King Fahd University of Petroleum & Minerals

College of Computer Science and Engineering

Information and Computer Science Department

First Semester 131 (2013/2014)

ICS 202 – Data Structures

Final Exam

Sunday, December 29th, 2013

Time: 120 minutes

Name: ____

ID#

Section 01 Dr. Ramadan 10-10:50am
Section 02 Dr. Sami 09-09:50am

Question #	Max Marks	Marks Obtained
1	30	
2	20	
3	20	
4	10	
5	20	
Total	100	

Instructions

1. Write your name and ID in the respective boxes above and circle your section.
2. This exam consists of 10 pages, including this page, plus one reference sheet, containing 5 questions.
3. You have to answer all 5 questions.
4. The exam is closed book and closed notes. No calculators or any helping aids are allowed.
5. Make sure you turn off your mobile phone and keep it in your pocket if you have one.
6. The questions are not equally weighed.
7. The maximum number of points for this exam is 100.
8. You have exactly 120 minutes to finish the exam.
9. Make sure your answers are readable.
10. If there is no space on the front of the page, feel free to use the back of the page. Make sure you indicate this in order not to miss grading it.

Q.1: (30 points: 3x10):

1) The big-O notation
   a) Can compare algorithms in the same complexity class
   b) Is an upper bound on the asymptotic complexity of the program
   c) Is a bottom bound on the asymptotic complexity of the program
   d) Provide a measure which is valid for different operating systems, compilers and CPUs.

2) Among the following operations which are more efficient in the doubly linked list compared to singly linked list:
   a) Append
   b) Prepend
   c) Extract(Object ob)
   d) ExtractFirst
   e) ExtractLast

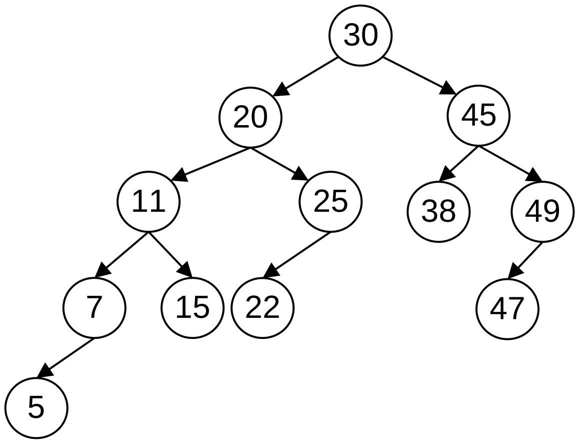
3) Consider the following method

```
1) public void final(int [] A, int n) {
2)   if (n ==0) {
3)     System.out.print(A[n]+" ");
4)     return;
5)   }
6)   final(A, n-1);
7)   System.out.print(A[n-1]+" ");
8)   final(A, n-1);
9) }
```

   The number of times the print statements in lines 3 and 7 are executed is equal to
   a) $2n - 1$
   b) $2^{n+1} - 1$
   c) $2^{n} - 1$
   d) log $(n+1) + 1$
   e) None of the above.

4) The method final in Question 2 when called on A=[5,4,3,2,1] and n = 2 outputs
   a) 4 3 4 5 5 5
   b) 5 4 5 3 5 4 5
   c) 0 0 0 1 0 0 0 3 0 0 0 1 0 0 0
   d) 5 5 5 4 5 5 5 3 5 5 5 4 5 5 5
   e) None of the above.

5) Consider the following AVL tree



The operation that will cause a double left-right rotation on the AVL tree is:

a) inserting Key 48
b) inserting Key 46
c) deleting Key 38
d) deleting Key 5
e) None of the above

6) A hypergraph is a generalization of a graph in which an edge can connect any number of vertices. What is the best representation for a hypergraph:

a) Adjacency matrix
b) Adjacency list
c) Incidence matrix
d) Simple list
e) None of the above.

