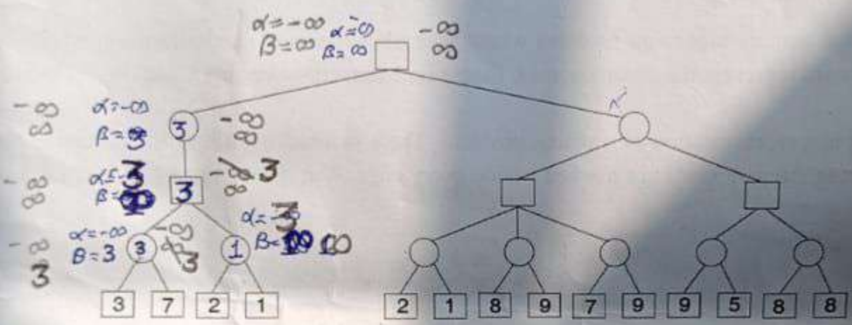
Artificial Intelligence : DS251

MidSem

Time - 120 Minutes

1. Three missionaries and three cannibals are on one side of a river, along with a boat that can hold one or two people. The goal is to find a way to get everyone to the other side, without ever leaving a group of missionaries outnumbered by cannibals. Remember, at least one person must be on the boat to make it cross the river. Represent the states of this problem indicating the initial state, the goal state and state transition rules. Draw the state space tree up to 2 levels below the root node i.e. for depth 0, 1 and 2. (6)

2. Apply α-□ pruning on the following tree. Show the (α, □) value of each node and indicate which branches to prune and why. The rectangles indicate "Max" nodes and circles indicate "Min" nodes. (5)



3. Consider the game of tic-tac-toe where X is the MAX player. Given the game board below where it is X's turn to play next assuming depth cutoff of 2 (i.e. 2 ply lookahead), show the game tree.

```
__ | X | __
0 | __ | __
X | __ | 0
```

The evaluation function is given by:

Evaluation(s) = $8X_3(s) + 3X_2(s) + X_1(s) - (8O_3(s) + 3O_2(s) + O_1(s))$ Where $X_n(s)$ is the number of rows, columns, or diagonals in state s with exactly n number of X's and no O's and $O_n(s)$ is the number of rows, columns, or diagonals in states with exactly n number of O's and no X's.

Can you observe any "horizon effect" here? (8+2)

4. Let's say, you are going to spend a month in the wilderness. Only thing you are carrying is the backpack which can hold a maximum weight of 40 kg. Now you have different survival items, each having its own "Survival Points" (which are given for each item in the table). Some of the items are so essential that if you do not take them, you incur some additional penalty.

Here is the table giving details about each item.

CS25

126

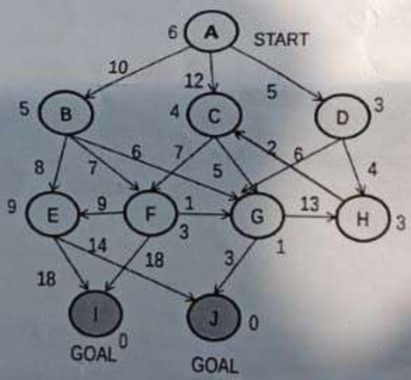
a. Draw the constraint graph for these states.
b. As per backtracking search algorithm, choose the first three states to color and decide which colors should be assigned to them. Mention your logic of choosing the state and corresponding color in every step. Note that if there is a tie, you can choose one of the options randomly.
c. After choosing the values for the first three states, do an Arc consistency check between the unassigned variables. Is a valid assignment possible?
d. Describe how you would have exploited the problem structure in this problem using the cutset principle.

(2+6+3+2)

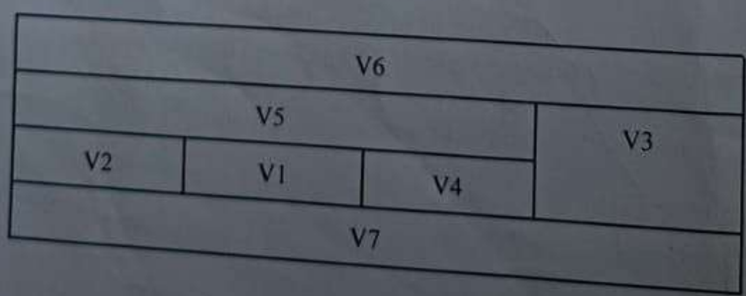
Item	Weight	Survival Value	Penalty if not taken
Sleeping Bag	30	20	0
Rope	10	10	0
Bottle	5	20	0
Torch+Battery	15	25	-20
Glucose	5	30	0
Pocket Knife	10	15	-10
Umbrella	20	10	0

