BITS PILANI – DUBAI
International Academic City, Dubai
First Semester 2009 – 2010
Data Structures and Algorithms CS C341 (III year)
Comprehensive Exam

Duration : 3 Hours **Weightage : 40%**
Date : 24.12.09 **Max Marks : 80marks**

Note: 1. Answer Part A and Part B in separate answer books provided.
2. Answer all questions of each part sequentially.

PART A

1. a. Write a pseudocode to perform the operation swap(node list , int i, int j) which swaps the i^{th} element with the j^{th} element of a linked list. For e.g. { 22, 33, 44, 55, 66, 77, 88 , 99} swap (list, 2, 5) will change the list to { 22,33,77,55,66,44,88,99 } 3M

b. Give the big-Oh notation of the following expressions.
i) $3n^4 + 2n^2 \log n$
ii) $2n^2$ X $3n \log n$ 1M

2. Given the array representation of the heap to be as represented in the figure below.

i) Draw the heap
ii) Does this heap satisfy the heap property ? Explain
iii) Insert data 65 into the above heap.
v) Delete the data at the root and show how the tree looks after the deletion.
(2 + 1 + 2 + 2)

3.a. Draw an expression tree for the given expression.
a * (b + c) * (d * e + f) 2M
b. Give the **algorithm** to print the arithmetic expression during the Euler tour of the given tree. 3M

4.a. Give an example of a full binary tree of height 3. 2M
b. How may binary trees of size 3 are possible ? List out all possibilities. 3M

5.a. How is a 2-4 tree different from a m-way multiway tree ? 1M
b. In a 5 way search tree what is
i) the maximum number of data nodes in the internal nodes of the tree

ii) maximum number of children of each of the internal nodes
iii) minimum number of children in the internal nodes
iv) minimum number of children at the root node. (0.5 X 4 =2M)

6.a. Construct a skip list of height 4 which contains elements 7,9,12,14,17,23,36,45 explain the concept of organization of the skip list and also indicate in your example how data element 36 is searched ? 3M
b. Give the **algorithm** for searching in the skip list. 2M

7.a. Represent the data { an, ant, all, alloy, aloe, are, ate, be } as a trie. 3M
b. Given the symbols and their frequency in the table below.

