1. [15 points] Map the definitions with the closest term in logic.

Agent	*Syntax*	*Semantics*	*Entailment*	*Sound*	*Complete*
Formula	*Tautology*	*Satisfiable*	*Unsatisfiable*	*Proof*	*Horn Clause*
Literal	*XOR*	*CNF*	*DNF*		

12.

Represented as a canonical conjunction of disjunctions.	CNF
Describes a sentence that is true in all models.	Tautology
Constructed from simpler sentences, parentheses, and connectors.	Formula
Perceives environment by sensors, acts by actuators.	Agent
Chain of inference rule conclusions leading to a desired sentence.	Proof
Atom or its negation.	Literal
Describes a sentence that is false in all models.	Unsatisfiable
Specifies all the sentences in a language that are well formed.	Syntax
An inference procedure that derives only entailed sentences.	Entailment X
Defines truth of each sentence with respect to each possible world.	Tantology X

2. Minimax with transposition tables takes more space than regular Minimax, but spends less time in searching.

(A) True
(B) False

A

3. Nogood learning is used to predict early that a certain branch will lead to failure

(A) True
(B) False

4

B X

4. Which of these agents cannot be satisfactorily modeled as a POMDP

(A) route planning for Mars rover
(B) a bridge player (card game in which two teams play against each other and opponents' cards are not known a priori)
(C) radiation planning agent for cancer patients
(D) none of the above

B

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5. What all is true about discount factor in MDPs

(A) its use in MDPs is related to the idea of discounting objects to attract customers to purchase it
(B) its rationale is similar to that in economics – same amount of money is worth more today than tomorrow
(C) it makes infinite horizon MDPs well formed, since long-term rewards can no longer diverge
(D) its value is between 0 and 1, typically very close to 0.

BC

6. The phase transition for SAT problems is governed by the parameter

(A) $\frac{\#clauses}{\#variables}$

(B) $\frac{\#literals}{max\ \#literals\ in\ a\ clause}$

(C) $\frac{max\ \#clauses\ with\ same\ variable}{\#variables}$

A

7. Which of the following algorithms is likely to converge with a fewer number of iterations?

(A) Value Iteration
(B) Policy Iteration

B

2

8. If the utility of money *m* for an agent is *log(1+m)*, then that agent is a

(A) risk-averse agent
(B) risk-neutral agent
(C) risk-prone agent

A

9. In the game of Othello

(A) Humans love competing with machines as they are of similar level.
(B) Humans don't like to play with machines as humans are too good.
(C) Humans don't like to play with machines as machines are too good.

C

10. GSAT is an example of

(A) Greedy hill climbing with random restarts
(B) Random walk with random restarts
(C) Greedy hill climbing and random walk with random restarts
(D) Random walk

C

11. Which optimization criterion on the rewards will be used by a highly pessimistic agent operating in a non-deterministic world (without known probabilities) for taking its actions?

B

(A) Minimax
(B) Maximin
(C) Minimin
(D) Maximax

12. Which of the following are used in typical chess programs such as Deep Blue?

(A) Alpha-beta pruning
(B) Evaluation functions
(C) Forward chaining
(D) Genetic algorithms
(E) Transposition tables
(F) Expectiminimax

ABEF X

13. Consider an adversarial game in which each state s has minimax value v(s). Assume that the maximizer plays according to the optimal minimax strategy, but the opponent (the minimizer) plays according to an unknown, possibly suboptimal strategy. Which of the following statements are true?

(A) The score for the maximizer from a state s under the maximizer's control could be greater than v(s).
(B) The score for the maximizer from a state s under the maximizer's control could be less than v(s).
(C) Even if the opponent's strategy is known, the maximizer should still continue playing its optimal minimax strategy.
(D) If both opponent and maximizer play optimally, then value v(s) of every state s encountered in the gameplay will be equal.

A X

14. If the set of successors are ordered randomly then the complexity of minimax with alpha beta pruning (for moderate b) is closest to

(A) O(b[illegible])
(B) O(b[illegible])
(C) O(b[illegible])
(D) O(b[illegible])

A X

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15. The optimal value function for a finite horizon POMDP is piecewise linear and convex even when the discount factor is less than 1.