Formulate this as a genetic algorithm problem where your objective is to maximize the survival points. Write how you would represent the chromosomes, fitness function, crossover and mutation. (3+2+2+1)

5. The following is a representation of a search problem. There is a heuristics h which is marked beside every node whereas the path costs are marked beside every edge. Run A* on this search space and show *the steps.* (8)



6. Consider the following map coloring problem where V1, V2,..V7 are different states of a country which need to be colored in a way such that no two neighboring states get the same color. Each state needs to be assigned one of the three colors - Red, Green and Blue.



5. Consider the following crossword puzzle. Formulate it as a constraint satisfaction problem (draw graph) and solve it. Show how arc consistencies are propagated. (8)

Words: astar, happy, hello, hoses, live, load, loom, peal, peel, save, talk, ant, oak, old

6

Action	Pre-Conditions	Effects
Cook	cleanhands	dinner
Wrap	quiet	present
Carry		¬garbage ∧ ¬cleanhands
Trolley		¬garbage∧ ¬quiet

(7+8)

3. a. In a quiz game show there are 3 levels, at each level one question is asked and if answered correctly a certain monetary reward based on the current level is given. Higher the level, tougher the question but higher the reward. At each round of play, if the participant answers the quiz correctly then s/he wins the reward and also gets to decide whether to play at the next level or quit. If quit then the participant gets to keep all the rewards earned so far. At any round if participants failed to answer correctly then s/he loses "all" the rewards earned so far. The game stops after level 3.

Playing at level1, level2, level3 generates rewards Rs 10, Rs. 100 and Rs 1000 with winning probabilities p = 0.9, 0.6, 0.1 respectively. At any level, the participant loses with probability (1- p).

Formulate the problem as a Markov Decision Process considering the overall goal is to decide on the actions to play or quit maximizing total rewards. No need to write/solve any equation here. Formulating the state-space and drawing the state transition diagram is sufficient.

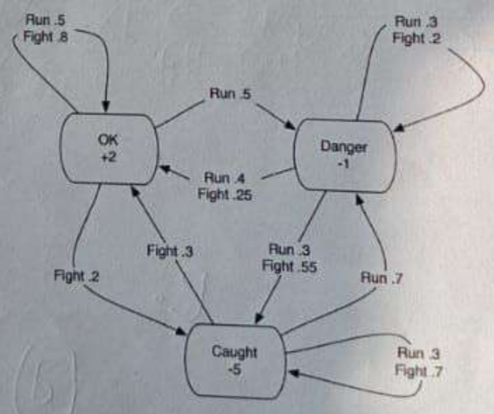
b. A boy is being chased around the school yard by bullies and must choose whether to Fight or Run. There are three states:
- Ok, where he is fine for the moment.
- Danger, where the bullies are right on his heels.
- Caught, where the bullies catch up with him and administer noogies.

13

The graph of the MDP is given here:

0

$V = R + V(s)$



Hold (c1, ship)

unload

DS251: AI
End Sem
Time: 3 hrs

1. Consider the following problem - There are two locations C1 and C2, and two containers L1 and L2. If the ship is in the same location as a container, and the ship is empty, the ship can hold the container, as a result of this action, the container is on the ship and the ship is no longer empty. If the ship is in location x, it can move to location y, as a result of this action, the ship is in location y. If the ship has a container on it, and is in location x, then it can unload, and the effect of the action is that the container is in location x and the ship is empty. In the initial state, both containers and the ship are in L1 and the ship is empty. The goal is to have container C2 in L2.

(a) Define the problem as a planning problem - Specify the predicates, objects, initial state, goal specification and the action schemas.

(b) Apply the partial-order planning algorithm to draw the final partial order plan clearly showing the causal links (including the subgoals that they achieve) and ordering links.

[3+6]

2. (a) In GraphPlan, what are the conditions to add a mutex link between a pair of actions?

(b) Consider a planning problem which requires an agent to hang a picture on the wall. In order to hang the picture, the wall must have a nail. The agent can drive a nail if it has a hammer and a nail. The agent can have an object by picking it up. It can also put down an object. The following table shows the possible set of operators. Draw the GraphPlan for the first layer and show all the mutex links.

