

Topic 2A, Linear Search: Group __

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- Name
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Come to agreement as a group on the responses to these questions, and insert your responses below each question. Everyone named above will get the same grade for this work. If there is a disagreement, you may write in the alternative solutions and explain the disagreement.

Searching Problem

(1) Write pseudocode for **linearSearch(A,v)**, an algorithm that scans through a sequence represented as an array A of length n looking for v , and provides the desired output (index i or NIL). Use Java style 0-based indexing (first item is at $A[0]$) and $A[i]$ to access elements. Number the lines for reference, as started below.

Input: A sequence of n numbers $A = \langle a_0, a_1, \dots, a_{n-1} \rangle$ (in no particular order) and a value v .

Output: An index i such that $v = A[i]$ or the special value NIL if v does not appear in A .

linearSearch(A,v)

1 ...

(2) Now calculate the runtime of this function in terms of number of steps. For an unknown input A , let n be the number of elements in A , and p be the number of array positions checked during execution. For example, $p=1$ when the element v is found in the first position of the list.

1. Write the number of times each line is executed in terms of p .
2. Write an expression for the runtime in terms of p if v is in the list.
3. Write an expression for the runtime in terms of p if v is not in the list.
4. What is the *worst case* runtime (in terms of n).
5. In what Θ (Theta) complexity class is this worst case? (Write as $\Theta(\text{_____})$.)
6. What is the *average case* runtime (in terms of n).
7. In what Θ (Theta) complexity class is this average case? (Write as $\Theta(\text{_____})$.)
8. Do the Θ -complexities of the worst and average case change if A is always sorted?

Clarifications:

- We are not assuming any ordering of the numbers (except the last question).
- The algorithm only returns the first index i where the key is found, not *all* locations. (This is common in search problems.)
- Use "Java-like" pseudocode, but don't worry about details of syntax
- Variable " p " is only a helper-variable for parts 2.1-2.3. It should not be used in the description of the worst and average case runtime (2.4-2.8).

Challenge Problem: Selection Sort

Consider sorting n numbers stored in array A by first finding the smallest element of A and exchanging it with the element in $A[1]$. Then find the second smallest element of A , and exchange it with $A[2]$. Continue in this manner for the first $n - 1$ elements of A .

1. Write pseudocode for this algorithm, which is known as selection sort.
2. What loop invariant does this algorithm maintain?
3. Why does it need to run for only the first $n-1$ elements, rather than for all n elements?
4. Give the best-case and worst-case running times of selection sort in Θ -notation.