-

Birla Institute of Technology & Science, Pilani
Work Integrated Learning Programmes Division
First / 2024-2025

Mid-Semester Test
(EC-2 Makeup)

Course No.	: AIMLCZG557
Course Title	: Artificial and Computational Intelligence
Nature of Exam	:
Weightage	: 30%
Duration	: 2 Hours
Date of Exam	: 13-07-2025 (AN)

No. of Pages = 4
No. of Questions = 4

Note to Students:
1. Please follow all the *Instructions to Candidates* given on the cover page of the answer book.
2. All parts of a question should be answered consecutively. Each answer should start from a fresh page.
3. Assumptions made if any, should be stated clearly at the beginning of your answer.

<table>
<tr>
<td>Q1</td>
<td>
Answer to the below question for the following scenarios. Vague theory will not be awarded marks. [2+2+2 = 6 Marks]
"Imagine you are tasked with designing an automated criminal identification system for a law enforcement agency. The system is equipped with 10 surveillance cameras strategically placed in high-crime areas to monitor suspicious activities and gather evidence. It scans for individuals with matching facial features or other identifying characteristics from a database of known criminals, aiding in the apprehension of suspects and the prevention of crimes"
a. Provide the complete problem formulation.
b. Provide the PEAS description.
c. Identify the various dimensions of the task environment with appropriate justification for each in no more than 30 words
Sample Solution and marking scheme:
a) Problem Formulation – [2 marks]
• Initial State: Surveillance cameras are operational; database of known criminals is loaded; no suspects have been identified yet.
• Goal State: All individuals captured by cameras are scanned and either matched or not matched with criminal records. Matched individuals are flagged for further action.
• Actions (Operators):
  o Capture live video feed from cameras
  o Detect and extract facial/biometric features
  o Compare features with criminal database
  o Classify individual as matched or not matched
</td>
<td>6 Marks</td>
</tr>
</table>

- Alert law enforcement if match is found

- Transition Model: After each scan and comparison, the system updates the suspect's status and triggers the appropriate response (alert, ignore, or log).
- Path Cost: Minimize false matches (false positives/negatives), reduce latency in detection, and optimize resource use and alert accuracy.

b. PEAS Description [0.5 * 4 = 2 marks]

Performance	Accuracy of suspect identification, false match rate, real-time detection speed, crime prevention success, and operational efficiency.
Environment	Streets and public areas under surveillance, varying lighting and weather conditions, moving crowds.
Actuators	Alert systems (audio/visual), control interfaces for notifying police, camera zoom/focus controls
Sensors	CCTV cameras, facial recognition software, motion sensors, infrared sensors, and biometric scanners.

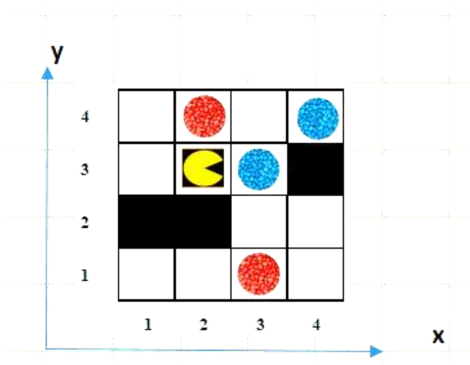
c. Dimensions of the Task Environment (with justification) – At least 4 with justification –[2 marks]

1. Fully Observable – Facial and biometric features are captured fully by surveillance systems
2. Deterministic – Given clear input, the recognition process follows a fixed identification algorithm.
3. Dynamic – People constantly move; environment changes during the identification process.
4. Discrete – Classification states are discrete: match or no match.
5. Multi-Agent – Both the system and potential suspects interact in the environment.

Q2 Consider the single player game; there are two types of food pellets available: red and blue. Pacman's objective/goal is to consume at least one red pellet and one blue pellet to end the game, (though Pacman may eat more than one of each pellet). Pacman has four directional actions (up, down, left, right) but cannot remain stationary. 9 Marks

[3+3+3 = 9 Marks]

Initial State:



a. Depict the search tree for up to exactly 3 levels (Given initial state can be assumed to be on level-0.)

b. Find the path cost and heuristic values of all the generated nodes in the search tree.

<u>Path cost Calculation:</u>

For Each transition consider a uniform cost = 5.

Path cost = Transition cost + No of remaining pellets in resultant state + Number of obstacles or black cells adjacent to Pacman's position in the resultant state.

