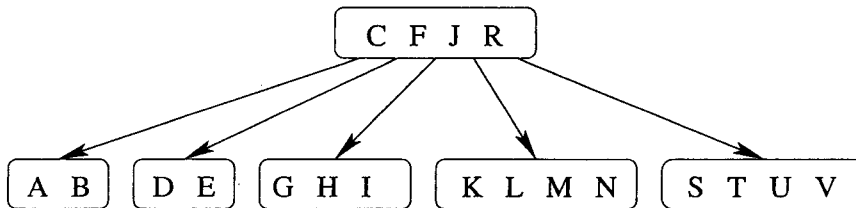


國立臺灣科技大學  
九十四學年度碩士班招生考試試題

系所組別：資訊工程系碩士班  
科 目：資料結構

\* 總分為100分

1. (13%) Consider the following B-tree of order 5:



- (a) (6%) What is the result of the tree after the key 'P' is inserted?
- (b) (7%) From the B-tree in question, what is the result after the key 'B' is deleted? **This problem is independent of (a).**
2. (8%) A star-shaped graph is a connected graph that has exactly one node having a number of arms of arbitrary lengths. Given an undirected graph stored in an adjacency list. How would you determine whether the graph is star-shaped in  $O(n)$  time? Briefly justify why your algorithm works in  $O(n)$  time.
3. (12%) Consider the following extension of a binary heap, called a *minmax heap*: The key of a node at an even level is less than or equal to the keys of its children and grandchildren; the key of a node at an odd level is greater than or equal to the keys of its children and grandchildren. The root of the minmax heap is at level 0.
- (a) (2%) What is the running time for finding the maximum key in this data structure? (4%) Briefly justify your answer.
- (b) (2%) What is the running time for inserting a new key in a minmax heap? (4%) Briefly justify your answer.

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4. (10%)
- (a) (4%) What is the maximum possible height of an AVL tree that contains 52 elements?
- (b) (3%) What is the maximum number of elements that can be contained in an AVL tree of height 6?
- (c) (3%) Suppose a 2-3 tree of height 4 includes 19 elements in 16 nodes. How many external nodes are there in the tree?
5. (9%) Least significant digit first (or LSD) is one way of sorting records on several keys. Let there be  $r$  keys,  $K^1, K^2, \dots, K^r$ , where  $K^1$  is the most significant key and  $K^r$  is the least. Explain why the sorting scheme used for sorting on the keys  $K^j, 1 \leq j < r$ , must be **stable** when we sort the records using LSD.
6. (14%) A computer is connected to a network by a dedicated communication line. Outbound packets are generated dynamically and they are scheduled for transmission by the computer one at a time. The lengths of the outbound packets are known when they are generated. If a packet arrives to find that the communication channel is busy, it is temporarily stored in a buffer by the scheduler waiting for its turn to be transmitted. To save the average waiting time for the packets the scheduler always selects the packet of the shortest length from the buffer (if it is not empty) for transmission once the communication channel becomes idle. If you are to design such a scheduler, what data structure will you use for organizing the packets in the buffer? Briefly argue for your choice.
7. (10%) Given a fixed unknown binary tree with its preorder traversal as BACHGFIDE. In that tree, we also know that a path from the root to a leaf is BCFDE. What is the complete binary tree that you guess? Please write down all possible answers if you got more than one answer (or without any possible answer at all). The necessary process to justify your answer(s) should also be included.

