If you get stuck on some problem for a long time, move on to the next one.
- The ordering of the problems is somewhat related to their relative difficulty. However, the order might be different for you!
- You should be better off by first reading all questions and answering them in the order of what you think is the easiest to the hardest problem.
- Keep the points distribution in mind when deciding how much time to spend on each problem.

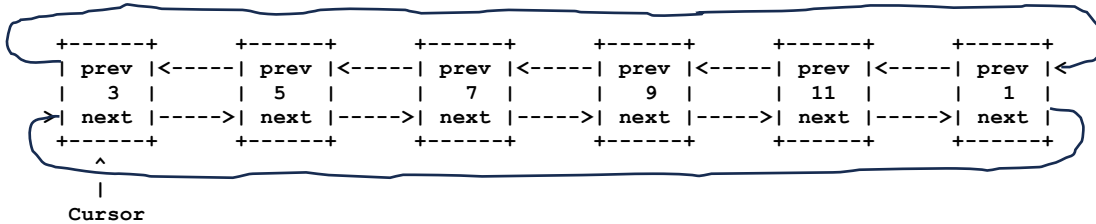
**Question 1**

[ **6 points - CLO 1** ]

**Part A:**

( **4 / points** )

Observe the following diagram that illustrates an ordered circular linked list with 6 nodes. Each node stores a next, previous pointer and an integer key.



**For Question 1, print your answers in this area only. DO NOT write answers anywhere else (it will not be graded).**

1	(A)	(B)	(C)	(D)
2	(A)	(B)	(C)	(D)
3	(A)	(B)	(C)	(D)
4	(A)	(B)	(C)	(D)
5	(A)	(B)	(C)	(D)
6	(A)	(B)	(C)	(D)

**Answer the following MCQs**

<b>1. Which of the following code snippets successfully inserts a node containing key = 4, after the cursor?</b>	
A) Node N = new Node(); N.key = 4; N.prev = Cursor; N.next = Cursor.prev; Cursor.next = Cursor; Cursor.prev = N;	B) Node N = new Node(); N.key = 4; N.prev = Cursor; N.next = Cursor.next; N.next = Cursor; N.prev = Cursor.prev;
C) Node N = new Node(); N.key = 4; N.prev = Cursor; N.next = Cursor.next; Cursor.next = N; N.next.prev = N;	D) Node N = new Node(); N.key = 4; N.prev = Cursor; N.next = Cursor.next; Cursor.next = N; Cursor.prev = N;
<b>2. Which of the following code snippets successfully removes the node containing key = 1?</b>	
A) Cursor.prev = Cursor.prev.prev; Cursor.prev.next = Cursor;	B) Cursor = Cursor.prev; Cursor.next = Cursor.next.next;
C) Cursor.prev = Cursor.next; Cursor.next = Cursor.prev;	D) Cursor = Cursor.next; Cursor.prev = Cursor.prev.next;

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**CCIS - Department of Computer Science**

<b>3. Which of the following code snippet searches and returns a node containing key 11?</b>	
A) while (Cursor != null) { if (Cursor.key == 11) return Cursor; Cursor = Cursor.next; }	B) while (Cursor.next != null) { if (Cursor.key == 11) return Cursor; Cursor = Cursor.next; }
C) for (int i=0; i<=size; i++) { if (Cursor.next == 11) return Cursor; Cursor = Cursor.next; }	D) for (int i=0; i<size; i++) { if (Cursor.key == 11) return Cursor; Cursor = Cursor.next; }
<b>4. Assume that this list is empty. Which of the following inserts a new node containing 10 as key?</b>	
A) Cursor = new Node(); Cursor.next = null; Cursor.prev = null; Cursor.key = 10;	B) Cursor = new Node(); Cursor.next = Cursor; Cursor.prev = Cursor; Cursor.key = 10;
C) Cursor = new Node(); Cursor.next = Cursor; Cursor.prev = null; Cursor.key = 10;	D) Cursor = new Node(); Cursor.next = null; Cursor.prev = Cursor; Cursor.key = 10;

