

Sign the exam with your student number - not your name _____

Answer all three questions to the best of your ability.

1. (40 pts) Provide a time and space analysis of the shaker sort algorithm below. (author Jason Harrison@cs.ubc.ca, with modifications by wds@cs.fit.edu 11/7/00)

1 *<Shaker Sort 1>*≡

```
void shakerSort(int a[]) throws Exception {
    int i = 0; int k = a.length- 1;
    while (i < k) {
        int min = i; int max = i; int j;
        for (j = i + 1; j <= k; j++) {
            if (a[j] < a[min]) { min = j; }
            if (a[j] > a[max]) { max = j; }
        }
        int T = a[min]; a[min] = a[i]; a[i] = T;
        if (max == i) {
            T = a[min]; a[min] = a[k]; a[k] = T;
        } else {
            T = a[max]; a[max] = a[k]; a[k] = T;
        }
        i++; k--;
    }
}
```

2. (40 pts) Consider the following algorithm that finds the maximum element in an array $A[0 \dots n - 1]$. Find a recurrence relation (and initial condition) that characterizes the running time complexity of the algorithm. Solve the recurrence you found.

2 \langle Maximum Element in Array 2 $\rangle \equiv$

```
public int maximum(int[] A, int lo, int hi) {
    if (hi - lo <= 1) {
        return (A[x] < A[y]) ? A[y] : A[x];
    }
    else {
        int max1 = maximum(A, lo, (lo + hi)/2);
        int max2 = maximum(A, (lo + hi)/2 + 1, hi);
        return (max1 < max2) ? max2 : max1;
    }
}
```

3. (20 pts) A little problem: “Rotate an array of N elements left by I positions.” For example, with $N = 8$ and $I = 3$, the array $ABCDEFGH$ is rotated to $DEFGHABC$.
- (a) Write a simple program (in the language of your choice) to do the job.
 - (b) What is the time and space complexity of your solution?
 - (c) Can you show how to rotate the array in time proportional to N in constants space?