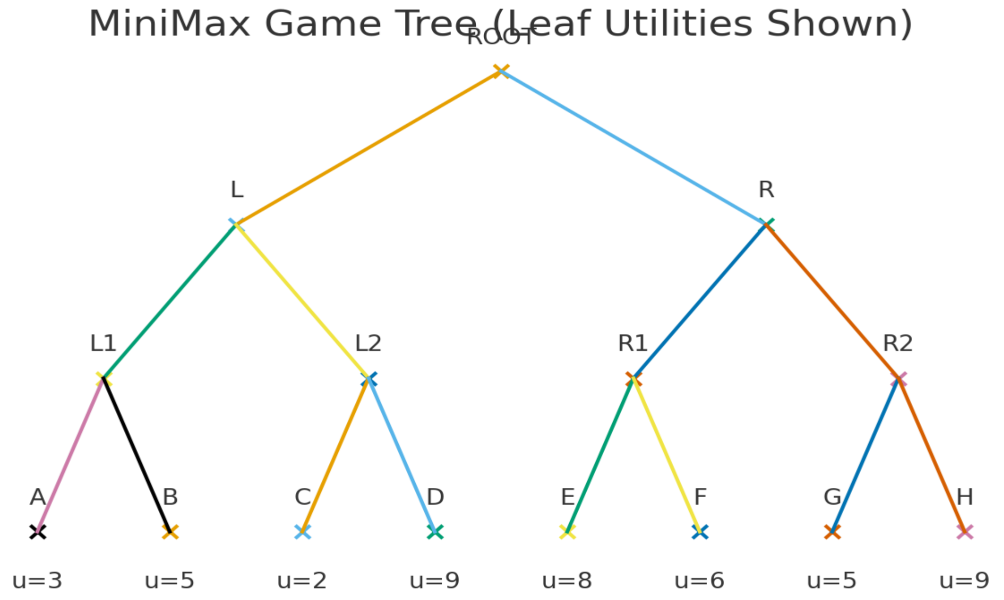
Artificial Intelligence – Numerical & Graphical Questions with Answers

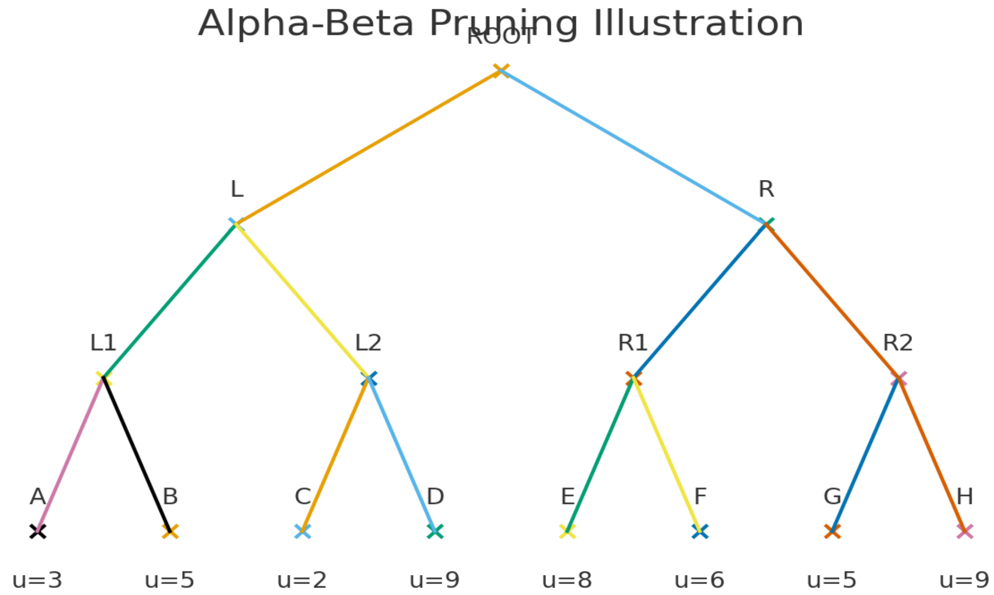
Covers five chapters: Search & Heuristics, Game Playing, Knowledge Representation & Prolog, Genetic Algorithms. Includes diagram-based problems.

G1. (Game Playing – MiniMax) Use the game tree image to compute the MiniMax value at the root and the optimal move.



