SEMESTER 1
2020-21

CS210FZ
Algorithms & Data Structures 1

Dr. Chengkuan Lin, Dr. J. Timoney, Dr. M. Huggard

Time allowed: 2 hours

Answer *all* questions

All questions carry equal marks

Instructions

	Yes	No
Log Books Allowed	☐	X
Formula Tables Allowed	☐	X
Other Allowed (*enter details*)	☐	X

General (*enter details*)

T6 **1** Give the worst case Big-O complexity of the following
algorithms:

(a) Heap Sort   [2 marks]
(c) Bubble sort   [2 marks]
(b) Selection Sort   [2 marks]
(d) Merge Sort   [2 marks]

[25 marks]

2 Given a sorted integer array arr[] with length n, and given a
integer value searchKey.

T4

(a) Write an efficient Java program to find out whether searchKey is   [15 marks]
in the array or not. If searchKey is in arr[], then output its
position; otherwise, output NONE. **You may not use a linear
search in your answer to this question.**
      Sample 1.
        Input:
          arr[] = { 1, 2, 5, 6, 8, 9 , 10, 13}
          searchKey = 9;
        Output:
          searchKey is in arr[5].
      Sample 2.
        Input:
          arr[] = { 1, 2, 5, 6, 8, 9 , 10, 13}
          searchKey = 3;
        Output:
          NONE

(b) Analyze the Big O complexity of your code in part (a).   [10 marks]

[10 marks]

T2

3 (a) Identify the output that the following Java code produces and   [5 marks]
explain your reasoning clearly.
```
int x = 7;
System.out.println((++x)+(++x));
```

(b) Identify the output that the following Java code produces and   [5 marks]
explain your reasoning clearly.
```
int x = 7;
System.out.println((x++)+(x++));
```

[17 marks]

T7 **4** (a) Show that the height of a binary tree with n nodes is at least   [10 marks]
$\lfloor \log_2 n \rfloor$.

(b) Briefly compare the advantages and disadvantages of array and   [7 marks]
linked list data structures.

5 Analyze the Big O complexity of the following code snippets. (Don't just write the answer to the final analysis. You need to write the process or method of analysis.)

T5

(a) int count = 0;   [6 marks]
```
int count = 0;
int temp = 0;
for(int i = 0; i < n+1; i++){
    count = count + i;
}
for(int j = 1; j <= count; j++){
    temp++;
}
```

(b) int count = 0;   [9 marks]
```
int count = 0;
for( int i = 0; i < n; i++) {
    for( int j = 100; j > 10; j--)
        for( int k = 0; k < i*n; k++)
            count++;
        }
    }
}
```

[10 marks]

6 Suppose that A[] = { 40, 20, 11, 19, 33, 31, 23, 80 }. Show step by step how the numbers of A[] would be sorted by:

T6

(a) Insertion sort   [5 marks]

(b) Merge sort   [5 marks]

[15 marks]

7 Let S be a sorted array and let x be element. Consider the following three operations on the array:

T7

(1) Insert(S, x): insert x to S
(2) Maximum(S): find the maximum element of S
(3) Extract-max(S): find the maximum element of S and remove it from S

Suppose that array A satisfies heap property, i.e., A[i] >= A[2i] and A[i] >= A[2i+1] for each i. Briefly analyze the Big-O complexity for the following three operations.

(a) Insert(A, x)   [5 marks]
(b) Maximum(A)   [5 marks]
(c) Extract-max(A)   [5 marks]