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| | King Saud University | College of Computer and Information Sciences<br>Department of Computer Science |
| | **Data Structures CSC 212** | **Final Exam Solution - 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.

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|---|---|
| Student ID: | Name: |
| Section: | Instructor: |

| 1 | 2.1 | 2.2 | 3.1 | 3.2 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

Question 1 ..... 16 points

**Grading scheme: Part a and b: 1pt fo each question. Part c: 2 pts for 1, 2, 3 and 1 pt for 4.**

(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:

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

Question 2 ..... 10 points

**Grading scheme: 1pt for every question.**

(a) Complete the code below by choosing the correct answer:

- Line 2:
  - (A) `!m.find(nb2)`
  - (B) `m.find(nb1)`
  - **(C) `!m.find(nb1)`**
  - (D) `m.find(nb2)`
  - (E) None
- Line 3:
  - (A) **return true**
  - (B) **return** `m.find(nb1)`
  - **(C) return false**
  - (D) **return** `!m.find(nb1)`
  - (E) None
- Line 4:
  - (A) `m.enqueue(nb2)`
  - **(B) `m.retrieve()`**
  - (C) `m.retrieve(nb1)`
  - (D) `m.find(nb2)`
  - (E) None
- Line 5:
  - **(A) false**
  - (B) `m.retrieve().serve()`
  - (C) **true**
  - (D) `m.find(nb1)`
  - (E) 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) Complete the code below by choosing the correct answer:

- 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

**Grading scheme: All questions 1 pt except part (a) Line 7: 2 pts.**

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

Question 4 ..... 14 points

**Grading scheme: Part (a) and (c) 1.5pts each question. Part (b) 2 pts.**

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

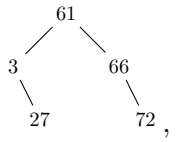
(b) What is the result of a bottom-up min-heap construction of the array: 1,5,11,4,6,0? (A) 0,1,4,6,5,11 (B) 1,0,4,5,6,11 **(C) 0,4,1,5,6,11** (D) 0,4,1,6,11,5 (E) None.

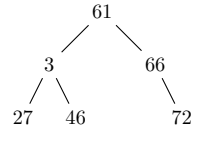
(c) Choose the correct answer:

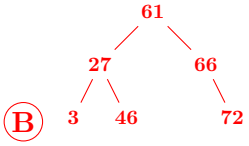
1. Bottom-up heap construction is: **(A)** $O(n)$ (B) $O(\log n)$ (C) $O(n^2 \log n)$ (D) $O(n^2)$ (E) None.
2. The serve operation in a heap priority queue is: (A) $O(1)$ **(B)** $O(\log n)$ (C) $O(n)$ (D) $O(n \log n)$ (E) None.
3. What is the minimum number of nodes in a heap of height $k$? (A) $2^k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

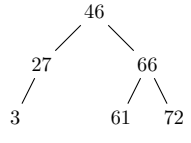
Question 5 ..... 14 points

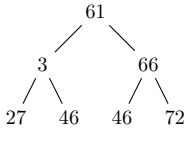
**Grading scheme: 2pt for every question.**

1. After inserting the key 46 in the AVL 

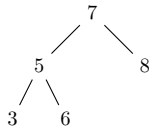
, the tree becomes: (A) 

(B) 

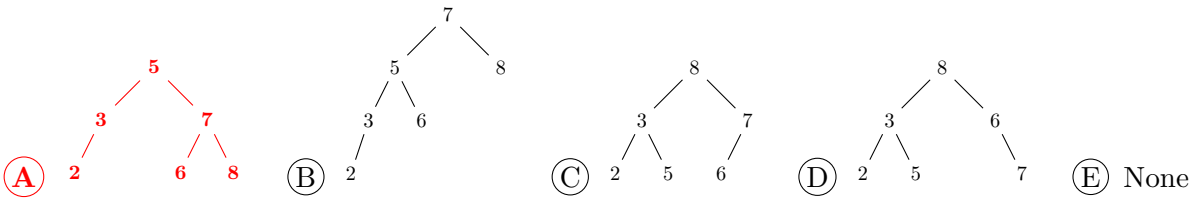
(C) 

