Computer Organization
Lab Assignment

Assignment 9

Quick Sort using EMU8086

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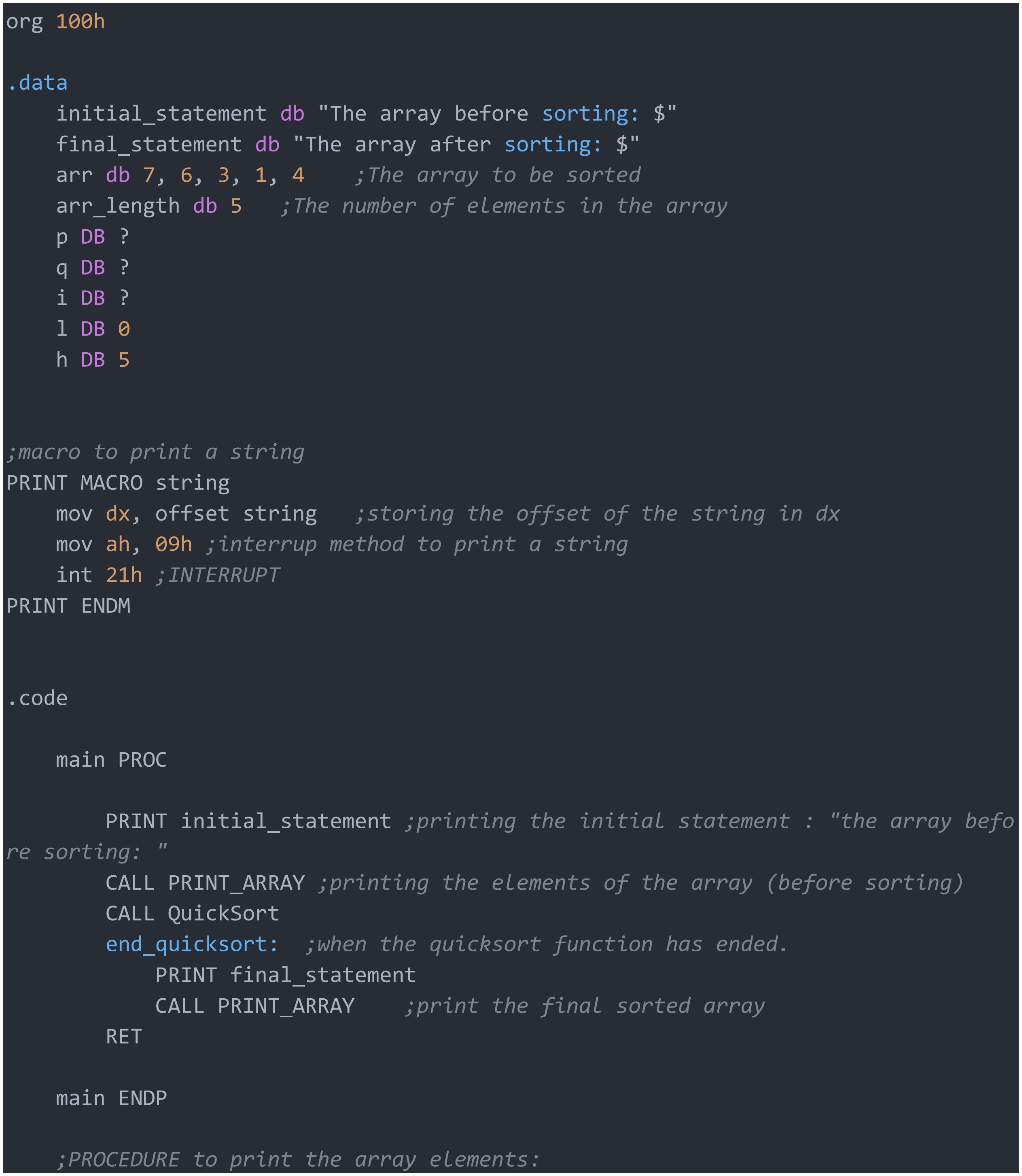
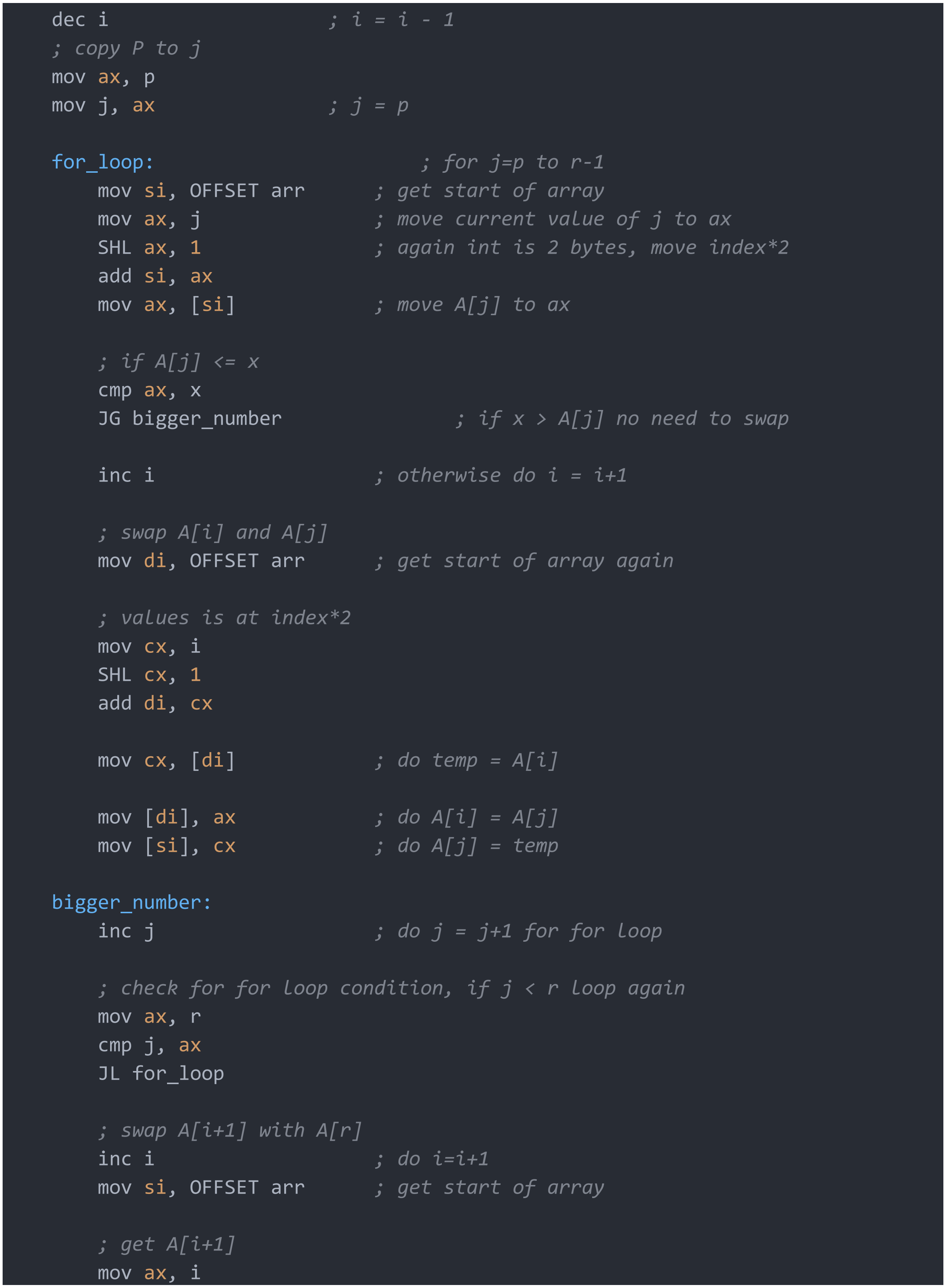
1. **Write an assembly program to implement Quick Sort.**



```
org 100h

.data
    initial_statement db "The array before sorting: $"
    final_statement db "The array after sorting: $"
    arr db 7, 6, 3, 1, 4     ;The array to be sorted
    arr_length db 5   ;The number of elements in the array
    p DB ?