Symbol	Frequency
A	24
B	12
C	10
D	8
E	8

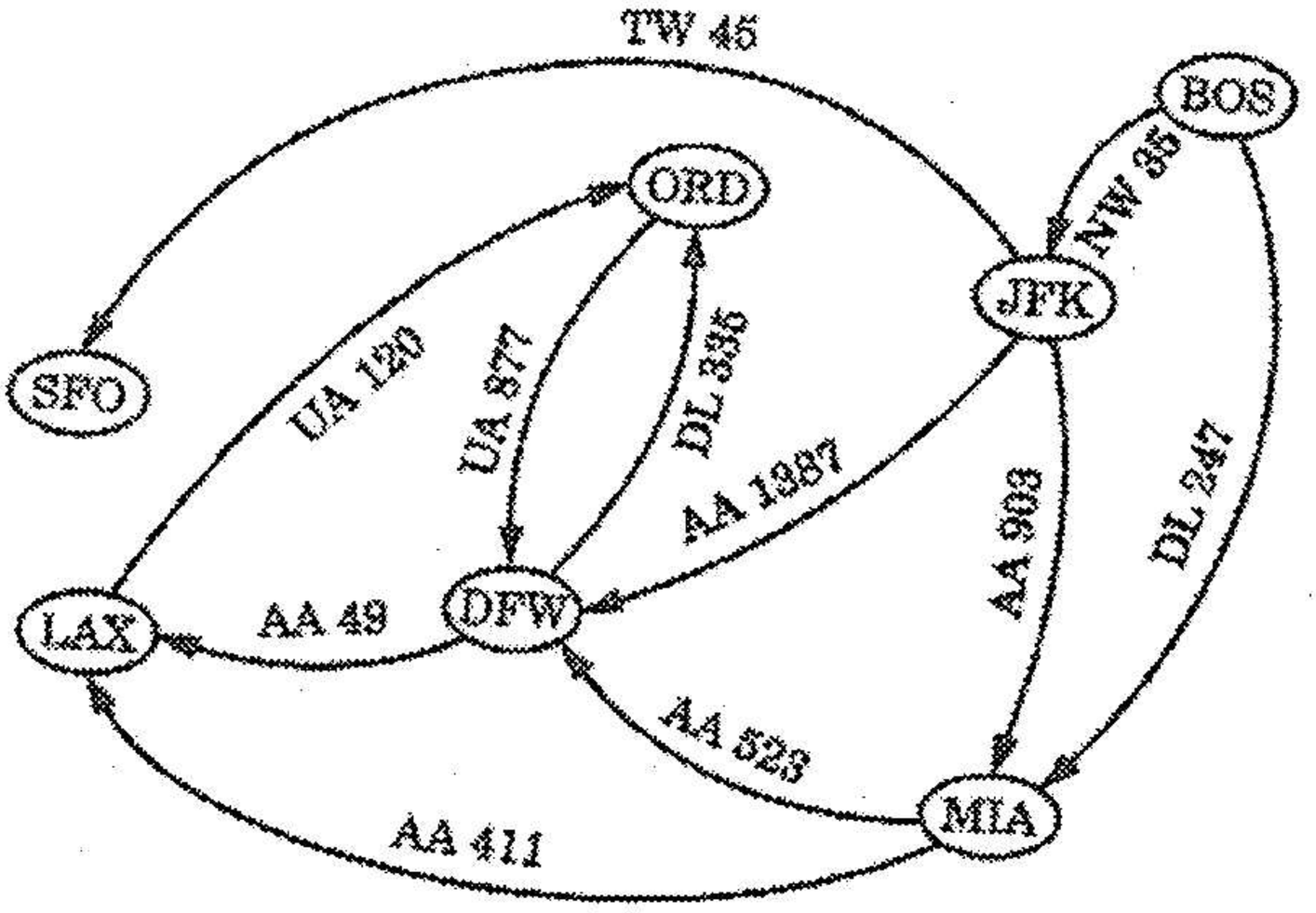
i) Calculate the number of bits used to represent the data , where all symbols are represented by the uniform minimum number of bits to represent the above data. 2M
ii) Use Huffman coding to represent the data and give the code for each symbol. 3M
iii) Give the **Brute-force** algorithm for pattern matching. 3M

PART B

1. a. Would a network of computers represented by a graph be a directed or non-directed? Explain.
b.For the directed graph given below, complete the data structure for
i) an edge
ii) a vertex

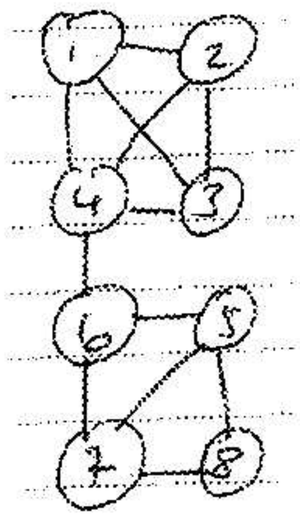
```
struct {                    struct {
...                         ...

...                         ...
} edge_t;                   } vertex_t;
```

in an implementation that uses adjacency list structure. (1+2+2 M)