**Part B:** ( 2 / points)

The following Implements a method `insertInOrder` in the class `Circular DoublyLinkedList` that accepts an integer `X` as an argument. This method will create a new node with the key `X` and insert it into the list in the appropriate position to maintain the list's order.

```

1 class CircularDoublyLinkedList {
2     class Node {
3         int key;
4         Node prev, next;
5
6         public Node(int key) {
7             this.key = key;
8             this.prev = this.next = null;
9         }
10    }
11    public void insertInOrder(int X) {
12        Node N = new Node(X);
13        Node Start = Cursor;
14        do {
15            if ( _____ ) {
16                N.next = Cursor.next;
17                N.prev = Cursor;
18                Cursor.next.prev = N;
19                Cursor.next = N;
20                return;
21            }
22            Cursor = Cursor.next;
23        } while ( _____ );
24    }
25    //other methods for remove/inserts/search etc.

```

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<b>5. What is an appropriate statement for the if condition on line 15?</b>	
A) Cursor.key <= X && X < Cursor.prev.key	B) Cursor.key <= X && X < Cursor.next.key
C) Cursor.key <= X	D) Cursor.next.key >= X

<b>6. What is an appropriate statement for the while loop condition on line 23?</b>	
A) Cursor != null	B) Cursor.key <= X
C) Cursor != Start	D) Cursor!=Cursor

**Question 2**

[ 6 points - CLO 3]

**Part A:**

( 3 / points)

Give the best Big-O characterization for each of the following running time estimates (where n is the size of the input problem). Then, order them by giving 1 to the fastest running time and 4 to the slowest running time in terms of their asymptotic growth rate. Assume  $n \geq 1$ .

(Note: Two methods can have the same growth rate.)

Function \ Method	Big-O notation	Order
$6 n \log_2 n$		
$n^3 \log_2 n$		
$2^{\log_2 n}$		
<pre>public int fun1(int n) {     int diff = 0;     for (int i = 0; i &lt; n; ++i) {         for (int j = 0; j &lt; n*n; ++j) {             diff += Math.abs(i-j);         }     }     return diff; }</pre>		
$15000 n + 178 \log n - 88 n^2$		
<pre>public int fun2(int n) {     int k= 50;     int sum = 0;     for (i = 1; i &lt;= k*k; i++) {         for (j = 1; j &lt;= n; j++) {             sum = sum + i + j;         }     } }</pre>		

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**Part B:** ( 3 / points)

For the following questions pick the worst-case running time in each case from these choices:  
**(Note:** one alternative may be used for more than one question)

A.  $O(1)$       B.  $O(n)$       C.  $O(n \log n)$       D.  $O(n^2)$       E.  $O(n^3)$

1	The time complexity to remove the last element in an array.	
2	The time complexity to remove the last element in a singly linked list.	
3	The time complexity to remove the element before the cursor in a circular linked list.	
4	Searching for a smallest number in an ordered array of integers.	
5	Searching for the maximum element in an ordered doubly linked list.	
6	Searching for the minimum element in an array.	

**Question 3**

[ 3 points - CLO 3]  
 ( 1 / points)

**Part A:**

Algorithms **A** and **B** spend exactly  $T_A(n) = 7n^2 + 3n \log_2 n$  and  $T_B(n) = n^3$ , respectively, for a problem of size  $n$ . Find the values of  $c$  and  $n_0$  where algorithm A is better than algorithm B.

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**CCIS - Department of Computer Science**

**Part B:** ( 2 / points)

The function  $f$  is defined for non-negative integers  $a$  and  $b$  recursively as follows:

```
public void  $f$  (int a, int b)
{
    if (a==0 || b==0)
        return 0;
    if ( a==b)
        return  $f(a - 1, b - 1) + 2a - 1$  ;
    if ( a > b)
        return  $f(a - b, b) + f(b, b)$  ;
    if ( a < b)
        return  $f(a, a) + f(b - a, a)$  ;
}
```

Compute  $f(4, 3)$  by drawing a recursion tree showing all of the computation required and then use your tree to compute the answer.

\*\*\*\*\* End of Exam \*\*\*\*\*