    q DB ?
    i DB ?
    l DB 0
    h DB 5


;macro to print a string
PRINT MACRO string
    mov dx, offset string   ;storing the offset of the string in dx
    mov ah, 09h ;interrup method to print a string
    int 21h ;INTERRUPT
PRINT ENDM


.code

    main PROC

        PRINT initial_statement ;printing the initial statement : "the array before sorting: "
        CALL PRINT_ARRAY ;printing the elements of the array (before sorting)
        CALL QuickSort
        end_quicksort:  ;when the quicksort function has ended.
            PRINT final_statement
            CALL PRINT_ARRAY    ;print the final sorted array
        RET

    main ENDP

    ;PROCEDURE to print the array elements:
```

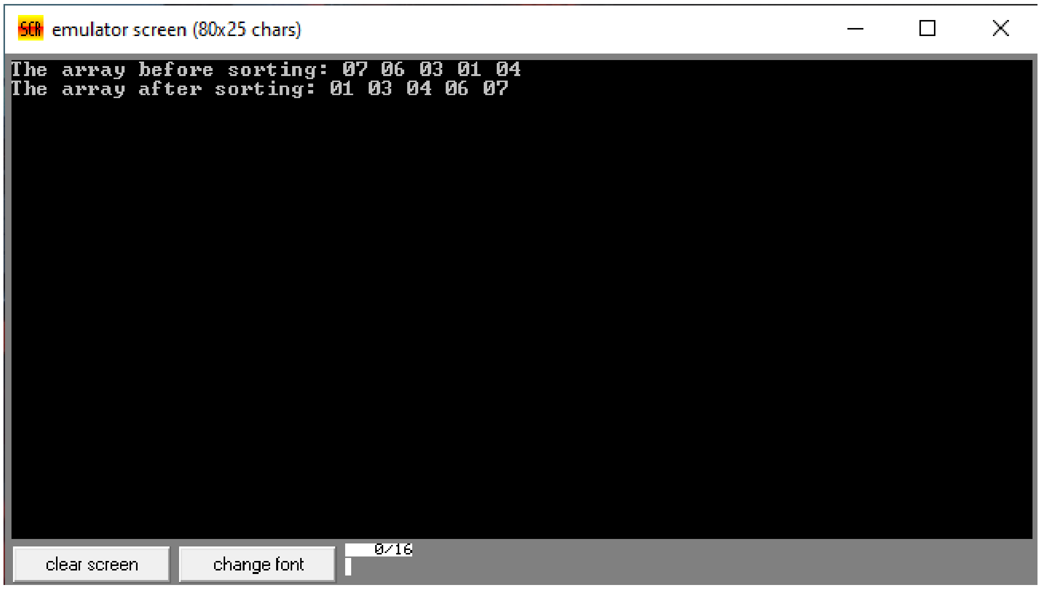
```
    PRINT_ARRAY PROC
        mov cl, arr_length
        print_loop:
           mov bl, arr_length  ;store the array length in bl
           sub bx, cx  ;subtract the counter pointer from the bx register (array_length - cx)
           mov ah, 02h ;the interrup method to print a digit
           mov dl, arr[bx]
           add dx, 30h ;adding 30h for the ASCII conversion
           int 21h ;INTERRUPT
        loop print_loop
        RET
    PRINT_ARRAY ENDP


    ;quicksort algo:
    ;quickSort(arr[], low, high)
    ;{
    ;    if (low < high)
    ;    {
    ;        pivot = partition(arr, low, high);
    ;        quickSort(arr, low, pivot - 1);
    ;        quickSort(arr, pivot + 1, high);
    ;    }
    ;}
    QuickSort PROC
        mov al, l
        cmp al, h   ;if l=>h then end the function
            jge end_quicksort
        mov al, l
        PUSH ax
        mov al, h
        PUSH ax
        CALL partition
        mov q, ax               ; store result in q

        ; pushing values to stack to keep the values stored when doing the recursive calls
        inc ax                  ; do q+1
        push ax                 ; push the value of q+1
        push r                  ; push the value of r

        ; setting the parameters for the first call, arr, p and q-1
        mov ax, q               ; get value of q
        mov r, ax               ; set second parameter to q
        dec r                   ; do q - 1
        CALL QuickSort              ; p is already p here, and r is now set to q-
1


        ;get previous values that were pushed, arr, q+1, r
        pop r                   ; pop to r (we last pushed to r)
        pop p                   ; pop to p = q+1
        CALL QuickSort              ; p is q+1 here, and r is r

        ret
    QuickSort ENDP


    ;partition algo:
    ;partition (arr[], low, high)
    ;{
    ;    pivot = arr[high];
