Artificial & Computational Intelligence MidSem – Makeup Exam

Question 1

The Explorer Bot is on a mission to navigate an ancient volcanic maze. The maze is a 4X4 grid, and each cell can be a safe path, a crystal, a firetrap, or a blockage. The goal of the bot is to collect as many crystals as possible and safely reach the exit at the other end of the maze. The bot starts at C1 and cannot move diagonally. It must avoid dangers like firetraps, which reduce its energy, and blocked cells. The Explorer Bot has limited energy and can move up, down, left, or right to adjacent cells. With a crystal, it automatically collects it [3+3+3 = 9 Marks]

	1	2	3	4
A	Cr	Cr		FT
B	FT	FT		FT
C	Bot	Cr	Cr	EXIT
D	Cr	FT	FT	Cr

a. Expand & depict the search tree for up to exactly two levels (level 1 & level 2). (Given initial state can be assumed to be on level-0)

b. Calculate the path cost and heuristic values for all generated nodes in the search tree.

Path cost calculation:

- If the agent enters a cell with a Fire trap, its energy diminishes and requiring recovery and adding a cost of +15. (Represent penalties or increases in effort required to proceed)
- Collecting a crystal restores the agent's energy, reducing the cost by -10. [Represent rewards or reductions in effort for beneficial actions.]

Heuristic design for calculation:

H(n) = (Min Manhattan distance from current position to goal) + (No of remaining crystals in the resultant state) + (Number of Fire Traps adjacent to Bot's position in the resultant state)

c. Apply IDA* search algorithm for the search tree obtained from part a and using heuristic design calculated under part b, only till first 4 closed list updates or till no more nodes are left. Show the status of OPEN and CLOSED list updates at each level and the step-by-step procedure as discussed in class

Question 2

Imagine you are tasked with designing an automated garbage collection and segregation robot for urban areas. The robot is equipped with sensors to detect waste, classify it into categories (e.g., biodegradable, recyclable, non-recyclable), and robotic arms to pick and sort the waste into appropriate compartments. The robot must navigate crowded streets efficiently, avoid obstacles like pedestrians and vehicles, and ensure optimal waste collection within a designated area.

a. Provide a complete problem formulation.
b. Provide the PEAS Description
c. Identify the various dimensions of task environment with appropriate justification for each in no more than 30 words

[2+2+2 = 6 Marks]

Question 3

Arya, a delivery manager for a logistics company, is responsible for ensuring timely deliveries across three key distribution centers in a city. He starts from the Main Warehouse (MW) and must visit the following distribution centers:

Distribution Center A (DCA)

Distribution Center B (DCB)

Distribution Center C (DCC)

After completing his deliveries, he must return to the Main Warehouse (MW). The distances between the centers are given in the Distance Matrix. Using Ant Colony Optimization (ACO), determine the optimal route for Arya to complete his deliveries to all distribution centers and return to the Main Warehouse (MW).

Distance Matrix (in Km):

	MW	DCA	DCB	DCC
MW	0	10	15	20
DCA	10	0	12	18
DCB	15	12	0	8
DCC	20	18	8	0

Initial Pheromone Matrix (τ):

	MW	DCA	DCB	DCC
MW	0	0.3	0.4	0.2
DCA	0.3	0	0.35	0.4
DCB	0.4	0.35	0	0.4
DCC	0.2	0.4	0.4	0

Rate of evaporation: 0.7, Q = 80. The relative importance of pheromone (α): 0.5 & Relative importance of distance (β): 0.6

[9 Marks]

Question 4

Imagine you are leading a genetic algorithm optimization project to optimize the production schedule of a factory that makes four types of products: Product A, Product B, Product C, and Product D. The goal is to determine the optimal number of units to produce for each product in order to maximize profit while adhering to resource constraints.

The variables (products) are:

X_1 = Number of units of Product A produced

X_2 = Number of units of Product B produced

X_3 = Number of units of Product C produced

X_4 = Number of units of Product D produced

Where X_1, X_2, X_3, X_4 are integers in the range [0 to 10]

Each product has an associated profit and the total profit is the sum of the profits from all selected products. The production of each product constrained by the total available machine hours and material usage.

Constraints:

- The total machine hours available = 20 hours
  Machine Hours Constraint: $2X_1 + 3X_2 + 4X_3 + 2X_4 \leq 20$ hours
- The total material available = 15 units
  Material Constraint: $X_1 + X_2 + X_3 + X_4 \leq 15$ units (total material available)

Objective Function (Profit): $P = 10X_1 + 8X_2 + 5X_3 + 6X_4$ (Maximize this)

a. Describe the Chromosome representation of a parent state for four products with their fitness score. Chromosome = [X_1, X_2, X_3, X_4].

NOTE: The fitness score for each chromosome is calculated as:

> Compute the total profit and use it as the fitness score if all constraints are satisfied. If any constraint is violated, set the fitness score to half of the profit (i.e., divide the profit by 2). A higher fitness score represents a better solution which maximizes the profit value while adhering to the machine hour and material usage constraints.

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

[6 Marks]