<u>Heuristic design for calculation:</u>

H(n) = The smallest Manhattan distance to any remaining pellet

Note for calculation: H(n) for Initial state can be calculated as below:

(X,Y)

- From Pacman's current position, the distance to the pellet at coordinates (2, 4) = 1
- From Pacman's current position, the distance to the pellet at coordinates (3,3) = 1
- From Pacman's current position, the distance to the pellet at coordinates (3,1) = 3
- From Pacman's current position, the distance to the pellet at coordinates (4,4) = 3

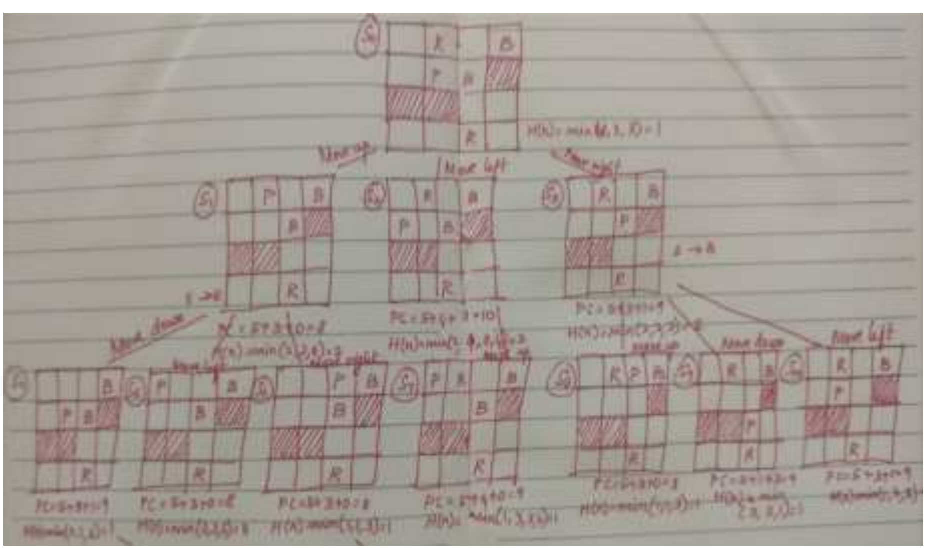
H(n) = min_distance(1,1,3,3) ➔ 1

c. Apply A* search algorithm for the search tree obtained from part a and using heuristic design calculated under part b, only till first 5 closed list updates or till no more nodes are left. Show the status of OPEN and CLOSE list at each level and the step-by-step procedure as discussed in the class.

Sample Solution and marking scheme:

a) Constructing the complete game tree – 3 Marks

- **Search Tree for level 1 expansion – 0.5 mark**
- **Search Tree for level 2 expansion – 0.5 mark**
- **Search Tree for level 3 expansion – 2 mark**



Level 3 needs to be derived

b. Calculating static evaluation functions- each level 1 mark (1* 3 = 3 Marks)

Open list	Close list	Goal	Successor
S0()	{}	Fail, S0 is not Goal state	S1(10), S2(12), S3(11)
S1(10), S2(12), S3(11)	{S0}	Fail, S1 is not Goal state	S4(10), S5(11), S6(9)
S4(10), S5(11), S6(9), S2(12), S3(11)	{S0, S1}	Fail, S6 is not Goal state	S13(10)
S13(10), S5(11), S6(9), S2(12), S3(11)	{S0, S1, S4}	S13 is Goal state	
S5(11), S6(9), S2(12), S3(11)	{S0, S1, S4, S13}		

.c. Using A* algorithm game tree construction – 2 Mark

Best path chosen – 1 Mark

Q3 | 8 Marks

You can write your answers in the provided space or write your answer on a piece of paper and scan and upload the handwritten answers using the QR Code available in the Scan and Upload Section of this exam.

Kindly ensure all answer sheets to be uploaded against the corresponding questions only. All sheets should not be uploaded against one question.

Suppose you are managing a fleet of delivery vehicles for a courier company. You have a Depot (D) where all the delivery trucks start, and a list of two customers (C1 and C2) that need to be visited for package deliveries. The distances between the depot and the customers, as well as between the customers themselves, are given in the form of a distance matrix shown below. Your task is to plan the most efficient route for the delivery truck to visit both customers exactly once and return to the depot, minimizing the total travel distance. To solve this, you are required to use the Ant Colony Optimization (ACO) algorithm to find the optimal delivery route.

Distance Matrix :

	D	C1	C2
D	0	7	5
C1	7	0	15
C2	5	15	0

Initial Pheromone Matrix :

	D	C1	C2
D	0	0.15	0.26
C1	0.15	0	0.48
C2	0.26	0.48	0

Rate of evaporation = 0.1; Q = 80; The relative importance of pheromone is 0.6 and the relative importance of distance is 0.7;

Marking Scheme and Sample Solution:

1) Next Transition Probability:

- **Formula : 1 Marks**
- **Calculation : 2 Marks**

Transition Probability Formula :

$$P_{ij} = \frac{(\tau_{ij})^{\alpha} \cdot (\eta_{ij})^{\beta}}{\sum_{h \notin V} (\tau_{ih})^{\alpha} \cdot (\eta_{ij})^{\beta}}$$

------------------ > 1 Mark

Between	τ	DIST	η	α	β
D-C1	0.15	7	0.1429	0.6	0.7
D-C2	0.26	5	0.2000		
C1-C2	0.48	15	0.0667		

	τ	η	α	β		Probability
D-C1	0.15	0.1429	0.6	0.7	0.0821	0.3623
D-C2	0.26	0.2000	0.6	0.7	0.1444	0.6377

