

**BRAC UNIVERSITY**  
**Department of Computer Science and Engineering**

Examination: Final Exam  
 Duration: 1 Hour 40 Minutes

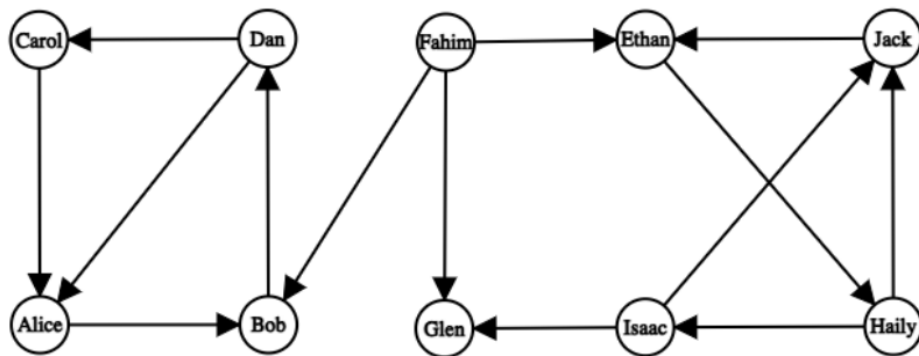
Semester: Summer 2023  
 Full Marks: 40

**CSE 221: Algorithms**

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

Name:	ID:	Section:
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1. Among a group of 10 friends, it's not feasible for each individual to visit the houses of all the others. With an upcoming tournament in mind, the friends need to establish groups. The criterion for forming these groups is that a friend must be capable of visiting the houses of every other member in their group. The task involves calculating the count of viable groups following this criterion. A group has to consist of a minimum of two people.



- |  |           |
|--|-----------|
| a) [CO1] The end result will showcase the list of groups and the members. <b>Name</b> the algorithm tailored for this situation.   | <b>01</b> |
| b) [CO1] <b>Show</b> a simulation of your chosen algorithm using the graph above. <b>Write</b> the number of groups that can be formed and the members of each group.                                | <b>05</b> |
| c) [CO1] Those who are incapable of forming a group will be identified as individuals ineligible for tournament participation. <b>Identify</b> those people if there are any.                        | <b>01</b> |
| d) [CO3] We also want to find the person who can visit the most houses. <b>Propose</b> an algorithm to implement this. Present your algorithm with a pseudocode/flowchart/step-by-step instructions. | <b>03</b> |

**Answer only one from 2, 2-OR**

2. Consider the following modified ASCII scheme and the encoded message using it.

Character	a	b	c	d	e	f	g	h	i	j
m_ascii	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001

Message encoded with m\_ascii code:

0000 0100 0100 1000 0100 1000 0100 1000 0001 0101 0001 0001 0110 0000 0100 1001 0010 1001

Now answer the following questions.

- a) [CO1] **Decode** the message. 01
- b) [CO1] **Show** simulation to find the encoding of each of the characters using Huffman coding technique. While creating a tree, less frequency nodes go to the left side of the root; left is considered as a 0, right is 1. 06
- c) [CO1] **Calculate** the number of bits required in the encoded message using Huffman technique. 03

**OR**

**2.** You study in a university and there are some faculties in your university and their class schedule (start and end time) are given below. As a pantomath (who wants to learn a lot) person you want to gather more knowledge and do class of the maximum faculties possible. But, due to the time conflict, one student cannot cover all the classes. So, you asked your friends Derke, Leo and Chronicle how you can maximize the number of classes. Derke said you should choose the classes which have the lowest duration and Leo said you should choose those classes which end early and Chronicle said you should pick classes that start early.

- a) [CO1] Who's method will you **select** in order to complete the classes of maximum faculties? 01
- b) [CO1] Using the method you mentioned in (a) **simulate** and find out the maximum number of classes you can do from the following schedule and also find out the initials of the faculties. 06

Faculty	Start Time	End Time
MIBA	1	10
MZU	2	3
AGD	6	8
MNR	10	11
RIM	5	7
FGZ	3	6
SBD	7	10

- c) [CO1] As one student cannot cover all the classes so you want to determine the minimum number of students needed so that all the classes are covered. **Explain** your algorithm in a pseudocode/flow-chart/step-by-step instructions format. 03

**3.** Karen started a website that displays different advertisements. She wants to maximize her advertisement revenue. Each month she receives a list of advertisements, each with a certain value (revenue) and a size (space taken on the webpage). The webpage has a limited amount of space, and she selects a subset of advertisements to display in order to maximize her total revenue, while staying within the available space. No advertisement is selected more than once, and each advertisement that is selected has to be displayed in full.

