	King Saud University	College of Computer and Information Sciences Department of Computer Science
	Data Structures CSC 212	**Final Exam - Spring 2018**
	Date: 05/05/2018	Duration: 3 hours

Guidelines

- No calculators or any other electronic devices are allowed in this exam.
- Use a pencil in choice questions.

Student ID:	Name:
Section:	Instructor:

1	2.1	2.2	3.1	3.2	4	5	6	7	8	Total

Question 1 ..... 16 points

(a) Choose the correct frequency for every line as well as the total O of the following code:

```
1  i = 1;
2  while(i < n)
3      i = i * 2;
```

1. Line 1: (A) 0 (B) 1 (C) 2 (D) n (E) n^2
2. Line 2: (A) n (B) $n+1$ (C) $\log(n)$ (D) $\log(n)+1$ (E) 2^n
3. Line 3: (A) n (B) $n+1$ (C) $\log(n)$ (D) $\log(n)+1$ (E) 2^n
4. Total O: (A) 1 (B) n (C) n^2 (D) $\log(n)$ (E) 2^n

(b) Choose the correct frequency for every line as well as the total O of the following code:

```
1  c = 10;
2  for (i = 1; i <= c; i++)
3    for (j = 0; j < n; j++)
4      count++;
```

1. Line 1: (A) 0 (B) 1 (C) 2 (D) n (E) n^2
2. Line 2: (A) n (B) c (C) 11 (D) 10 (E) 9
3. Line 3: (A) n (B) $10n$ (C) $10(n+1)$ (D) c (E) n^2
4. Line 4: (A) $count+2$ (B) $10n$ (C) $11n$ (D) n^2 (E) $n(n+1)/2$
5. Total O: (A) 1 (B) n (C) n^2 (D) $n\log(n)$ (E) n^3

(c) Choose the correct answer:

1. $n^3 + n^2 \log n$ is : (A) $O(n^3)$ (B) $O(n^2)$ (C) $O(n^2\log(n))$ (D) $O(n^5)$ (E) None
2. $2^n + n^n$ is : (A) $O(n)$ (B) $O(n^2)$ (C) $O(2^n)$ (D) $O(n^n)$ (E) None
3. $n^4 \log n + 2^n$ is : (A) $O(n)$ (B) $O(n^4)$ (C) $O(n^5)$ (D) $O(\log(n))$ (E) None

4. When traversing all nodes in a binary tree of depth d. The complexity would be:

   Ⓐ $O(d)$ Ⓑ $O(d^2)$ Ⓒ $O(2^d)$ Ⓓ $O(\log(d))$ Ⓔ None

Question 2 ..... 10 points

(a) Given a map of queues of call records, we want to find out if there was call from a given number to another. Write the method **boolean** `callFrom(Map<String, Queue<Record>> m, String nb1, String nb2)`, which checks if there was a call from `nb1` to `nb2` without changing `m`. The map `m` is indexed by the **caller** number.

```
public interface Map<K extends Comparable<
    K>, T> {
  boolean empty();
  boolean full();
  T retrieve();
  void update(T e);
  boolean find(K key);
  boolean insert(K key, T data);
  boolean remove(K key);
}
```

```
public class Record {
  public String from, to;
  public Date start, end;
  ...
}
```

Complete the code below by choosing the correct answer:

```
1  boolean callFrom(Map<String, Queue<Record>> m, String nb1, String nb2) {
2    if (...)
3      ...;
4    Queue<Record> q = ...;
5    boolean found = ...;
6    ... {
7      Record r  = ...;
8      ...;
9      if (...)
10       ...;
11   }
12   ...;
13 }
```

