1. Imagine you have an empty stack of integers, S, and an empty queue of integers, Q. Draw a picture of S and Q after the following operations: (10 points)

```
1  pushStack (S, 9)
2  pushStack (S, 16)
3  enqueue   (Q, 7)
4  enqueue   (Q, 6)
5  popStack  (S, x)
6  pushStack (S, 4)
7  enqueue   (Q, x)
8  dequeue   (Q, y)
9  pushStack (S, y)
10 pushStack (S, x)
```

2. Draw the expression tree and find the infix and prefix expressions for the following postfix expression: (15 points)

A B * C D / + E F - *

3. Define the term **red-black tree**. (15 points)

4. Draw all possible binary search trees for the data elements 5, 9, and 12. (10 points)

5. Determine the computational complexity of the following two loops: (10 points):

a.
```
for ( i = 0; i < n; i++)
    for (j = 0; j < n; j++)
        a[i][j] = b[i][j] + c[i][j];
```

b.
```
for (i = 0; i < n; i++)
    for (j = 0; j < n; j++)
        for (k = a[i][j] = 0; k < n; k++)
            a[i][j] += b[i][k] * c[k][j];
```

6. Show how to determine in $O(n^2 \log n)$ time whether any three points in the set $S = \{(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)\}$ are collinear. (20 points)

7. Two character strings may have many common substrings. Substrings are required to be contiguous in the original string. For example, *photograph* and *tomography* have several common substrings of length one (i.e., single letters), and common substrings *ph*, *to*, and *ograph* (as well as all the substrings of *ograph*), The maximum common substring length is 6..

Let $X = x_1 x_2 \ldots x_m$ and $Y = y_1 y_2 \ldots y_n$ be two character strings. Give an $O(mn)$ -time algorithm to find the maximum common substring length for X and Y.

(20 points)

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