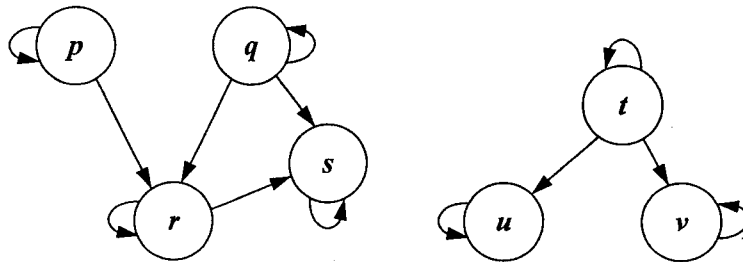
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8. (15%) Given a directed graph  $G = (V, E)$  as follows:



- (a) (5%) We use the adjacency matrix  $A$  shown below to store the graph:

$$A = \begin{matrix} & \begin{matrix} p & q & r & s & t & u & v \end{matrix} \\ \begin{matrix} p \\ q \\ r \\ s \\ t \\ u \\ v \end{matrix} & \begin{bmatrix} 1 & & & & & & \\ & 1 & & & & & \\ & & 1 & & & & \\ & & & 1 & & & \\ & & & & 1 & & \\ & & & & & 1 & \\ & & & & & & 1 \end{bmatrix} \end{matrix}$$

Please complete the matrix  $A$ .

- (b) (5%) Suppose we are given an arithmetic system as  
*addition:*  $0 + 0 = 0, 0 + 1 = 1 + 0 = 1 + 1 = 1,$   
*multiplication:*  $0 \cdot 0 = 0 \cdot 1 = 1 \cdot 0 = 0, 1 \cdot 1 = 1.$   
 Please compute  $A^{100} + A^{30}$ .

- (c) (5%) Given another graph  $G' = (V', E')$  with its adjacency matrix  $B$ , following the similar notations, and assuming again that all the diagonal entries of  $B$  are 1, let us define  $B^*$  as  $B^* \equiv \lim_{n \rightarrow +\infty} B^n$ . Suppose  $B^*$  is now given by

$$B^* = \begin{matrix} & \begin{matrix} p & q & r & s & t & u & v \end{matrix} \\ \begin{matrix} p \\ q \\ r \\ s \\ t \\ u \\ v \end{matrix} & \begin{bmatrix} 1 & 1 & 1 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 \end{bmatrix} \end{matrix},$$

please find a topological sort of  $G'$ . You should answer "impossible" if you think the topological sort can not be applied in this case.

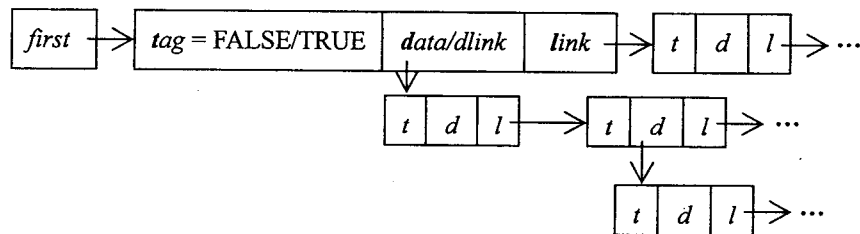
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9. (9%) A data structure of the generalized list is given as follows, three fields in each node and the field *tag* to indicate if the following field is a data (*tag* = FALSE) or a link (*tag* = TRUE)



Let us use the following C++-like code to recursively perform the list copy.

```

void GenList :: Copy(const GenList &l)
1  {
2  first = Copy(l.first);
3  }

GenListNode* GenList :: Copy(GenListNode *p)
1  {
2  GenListNode *q = 0;
3  if (p) {
4  q = new GenListNode;
5  q -> tag = p -> tag;
6  if (!p -> tag) q -> data = p -> data;
7  else q -> dlink = Copy (p -> dlink)
8  q -> link = Copy (p -> link);
9  }
10 return q;
11 }

```

Given three lists with their initial values  $L_1 = (a, b)$ ,  $L_2 = ((L_1, L_1, c), d)$ ,  $L_3 = (e, L_3)$  (that means  $L_2$  has a shared list  $L_1$ ), if we want to make copies of the lists  $L_2$  and  $L_3$  by the above procedure, what are the answers? To be complete, please write down the lists and their corresponding data structures. (Note: shared lists, like  $L_1$  should be indicated by some mentioned variables)

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