For example, following is a list of advertisements she received for the month of August:

Advertisements: Ad 1 - Value: \$10, Size: 2 Ad 2 - Value: \$8, Size: 1 Ad 3 - Value: \$15, Size: 3 Ad 4 - Value: \$6, Size: 2 Maximum Space Available: 5	Solution: Select Advertisements: Ad 1, Ad 3 Total Revenue: \$10 + \$15 = \$25 Space Occupied = 2 + 3 = 5
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- a) [CO1] Suppose, you are trying to come up with a Dynamic Programming approach to solve this problem. You build a table, each cell representing the solution (optimal revenue value) to a subproblem. **Give** the formula for filling up each entry of the table. **02**
- b) [CO1] Suppose in the month of September, she received the following list of advertisements: **06**

Advertisements:

Ad 1 - Value: \$12, Size: 4

Ad 2 - Value: \$8, Size: 2

Ad 3 - Value: \$9, Size: 3

Ad 4 - Value: \$7, Size: 2

Ad 5 - Value: \$5, Size: 1

The maximum available space is 5.

**Fill** the following table according to the formula you developed in question (a). Then write the set of advertisements Karen should select.

Value	Size	Item	Maximum Available Space					
			0	1	2	3	4	5
-	-	0						
12	4	1						
8	2	2	0	0	8	8	12	12
9	3	3						
7	2	4						
5	1	5						

- c) [CO3] Suppose, Karen discovered that the top half of some of the advertisements contain nothing. So, from the month of October she is implementing a new feature, the size of at most K items can be changed to half of its original size. Revenue will stay the same. For example, **02**

There are four advertisements to select from,

Value = [10, 12, 8, 6]

Required Space = [4, 5, 6, 6]

Max Available Space = 7

K = 1

**Output: 22**

Explanation: Without changing the required space of any item, the solution would be taking only Ad-2, giving a revenue of 12. But if we change the size of Ad-1 into half of its original size, we can take both Ad-1 and 2. Then the total revenue is 22, which is the maximum.

Think about how you would solve this problem using a Dynamic Programming approach. Then, **write** a recursive formulation of your solution or **explain** your idea in pseudocode/flow-chart/step-by-step instructions format.

4. The white council once decided to install bidirectional rail tracks to connect several realms of middle earth. Upon their request, the elves and the dwarves devised a plan. The following table lists the tracks that can be constructed.

From	To	Length of the track	Construction cost	Construction time
Arnor	Fangorn	25	70	80
Arnor	Lindon	20	40	30
Arnor	Mirkwood	30	80	70
Fangorn	Gondor	10	30	40
Fangorn	Lindon	40	90	110
Fangorn	Mirkwood	20	60	50
Gondor	Harad	25	100	90
Gondor	Lindon	45	110	100
Gondor	Mirkwood	30	50	60
Gondor	Rhun	40	120	130
Harad	Mirkwood	45	150	180
Mirkwood	Rhun	25	180	150

As there is only one engine available for the task, simultaneous construction of multiple tracks is not possible. Going through the plan, the council decided that the following tracks **must be constructed**.

- Gondor to Lindon
- Arnor to Mirkwood

However, due to a financial crisis, the council wants to connect all the realms with **minimum total construction cost**. Now answer the following questions.

- [CO1] Which other tracks should they select for construction? **Show** a simulation of your procedure. **05**
- [CO1] **Write** the total construction cost of the selected tracks. **01**
- [CO1] **Calculate** the total construction time required if no two tracks are constructed simultaneously. **01**
- [CO1] After these tracks have been constructed, what would be the minimum distance of Rhun from all other realms? Just **write** the distance from each realm. **03**