2) Pheromone Updation :

- **Formula : 0.5 Marks**
- **Calculation : 4 Marks**
- **Final path : 0.5 Marks**

$$\tau_{ij}^{new} = (1-\rho)\tau_{ij}^{old} + \Delta\tau_{ij}^{k}$$

$$\Delta\tau_{ij}^{k} = \begin{cases} \frac{Q}{f_k} & ; \text{ if } k^{th} \text{ ant passes } i\text{-}j \\ 0 & ; \text{ otherwise} \end{cases}$$

--→ 0.5 Marks

	1.5 Marks VISIT [D - C2] **Between** | τ | 1-ρ | Δτ | (1-ρ)τ+ Δτ D-C1 | 0.15 | 0.9 | 0 | 0.1350 D-C2 | 0.26 | 0.9 | 16 | 16.2340 C1-C2 | 0.48 | 0.9 | 0 | 0.4320	

1.5 Marks

VISIT [D - C2]

Between	**τ**	1-ρ	Δτ	(1-ρ)τ+ Δτ
D-C1	0.15	0.9	0	0.1350
D-C2	0.26	0.9	16	16.2340
C1-C2	0.48	0.9	0	0.4320

1.5 Marks

VISIT [D-C2-C1]

Between	**τ**	1-ρ	Δτ	(1-ρ)τ+ Δτ
D-C1	0.1350	0.9	0	0.1215
D-C2	16.2340	0.9	0	14.6106
C1-C2	0.4320	0.9	5	5.7221

1 Marks

VISIT [D-C2-C1-D]

Between	**τ**	1-ρ	Δτ	(1-ρ)τ+ Δτ
D-C1	0.1215	0.9	11	11.5379
D-C2	14.6106	0.9	0	13.1495
C1-C2	5.7221	0.9	0	5.1499

Final tour D-C2-C1-D
Total distance is 27---------------------- > 0.5 Marks

Q4	Imagine you are leading a genetic algorithm optimization project for optimizing the equipment load of a mountain rescue drone deployed during an emergency relief operation in remote, high-altitude terrain. The goal is to select equipment items such that the total weight does not exceed the drone's carrying capacity of 9 kg, while maximizing the total rescue value, which reflects the importance of each item for ensuring the safety and survival of stranded individuals. The available equipment items are: Emergency Food Pack (FP), Portable Heater (PH), First Aid Kit (FAK), Signal Flare (SF) The variables representing these items are FP, PH, FAK, and SF respectively. Each variable can take values from the set {0, 1}, where: 0 indicates that the item is excluded from the drone's load.	7 Marks

1 indicates that the item is included in the drone's load.

[3+3 = 6 Marks]

a. Describe the Chromosome representation of a parent state for four randomly selected states with their fitness score.

NOTE: The fitness score for each chromosome is calculated as the sum of the rescue values of the selected items, provided the total weight does not exceed the drone's capacity of 9 kg. If the total weight exceeds 9 kg, the fitness score is penalized by considering only 50% of the total rescue value, representing the reduced effectiveness due to overloading. A higher fitness score represents a better solution, maximizing the total rescue value while respecting the weight constraint.

Item	Weight (kg)	Rescue Value
Emergency Food Pack (FP)	4	40
Portable Heater (PH)	3	35
First Aid Kit (FAK)	2	30
Signal Flare (SF)	5	50

b. Suggest an appropriate process of selection, crossover and mutation steps for this problem. Show these with only one iteration of numerical example.

Sample Solution and marking scheme:

a) Four randomly selected Parent states with their fitness score: **4 Marks**

Parent	FP	PH	FAK	SF	Total Weight	***Total_rescue value***	Final Fitness Score
P1	**0**	**1**	**1**	**1**	**3 + 2 + 5 = 10**	**115**	**57.5** ***weight exceeds 9***
P2	**0**	**1**	**0**	**1**	**3+5 =8**	**85**	**85**
P3	**1**	**1**	**0**	**0**	**4 +3 = 7**	**75**	**75**
P4	**0**	**0**	**1**	**1**	**5+2 = 7**	**80**	**80**

b) Selection: 1 Mark , without explanation 0.5

P2 : 85

0	**1**	**0**	**1**

P3:75

1	**1**	**0**	**0**

P4:80

0	**0**	**1**	**1**

P1:57.5

0	**1**	**1**	**1**

Crossover: 1 Mark , without explanation 0.5

P2 : 85

0	**1**	**0**	**1**

P3:75

1	**1**	**0**	**0**

Offspring : using single split

0	**1**	**0**	**0**

1	**1**	**0**	**1**

Offspring : using double split

P4:80

0	**0**	**1**	**1**

P1:57.5

0	**1**	**1**	**1**

0	**1**	**1**	**1**

0	**0**	**1**	**1**

Mutation: 1 Mark , without explanation 0.5

C1

0	**1**	**1**	**0**

C2

1	**0**	**0**	**1**

C3

0	**1**	**0**	**1**

C4

0	**0**	**1**	**0**

*****