Action	Pre-condition	Effect
Pick(x)		Has(x)
Drop(x)	Has(x)	EmptyHand $\wedge \neg$ Has(x)
HangPicture	On(Wall, Nail)	On(Wall, Picture)
DriveNail	Has(Nail) $\wedge$ Has(Hammer)	On(Wall, Nail) $\wedge \neg$ Has(Nail)

[2+5]

2. Consider the following problem Statements to be coded in first order predicate logic and solved using resolution refutation method:

Pritam played for BigTeam. Mohan was the captain of BigTeam. All those who played for BigTeam were either a friend of Mohan or disliked him. People who are friends of anyone do not betray their friends. People betray those whom they are not friends with. Pritam betrayed Mohan. Therefore, we can conclude that Pritam disliked the captain of a team he played for.

friend (x,y)

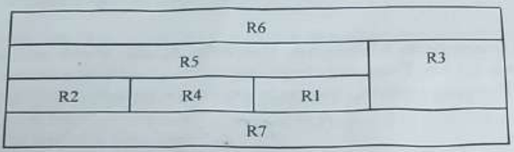
dislike (x,y)

betray (x,y)

capt (x)

DS251: Artificial Intelligence
Midsem
Time 2 hrs

1. Consider the following university dormitory assignment problem, where rooms R1, R2, ..R7 represent different dormitory rooms, and each room needs to be assigned to one of the three dormitory styles: Modern (M), Vintage (V), and Contemporary (C). The goal is to assign dormitory styles to the dormitory rooms in a way that no two neighboring rooms have the same style.

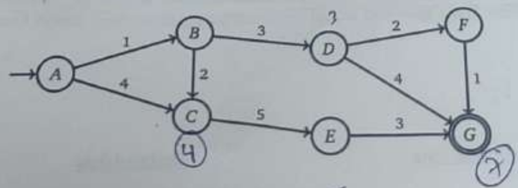


Rem. value
Min Max
Degree
Least Limiting

a. Map the ~~problem as~~ a constraint satisfaction problem and draw the constraint graph.
b. As per backtracking search algorithm, choose the first three rooms to be chosen and decide which styles should be assigned to them. Mention your logic of choosing the room and corresponding style in every step.
c. After choosing the styles for the first three rooms, run an Arc consistency check between the unassigned rooms. Is a valid assignment possible?
d. Describe how you would have exploited the problem structure in this problem using the cutset principle.

(2+6+3+2 = 13)

2. The following is a representation of a search problem, where A is the start node and G is the goal. There is also a heuristics h which is defined in the table. Note that h(B) is unknown.



n	h(n)
A	5
B	?
C	4
D	3
E	3
F	1
G	0

$\delta \cdot (n-1) \cdot \delta$

What values of h(B) make h admissible? ≤ 6
What values of h(B) make h consistent? ≤ 6

(2+2 = 4)

3. For the following tree, show the order of nodes visited for uniform cost search. . The goal node is I and the numbers next to the edges indicate the associated cost.

g(n)

Answer the following questions:

(a) List all predicates that you will use for encoding the problem

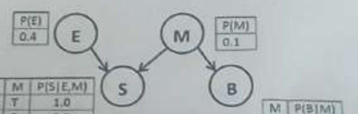
(b) Code the sentences and goal in first order predicate logic using the predicates defined in (a)

(c) Convert each of them to Clausal Form and List the Clauses

(d) Use Resolution Refutation Method to show whether the goal can be logically concluded from the facts or not. Clearly show the method and all derived clauses.

[2+3+3+3]

3. A smell of sulfur (S) can be caused either by rotten eggs (E) or as a sign of the doom brought by the Mayan Apocalypse (M). The Mayan Apocalypse also causes the oceans to boil (B). The Bayesian network and corresponding conditional probability tables for this situation are shown below.