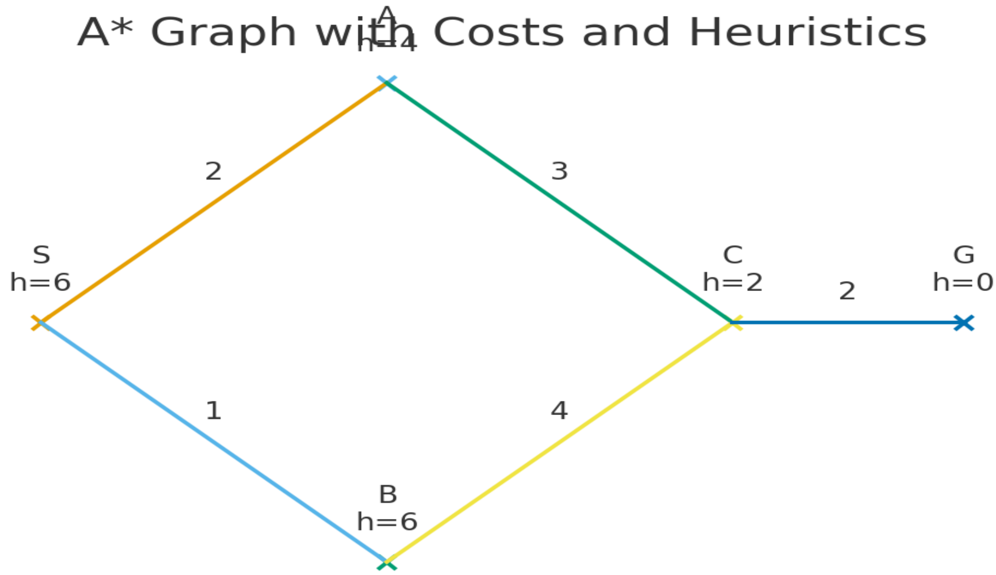
Solution (Step-by-step):
Leaves have utilities: A=3, B=5, C=2, D=9, E=8, F=6, G=5, H=9.
At each MIN node: L1=min(3,5)=3, L2=min(2,9)=2, R1=min(8,6)=6, R2=min(5,9)=5.
At each MAX node: L=max(3,2)=3, R=max(6,5)=6. Root=max(3,6)=6.
Answer: Root value = 6; choose the right branch (R → R1).

G2. (Game Playing – Alpha-Beta) On the same tree, show the alpha–beta bounds and identify any pruned leaves.



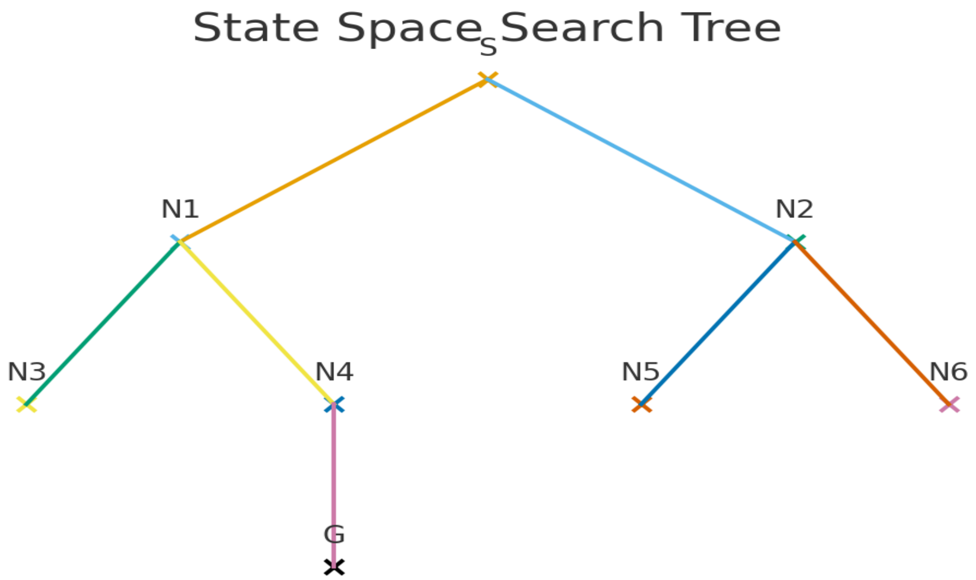
Solution Outline:
Assume left subtree evaluated first. After evaluating left MIN nodes, MAX gets α=3 at L. Exploring right MIN subtree:
• At R1, MIN returns 6 → MAX updates α=max(3,6)=6.
• At R2, observe first child G=5; since 5 ≤ α(6), MIN can still drop; must check H=9 to take min(5,9)=5. If move ordering were (9 then 5), a β-cutoff would prune the other child.
Key Point: Proper move ordering increases pruning; final root value remains 6.