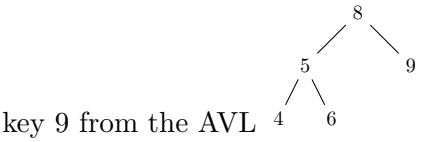
(D) 

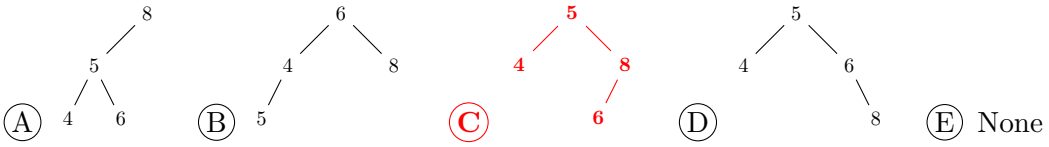
(E) None

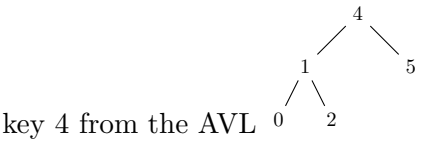
2. After inserting the key 2 in the AVL 

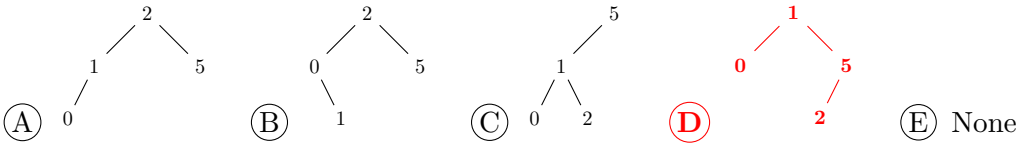
, the tree becomes:

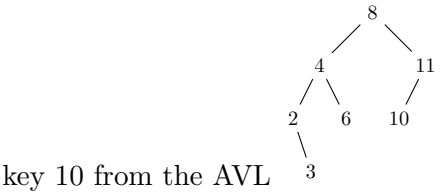


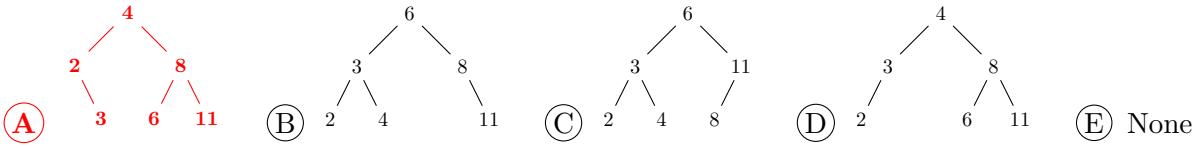

3. After deleting the key 9 from the AVL  , the tree becomes:

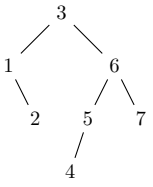


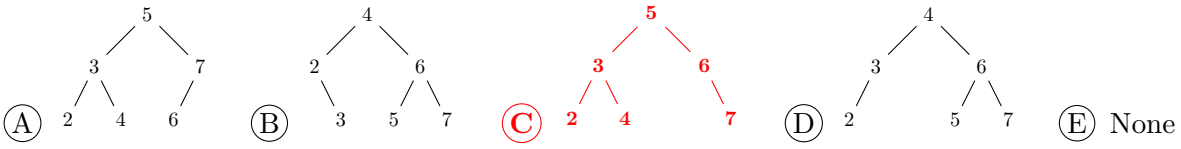

4. After deleting the key 4 from the AVL  , the tree becomes:

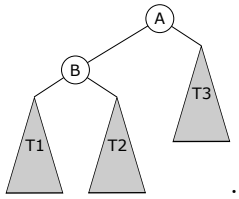



5. After deleting the key 10 from the AVL  , the tree becomes:




6. After deleting the key 1 from the AVL  , the tree becomes:




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: 0

   (b) The balance of B becomes: 0

Question 6 ..... 14 points

**Grading scheme: (Total number of mistakes / 50 * 14) rounded up to the nearest 0.5.**

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

| Key | 14 | 15 | 4 | 16 | 27 | 20 | 35 | 47 | 10 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|
| Position | 4 | 5 | 6 | 8 | 7 | 0 | 9 | 1 | 2 | 3 |
| Number of probes | 1 | 1 | 2 | 2 | 1 | 1 | 3 | 3 | 2 | 4 |

