

Q1. (10 pts, Big-O) Please express each of the following formula in big-O notation.

(A) $n^3 + 10 \cdot 2^n$

(B) $n^2 + 3 \log_2 n$

(C) $5n \cdot \log_2 n + 2n^2$

(D) $1 + 2 + 3 + \dots + (n-1) + n$

(E) What is the worst-case big-O complexity of the following code fragment? _____

```
int ans = 0;
for(int i=0; i<n ; i++){
    for(int j=0; j<n; j++){
        break;
    }
}
```

Q2. (OOP) For a given Student class, please answer the following questions.

```
public class Student {
    public int sno;          //student id
    public String sname;     //student name
```

//(1) (2pts) Define and implement a no-argument constructor.

//(2) (4pts) Define and implement the accessor and mutator methods for “sno”.

```
}
```

Q3. (Collection class) Given the class IntArraySet, please answer the following questions.

```
public class IntArraySet {
    //The invariant for this class is:
    // 1. The number of elements in the collection is recorded with the instance variable
    //    num, which is no more than data.length.
    //2. For an empty set, we do not care what is stored in the data array;
    //    For a non-empty set, the elements in the set are stored in data[0] ... ..
    //    through data[num-1], and we do not care what is in the rest of data array.
    //3. NO elements in data[0] ... data[num-1] are the same

    private int num;
    private int [] data;
    public IntArraySet ()           { num =0; data = new int[2];}
    public IntArraySet (int size)   { if(size>0){num =0; data = new int[size];}}

    //(1) (10pts) A method which adds a given element to the first available space of the data
    array in this instance. (a) When the collection space is sufficient to hold the new element,
    this element can be directly added to the collection. (b) Otherwise, you need to double the
    space of the instance array.
    Note that if the collection contains one value that equals to the given parameter
    "element", the parameter value should NOT be added to the collection. I.e., we will NOT
    get a collection class with duplicated values when we use this method.
```

```
    public void addNoDuplicate(int element){

    }
}
```

(2) (10 pts) The following function tries to implement the equals method for IntArraySet. Will this function work correctly? If so, please explain why. If not, please identify the bug and fix it. (Hint: please focus on the logic.)

```
public boolean equals(Object o){
    if(o==null) return false;
    if(!(o instanceof IntArraySet)) return false;

    IntArraySet bag = (IntArraySet)o;

    for(int i=0;i<bag.num;i++)
        if(data[i]!=bag.data[i]) return false;
    return true;
}
```

Q4. (Singly linked list) For the IntNode class, which is used to define a singly linked list, please answer the following questions.

```
public class IntNode{
    private int data;          // contain the real content
    private IntNode link;      // point to the current node's next node

    public IntNode()           { data = 10; link = null;}
    public IntNode(int _data, IntNode _link) {data = _data; link = _link; }
    public void addNodeAfter(int item)       {link = new IntNode(item, link);}

    // (1) (5 pts) Implement a method to remove an element e after the current node.
    public void removeNodeAfter(int e)
    {
```

} What's the time complexity of your algorithm? _____

//Other methods are here.

```
}
```

(2) (8 pts) Given the following f2 function in IntNode class,

```
public double f2() {
    IntNode cursor;
    int num1 = 0;
    int num2 = 0;

    for (cursor = this; cursor != null; cursor = cursor.link) {
        if(cursor.data%2==1) num1+=cursor.data;
        else num2+=cursor.data;
    }
    return ((num1)*1.0/num2);
}
```

For the above method, what's the time complexity?

First, define $n =$ _____

Then, the complexity in Big-O is _____

Given the following linked list:

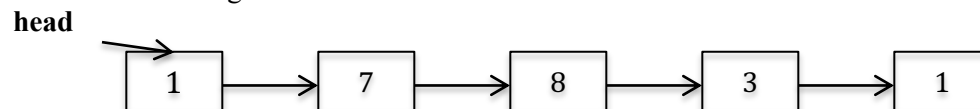


Fig. 1

What will be the returned result after running **head.f2()**? _____

(3) (10 pts) Given the following f3 function in IntNode,

```
public void f3(int item) {
    IntNode newNode = new IntNode();
    newNode.setData(item);

    IntNode preCursor = null;
    IntNode cursor = this;
    while(cursor!=null){
        preCursor = cursor;
        cursor = cursor.getLink();
    }
    preCursor.setLink(newNode);
}
```

Given the linked list shown in Fig.1, after running **head.f3(2)**, What will the linked list starting from **head** look like? Draw this linked list.

