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CSEN 703 Analysis and Design of Algorithms, Winter Term 2024
Practice Assignment 5

Exercise 5-1

Recall the following QuickSort algorithm discussed in class.

```
1  QuickSort(A, p, r)
2  if p < r then
3  |  q = Partition(A, p, r);
4  |  QuickSort(A, p, q − 1) ;
5  |  QuickSort(A, q + 1, r) ;
6  end
```

Suppose that the Partition function at line 2 was replaced by the following function Modified_Partition.

```
1  Modified_Partition(A, p, r)
2  x = A[p];
3  i = p;
4  j = r;
5  while TRUE do
6  |  while j > p and A[j] ≥ x do
7  |  |  j = j − 1;
8  |  end
9  |  while i < r and A[i] ≤ x do
10 |  |  i = i + 1;
11 |  end
12 |  if i < j then
13 |  |  Exchange A[i] with A[j];
14 |  else
15 |  |  Exhange A[p] with A[j];
16 |  |  return j;
17 |  end
18 end
```

(a) Demonstrate the operation of Modified_Partition when called with $A = [13, 19, 9, 5, 14, 8, 7, 4, 21]$, $p = 1$, and $r = 9$. Show the values of the array after each iteration of the while loop in lines 5-18 and the final return value.

(b) Explain the functionality of Modified_Partition.

(c) Is the modified QuickSort algorithm correct when it uses Modified_Partition? Explain your reasoning.

(d) What is the best and worst cases of the modified QuickSort?

(e) Write the recurrences representing the best and worst case running times of the modified QuickSort (you don't need to solve them).