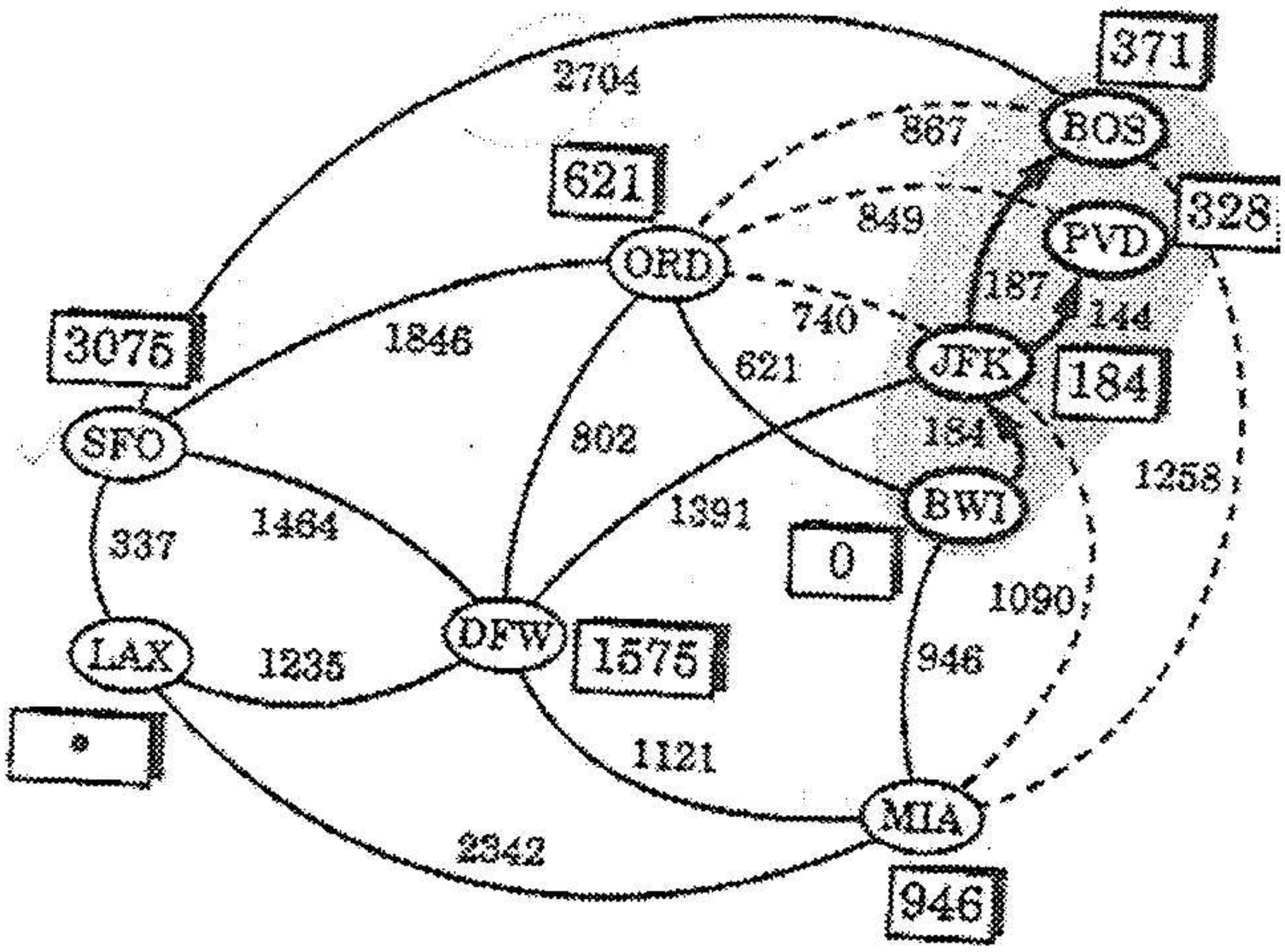


2. a. For the graph given below, determine
   i) discovery (tree) edges
   ii) back edges (or backtracking edges)
   for a Depth First Search (DFS) traversal starting at node 1.

b. For the same graph below, determine
   iii) discovery (tree) edges
   iv) cross edges (or backtracking edges)
for a Breadth First Search (BFS) traversal starting at node 1. 5M



3. The graph below depicts the execution of an algorithm at an intermediate stage.



For ***each one*** of the following scenarios, answer the questions that follow:

1) Dijkstra's algorithm is being executed
2) Prim's algorithm is being executed
3) Kruskal's algorithm is being executed

a) What are the possible vertex/vertices and edges that can be added to the cloud in the next step of the algorithm? (2 x 3 M)
b) Which vertex/vertices and edge is/are actually added to the next step? Explain clearly on what basis this selection made?
(3 x 3 M)

4. a. Consider the product of 4 matrices: ABCD where

a) A is a 10 x 5 matrix
b) B is a 5 x 2 matrix
c) C is a 2 x 20 matrix
d) D is a 20 x 12 matrix

i) List all the possible parenthesizations (different ways of obtaining the product) of the product.
ii) What is the number of multiplications for each parenthesizations?
iii) What is the parenthesization that results in the minimum number of multiplications?

b. Explain the greedy choice property with an example.
c. State the optimization problem in mathematical terms(as objective and constant function) for the following:

i) fractional knapsack problem
ii) 0-1 knapsack problem. (5 + 3 + 2 M)

5.a) What is the Conjunctive Normal Form (CNF) formula for the following truth table?

a	b	c	B
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

b) Define the complexity class P.
c) Define the complexity class NP.
d) Name two problems that are NP complete. (2 + 1 + 1 + 1 = 5M)

********** ALL THE BEST **********

BITS PILANI – DUBAI
International Academic City, Dubai
First Semester 2009 – 2010
Data Structures and Algorithms CS C341 (III year)
Test – II (Open Book)

Duration : 50 minutes **Weightage : 20%**
6.12.09 **MAX : 40 Marks**

Note: Only prescribed text book and handwritten class notes are permitted.
Answer the questions sequentially.