- Line 2:
  - Ⓐ `!m.find(nb2)`
  - Ⓑ `m.find(nb1)`
  - Ⓒ `!m.find(nb1)`
  - Ⓓ `m.find(nb2)`
  - Ⓔ None
- Line 3:
  - Ⓐ **return true**
  - Ⓑ **return** `m.find(nb1)`
  - Ⓒ **return false**
  - Ⓓ **return** `!m.find(nb1)`
  - Ⓔ None
- Line 4:
  - Ⓐ `m.enqueue(nb2)`
  - Ⓑ `m.retrieve()`
  - Ⓒ `m.retrieve(nb1)`
  - Ⓓ `m.find(nb2)`
  - Ⓔ None
- Line 5:
  - Ⓐ **false**
  - Ⓑ `m.retrieve().serve()`
  - Ⓒ **true**
  - Ⓓ `m.find(nb1)`
  - Ⓔ None

- Line 6:
  - (A) `for (int i = q.length(); i >=0 ; i--)`
  - (B) `for (int i = 1; i <= q.length(); i++)`
  - (C) `while (q.length()> 0)`
  - (D) `for (int i = 0; i <= q.length(); i++)`
  - (E) None
- Line 7:
  - (A) `q.serve()`
  - (B) `q.serve(nb2)`
  - (C) `m.retrieve()`
  - (D) `q.head.data`
  - (E) None
- Line 8:
  - (A) `q.enqueue(r)`
  - (B) `m.enqueue(r)`
  - (C) `q.enqueue()`
  - (D) `q.serve(r)`
  - (E) None
- Line 9:
  - (A) `nb2 == r.to`
  - (B) `nb1.equals(r.to)`
  - (C) `nb1 == r.from`
  - (D) `nb2.equals(r.from)`
  - (E) None
- Line 10:
  - (A) `found = (nb2 == r.to)`
  - (B) `found = false`
  - (C) `found = true`
  - (D) `found = !found`
  - (E) None
- Line 12:
  - (A) `return found`
  - (B) `return found || (q.length()== 0)`
  - (C) `return false`
  - (D) `return true`
  - (E) None

(b) Given a queue of stack of call records, we want to find out if there was any call to a given number. Write the method **boolean** `anyCallTo(Queue<Stack<Record>> q, String nb)`, which checks if there was any call to `nb` without changing `q`.

Complete the code below by choosing the correct answer:

```
1  boolean anyCallTo(Queue<Stack<Record>> q, String nb) {
2    boolean found = false;
3    ... {
4      Stack<Record> st = q.serve();
5      ...;
6      if (...) {
7        Stack<Record> ts = new LinkedStack<Record>();
8        while (...) {
9          Record r = ...;
10         ...;
11         if (...)
12           ...;
13       }
14       while (...)
15         ...;
16     }
17   }
18   return found;
19 }
```

- Line 3:
  - (A) `while (i < q.length())`
  - (B) `while (q.length()> 0)`
  - (C) `for (int i = 1; i <= q.length(); i--)`
  - (D) `for (int i = 0; i < q.length(); i++)`
  - (E) None
- Line 5:
  - (A) `q.serve()`
  - (B) `st.push(q)`
  - (C) `q.enqueue()`
  - (D) `st.pop()`
  - (E) None
- Line 6:
  - (A) `found && st.empty()`
  - (B) `found`
  - (C) `!found`
  - (D) `found && !st.empty()`
  - (E) None
- Line 8:
  - (A) `!st.empty()&& !found`
  - (B) `!found`
  - (C) `st.empty()|| found`
  - (D) `st.empty()&& !found`
  - (E) None
- Line 9:
  - (A) `st.push()`
  - (B) `st.pop()`
  - (C) `q.serve()`
  - (D) `st.serve()`
  - (E) None
- Line 10:
  - (A) `ts.push(r)`
  - (B) `ts.push(st.pop())`
  - (C) `st.push(r)`
  - (D) `ts.pop()`
  - (E) None
- Line 11:
  - (A) `nb.equals(r.from)`
  - (B) `nb == r.from`
  - (C) `nb == r.to`
  - (D) `nb.equals(r.to)`
  - (E) None
- Line 12:
  - (A) `found = (nb == r.to)`
  - (B) **return true**
  - (C) `found =` **true**
  - (D) `found =` **false**
  - (E) None
- Line 14:
  - (A) `ts.empty()`
  - (B) `!st.empty()`
  - (C) `!ts.empty()`
  - (D) `st.empty()`
  - (E) None
- Line 15:
  - (A) `st.push(q.serve().pop())`
  - (B) `st.push(st.pop())`
  - (C) `ts.push(st.pop())`
  - (D) `st.push(ts.pop())`
  - (E) None