7) The degree of a vertex of a graph is the number of edges incident to the vertex. The sum of all the degrees is equal to:

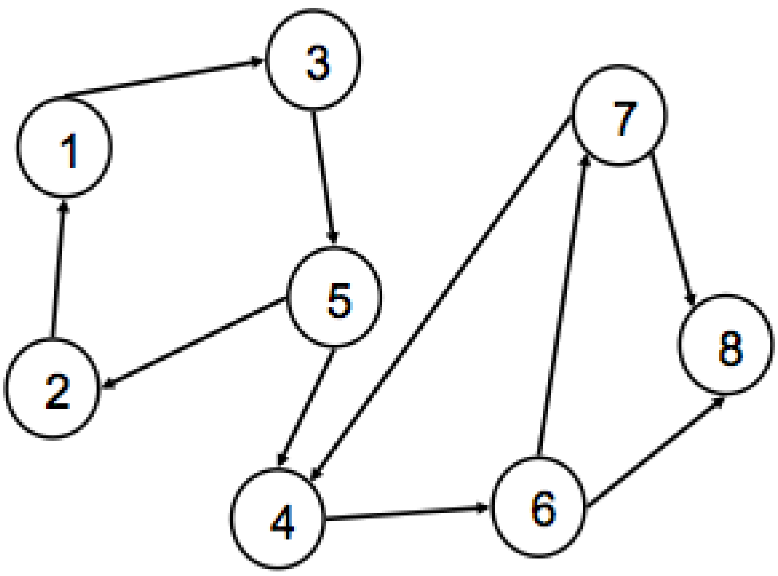
a) twice the number of edges
b) twice the number of vertices
c) the number of edges
d) the number of vertices
e) None of the above.

8) log(n!) is
   a) O(log(n))
   b) O(n log(n))
   c) O(n)
   d) O(log(n)^2)
   e) None of the above.

log(n)+log(n-1)....

9) With open addressing, the load factor value should be:
   a) > 1.0
   b) > 0.5
   c) < 1.0
   d) < 0.5
   e) None of the above.

10) How many strongly connected components in the following graph?
   a) 1
   b) 2
   c) 3
   d) 4
   e) None of the above.

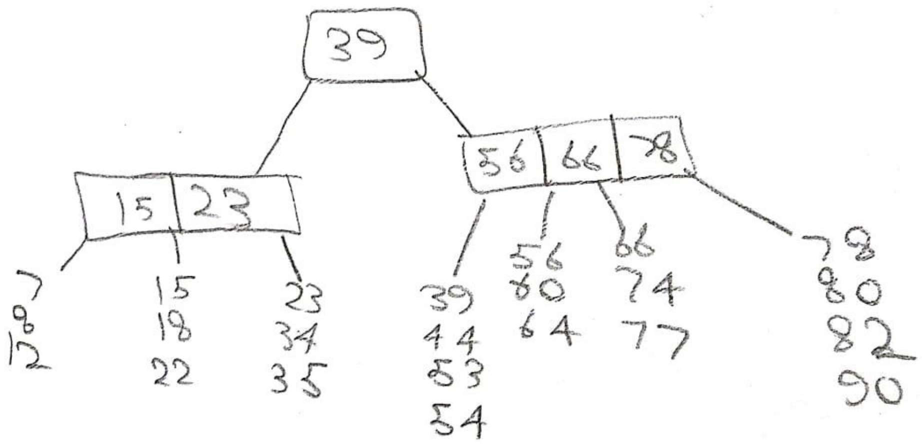


Q.2: (20 points)

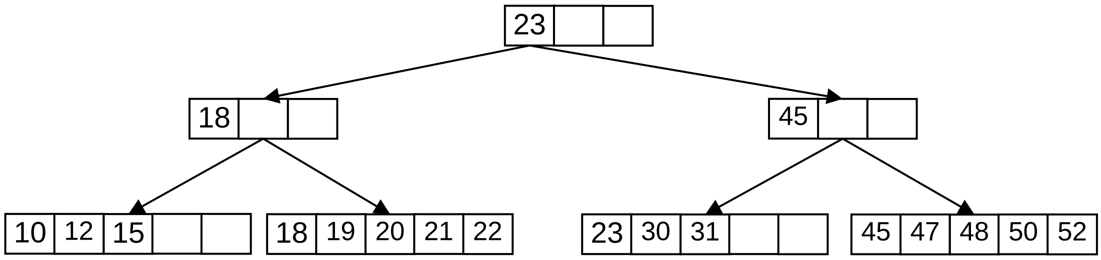
Consider inserting the following keys:

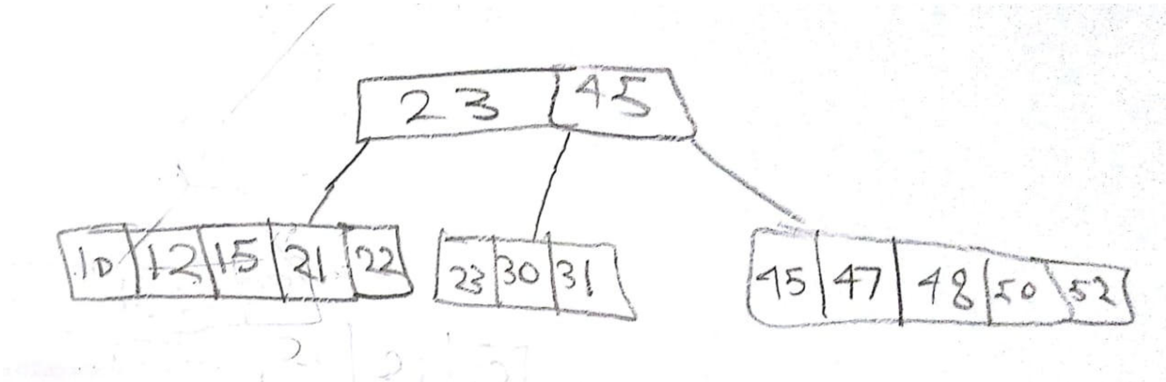
12 , 22 , 23 , 15 , 80, 34 , 56 , 78 , 39 , 8 , 44 , 74 , 35 , 53 , 82 , 77 , 66 , 90 , 54 , 18 , 7 , 64 , 60

1. Insert the above keys, respectively, into an empty B+-Tree of order 5, where each leaf can contain up to 5 keys.



2. Show the resulting B+-Tree after deleting keys 18, 19, and 20, respectively, from the following B+-Tree.

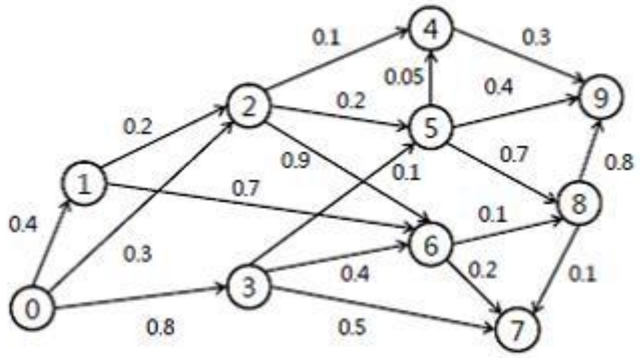




3. Assume that you have a B+-tree whose internal nodes can store up to 100 children and whose leaf nodes can store up to 15 records. What are the minimum and maximum number of records that can be stored by the B+-tree for 1, 2, 3, 4, and 5 levels?

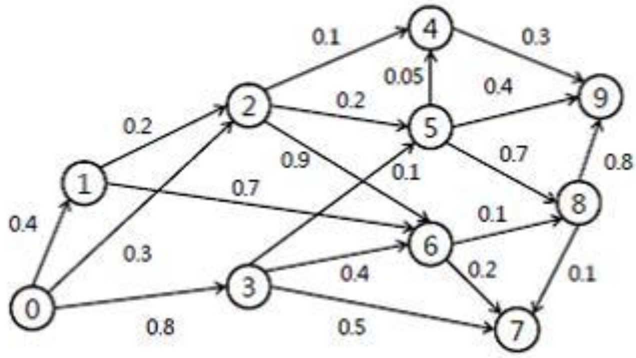
M = 100
L = 15
Max = M^(level-1)*L
Min = ceil(M/2)^(level-1)*ceil(L/2) - I think