PART A

1. Consider the following sequence of keys:
(5, 16, 22, 45, 2, 10, 18, 30, 50, 12, 1)
Consider the insertion of items with this set of keys, in the order given, into:
   a) An initially empty binary search tree. **(2M)**
   b) An initially empty AVL tree. **(4M)**
   c) An initially empty (2, 4) tree. **(5M)**

Note: Show all steps in the above insertions to get full credit.

For each type of tree (***for the specific keys given***), indicate **(4M)**
   a) how you would measure the complexity of the ***insertion*** algorithm?
   b) how you would measure the search algorithm running time for searching the ***key 30***?

2. Suppose we are given a set of tasks by pairs of the start times and finish times as T = {(1, 2), (1, 3), (1, 4), (2, 5), (3, 7), (4, 9), (5, 6), (6, 8), (7, 9)}. Show the task scheduling problem for this set of tasks with the following assumptions:

   a) the tasks are scheduled based on smallest start times of the tasks. **(2M)**
   b) the tasks are scheduled based on shortest duration of tasks **(2M)**

Do both algorithms and solutions possess greedy-choice property? Explain **(1M)**

PART B

3.a. In the worst case the quick sort algorithm has a running time of $O(n^2)$. Explain why, give a sample input where the running time is $O(n^2)$. **(3M)**

b. Give the running time of merge sort on :
   a. An array that is already sorted
   b. An array that is sorted in reverse order **(2M)**

4. Find each of the following properties for the graph shown in Fig 1 .

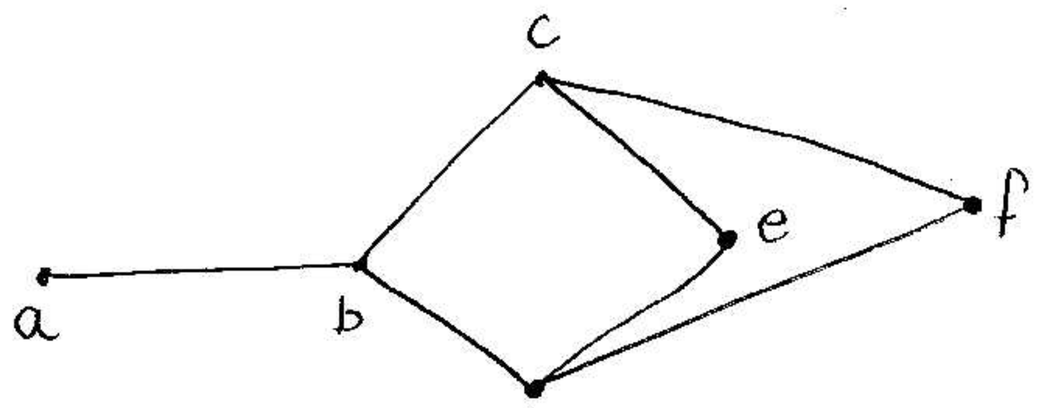


Fig 1

a. Its size n
b. Its vertex set V
c. Its edge set E **(3M)**

5. Let G be the graph whose adjacency matrix is shown in fig 2 .

$$\begin{bmatrix} 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 1 \\ 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$

Fig 2

a. Draw G. **(3M)**
b. Is G a directed graph ? Explain **(1M)**
c. Is G a strongly connected graph ? Explain **(1M)**

6. Show the step by step working of Dijkstra's algorithm on the graph shown in Fig 3 , show the shortest path from node V1 to every other node. **(7M)**

