Please use C++ (or Java) for all programming questions.

1. **(15 %)** Suppose that there are a singly linked list class called SList and the stored node class called SListNode, which contains a pointer next and a string called item. In the list class, there are a pointer called head and an integer called size for keeping the number of nodes in the list. Write a function called shorten in the SList class for concatenating each successive pair of strings (nodes) into a single string (node). Upon completion, the number of nodes is reduced by half. For example, [enjoy ntu esoe ms entrance exam] becomes [enjoyntu esoems entranceexam]. If the size is odd, the last node in the list is not changed.

2. **(15 %)** A next-to-minimum spanning tree of a graph is a spanning tree whose total weight is as small as possible but greater than the weight of a minimum spanning tree of the graph. For a weighted graph G, develop an algorithm to construct the next-to-minimum spanning tree of G.

3. **(15 %)** Consider the following algorithm to evaluate a polynomial $f(x) = \sum_{i=0}^{n} a_i x^i$,
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poly = 0;
for (i = n; i >= 0; --i)
    poly = x * poly + a[i];
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   a. (5 %) Show how the steps are performed by this algorithm for $x = 2$, $f(x) = 3x^4 - 5x^3 + 6x - 4$.
   b. (5 %) Explain or show why this algorithm works.
   c. (5 %) What is the running time of this algorithm.

4. **(10 %)** Write a program called nodesAtLevel that returns the number of nodes at a particular level of a binary tree. Assume root of the tree is at level 0.

5. **(10 %)** Would you use the adjacency list structure or the adjacency matrix structure in each of the following cases? Please justify your choice.
   a. (5 %) The graph has 12,000 vertices and 25,000 edges, and it is important to use as little space as possible.
   b. (5 %) The graph has 12,000 vertices and 30,000,000 edges, and it is important to use as little space as possible.

6. **(10 %)** Suppose we are using a tree-based disjoint set data structure with union-by-size and path compression.
   a. (5 %) Draw a 16-node disjoint set tree that has the maximum height possible. *Hint*: The tree must be one that can be created through union and find operations.
   b. (5 %) What is the minimum number of find operations it would take to transform the tree in (a) to have the minimum height possible? Why?

7. **(10 %)** Draw the 2-3-4 tree that results from inserting o, d, j, h, s, g, and a, in the order given, into a 2-3-4 tree that contains a single node whose value is n.

8. **(15 %)** Consider a modification of the quick-sort algorithm where we choose the element at index $\lfloor n/2 \rfloor$ as our pivot. Describe the kind of sequence that would cause this version of quick-sort to run in $\Omega(n^2)$ time. Give an example to illustrate your argument.

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