A

BRAC UNIVERSITY
Department of Computer Science and Engineering

Examination: Mid Semester Exam | Semester: Summer 2025
Duration: 1 Hour 30 Minutes | Full Marks: 30

CSE 221: Algorithms

Answer the following questions.
Figures in the right margin indicate marks.

Name:	ID:	Section:

1 a. CO2 Examine the following code segment and answer the following questions:

```
int funcB (int n) {
    int m = 0;
    for (int k = 1; k <= n; k += 2) {
        for (int j = n; j >= 1; j--) {
            for (int i = 1; i <= n; i += 2) {
                if (i%2 != 0) {
                    break;
                } else {
                    m = k - j + i;
                }
            }
        }
    }
    return m;
}
```

```
int funcA (int n) {
    if (n == 1) {
        return n;
    } else {
        x = funcA(n/2);
        y = funcA(n/4);
        z = funcA(n/6);
        w = funcB(n/2);
        return w;
    }
}
```

(i) **Express** the time complexity of the function 'funcB' using the Big O-notation. **03**
(ii) **Write** the recurrence relation of the function 'funcA'. (You can use your answer from question (i) if required.) **02**
(iii) **Solve** the recurrence relation of no (ii) using any suitable method. **03**

b. CO2 **Prove** (with proper explanation or a formula): $\sqrt[4]{10n^4 + 9n^3 + 8n} = \Theta(n)$ **02**

2 You are working with a weather monitoring station that records the temperature every hour for 12 hours during the night shift. During the night, the temperature gradually drops to reach the coldest hour, and then begins to rise again. Your task is to find the minimum temperature of the night, which corresponds to the coldest hour.

The station tracks temperature every hour over a 12-hour period. A sample pattern of the temperature reading per hour is given here:

Hour	1	2	3	4	5	6	7	8	9	10	11	12
Temperature (°C)	28	24	20	16	12	10	9	11	15	19	23	27

In this example, the temperature decreases from hour 1 to hour 7 (coldest at 9°C). Then it increases from hour 8 to hour 12.

a. **CO1** **Propose** a linear search approach to find the minimum temperature. Present the solution with pseudocode/programmable code/step-by-step logical instructions. **02**

b. **CO3** Now **propose** a modification to binary search to solve the same problem. Present the solution with pseudocode/programmable code/step-by-step logical instructions. **03**

3 **a** **CO1** You are working on a grading system for a national standardized exam where students are marked out of 100. You need to sort millions of student scores as efficiently as possible. Speed is critical, and memory is not a major constraint. Comparisons are costly. **02**

Which algorithm is the most suitable for the above scenario? **Explain** your choice.
Write the time complexity of your preferred algorithm.

b **CO3** Suppose your friend wants to implement a variant of Merge Sort called Ternary Merge Sort, where instead of dividing the array into two halves, **he divides it into three equal (or nearly equal) parts** and recursively sort each part, and then merge the three sorted subarrays into a single sorted array. It is guaranteed that the input array will have a size of at least 3. **02**

Now, he asks your help to **implement the 'dividing step' of the algorithm**. Present your idea with pseudocode/programmable-code/step-by-step logical instructions.

c **CO2** Does dividing into three subarrays make the algorithm asymptotically faster? **Explain** why or why not. **01**

4 You are participating in a competitive multiplayer strategy game where the objective is to defeat your opponent within a fixed time constraint. Throughout the game, various perks are provided at each level in the form of health boxes. At **Level 1**, you are presented with a list of health boxes, each represented by an integer. Positive values indicate a health boost to your own character, while negative values correspond to a reduction in your opponent's health. At this level, you are allowed to select exactly one box, and you want to maximize the health damage to your opponent. This list of health points is given below:

```
[2, 3, -4, -3, 5, -1, 2, -2]
```

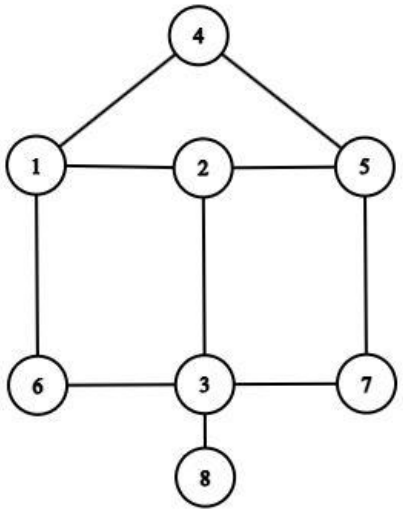
Here, each element corresponds to a distinct health box.

a **CO1** For the above scenario, can you find the box that will cause the maximum possible reduction in enemy health by applying a **divide and conquer** approach? **Explain** your idea in brief, *no need to write full code*. **02**

b **CO3** At **Level 2**, you are offered the same collection of health boxes. However, this time you are allowed to choose **one or a block of consecutive boxes without gaps**. Now you want to increase your own health by collecting points that yield the highest points gain. You came up with an algorithm with **O(N*logN)** time complexity to compute this optimal health gain. Where 'N' is the number of health boxes. **03**

Show a simulation of the algorithm with proper steps.