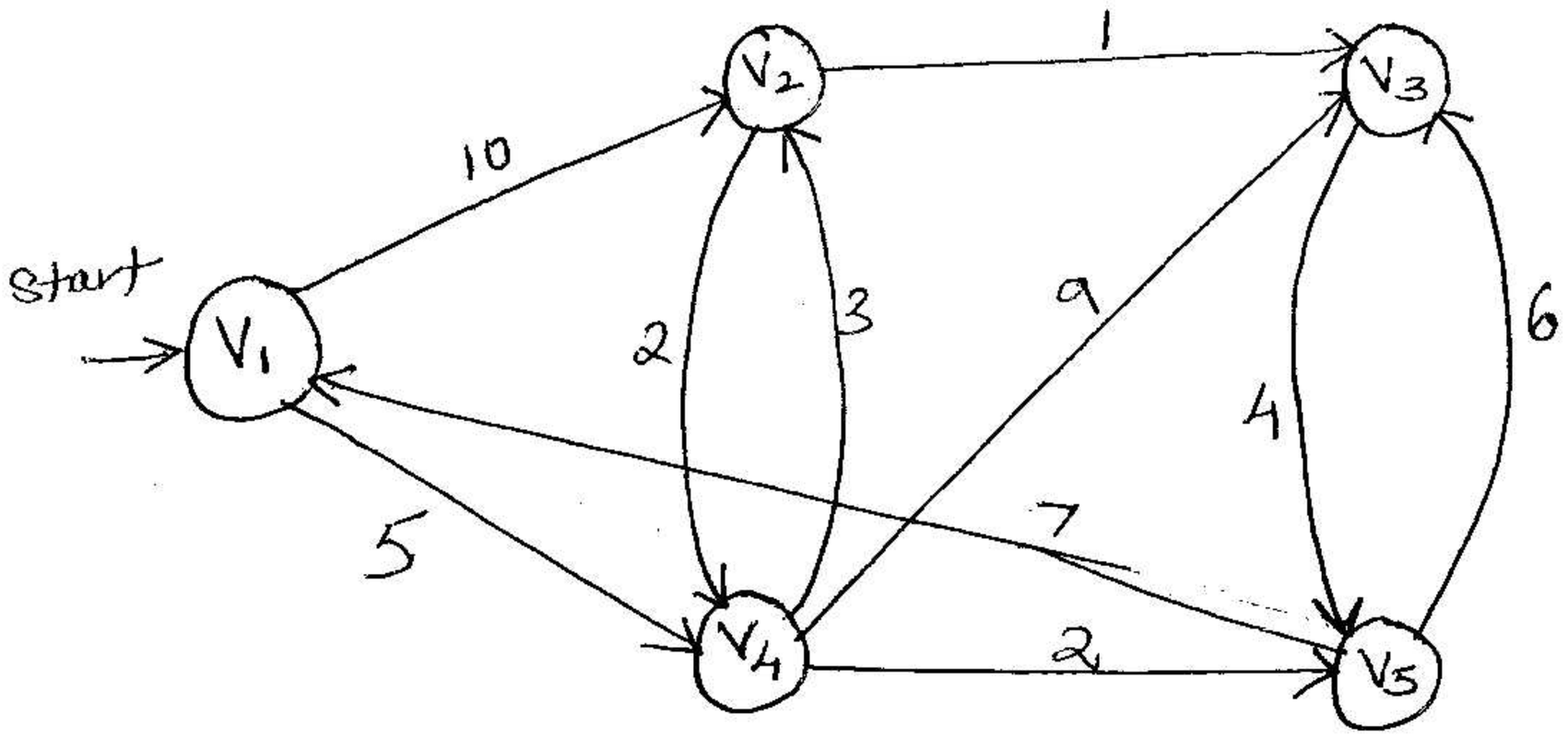


Fig 3

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First Semester 2009 – 2010
Data Structures and Algorithms CSC341 (III year)
Test – 1 (Closed Book)

Duration : 50 minutes **Weightage : 25%**
11.10.09 **MAX : 50 Marks**

Note: Answer all the questions of each part together and in sequence.

PART – A

1. Give a big-oh characterization, in terms of *n*, of the running time of the loop method shown in the algorithm below. (3 Marks)

```
Algorithm Loop(n):
S <- 0
for i ← 1 to n^2 do
        s ← s + i
```

2. Consider the program below. Assuming that a stack is used to store the important values of the program. Show the step-by-step changes in the stack as the program is executed. Each element in the stack for a function called is its *Program Counter (PC)* (given in code below), the *value of parameter(s) passed*, and the *value returned by the function called.* (5 Marks)