P(E)
0.4

P(M)
0.1

E	M	P(S|E,M)
T	T	1.0
T	F	0.8
F	T	0.3
F	F	0.1

M	P(B|M)
T	1.0
F	0.1

(a) Compute P(E'S'M'B') ০.৪৩৭৪

(b) What is the probability that the oceans boil? ০.১৯

(c) What is the probability that the Mayan Apocalypse is occurring, given that the oceans are boiling? ০.৫২৬

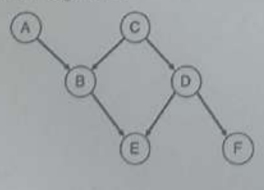
(d) What is the probability that the Mayan Apocalypse is occurring, given that there is a smell of sulfur, the oceans are boiling, and there are rotten eggs? ~~০.০৬৮~~

০.৫৮ [2+2+2+3]

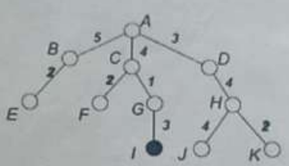
4. Given the structure of the Bayes network as illustrated in the figure below, confirm/contradict the following independence assertions with appropriate reasoning.

(a) A is conditionally independent of F given D

(b) A is conditionally independent of C given E [2+2]



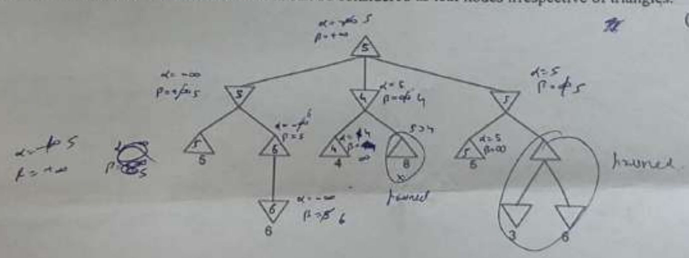
ADCBGFHEI



(5)

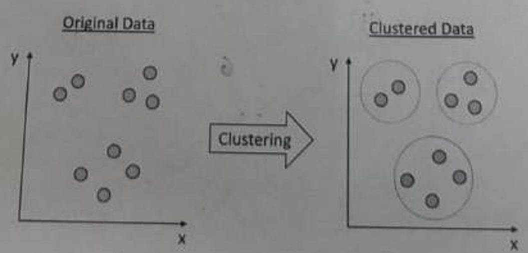
4. Apply α-β pruning on the following tree. Show the (α-β) value of each node and indicate which branches to prune and why. The upward triangles indicate "Max" nodes and downward triangles indicate "Min" nodes. Nodes with associated values can be considered as leaf nodes irrespective of triangles.

(5)



5. Clustering is a task of grouping data points based on their distances. Suppose, we need to cluster 9 two dimensional data points into k clusters such that within cluster average pairwise euclidean distance is minimized and across clusters average pairwise euclidean distance is maximized. Formulate this as a genetic algorithm problem. Write how you would represent the chromosomes, fitness function, crossover and mutation.

(3+2+2+1 = 8)



Artificial Intelligence : DS251
EndSem
Time - 2.5 hours

1. a. Write the argument below in 'proposition logic' form. If the argument is valid, prove it. If the argument is not valid, give a counterexample:

5

If I watch football, then I don't do mathematics
If I do mathematics, then I watch hockey
So, if I don't watch hockey, then I watch football

b. Consider the following axioms:

3

Every coyote chases some roadrunner.
Every roadrunner who says ``beep-beep" is smart.
No coyote catches any smart roadrunner.
Any coyote who chases some roadrunner but does not catch it is frustrated.
(Conclusion) If all roadrunners say ``beep-beep", then all coyotes are frustrated.

Prove the conclusion using the resolution refutation method. Show all required steps like conversion to CNF, skolemization etc. (5+10)

2. a. The following table of actions describe a planning problem for determining the steps in starting a car. The initial and final states are also indicated. Apply the partial-order planning algorithm to draw the final partial order plan clearly showing the causal links (including the subgoals that they achieve) and ordering links. For each causal and ordering link, mention the justification for adding them.

7

Action	Pre-condition	Effects
Turn-Key	$\neg$ Accelerator $\wedge \neg$ Ignition	Ignition
Press-Clutch	$\neg$ Clutch	Clutch
Release-Clutch	Clutch	$\neg$ Clutch
Press-Accl	$\neg$ Accelerator	Accelerator
Release-Accl	Accelerator	$\neg$ Accelerator
Set-Gear	Clutch	Gear-Set
Engage-Gear	Clutch $\wedge$ Gear-Set $\wedge \neg$ Accelerator $\wedge$ Ignition	Gear-Engaged $\wedge \neg$Clutch
START	$\neg$ Clutch $\wedge \neg$ Accelerator $\wedge \neg$ Ignition	
FINISH	Gear-Engaged $\wedge \neg$Clutch $\wedge$ Accelerator $\wedge$ Ignition	

b. Solve the following planning problem using graphplan. The aim here is to plan an event - cooking food, wrapping presents for guests and cleaning garbage by manually carrying them to the trash can or using a trolley for the same. Show mutex links properly and mention the reasons to add them.

