INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR
Class Test 1, 2019-20

Stamp/Signature of the Invigilator

QUESTION PAPER CUM ANSWER BOOKLET

Roll Number											**Name**	

Subject Number	C	S	6	0	0	4	5		**Subject Name**	***Artificial Intelligence***
Department/Centre of the Student										

Signature of the Student

To be filled in by the Examiner

Question Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Marks obtained											

ANSWER ALL QUESTIONS **Time = 50 minutes** **Total Marks = 30**

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1. Consider a search problem where all edges have cost 1 and the optimal solution has cost C. Let h be a heuristic which is $max\{ h^* - k, 0 \}$, where h^* is the actual cost to the closest goal and k is a non-negative constant unknown to the search algorithm. A heuristic is *monotone* if at each node, n, with successor, m, $h(n) \leq h(m) + c(n,m)$.

[4+4+4 = 12 marks]

(a) Write True/False in the boxes for the following statements:

(i)	h is admissible	True
(ii)	h is monotone	True
(iii)	A^* search without closed list will be optimal	True
(iv)	A^* search with closed list will be optimal	True

(b) Which of the following is the most reasonable description of how many more nodes will be expanded in the worst case with heuristic h compared to h^*, as a function of k? [Assume a branching factor of b]

(i) Constant in k (ii) Linear in k (iii) Exponential in k (iv) Unbounded

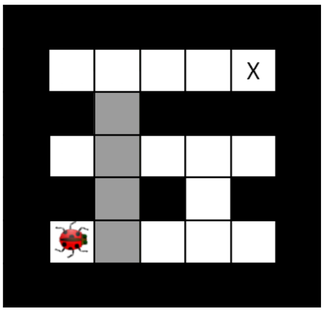
Answer with brief justification:

Exponential in k. At k = 0: only the d nodes on an optimal path to the closest goal are expanded for search depth (= optimal path length) d. At k = max(h); the problem reduces to uninformed search and BFS expands b^d nodes for branching factor b . In general, all nodes within distance k of the closest goal will have heuristic h = 0 and uninformed search may expand them. Note that search reduces to BFS since A* with h = 0 is UCS and in this search problem all edges have cost 1 so path cost = path length.

(c) Now consider the same search problem, but with a heuristic *h′*, which is 0 at all states that lie along an optimal path to a goal and *h** elsewhere. Write True/False for the following statements in the boxes.

(i) *h′* is admissible	True
(ii) *h′* is monotone	False
(iii) *A** using *h′* without closed list will be optimal	True
(iv) *A** using *h′* with closed list will be optimal	True

2. We have to help the insect in a rectangular maze-like environment with dimensions $M \times N$, as shown to the right. At each time step, the insect can move into a free adjacent square or stay in its current location. All actions have cost 1.



In this particular case, the insect must pass through a series of partially flooded tunnels. Flooded squares are lightly shaded. The insect can hold its breath for *k* time steps in a row. Moving into a flooded square requires our insect to expend 1 unit of air, while moving into a free square refills its air supply.

The state of the insect at any point of time can be defined as $\langle x, y, z \rangle$, where *x* and *y* are the coordinates of its present position in the maze, that is, column number and row number respectively. What do you think is *z*?

[4 marks]

Answer with brief justification:

The remaining breath of the insect. The insect needs to reach X without reaching any state where it has zero breath left.

3. Complete the following simulated annealing function for a maximization problem: [4 marks]

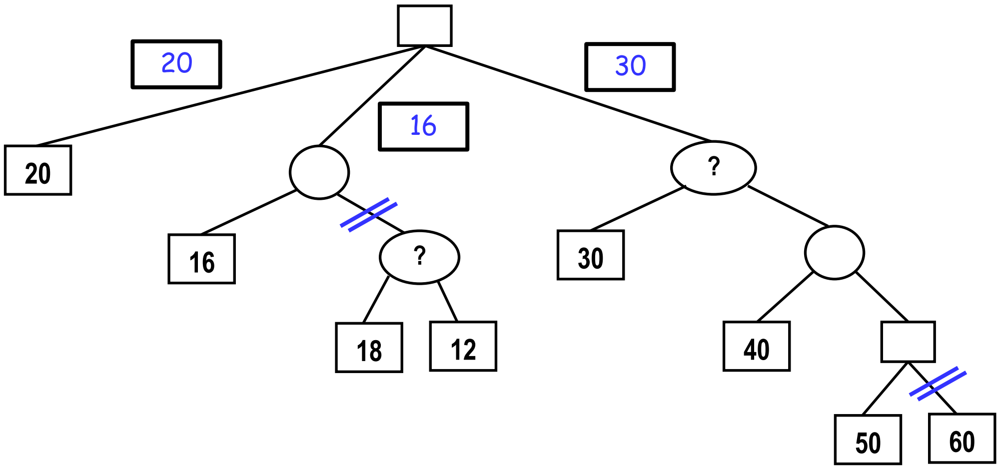
```
function SIMULATED-ANNEALING( problem, schedule )
    current ← INITIAL-STATE[ problem ]
    for $t$ ← 1 to $\infty$ do
        $T$ ← schedule[ $t$ ]
        if $T = 0$ then return current
        next ← a randomly selected successor of current
        $\Delta E$ ← VALUE[ next ] – VALUE[ current ]

        if $\Delta E > 0$ then current ← next

        else current ← next with probability $e^{\Delta E / T}$
```

4. Consider the game tree in the figure, which contains *max* nodes (square), *min* nodes (round), and *chance* nodes (oval). At the *chance* nodes, the probability of each outcome is equally likely. You represent the *max* nodes and your opponent represents the *min* nodes.

   (a) Your opponent is *rational* if she always goes for the move with *guaranteed* minimum returns. Under the assumption that your opponent is rational, indicate the values propagated to the root node by its children in the empty boxes provided besides the edges.

   (b) Is pruning possible if nodes are evaluated in *left-to-right* order? If so, cross out the branches that may be pruned.

[3+3= 6 marks]



5. You are given a maximization problem with a search space of size 10^{12}. You decide to run Gradient Descent 1000 times, each time with a randomly selected starting point. The lowest value produced by your 1000 runs is 1.3, the highest value is 4.9, and the average is 3.2. The algorithm on average takes 5 iterations to converge and return a result.

[2+2 = 4 marks]

   (a) Will you be justified in reporting 4.9 as the global optimum? Explain your answer!

No, because my runs are very quickly converging to significantly different values, indicating that the search landscape contains many local optima. Gradient Descent is not an appropriate search algorithm for this type of search landscape, and therefore it is highly unlikely that I have actually found the global optimum.

   (b) If you were asked to validate your result with further experiments, which local search algorithms would you use and why?

For this type of search landscape containing many local optima, a search algorithm with the ability to escape local optima is needed such as stochastic beam search, simulated annealing, or evolutionary algorithms.

ROUGH WORK