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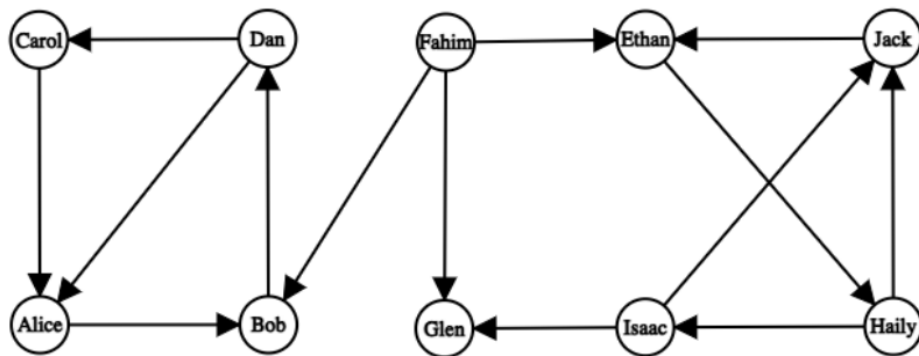
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Message encoded with m\_ascii code:

0010 0000 0010 0000 0011 0110 0111 1000 0011 1001 0000 0010 0011 0010 1001 1000 0010 0111

Now answer the following questions.

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- a) [CO1] Who's method will you **select** in order to complete the classes of maximum faculties? 01
- b) [CO1] Using the method you mentioned in (a) **simulate** and find out the maximum number of classes you can do from the following schedule and also find out the initials of the faculties. 06

Faculty	Start Time	End Time
MIBA	2	11
MZU	3	4
MNR	7	9
AGD	11	12
FGZ	6	8
MNR	4	7
SBD	8	11

- c) [CO1] As one student cannot cover all the classes so you want to determine the minimum number of students needed so that all the classes are covered. **Explain** your algorithm in a pseudocode/ flow-chart/ step-by-step instructions format. 03

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a) [CO1] Suppose, you are trying to come up with a Dynamic Programming approach to solve this problem. You build a table, each cell representing the solution (optimal revenue value) to a subproblem. **Give** the formula for filling up each entry of the table. **02**

b) [CO1] Suppose in the month of September, she received the following list of advertisements: **06**  
 Advertisements:  
 Ad 1 - Value: \$1, Size: 1  
 Ad 2 - Value: \$4, Size: 3  
 Ad 3 - Value: \$5, Size: 4  
 Ad 4 - Value: \$7, Size: 5  
 The maximum available space is 7.

**Fill** the following table according to the formula you developed in question (a). Then write the set of advertisements Karen should select.

Value	Size	Item	Maximum Available Space							
			0	1	2	3	4	5	6	7
0	0	0								
1	1	1								
4	3	2	0	1	1	4	5	5	5	5
5	4	3								
7	5	4								

c) [CO3] Suppose, Karen discovered that the top half of some of the advertisements contain nothing. So, from the month of October she is implementing a new feature, the size of at most K items can be changed to half of its original size. Revenue will stay the same. For example, **02**  
 There are four advertisements to select from,  
 Value = [17, 20, 10, 15]  
 Required Space = [4, 2, 7, 5]  
 Max Available Space = 4  
 K = 1

**Output: 37**

Explanation: Without changing the required space of any item, the solution would be taking only Ad-2, giving a revenue of 20. But if we change the size of Ad-1 into half of its original size, we can take both Ad-1 and 2. Then the total revenue is 37, which is the maximum.

Think about how you would solve this problem using a Dynamic Programming approach. Then, **write** a recursive formulation of your solution or **explain** your idea in pseudocode/flow-chart/step-by-step instructions format.

4. The white council once decided to install bidirectional rail tracks to connect several realms of middle earth. Upon their request, the elves and the dwarves devised a plan. The following table lists the tracks that can be constructed.

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Gondor	Mirkwood	30	50	60
Gondor	Rhun	40	120	130
Harad	Mirkwood	45	150	180
Mirkwood	Rhun	25	180	150

As there is only one engine available for the task, simultaneous construction of multiple tracks is not possible. Going through the plan, the council decided that the following tracks **must be constructed**.

- Mirkwood to Rhun
- Fangorn to Lindon

As the election is nearby, the council wants to connect all the realms with **minimum total construction time**. Now answer the following questions.

- [CO1] Which other tracks should they select for construction? **Show** a simulation of your procedure. **05**
- [CO1] **Write** the total construction time of the selected tracks. No two tracks are constructed simultaneously. **01**
- [CO1] **Calculate** the total construction cost required. **01**
- [CO1] After these tracks have been constructed, what would be the minimum distance of Harad from all other realms? Just **write** the distance from each realm. **03**