Q.3 (20 points) Consider the following definition of the Binary Tree:



[10 points] Use the graph above to trace the execution of *Dijkstra's algorithm* as it solves the shortest path problem starting from vertex **0**

Pass	initially											weight	V1
Active Vertex													
0													
1													
2													
3													
4													
5													
6													
7													
8													
9													



[10 points] Use the graph above to trace the execution of *Prim's algorithm* as it finds the minimum-cost spanning tree starting from vertex 2. Draw the resulting spanning tree.

Pass	initially											weight	V1
Active Vertex													
0													
1													
2													
3													
4													
5													
6													
7													
8													
9													

Q.4: (10 points)

Use the hash function h(x) = x mod 11 to load the following values 28, 17, 39, 50 using each of following to resolve collisions:

(a) **c(i) =** $\pm i^2$

index	0	1	2	3	4	5	6	7	8	9	10
	33		50			39	28	17			**21**

(b) **c(i) =** $i * h_p(x)$ **where** $h_p(x) = 1 + x \bmod 10$

index	0	1	2	3	4	5	6	7	8	9	10
	33			17		39	28	50			**21**

Q.5: (20 points)

(a): [10 points] Compress the string: **ABBADDDDABA**
using the **LZ78** compression algorithm. Show all details of your work using a properly labeled table (i.e. you **must** indicate the title of each column in your table)

(b): [5 points]
What is the compression ratio? Is it worth compressing the message? Justify your answer.

(c): [5 points] Decompress the codewords: (0,B) (1,A) (2,A) (3,A) (2,B) (4,D)
using the LZ78 decompression algorithm. Show all details of your work using a properly labeled table.

code	index	word
(0,A)	1	A
(0,B)	2	B
(2,A)	3	BA
(0,D)	4	D
(4,D)	5	DD
(5,A)	6	DDA
(3,)	7	BA

message: (11)(8) = 88 bit
compressed message: 0A0B10A00D100D101A011
15 + 8(6) = 63 bits
71% of original bits

code	ind	word
(0,B)	1	B
(1,A)	2	BA
(2,A)	3	BAA
(3,A)	4	BAAA
(2,B)	5	BAB
(4,D)	6	BAAAD

B BA BAA BAAA BAB BAAAD

Quick Reference Sheet

$$\sum_{i=1}^{n} i = \frac{n(n+1)}{2}$$,

$$\sum_{i=1}^{n} i^2 = \frac{n(n+1)(2n+1)}{6}$$,

$$\sum_{i=1}^{n} i^3 = \left(\frac{n(n+1)}{2}\right)^2$$,

$$\sum_{i=0}^{n} x^i = \frac{x^{n+1}-1}{n-1}$$

$$\sum_{k=0}^{n} x^k = 1 + x + x^2 + \ldots + x^n = \frac{x^{n+1}-1}{x-1} (x \neq 1)$$

$$\sum_{k=0}^{n-1} 2^k = 2^n - 1$$

$$\sum_{k=0}^{\infty} x^k = \frac{1}{1-x}$$ if x < 1

$$\sum_{k=1}^{n} k = 1 + 2 + \ldots + n = \frac{n(n+1)}{2}$$

$$\sum_{k=1}^{n} \frac{1}{k} = 1 + \frac{1}{2} + \ldots + \frac{1}{n} \approx \ln n$$

$$\sum_{k=1}^{n} k^2 = \frac{n(n+1)(2n+1)}{6}$$

$$\sum_{k=1}^{n} \lg k \approx n \lg n$$

$$\sum_{k=0}^{n-1} c = cn.$$

$$\sum_{k=0}^{n} k(k+1) = \frac{n(n+1)(n+2)}{3}$$

$$\sum_{k=0}^{n-1} \frac{1}{2^k} = 2 - \frac{1}{2^{n-1}}$$