(A) True
(B) False

A

16. The Equal likelihood criterion and the criterion of realism 0.5 will always result in the same best action.

(A) True
(B) False

B

17. [10 points] Short answer questions.
[6 points] Give two advantages of Iterative Deepening minimax algorithms over Depth Limited minimax algorithms

1. ~~Unlike~~ Under time limit situations, iterative deepening minimax algorithms have an added flexibility that they can stop the search if they are able to find very good solutions at depths less than the maximum depth that depth limited algorithms search for.

2. As ~~the~~ iterative deepening minimax algorithms have had searched all the nodes upto that depth for a particular no they can ~~search~~ devote more time for searching further in case of unstable nodes whereas this control is ~~not~~ weak in case of depth limited minimax algorithms where the ~~depths~~ nodes upto that depth have not been searched for and hence the time required to search them is unknown

[4 points] Give one advantage of WalkSat over DPLL. Give one advantage of DPLL over WalkSat.

Advantage of Walksat over DPLL

Walksat makes use of a heuristic to ~~find~~ ~~local~~ search locally good neighbours such that the number of contradictions minimised. This ~~ke~~ may lead to a faster convergence and h a faster solution.

Advantage of DPLL over Walksat

DPLL

6

18. [10 points] If Fred is rich, he is happy. But if he's not rich, then he's an unhappy liar. If Fred is either happy or a liar, then he is funny. Fred smells bad when he's funny. Let R denote that Fred is rich, H happy, L liar, F funny, and S smells bad. Using propositional logic, can you prove that Fred is both rich and smelly? Provide either a proof or a succinct argument explaining why no such proof exists.

~~Knowledge Base -~~

~~1. $\neg R \vee H$~~
~~2. $R \vee \neg H$~~
~~3. $R \vee L$~~
~~4. N~~

~~Knowledge Base~~

~~1. $\neg R \vee H$~~
~~2. $R \vee \neg H$~~
~~3. R~~

Knowledge Base -

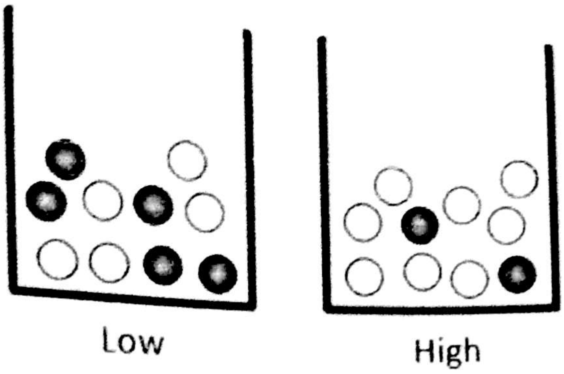
1. $\neg R \vee H$
2. $R \vee \neg H$
3. $R \vee L$
4. $\neg H \vee F$
5. $\neg L \vee F$
6. $\neg F \vee S$

To Prove - $R \wedge S$

Consider the negation of the conclusion and add it to the

7. $\neg R \vee \neg S$

19. [35 points] Mr. Kashyap heads to a casino for some fun. This casino has two games: Low and High. In each game there is a bin of marbles. The low bin contains 5 white and dark marbles each, and the High bin contains 8 white and 2 dark marbles.



The play for each game proceeds as follows: the dealer draws a single marble uniformly at random from the bin. If a dark marble is drawn, the game pays out. The low payout is \$300 and the high payout is \$3000. The payout is divided evenly among everyone playing that game. For example, if two people are playing Low and a dark marble is drawn, they each receive \$150. If a white marble is drawn, they receive nothing. The drawings for both games are done simultaneously, and only once per night (there is no repeated play).

(a) [2 points] What is Mr Kashyap's expected earnings for each game if he is the only one at the casino. Show your work.

1.5

Expected earning for choosing low = 150\$ (0.5×3

" " " " high = 600\$ (0.2×30

600\$ > 150\$.

⇒ $\boxed{\text{Expected earning} = 600\$}$

(b) [3 points] Mr. Kashyap has some unknown utility $U_h(m)$ for any money m that he makes. If you observe that he chooses to play Low, under what conditions would that be an optimal play? Assume $U_h(0)=0$. Show your work.