2. External chaining. Fill in the following table:

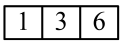
| Key | 14 | 15 | 4 | 16 | 27 | 20 | 35 | 47 | 10 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|
| Index of the list | 4 | 5 | 4 | 6 | 7 | 0 | 5 | 7 | 0 | 7 |

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 | 0 | 1 | 4 | 2 | 6 | 9 | 8 | 5 | 3 | 7 |
| Index of next element | 8 | -1 | -1 | -1 | 9 | -1 | 7 | -1 | -1 | -1 |

Question 7 ..... 14 points

**Grading scheme: 2pt for every question.**




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

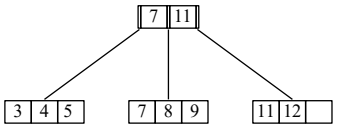
(A) 

(B) 

**(C)** 

(D) 

(E) None




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

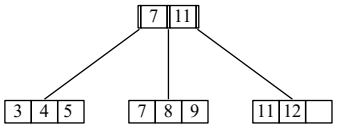
**(A)** 

(B) 

(C) 

(D) 

(E) None



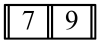

3. After inserting the key 10 in the B+ tree , the **root** of the tree

becomes:

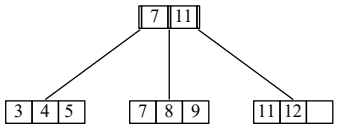
(A) 


(B) 


**(C)** 


(D) 


(E) None




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

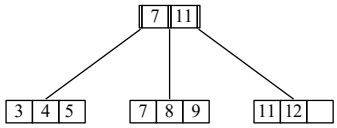
(A) 


**(B)** 


(C) 


(D) 


(E) None




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

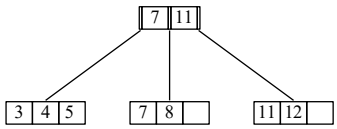
(A) 


(B) 

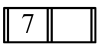

(C) 

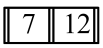

**(D)** 

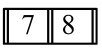

(E) None




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

**(A)** 


(B) 


(C) 


(D) 


(E) None

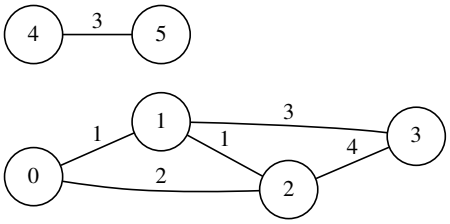
7. A B+ tree of order 4 leaves can contain the following number of data elements:

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

Question 8 ..... 8 points

**Grading scheme: (1) 3pts: -0.5pts for every incorrect edge (missing or extra); (2) 3pts: -0.25pts for every incorrect edge (missing or extra) and round up to the nearest 0.5; (3) 2pts (1 + 1).**

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



2. Give the adjacency list representation of the graph.

| | |
|---|---|
| 0 | $\rightarrow (1,1) \rightarrow (2,2)$ |
| 1 | $\rightarrow (0,1) \rightarrow (2,1) \rightarrow (3,3)$ |
| 2 | $\rightarrow (0,2) \rightarrow (1,1) \rightarrow (3,4)$ |
| 3 | $\rightarrow (1,3) \rightarrow (2,4)$ |
| 4 | $\rightarrow (5,3)$ |
| 5 | $\rightarrow (4,3)$ |

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

   Cycle: $(0,1,3,2,0)$ or any other equivalent cycle.

   Total weight: 10.