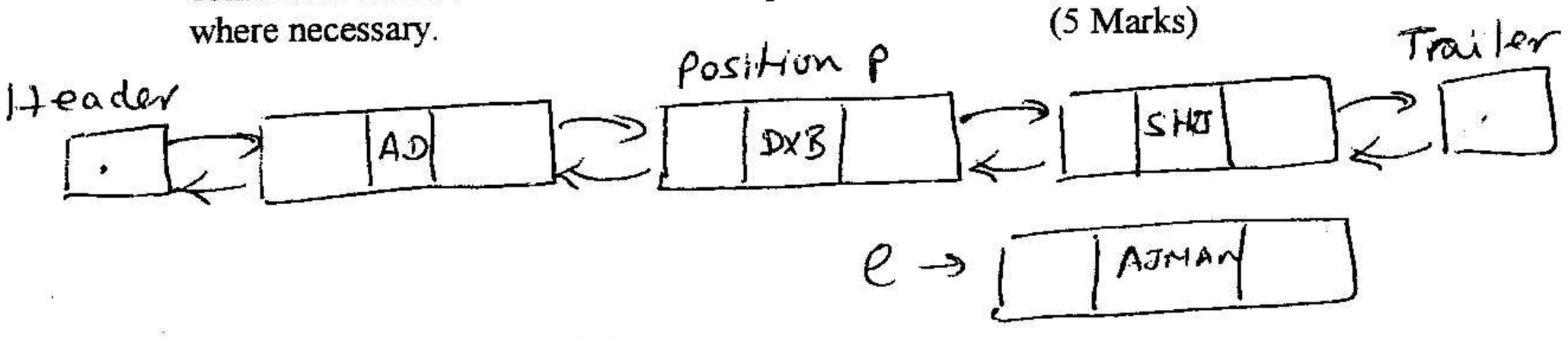
```
        void main() {
          int i = 10;
          float avg_value;

214       avg_value = average(i);
        }

        float average(int j) {
          float avg;
320       avg = ((float)sum(j)/(float)j);
          return(avg);
        }
682     int sum(int k) {
          int sum = 0;
          for(int m = 1; m <= k; m++)
            sum += m;
          return(sum);
        }
```

3. Consider a circular array-based queue. Assume that at a particular instant the following is the state of the queue: front = 97, rear = 2. Also assume the size of the array is 100. What are the values of the *front* and *rear* after
   a. each statement is executed
   b. ***all*** the statements are executed? (5 Marks)

Q.dequeue();
Q.dequeue();
Q.dequeue();
Q.enqueue('B');
Q.enqueue('C');
Q.enqueue('D');
Q enqueue('E');

4. Write an algorithm for *insertAtRank(r, e)* for a simple array-based implementation of a vector. What is the worst-case big-oh performance for a running time of this function? (3 Marks)
5. Write an algorithm for *remove(p)* for a doubly linked list. What is the worst-case big-oh performance for running time of this function? (4 Marks)

6. Consider the following sequence. What would be the output for each of the set of commands below? Give numerical output where necessary and draw the output linked list where necessary. (5 Marks)




```
a.      replaceAtRank(1, e);
atRank(1);
rankOf(p);

b.      swapElements(p, q);
atRank(1);
rankOf(p);

c.      remove(p)
atRank(1);
rankOf(p);
```