(4) (10 pts, **ONLY GRADUATE STUDNETS who take CS 463 need to answer this question**)

```
public static IntNode f4(IntNode head, int x){
    if (x <= 0) return null;

    IntNode cursor = head;
    for (int i = 1; (i < x) && (cursor != null); i++)
        cursor = cursor.link;
    return cursor;
}
```

Given the f4 method as above, if we run the following several lines of code:

```
IntNode node = new IntNode(1,null);
node.addNodeAfter(2);
node.addNodeAfter(4);
node.addNodeAfter(4);
IntNode x = IntNode.f4(node, 2);
```

What does the linked list starting from x look like? _____

Q5. (Doubly linked list) Given the following DNode class, which is used to define a doubly linked list, please answer the following questions.

```
public class DNode {
    public int data;           //The value for the node
    public DNode next = null;  //The next node of the current one
    public DNode prev = null;  //The previous node of the current one
    public DNode(){;}         //Constructor
}
```

```
public class DoublyLinkedListDummy {
    //The head and the tail of a doubly linked List, which are dummy nodes, NOT null
    public DNode head;
    public DNode tail;

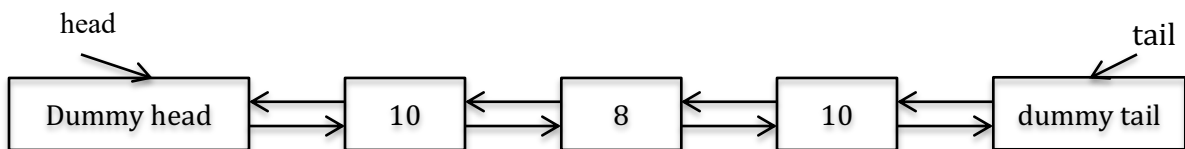
    //constructor
    public DoublyLinkedListDummy ( ){
        head = new DNode ();
        tail = new DNode ();
        head.next = tail;
        tail.prev=head;
    }
}
```

// (1) (5 pts) Define and implement a function to get the actual head of the doubly linked list with dummy head and tail. If the linked list is empty, return null.

//(2) (10 pts) A method to return the actual number of nodes in a doubly linked with dummy head and tail.

```
public int listLength(){  
  
    }  
  
    // Other methods of the DoublyLinkedListDummy class are here  
}  
  
public void func(int element)  
{  
    DNode newnode = new DNode ();  
    newnode.data = element;  
    newnode.prev = tail.prev;  
    newnode.next = tail;  
  
    tail.prev.next = newnode;  
    tail.prev = newnode;  
}
```

(3) (6 pts) Given the following doubly linked list **List** and the above **func** function defined in the *DoublyLinkedListDummy* class.



What will the doubly linked list look like after running the following code?

List.func(5): _____

Q6. (Miscellaneous) You are required to design a system to manage the computers in our department by using data structures and algorithms that we learned in this class so far. For each computer, you need to keep its unique id, its CPU model, and the size of its memory. For the whole department, the system should maintain data structure(s) that allow (i) adding a new computer to the system and (ii) searching for a computer given its id and printing all the information of the found computer (id, CPU model, and memory size). The addition algorithm should be in time complexity of $O(1)$ and the searching algorithm can be a $O(1)$ or $O(n)$ algorithm where n denotes the total number of computers stored in the system. (PLEASE WRITE CLEARLY. I can only grade the text that I can read. If the text is too sketchy such that I cannot recognize your writing, I have to give zero to those text content.)

(1) (5 pts) Describe what data structures you plan to have, write down clearly what are the instances member and methods (you do not need to implement the methods).

(2) (5 pts) Describe your addition and searching algorithms. (No need to write code, write down pseudo-code) and explain why they meet the running time requirement.

===== END =====