Artificial Intelligence Quiz 01

Instructor: Ayesha Enayet

CMS: _____ **Name:** _____

Instructions:

- Students are **not allowed to use any device** during the quiz.
- Only **blue or black ink pens** are allowed.
- Show essential steps of your reasoning for credit.

Question 1: 4-Queens via A* **Points: 20**

Place 4 queens on a 4×4 chessboard so that no two queens attack each other (no two in the same row, column, or diagonal). Use A* to solve the 4-Queens problem.

a) (10 pts) Specify a search formulation: *state, actions, step cost, goal test*, and an *admissible & consistent* heuristic.

b) (8 pts) Run A* and show the sequence of node expansions (with g, h, f) *until the first solution is found*, assuming you place queens column-by-column (1→4), try rows 1→4 in order, and break ties by *smaller* h (i.e., deeper nodes first since h decreases as you go deeper). **Hint:**Start: (), g=0, h=4, f=4. Expand ⇒ children for col1: (1), (2), (3), (4).

c) (2 pts) Give the first solution you reach in (Q_1, Q_2, Q_3, Q_4) form, where Q_i is the row of the queen in column i.

Question 2: BFS vs DFS Expansions on 4-Queens **Points: 20**

Consider the 4-Queens problem under this *standard search setup*:

- **Initial state:** the empty tuple () (no queens placed).
- **Start rule:** begin by placing one queen in *column 1*; children of () are (1), (2), (3), (4), corresponding to choosing rows 1..4 for column 1.
- **State:** a conflict-free partial placement $(Q_1, \ldots, Q_c)$ of queens in columns 1..c (one queen per column), $0 \leq c \leq 4$.
- **Action:** from column c, place a queen in column $c{+}1$ in any *safe* row (no same-row or diagonal conflicts).
- **Goal:** $c = 4$ (four queens placed without conflict).
- **Child generation order:** when expanding a node at column c, try rows $1 \rightarrow 4$ for column $c{+}1$.
- **BFS:** FIFO by depth; within a depth, use the given child order.
- **DFS:** pre-order (backtracking) using the same child order; backtrack immediately on dead ends.
- **State notation:** write tuples like $(2, 4, 1)$ to mean $Q_1{=}2$, $Q_2{=}4$, $Q_3{=}1$.

Tasks

1. (8 pts) Write the *node expansion order* for **BFS** *until the first goal is found*, starting from ().

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2. (8 pts) Write the *node expansion order* for **DFS** *until the first goal is found*, starting from ().

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3. (4 pts) Report and briefly compare the **total number of nodes expanded** by BFS vs DFS to reach the first solution.
   BFS total: _____ **DFS total:** _____

Question 3: Completeness of A* **Points: 10**

A* search runs with an OPEN list ordered by $f(n) = g(n) + h(n)$. **Write down the condition(s)** that must be met to ensure A* is *complete* (i.e., guaranteed to find a goal if one exists).