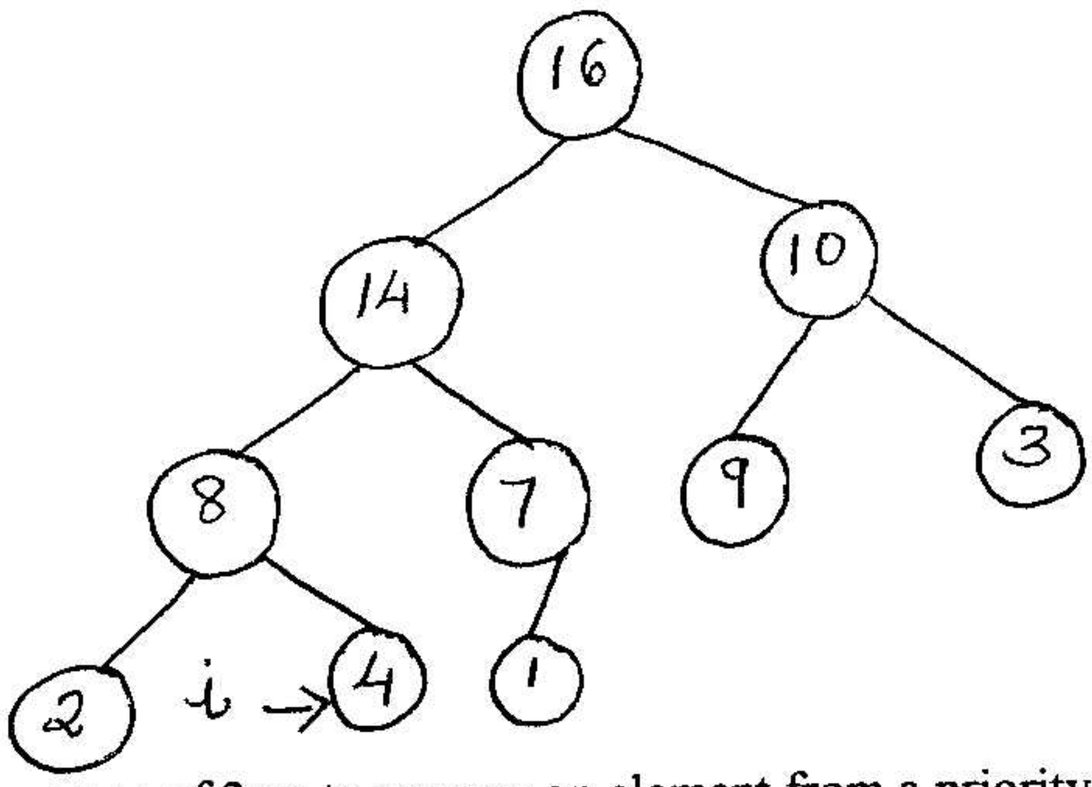
PART B

1.a. Write a recursive algorithm to find the minimum element in a binary search tree.
b. Give an example of a binary search tree with n nodes and where the height of the tree is n-1, assume n=5.
c. How many leaf nodes does a full binary tree of height=9 have ?
d. How many internal nodes does a full binary tree of height = 9 have ?

(5 + 2 + 2 + 2 Marks)

2. a. Show the trace (step by step working) of the insertion of each of the keys 44,66,33,88,77,55,22 into a heap, the heap is arranged such that the root node contains the largest data and the heap condition is satisfied after each insertion.

b. Given the heap shown in the figure, if the data 4 is changed to 14, show the steps required to maintain the heap property. Write an algorithm HeapIncreaseKey(A, i, key) where A is the array used to represent the heap, i is the index position at which the change in data occurs, and key is the new data to be added at the position i. This algorithm only allows a larger value to replace the existing value and brings the newly added data to the correct position in the heap.



c. If it takes an average of 3ms to remove an element from a priority queue with 1,000 elements, how long would you expect it to take to remove an element from a priority queue with 1,000,000 elements ?

d. Suppose a method is devised to sort an array by storing its elements in a priority queue and then removing them back into the array. What is the run time for such an algorithm ?

(5 + 5 + 2 +2 Marks)

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First Semester 2009 – 2010
Data Structures and Algorithms CS C341 (III year)
Quiz (Closed Book)

Duration : 20 minutes **Weightage : 8%**
28.10.09 **MAX : 16 Marks**

SET A

Name : _____ **ID No:** _____ **Sec**____

1. Is a binary tree suitable to organize files in an Operating System? Why or Why not? (1M)

2. Which type of traversal (postorder, inorder, preorder) should one most likely use to evaluate the following mathematical expression in a C program

   Z = ((((X3 + X1) * X3)/((X9 – X5) + X2)) – ((X3 * (X7 – X4)) + X6)) ?
   (1M)

3. What is the relationship between the number of internal nodes and external nodes in a proper binary tree? (1M)

4. Is a complete binary tree a proper binary tree? Why? (2M)

5. What is the big-oh for heap sort algorithm? (1 M)

6. Does the Binary Search Tree satisfy the heap order property? Justify your answer (2M)

7.Explain how the open addressing technique used in linear probing / quadratic probing different from the chaining technique of hashing ? (2M)

8. Given an initially empty AVL tree, insert data 10,20,30,25,27,7,4 sequentially . Show the AVL tree at each stage and explain which rotation is required and why ? (4 M)

9. Given the data 1,2, 3,5,7,8,9,10,11,12,14,17 give the number of steps involved in searching for the element 12 using chaining, the hash function used is key mod 10. (2M)

********** ALL THE BEST **********