Question 3 ..... 10 points

(a) Write the method **public boolean** `isPathTree()`, member of the BT class, which returns true if the BT is a path tree, and false otherwise. A BT is a path tree if it does not have any node that has two children. The method **public boolean** `isPathTree()` calls a **recursive** method **private boolean** `isPTRec(BTNode p)`. Choose the correct option to complete the code of these methods:

```
1 public boolean isPathTree() {
2   ...
3 }
4 private boolean isPTRec(BTNode<T> p) {
5   ...
6   ...
7   ...
8 }
```

1. Line 2:
   - (A) `return ((isPTRec(root.left))&&(isPTRec(root.right)));`
   - (B) `return ((isPathTree(root.left))&&(isPathTree(root.right)));`
   - (C) `return ((isPTRec(current.left))&&(isPTRec(current.right)));`
   - (D) `return isPTRec(root);`
   - (E) None
2. Line 5:
   - (A) `if (p != null)return true;`
   - (B) `if (p == null)return true;`
   - (C) `if (root == null)return true;`
   - (D) `if (p != null)return false;`
   - (E) None
3. Line 6:
   - (A) `if ((p.left==null)||(p.right==null))return false;`
   - (B) `if ((p.left!=null)||(p.right!=null))return false;`
   - (C) `if ((p.left==null)&&(p.right==null))return true;`
   - (D) `if ((p.left!=null)&&(p.right!=null))return false;`
   - (E) None
4. Line 7:
   - (A) `return true;`
   - (B) `return isPTRec(p.left)&& isPTRec(p.right);`
   - (C) `return isPTRec(p.left)|| !isPTRec(p.right);`
   - (D) `return !isPTRec(p.left)|| !isPTRec(p.right);`
   - (E) None

(b) Consider the function `f` below, member of `DoubleLinkedList`:

```
public void f(int n) {
  Node<T> p = head, q;
  for(int i = 0; i < n; i++)
    if(p.next != null)
      p = p.next;

  if(p != null && p.next != null){
    q = p;
    while(q.next != null)
      q = q.next;
    q.previous.next = null;
    q.previous = null;
    q.next = p;
    p.previous = q;
    head = q;
  }
}
```

Choose the correct result in each of the following cases:

1. The list `l`: A, B, C, D, E, after calling `l.f(1)`, `l` becomes:

Ⓐ B, C, D, E Ⓑ A, B, E, C, D Ⓒ E, B, C, D Ⓓ A, D, E, B, C Ⓔ None

2. The list `l`: A, B, C, D, E, after calling `l.f(0)`, `l` becomes:
   Ⓐ *empty* Ⓑ E, A, B, C, D Ⓒ B, C, D, E, A Ⓓ A, B, C, D, E Ⓔ None
3. The list `l`: A, B, C, D, E, after calling `l.f(2)`, `l` becomes:
   Ⓐ *empty* Ⓑ E, D, C, B, A Ⓒ A, D, E, B, C Ⓓ E, C, D Ⓔ None
4. The list `l`: A, B, C, D, E, after calling `l.f(5)`, `l` becomes:
   Ⓐ A Ⓑ E, A, B, C, D Ⓒ C, D, E, A, B Ⓓ A, B, C, D, E Ⓔ None

Question 4 ..... 14 points

(a) Consider the following heap represented as an array: 4, 16, 14, 22, 20, 18. Choose the correct answer for every operation (all operations are done on the above heap).

