Answer all questions on the exam. You may use the back for additional space. Total: 100 points. Good Luck.

1. (15 pts) Using the big-O notation, estimate the running time of proc(N) in terms of N which is a positive integer. Explain your answer.

   ```c
   void proc(int x)
   {
      int i;

      if (x >= 1)
      {
         proc(x/2);
         for (i = 0; i < x; i++)  // loop x times
            /* constant-time operation */
      }
   }
   ```

2. (15 pts) Use BNF (Backus-Naur Form) to specify floating-point constants such as 1.5, -0.5, -.7,.7 (you may exclude considering those with exponents like 1e5).
3. (50 pts) C, C++, Ada, or pseudocode with sufficient details can be used for this question:

(a) Specify the language you are using.

(b) Give a collection of type declarations for a binary tree.

(c) Using your declarations from (b), give a function for calculating the height of a given tree. For this question you may assume that an empty tree (one containing no nodes) has height 0, and a tree containing a single node has height 1.

(d) Using your declarations from (b), give a function for determining the total number of nodes in a tree.
4. (20 pts) On the number of comparisons of array elements in Quicksort:

(a) Describe when the best case occurs.
(b) Explain the run-time complexity for the best case and state it in big-O.
(c) Describe when the worst case occurs.
(d) Explain the run-time complexity for the worst case and state it in big-O.