G3. (Heuristic Search – A*) Using the graph, run A* from S to G. Show the order of expansion and final path.



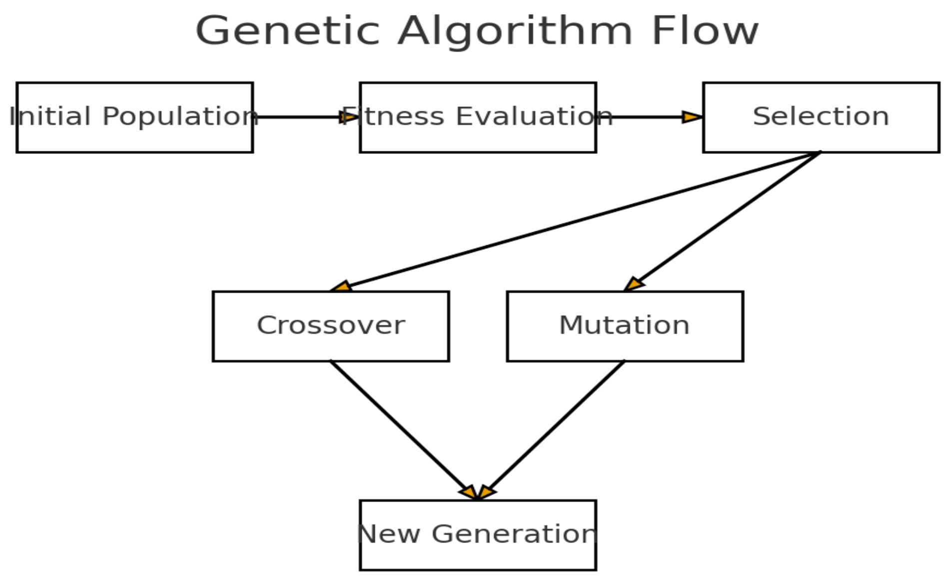
Data: Edge costs: S–A=2, S–B=1, A–C=3, B–C=4, C–G=2. Heuristics: h(S)=6, h(A)=4, h(B)=6, h(C)=2, h(G)=0.
Step 1: f(S)=0+6=6; expand S → Open: A(g=2,f=6), B(g=1,f=7).
Step 2: Pop A (lowest f=6). From A → C with g=5, f=7. Open: C(f=7), B(f=7).
Step 3: Tie at f=7; expand C → G with g=7, f=7. Goal reached.
Answer: Path S→A→C→G with total cost 7.

G4. (State Space Search) Using the tree, list BFS and DFS orders, and the first path to goal G.



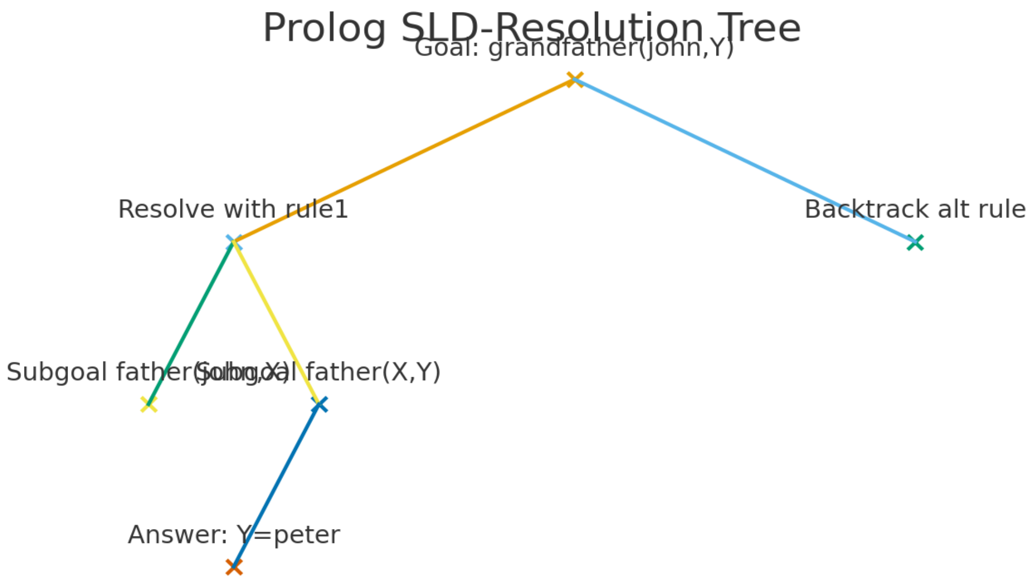
BFS Order: S, N1, N2, N3, N4, N5, N6, G → First path: S→N1→N4→G.
DFS (Left-to-Right): S, N1, N3, (backtrack), N4, G → First path: S→N1→N4→G.