1. Heap after inserting 6: Ⓐ 4,16,14,22,20,18,6 Ⓑ 4,6,16,22,20,18,14 Ⓒ 4,16,14,22,20,6,18 Ⓓ 6,16,4,22,20,18,14 Ⓔ None
2. Heap after inserting 16: Ⓐ 4,16,14,22,20,18,16 Ⓑ 4,16,16,22,20,18,14 Ⓒ 4,16,14,22,20,16,18 Ⓓ 4,16,14,16,20,18,22 Ⓔ None
3. Heap after inserting 0: Ⓐ 4,16,14,22,20,18,0 Ⓑ 0,16,4,22,20,18,14 Ⓒ 4,16,0,22,20,18,14 Ⓓ 0,16,4,22,20,14,18 Ⓔ None
4. Heap after deleting one key: Ⓐ 16,22,14,18,20 Ⓑ 14,16,18,22,20 Ⓒ 16,14,20,18,22 Ⓓ 16,20,14,22,18 Ⓔ None
5. Heap after deleting two keys: Ⓐ 16,22,14,18 Ⓑ 20,18,14,22 Ⓒ 16,20,14,22 Ⓓ 22,14,20,18 Ⓔ None

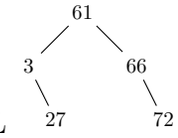
(b) What is the result of a bottom-up min-heap construction of the array: 1,5,11,4,6,0? Ⓐ 0,1,4,6,5,11 Ⓑ 1,0,4,5,6,11 Ⓒ 0,4,1,5,6,11 Ⓓ 0,4,1,6,11,5 Ⓔ None.

(c) Choose the correct answer:

1. Bottom-up heap construction is: Ⓐ $O(n)$ Ⓑ $O(\log n)$ Ⓒ $O(n^2 \log n)$ Ⓓ $O(n^2)$ Ⓔ None.
2. The serve operation in a heap priority queue is: Ⓐ $O(1)$ Ⓑ $O(\log n)$ Ⓒ $O(n)$ Ⓓ $O(n \log n)$ Ⓔ None.
3. What is the minimum number of nodes in a heap of height k? Ⓐ $2^k - 1$ Ⓑ $\log k$ Ⓒ 2^k Ⓓ 2^{k-1} Ⓔ None.

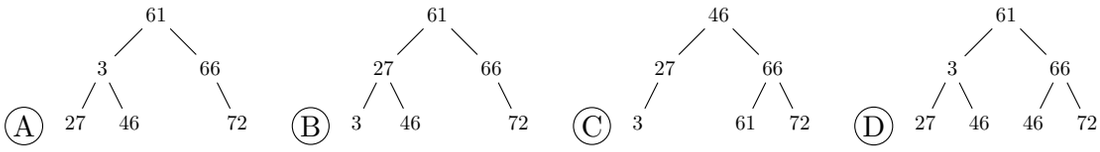
Question 5 ..... 14 points

Choose the correct result in each of the following cases (follow the the convention of replacing with the smallest key in the right sub-tree when necessary):

1. After inserting the key 46 in the AVL 

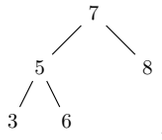
,

the tree becomes:

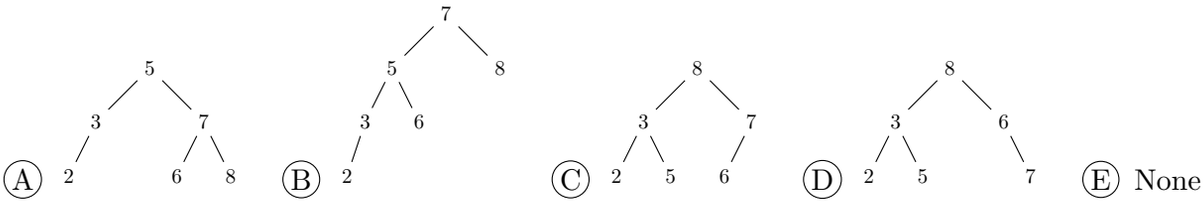


(E) None

2. After inserting the key 2 in the AVL

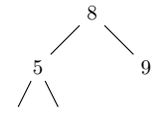


, the tree becomes:

