1. Describe two advantages of Iterative Deepening Minimax algorithms over Depth Limited Minimax algorithms. [6]
   I) Solution availability: i.e., you always have the solution of the previous iteration available during the execution of the current iteration (this is particularly useful when under a time constraint).
   II) Information gleaned during the current iteration can be employed to increase pruning in successive iterations (e.g., history table). Because successive iterations require exponentially more CPU time, the overhead of searching at lower depths is typically insignificant while increased pruning at higher depths can be very significant.

2. Explain briefly how the local search technique Stochastic Hill Climbing works. [3]
   Stochastic Hill Climbing chooses at random from among the uphill moves; the probability of selection can vary the steepness of the uphill move.

3. Explain briefly how the local search technique Local Beam Search works. [3]
   Local Beam Search works by keeping track of k states. After randomly initializing the states, at each step all the successors of all k states are generated. If any one is a goal, the algorithm halts; otherwise it chooses the overall best k successors and repeats.

4. Explain briefly how the local search technique Simulated Annealing works. [5]
   Simulated Annealing search is inspired by the process of annealing in metallurgy, with the aim to combine the benefits of hill-climbing search (efficiency) and random search (completeness). It works by selecting randomly from the successor moves, always accepting the selected move if it resulted in an improvement, and otherwise accepting it with a probability less than 1. The probability decreases exponentially with the amount by which the evaluation is worsened; it also decreases as the temperature goes down. The algorithm terminates upon reaching a temperature of zero.

5. One problem in adversarial search is the “horizon effect” and a possible solution is the use of “singular extensions”.
   (a) Explain briefly what the “horizon effect” is. [3]
      This effect arises when the program is facing a move by the opponent that causes serious damage and it is ultimately unavoidable, but because the stalling moves push the event over the search horizon it incorrectly believes the event has been avoided.
   (b) Explain briefly what “singular extensions” are. [3]
      Singular extensions are moves which are clearly better than all other moves in a given position and a sequence of such moves is referred to as a singular extension search; because the branching factor is 1 such a search can exceed the regular depth limit without incurring significant overhead.

6. Assuming a bound of [-10,10] on the state eval values, calculate first the bound on node C before evaluating node D1, then after evaluating node D1, and finally after evaluating both node D1 and D2. Show all your calculations for full points! [7]

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• Before evaluating any max node, the bound on C is [-10,10].
• After evaluating D1, the bound can be computed as follows:
  [\frac{1}{10} \cdot 5 + \frac{9}{10} \cdot -10, \frac{1}{10} \cdot 5 + \frac{9}{10} \cdot 10] = [-8.5, 9.5]
• After evaluating D2, the bound is tightened to:
  [\frac{1}{10} \cdot 5 + \frac{9}{10} \cdot -1 + \frac{8}{10} \cdot -10, \frac{1}{10} \cdot 5 + \frac{9}{10} \cdot -1 + \frac{8}{10} \cdot 10] = [-7.6, 8.4]
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The final questions are about the following adversarial search tree. State evaluation heuristic values for the max player are provided in the form of numbers following the letter labels of the states (e.g., A9 indicates that the heuristic value of state A for the max player is 9). The order in which successors are generated is from left to right. Example: A generates first B, then C, and finally D. Non-quiescent states are indicated by bold circled states.

7. Give the execution trace for HTQSABIDM(A,3,2,−∞,∞). [40]

8. Indicate for each depth iteration of HTQSABIDM(A,3,2,−∞,∞) which nodes, if any, get pruned. [6]

9. What is the Principal Variant (PV) found by HTQSABIDM(A,3,2,−∞,∞)? [4]

A,C,I,S,AJ