Name: _____ Student ID: _____ Web ID: _____

**Problem 1. (10 pts)** Give the **letter** input, **GOTAIWAN**. Show the major operations of **Quicksort** on this input to make the eight characters into alphabetical order. Please mark the two $A$'s as $A_1$ and $A_2$, according to their orders in the input, and show their positions during the processing.

**Problem 2. (15 pts)** Search trees.

(a) (5 pts) Give the binary search tree that results from successively inserting the keys 9, 10, 2, 1, 6, 5, 7 into an initially empty tree.

(b) (5 pts) Label each node in the tree with $R$ or $B$ denoting the respective colors RED and BLACK so that the tree is a legal red-black tree.

(c) (5 pts) Give the red-black tree that results from inserting the key 8 into the tree of (b).

**Problem 3. (15 pts)** Given $X =< J, A, P, A, N >$ and $Y =< T, A, I, W, A, N >$, find the longest common subsequence (LCS) of $X$ and $Y$:

(a) (10 pts) Fill the missing fields in the table below and mark an arrow for each derived field, as discussed in class, to find the LCS. What is the LCS?

(b) (5 pts) Explain how you obtain your LCS.

| $j$ | | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| $i$ | | $y_j$ | $T$ | $A$ | $I$ | $W$ | $A$ | $N$ |
| 0 | $x_i$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | $J$ | 0 | ↑0 | ↑0 | ↑0 | ↑0 | ↑0 | ↑0 |
| 2 | $A$ | 0 | ↑0 | | | | | |
| 3 | $P$ | 0 | | | | | | |
| 4 | $A$ | 0 | | | | | | |
| 5 | $N$ | 0 | | | | | | |