5 Suppose, you and your classmates are trapped inside an ancient castle during a field trip. The only way out is to solve some tasks. The tasks involve navigating the castle and resolving ancient conflicts between the spirits that guard it. Your goal is to escape through the Gate of Reason before the castle resets and traps you forever.
There are 8 rooms in the castle and you can navigate from one room to another using some corridors. The map of the castle is given below:



a **CO1** Suppose, you are in Room 4. Your first task is reaching Room 6 which is the control room and the Gate of Reason is also situated here. However, the castle is flooding and some of the corridors have been blocked. How can you determine the minimum number of steps required to reach Room 6 from Room 4 avoiding the blocked corridors? **03**

Explain your idea in brief, *no need to write full code*.

b **CO1** Now that you have reached Room 6 and stopped the flood, all corridors are accessible once again. Only one challenge remains: unlocking the Gate of Reason to escape the castle. Each of the 8 rooms in the castle is guarded by a magical spirit. The ancient Gate of Reason only opens if the spirits can be divided into two opposing groups such that: **02**

- No two spirits in the same group are in conflict (the rooms they are guarding should not be connected by corridors).
- The two groups must have the same number of spirits.

Propose a suitable algorithm to determine whether the Gate of Reason can be opened. Present your idea with pseudocode/programmable-code/step-by-step logical instructions.

B

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        for (int j = n; j >= 1; j--) {
            for (int i = 1; i <= n; i += 2) {
                if (i%2 != 0) {
                    break;
                } else {
                    m = k - j + i;
                }
            }
        }
    }
    return m;
}
```

```
int funcA (int n) {
    if (n == 1) {
        return n;
    } else {
        x = funcA(n/2);
        y = funcA(n/4);
        z = funcA(n/8);
        w = funcB(n/4);
        return w;
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(ii) **Write** the recurrence relation of the function 'funcA'. (You can use your answer from question (i) if required.) **02**
(iii) **Solve** the recurrence relation of no (ii) using any suitable method. **03**

b. CO2 **Prove** (with proper explanation or a formula): $\sqrt[4]{7n^4 + 6n^3 + 5n} = \Theta(n)$ **02**

2 You are analyzing the hourly shipment volumes of a logistics company. During the day, the shipment volume gradually increases to a peak hour, and then decreases. Your task is to find the hour with maximum shipment volume, i.e. the true peak hour.

The company tracks its shipment volume every hour over a 12-hour period. A sample pattern of the shipment volume is given here:

Hour	1	2	3	4	5	6	7	8	9	10	11	12
Shipment volume	2	4	6	8	10	13	17	15	12	7	4	1

In this example, the volume increases from hour 1 to hour 7 (peak at 17). Then it decreases from hour 8 to hour 12.

a. **CO1** **Propose** a linear search approach to find the maximum hourly shipment volume. Present the solution with pseudocode/programmable code/step-by-step logical instructions. **02**

b. **CO3** Now **propose** a modification to binary search to solve the same problem. Present the solution with pseudocode/programmable code/step-by-step logical instructions. **03**

3 **a** **CO1** You are developing an e-commerce platform that collects product ratings from users (out of five stars). For analytics, the system needs to sort millions of these ratings quickly every day. Memory is not an issue, but comparison operations are expensive. **02**

Which algorithm is the most suitable for the above scenario? **Explain** your choice.
Write the time complexity of your preferred algorithm.

b **CO3** Suppose your friend wants to implement a variant of Merge Sort called Ternary Merge Sort, where instead of dividing the array into two halves, **he divides it into three equal (or nearly equal) parts** and recursively sort each part, and then merge the three sorted subarrays into a single sorted array. It is guaranteed that the input array will have a size of at least 3. **02**

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```
[-2, 3, 4, -3, -5, 1, 2, 2]
```

Here, each element corresponds to a distinct health box.

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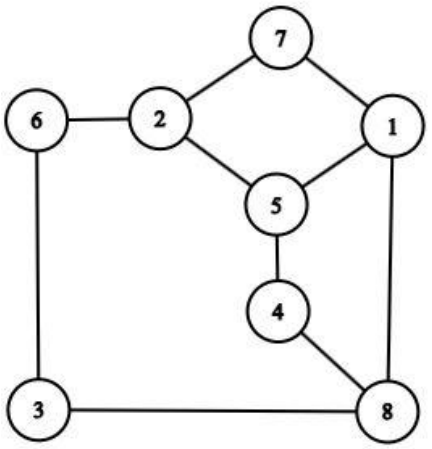

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