Data Structure (CS2351)   Midterm Exam   April 18, 2005

1. What is abstract data type? What are their advantages? (6%)

2. Using both variable count and tabular methods to compute the program steps of the following program. (10%)

```
void insert_max_heap(element item, int *n)
{
/*insert item into a max heap of current size *n */
   int i;
   if (HEAP_FULL(*n)){
      fprintf(stderr, "The heap is full. \n");
      exit(1);
   }
   i = ++(*n);
   while ((i != 1) && (item.key > heap[i/2].key)) {
      heap[i] = heap[i/2];
      i /= 2;
   }
   heap[i] = item;
}
```

$n^2 + 2n \Rightarrow n^2$

Program 5.13: Insertion into a max heap

3. What are the meaning of asymptotic notation (O, Ω, Θ)? (9%)

4. A *square band matrix* $D_{n,a}$ is an $n \times n$ matrix in which all the nonzero terms lie in a band centered around the main diagonal.   The band includes the main diagonal and $a-1$ diagonals below and above the main diagonal (Figure 1).

$D_{n,a}$
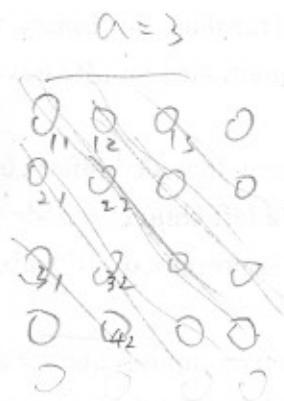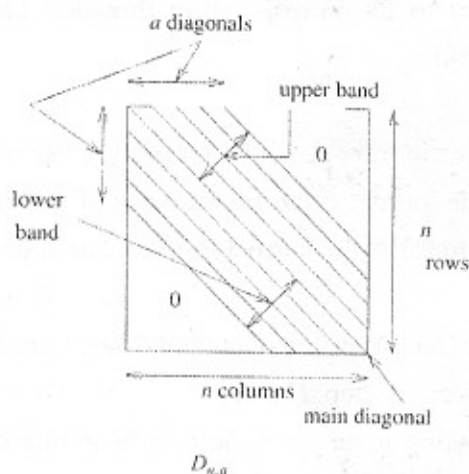
(a) How many elements are there in the band $D_{n,a}$? (5%)
(b) What is the relationship of i and j for element $d_{i,j}$ in the band $D_{n,a}$? (5%)

(c) Assume that the band of $D_{n,a}$ is stored sequentially in an array b by diagonals, starting with the lowermost diagonal. Obtain an addressing formula for the location of an element, $d_{i,j}$, in the lower band of $D_{n,a}$. (5%)

5. Given an infix expression $(a + b) / d * e * (f + a * b) - c$.
   (a) What is its corresponding prefix expression? (4%)
   (b) What is its corresponding postfix expression? (4%)
   (c) What is its corresponding binary tree in which we can apply preorder and postorder traversal to get the prefix and postfix expressions shown in (a) and (b), respectively? (4%)

6. Given set $S = \{a, b, c, d, e, f, g, h, i, j, k, l\}$ and the following equivalence pairs

$$a \equiv e, g \equiv k, d \equiv b, j \equiv i, h \equiv e, g \equiv i, d \equiv f, c \equiv l, l \equiv a$$

Find the corresponding equivalence classes. (6%)

7. Given a tree $(A(B(E(K(L,O)),F),C(G,N),D(H(M,I),J)))$ that is represented as a list, where the root node comes first followed by a list of the subtrees of that node.
   (a) Draw the corresponding tree structure. (3 %)
   (b) Transfer the tree shown in (a) to its corresponding left-child right-sibling tree. (3 %)
   (c) What is the preorder sequence of the tree shown in (b). (3 %)
   (d) What is the inorder sequence of the tree shown in (b). (3 %)
   (e) What is the postorder sequence of the tree shown in (b). (3 %)
   (f) What is the level-order sequence of the tree shown in (b). (3 %)
   (g) Translate the binary tree shown in (b) to its corresponding threaded binary tree that maintains inorder traversal property. (3%)

8. Given a threaded binary tree T that maintains inorder traversal property. How to insert node r as a left child of a node s in T such that the inorder traversal property of the threaded binary tree is preserved? Please use an example to show the correctness of your approach. (5 %)

9. Given an input sequence as Mar, Feb, Nov, Dec, Aug, Jan, Oct, Jun, May, Sep, July, Apr.
   (a) Construct the corresponding min heap step by step. (10 %)
   (b) What is the output sequence when deleting node from the min heap one node at a time until the heap is empty? (6%)