

PARTITION(A, p, q, r)

Input: Array A , indices p and q with $p \leq q$

Output: By swapping elements of $A[p \dots q]$, we have that all elements of $A[p \dots r - 1]$ are at most $A[r]$, and all elements of $A[r + 1 \dots q]$ are at least $A[r]$.

```
1  $x \leftarrow A[p]$ 
2  $left \leftarrow q + 1$ 
3  $right \leftarrow p$ 
4 while TRUE
5     /* Invariant:  $A[right] = x$ 
6     /* Invariant:  $right \leq left$ 
7     /* Invariant:  $A[p] \leq x, A[p + 1] \leq x, \dots, A[right] \leq x$ 
8     /* Invariant:  $A[left] \geq x, A[left + 1] \geq x, \dots, A[q] \geq x$ 
9     repeat  $left \leftarrow left - 1$ 
10    until  $A[left] \leq x$ 
11    if  $left = right$  then return(  $r \leftarrow left$ )
12    else
13         $A[right] \leftarrow A[left]$ 
14         $A[left] \leftarrow x$ 
15    endif
16    /* Invariant:  $A[left] = x$ 
17    /* Invariant:  $right \leq left$ 
18    /* Invariant:  $A[p] \leq x, A[p + 1] \leq x, \dots, A[right] \leq x$ 
19    /* Invariant:  $A[left] \geq x, A[left + 1] \geq x, \dots, A[q] \geq x$ 
20    repeat  $right \leftarrow right + 1$ 
21    until  $A[right] \geq x$ 
22    if  $left = right$  then return( $r \leftarrow left$ )
23    else
24         $A[left] \leftarrow A[right]$ 
25         $A[right] \leftarrow x$ 
26    endif
27 endwhile
```