Selected Solutions for Chapter 2: Getting Started

Solution to Exercise 2.2-2

```
SELECTION-SORT(A)
n = A.length
for j = 1 to n - 1
    smallest = j
    for i = j + 1 to n
        if A[i] < A[smallest]
            smallest = i
    exchange A[j] with A[smallest]
```

The algorithm maintains the loop invariant that at the start of each iteration of the outer **for** loop, the subarray $A[1 .. j-1]$ consists of the $j-1$ smallest elements in the array $A[1 .. n]$, and this subarray is in sorted order. After the first $n-1$ elements, the subarray $A[1 .. n-1]$ contains the smallest $n-1$ elements, sorted, and therefore element $A[n]$ must be the largest element.

The running time of the algorithm is $\Theta(n^2)$ for all cases.

Solution to Exercise 2.2-4

Modify the algorithm so it tests whether the input satisfies some special-case condition and, if it does, output a pre-computed answer. The best-case running time is generally not a good measure of an algorithm.

Solution to Exercise 2.3-5

Procedure BINARY-SEARCH takes a sorted array A, a value v, and a range $[low .. high]$ of the array, in which we search for the value v. The procedure compares v to the array entry at the midpoint of the range and decides to eliminate half the range from further consideration. We give both iterative and recursive versions, each of which returns either an index i such that $A[i] = v$, or NIL, if no entry of

$A[low .. high]$ contains the value v. The initial call to either version should have the parameters $A, v, 1, n$.

```
ITERATIVE-BINARY-SEARCH(A, v, low, high)
while low ≤ high
    mid = ⌊(low + high)/2⌋
    if v == A[mid]
        return mid
    elseif v > A[mid]
        low = mid + 1
    else high = mid - 1
return NIL
```

```
RECURSIVE-BINARY-SEARCH(A, v, low, high)
if low > high
    return NIL
mid = ⌊(low + high)/2⌋
if v == A[mid]
    return mid
elseif v > A[mid]
    return RECURSIVE-BINARY-SEARCH(A, v, mid + 1, high)
else return RECURSIVE-BINARY-SEARCH(A, v, low, mid - 1)
```

Both procedures terminate the search unsuccessfully when the range is empty (i.e., $low > high$) and terminate it successfully if the value v has been found. Based on the comparison of v to the middle element in the searched range, the search continues with the range halved. The recurrence for these procedures is therefore $T(n) = T(n/2) + \Theta(1)$, whose solution is $T(n) = \Theta(\lg n)$.

Solution to Problem 2-4

a. The inversions are $(1, 5), (2, 5), (3, 4), (3, 5), (4, 5)$. (Remember that inversions are specified by indices rather than by the values in the array.)

b. The array with elements from $\{1, 2, \ldots, n\}$ with the most inversions is $\langle n, n-1, n-2, \ldots, 2, 1 \rangle$. For all $1 \le i < j \le n$, there is an inversion (i, j). The number of such inversions is $\binom{n}{2} = n(n-1)/2$.

c. Suppose that the array A starts out with an inversion (k, j). Then $k < j$ and $A[k] > A[j]$. At the time that the outer **for** loop of lines 1–8 sets $key = A[j]$, the value that started in $A[k]$ is still somewhere to the left of $A[j]$. That is, it's in $A[i]$, where $1 \le i < j$, and so the inversion has become (i, j). Some iteration of the **while** loop of lines 5–7 moves $A[i]$ one position to the right. Line 8 will eventually drop key to the left of this element, thus eliminating the inversion. Because line 5 moves only elements that are less than key, it moves only elements that correspond to inversions. In other words, each iteration of the **while** loop of lines 5–7 corresponds to the elimination of one inversion.

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Neil Thomson

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