3

This means that he ~~is~~ a risk averse player.

$$0.5\,U_h(300\$) + 0.5\times 0 > 0.2\,U_h(3000\$) + 0.5\times 0$$

$$\Rightarrow \frac{U_h(3000\$)}{U_h(300\$)} < 2.5$$

Mr. Kashyap is an optimal player under if the ~~above~~ utility function follows the above inequality

(c) Now imagine that Mrs. Kashyap is joining Mr. Kashyap at the casino. First Mr. Kashyap arrives and chooses his game. Then Mrs. Kashyap arrives and chooses hers. Let m_h denote the money earned by Mr. Kashyap and m_w denote that of Mrs. Kashyap. Moreover, since both Mr. and Mrs. Kashyap are rational agents let us describe their utilities by functions $V_h(m_h, m_w)$ and $V_w(m_h, m_w)$, respectively.

[i] [10 points] Suppose $V_h(m_h, m_w) = m_h$ and $V_h(m_h, m_w) = m_w$, i.e., both players are attempting to maximize their own expected earnings. Compute expected utility for both players, for each combination of games they could play. Show your calculations.

Mr. Kashyap	Mrs. Kashyap	$E[V_h(m_h,m_w)]$	$E[V_w(m_h,m_w)]$
Low	Low	(	
Low	High		
High	Low		
High	High		

Since Mr. Kashyap chooses first, and Mrs. Kashyap later, what are optimal plays for both of them?

[ii] [6 points] Now rather than maximizing their own individual earnings, Kashyaps have different objectives. Here are five utility functions $V_h(m_h, m_w)$:

m_h $\qquad$ m_h+m_w $\qquad$ m_w $\qquad$ $(m_h+m_w)^2$ $\qquad$ $-m_w$

and five utility functions $V_w(m_h, m_w)$:

m_w $\qquad$ m_h+m_w $\qquad$ $- m_h$ $\qquad$ $2m_w - m_h$ $\qquad$ $log_{10}(m_w)$

For each of the following scenarios, give the utility function listed above that best encodes the needs of each player. A function may appear multiple times. The first scenario is done for you:

$V_h(m_h,m_w)$	$V_w(m_h,m_w)$	Scenario
m_h	m_w	Both players want to maximize their own expected winnings.
		Kashyaps have had a terrible fight and are very angry at each other. Each wants the other to lose as much money as possible.
		Mr. Kashyap has gotten over the fight, and now wants to maximize their expected combined winnings. However, Mrs. Kashyap doesn't trust her husband, that he would give her her due share, so she just wants to maximize her own expected earnings.
		Mr. Kashyap is being extorted by gundas, who will immediately confiscate any money that he wins. Gundas are not monitoring Mrs. Kashyap and do not know about her winnings, so they will not be taken. Both Kashyaps want to maximize the expected total amount the couple gets to keep.

(d) [7 points] Let us go back to the original problem of part (a) where only Mr. Kashyap is playing. However, now assume that three of the light marbles in each bin are replaced with three multicolored marbles. The rules of the game are the same, except that if the multicolored marble is drawn, it is put back in the bin, all players are asked to pay 20% of the total payoff of the game, and the dealer repeats the process to draw another marble. The game continues until a light or a dark marble is drawn. For example, if Mr. Kashyap is playing Low game, and the dealer draws multicolored, multicolored and then dark, then Mr. Kashyap wins a total of \$180. However, if the last marble is light, he actually loses \$120.

Write down the equations for the expected utility of each game for Mr. Kashyap. Let $U_h(m) = m$. Which game should he play (if any)? Show your work.

(e) [7 points] Finally, in the original game of Part (a), Mr. Kashyap decides to play High. However, before the game is started, the dealer makes him an offer to sell each light marble for *\$p* each. If Mr. Kashyap decides to buy *k* light marbles then he will have to pay an upfront cost of *\$p.k* to the dealer, and the game will be played with *10-k* marbles. This will increase Mr. Kashyap's chances of winning. If Mr. Kashyap decides to buy all light marbles in the bin, what can we say about the price *\$p*? Show your work.

0	0	180	429
0	1	172	444
0	2	165	462
0	3	152	484
1	3	282	484
1	2	282	462
1	1	282	444
1	0	282	429
2	0	387	428
2	1	393	442
2	2	399	460
2	3	407	479
2	4	416	501
1	4	279	505
1	5	276	534
1	6	274	565
1	7	272	605
2	5	426	531
2	6	436	561
2	7	449	602
~~2~~	~~8~~	~~470~~	~~652~~