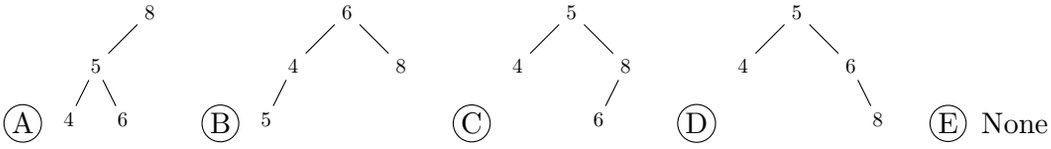


(E) None

3. After deleting the key 9 from the AVL

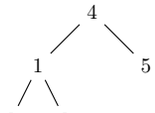


, the tree becomes:

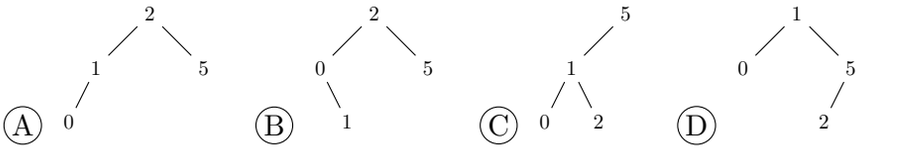


(E) None

4. After deleting the key 4 from the AVL

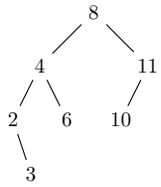


, the tree becomes:

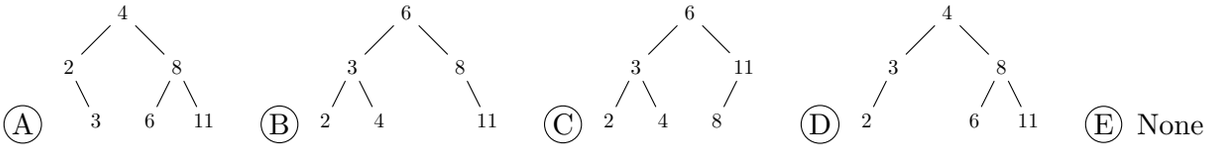


(E) None

5. After deleting the key 10 from the AVL

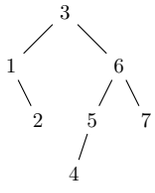


, the tree becomes:

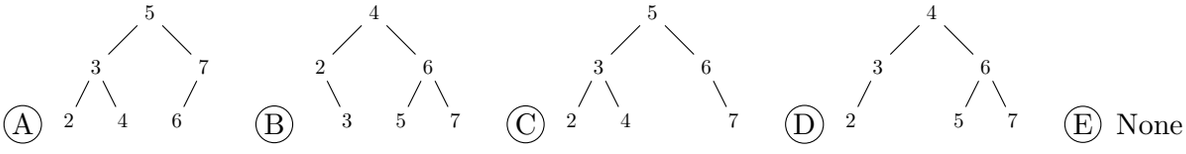


(E) None

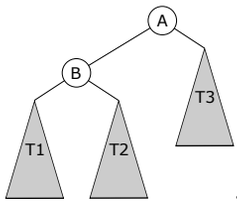
6. After deleting the key 1 from the AVL



, the tree becomes:



(E) None

7. Consider the following tree 

. If the balance of A is -2 and that of B is -1, then after performing a single right rotation at A, then:

   (a) The balance of A becomes: ☐

   (b) The balance of B becomes: ☐

Question 6 ..... 14 points

Use the hash function $H(key) = key\%10$ to store the sequence of keys $14, 15, 4, 16, 27, 20, 35, 47, 10, 7$ in a hash table of size 10. Use the following collision resolution strategies:

1. Linear rehashing (c=2). Fill in the following table:

Key	14	15	4	16	27	20	35	47	10	7
Position										
Number of probes										

2. External chaining. Fill in the following table:

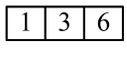
Key	14	15	4	16	27	20	35	47	10	7
Position of the list										

3. Coalesced chaining with cellar size 3 and address region size 7 (you must change the hash function to $H(key) = key\%7$.) Fill in the following table (put -1 if there is no next element):