    ;    i = (low - 1) // Index of smaller element
    ;    for (j = low; j <= high- 1; j++)
    ;    {
    ;        if (arr[j] < pivot)
    ;        {
    ;            i++;    // increment index of smaller element
    ;            swap arr[i] and arr[j]
    ;        }
    ;    }
    ;    swap arr[i + 1] and arr[high])
    ;    return (i + 1)
    ;}

    partition PROC
        mov si, OFFSET arr      ; load address of array
    mov ax, r               ; get r

    ; since every int is 2 bytes, we need to move index*2 times from start of arr
ay
    SHL ax, 1               ; shift left will multiply ax by 2
    add si, ax              ; add the result to start of array, we are at A[r] no
w
    ; copy A[r] to x
    mov ax, [si]
    mov x, ax               ; x = A[r]
    ; copy p - 1 to i
    mov ax, p
    mov i, ax               ; i = p
```



```
dec i                   ; i = i - 1
; copy P to j
mov ax, p
mov j, ax               ; j = p

for_loop:                       ; for j=p to r-1
    mov si, OFFSET arr      ; get start of array
    mov ax, j               ; move current value of j to ax
    SHL ax, 1               ; again int is 2 bytes, move index*2
    add si, ax
    mov ax, [si]            ; move A[j] to ax

    ; if A[j] <= x
    cmp ax, x
    JG bigger_number               ; if x > A[j] no need to swap

    inc i                   ; otherwise do i = i+1

    ; swap A[i] and A[j]
    mov di, OFFSET arr      ; get start of array again

    ; values is at index*2
    mov cx, i
    SHL cx, 1
    add di, cx

    mov cx, [di]            ; do temp = A[i]

    mov [di], ax            ; do A[i] = A[j]
    mov [si], cx            ; do A[j] = temp

bigger_number:
    inc j                   ; do j = j+1 for for loop

    ; check for for loop condition, if j < r loop again
    mov ax, r
    cmp j, ax
    JL for_loop

    ; swap A[i+1] with A[r]
    inc i                   ; do i=i+1
    mov si, OFFSET arr      ; get start of array

    ; get A[i+1]
    mov ax, i
```

```
        SHL ax, 1
        add si, ax
        mov ax, [si]            ; ax = A[i+1]

        ; get A[r]
        mov di, OFFSET arr
        mov cx, r
        SHL cx, 1
        add di, cx
        mov cx, [di]            ; cx = A[r]

        ; swap A[i+1] and A[r]
        mov [di], ax            ; A[r] = ax
        mov [si], cx            ; A[i+1] = cx

        mov ax, i               ; i is already i+1, set ax to return value
        ret                     ; and return

    ret

    partition ENDP

    end:
ret
```

Output:



```
The array before sorting: 07 06 03 01 04
The array after sorting: 01 03 04 06 07
```