Northeastern University
College of Engineering
Department of Electrical & Computer Engineering

EECE7205: Fundamentals of Computer Engineering

Fall 2019 - Homework 2

Instructions

- For programming problems:
  - Your code must compile and run on the COE Linux server before submitting it on Blackboard.
  - Your code must be well commented by explaining what the lines of your program do. Have at least one comment for every 4 lines of code.
  - At the beginning of your source code files write your full name, students ID , and any special compiling/running instruction (if any).

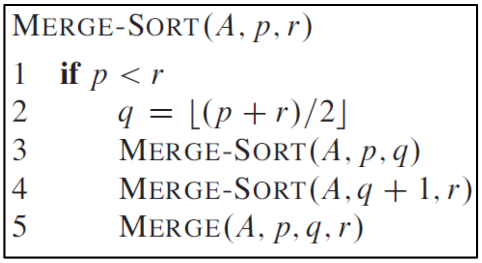
- Submit the following to the homework assignment page on Blackboard:
  - Your homework report submitted as one PDF file. The report includes the answers to the non-programming problems and the screen shots of your program's sample runs for the programming problems. Your report must be developed by a word processor (no hand written or drawn contents are acceptable).
  - Your well-commented source code file(s) for the programming problems.
  - Do NOT submit your files (the PDF and source code) as a compressed (zipped) package. Rather, upload each file individually.

__Note__: Yon can submit multiple attempts for this homework, however, only your last submitted attempt will be graded.

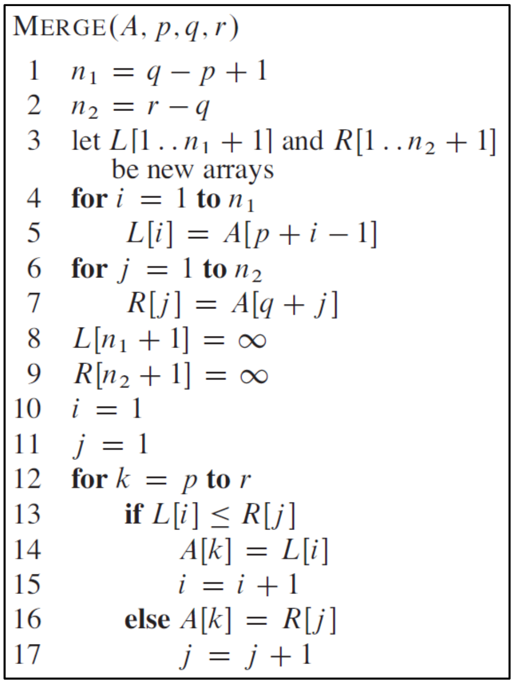
Problem 1 (40 Points)

Write a C++ program for sorting an array *A* of *n* integers. First you need to implement both the MERGE-SORT and MERGE algorithms (shown below). The `main()` function of the program carries out the following tasks:

1. Ask the user to input the value of *n*, where $1 < n \leq 50$
2. Fill *A* with random integers in the range 0 to 100. To generate such random numbers, you need to use the <random> header. Check the following link for an example: http://en.cppreference.com/w/cpp/numeric/random/uniform_int_distribution
3. Call the MERGE-SORT function to sort the contents of *A*. MERGE-SORT needs to call the MERGE function.
4. Display on the screen the contents of the sorted array *A*.



```
MERGE-SORT$(A, p, r)$
if $p < r$
    $q = \lfloor (p + r)/2 \rfloor$
    MERGE-SORT$(A, p, q)$
    MERGE-SORT$(A, q + 1, r)$
    MERGE$(A, p, q, r)$
```



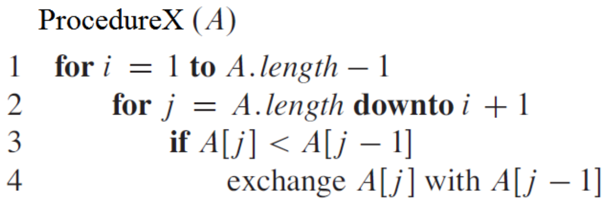
```
MERGE$(A, p, q, r)$
$n_1 = q - p + 1$
$n_2 = r - q$
let $L[1 \,..\, n_1 + 1]$ and $R[1 \,..\, n_2 + 1]$
    be new arrays
for $i = 1$ to $n_1$
    $L[i] = A[p + i - 1]$
for $j = 1$ to $n_2$
    $R[j] = A[q + j]$
$L[n_1 + 1] = \infty$
$R[n_2 + 1] = \infty$
$i = 1$
$j = 1$
for $k = p$ to $r$
    if $L[i] \leq R[j]$
        $A[k] = L[i]$
        $i = i + 1$
    else $A[k] = R[j]$
        $j = j + 1$
```

Problem 2 (20 Points)

In the above MERGE algorithm and to avoid having to check whether either list is empty in each basic step, a sentinel value of ∞ is placed at the end of each list.

Rewrite the algorithm (no need to submit any C++ program code) so that it does not use sentinels, instead it stops once either array *L* or *R* has had all its elements copied back to *A* and then copying the remainder of the other array back into *A*.

Problem 3 (20 Points)



```
ProcedureX ($A$)
for $i = 1$ to $A.length - 1$
    for $j = A.length$ downto $i + 1$
        if $A[j] < A[j-1]$
            exchange $A[j]$ with $A[j-1]$
```

The above code is for **ProcedureX** that takes list *A* of integers as an input parameter.

a) In 70 words or less, explain the purpose of ProcedureX and how it achieves that purpose.

b) If *n* = *A.length*, determine ProcedureX's worst-case running time formula as a function of *n* (show your steps).

Problem 4 (20 Points)

In order to sort the contents of array $A[1..n]$ using a recursive version of the insertion sort algorithm, you can recursively sort $A[1..n\text{-}1]$ and then insert $A[n]$ into the sorted array $A[1..n\text{-}1]$. Write the recurrence equation for the running time of this recursive version of insertion sort. Solve the recurrence equation to find the asymptotic notation of the running time.