Key	14	15	4	16	27	20	35	47	10	7
Position										
Index of next element										

Question 7 ..... 14 points

Choose the correct result in each of the following cases (when possible, always borrow and transfer to the left):



1. After inserting the key 7 in the B+ tree , the **root** of tree becomes:

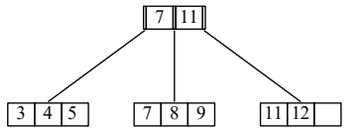
   (A) 

   (B) 

   (C) 

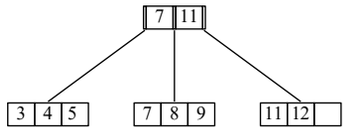
   (D) 

   (E) None

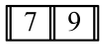


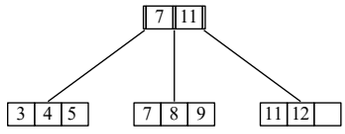
2. After inserting the key 14 in the B+ tree , the **root** of the tree becomes:

Ⓐ  Ⓑ  Ⓒ  Ⓓ  Ⓔ None



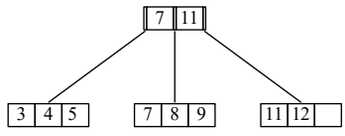
3. After inserting the key 10 in the B+ tree , the **root** of the tree becomes:

Ⓐ  Ⓑ  Ⓒ  Ⓓ  Ⓔ None

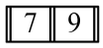


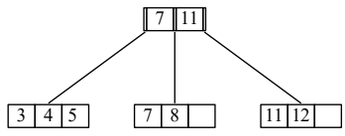
4. After deleting the key 9 from the B+ tree , the **root** of the tree becomes:

Ⓐ  Ⓑ  Ⓒ  Ⓓ  Ⓔ None

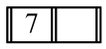
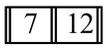
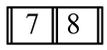


5. After deleting the key 12 from the B+ tree , the **root** of the tree becomes:

Ⓐ  Ⓑ  Ⓒ  Ⓓ  Ⓔ None



6. After deleting the key 11 from the B+ tree , the **root** of the tree becomes:

Ⓐ  Ⓑ  Ⓒ  Ⓓ  Ⓔ None

7. A B+ tree of order 4 leaves can contain the following number of data elements:

   Ⓐ 3 to 4 elements Ⓑ 2 to 4 elements Ⓒ 1 to 4 elements Ⓓ 4 to 4 elements Ⓔ None

Question 8 ..... 8 points

1. Given the following adjacency matrix, draw the weighted graph it represents.

	0	1	2	3	4	5
0		1	2			
1	1		1	3		
2	2	1		4		
3		3	4			
4						3
5					3	

2. Give the adjacency list representation of the graph.

3. What is the cycle with the largest number nodes in the graph? What is its total weight?

ADT Queue Specification

- enqueue (Type e): **requires**: Queue Q is not full. **input**: Type e. **results**: Element e is added to the queue at its tail. **output**: none.
- serve (Type e): **requires**: Queue Q is not empty. **input**: none. **results**: the element at the head of Q is removed and its value assigned to e. **output**: Type e.
- length (int length): **requires**: none. **input**: none. **results**: The number of elements in the Queue Q is returned. **output**: length.
- full (boolean flag): **requires**: none. **input**: none. **results**: If Q is full then flag is set to true, otherwise flag is set to false. **output**: flag.

ADT Stack Specification

- push(Type e): **requires**: Stack S is not full. **input**: Type e. **results**: Element e is added to the stack as its most recently added elements. **output**: none.
- pop(Type e): **requires**: Stack S is not empty. **input**: **results**: the most recently arrived element in S is removed and its value assigned to e. **output**: Type e.
- empty(boolean flag): **requires**: none. **input**: none. **results**: If Stack S is empty then flag is true, otherwise false. **output**: flag.
- full(boolean flag): **requires**: none. **input**: none. **results**: If S is full then Full is true, otherwise Full is false. **output**: flag.