G5. (Genetic Algorithms) Refer to the GA flow diagram. Given initial population P0 = {01101, 11000, 01000, 10011}, f(x)=x^2.



Tasks: (a) Compute fitness and selection probabilities. (b) Perform one single-point crossover between the two fittest parents. (c) Flip one random bit as mutation to produce P1.
Solution:
Binary→decimal: 01101=13, 11000=24, 01000=8, 10011=19 → Fitness: 169, 576, 64, 361; Σ=1170.
Selection probabilities: 0.144, 0.492, 0.055, 0.309. Parents: 11000 & 10011. Crossover at pos3 ⇒ Offspring: 11011, 10000. Mutation (flip 1 bit of 10000 at LSB) ⇒ 10001. New gen example P1 = {11011, 10001, 01101, 01000}.

G6. (Prolog – SLD Tree) Using the SLD tree, answer the query: grandfather(john, Y) given facts father(john, david), father(david, peter).



Resolution: grandfather(X,Y) :- father(X,Z), father(Z,Y). With facts father(john,david), father(david,peter). Resolve subgoals left-to-right, backtracking if needed. **Answer:** Y = peter.

Additional Solved Numericals & Logical Derivations

N1. (Alpha-Beta Ordering Effect) Given leaf order [8,6] on left and [9,5] on right, show that good ordering yields more pruning than bad ordering.

Solution: If MAX explores right subtree first and MIN returns 9 at R1, $\alpha=9$. In R2, seeing 5 gives $\beta=5\leq\alpha(9)$, prune remaining branch. With poor ordering (5 then 9), less pruning occurs. Outcome value unchanged, pruning improved with better ordering.

N2. (A* Admissibility) Show that straight-line distance hSLD(n) to goal never overestimates true road distance.

Solution: Triangle inequality ensures hSLD(n) ≤ actual path cost from n to goal. Hence h is admissible; A* remains optimal.

N3. (Simulated Annealing Acceptance) At temperature T=2, current cost=10, neighbor cost=12. Compute acceptance probability.

Solution: $\Delta E=2$. $P=\exp(-\Delta E/T)=\exp(-1)\approx0.3679$ → 36.8% chance to accept uphill move, aiding escape from local optima.

N4. (Resolution in Predicate Logic) Prove Mortal(socrates) from ∀x(Human(x)→Mortal(x)), Human(socrates).

Solution: CNF: ¬Human(x)∨Mortal(x), Human(socrates). Negate goal: ¬Mortal(socrates). Resolve to contradiction → therefore Mortal(socrates) holds.

N5. (Prolog Query Tracing) For rules: ancestor(X,Y):-parent(X,Y). ancestor(X,Y):-parent(X,Z),ancestor(Z,Y). Facts: parent(a,b). parent(b,c). Trace goal ancestor(a,c).

Solution: First rule fails. Second rule: reduce to parent(a,Z) (Z=b) then ancestor(b,c). Apply first rule with parent(b,c) → success.

N6. (Hill Climbing Trap) Given f(x)=-(x-2)^2+4 with start x0= -3 and step 1, show it reaches global max.

Solution: Evaluate neighbors: -2→ -(-4)+4=0, ... up to x=2 → f(2)=4. No higher neighbor → stop at global maximum 4 at x=2.

N7. (GA Selection Math) Roulette selection with fitness [10, 30, 60]. Probabilities: [0.1, 0.3, 0.6]. Expected selections in 5 draws: [0.5, 1.5, 3.0].

Solution: Multiply probabilities by 5 to get expected counts; variance handled by stochastic sampling in practice.

N8. (CNF Conversion) Convert (P→Q)∧(Q→R)→(P→R) to CNF sketch.

Solution: Use implications elimination, move negations inward, distribute ∨ over ∧. (Proof sketch acceptable for 5–6 marks).