6

Initial conditions: garbage $\wedge$ cleanhands $\wedge$ quiet
Goal: dinner $\wedge \neg$garbage $\wedge$ present

5. This gridworld MDP operates like we describe below. The states are grid squares, identified by their row and column number (row first). The agent always starts in state (1,1), marked with the letter S. There are two terminal goal states, (2,3) with reward +5 and (1,3) with reward -5. Rewards are 0 in non-terminal states. (The reward for a state is received as the agent moves into the state.) The transition function is such that the intended agent movement (North, South, West, or East) happens with probability .8. With probability .1 each, the agent ends up in one of the states perpendicular to the intended direction. If a collision with a wall happens, the agent stays in the same state.

A	B	+5
S	C	-5

Gridworld

Transition Probabilities

$V(B) = 0.8(+5) + 0.1(0 + 0.9\,V_A) + 0.1(0 + 0.9\,V_B)$

Suppose the agent knows the transition probabilities. Give the first two rounds of value iteration updates for each state, with a discount of 0.9. (Assume V_0 is 0 everywhere and compute V_i for times i = 1, 2) [6]

6. A toymaker is able to make 0, 1, or 2 wooden toys on any given day. The state of his shop is well summarized by s = the number of toys that he has for sale. On April 8, 2024, he has $s_t = 7$ toys for sale, and earns R(7) = Rs. 50. He decides to produce $a_t = 2$ new toys. On April 9, he learns that he now has $s_{t+1} = 8$ toys left in the store; on this day, he decides to produce $a_{t+1} = 0$ new toys and earns R(8) = Rs. 60. Prior to the April 8 action, he estimated that the quality of each (state,action) pair is as given in the following table:

	$Q_t(s,a=0)$	$Q_t(s,a=1)$	$Q_t(s,a=2)$
$s=7$	25	60	90
$s=8$	10	100	30

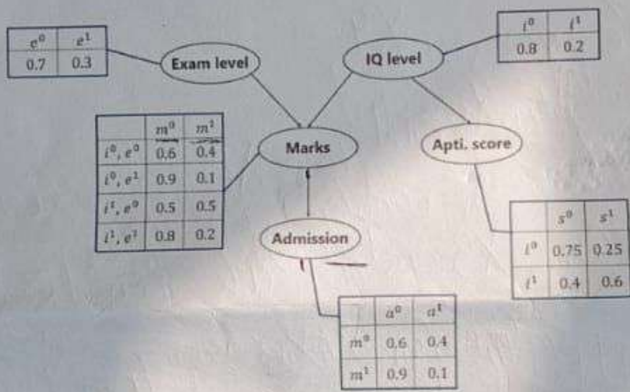
Find $Q_{t+1}(s=7, a=2)$ using Q learning. It should be written as a function of the learning rate, α, and the discount factor, γ; there should be no other variables on the right-hand-side of your answer. [4]

7. You are a Hollywood producer. You have a set of scripts in your hand and you want to make a movie from one of them. Before starting, however, you want to predict if the film you want to make will rake in huge profits, or utterly fail at the box office. You hire two critics A and B to read the scripts and rate them on a scale of 1 to 5 (assume only integer scores). Each critic reads the script independently and announces their verdict. Of course, the critics might be biased and/or not perfect, therefore you may not be able to simply average their scores. Instead, you decide to use a perceptron to classify your data. There are three features: a constant bias, and the two reviewer scores. Thus $f_0 = 1$ (a constant bias), f_1 = score given by reviewer A, and f_2 = score given by reviewer B.

Assuming the initial values of OK, Danger and Caught states as +2, -1 and -5 respectively, calculate the values of those states after one iteration of the value iteration method. Consider the discount factor $\gamma = .9$. After this iteration, what seems to be the best actions from each state.

(5+9)

4. a. Let us imagine that we are given the task of modeling a student's marks (m) for an exam he has just given. From the given Bayesian Network Graph below, we see that the marks depend upon two other variables. They are, Exam Level (e)– This discrete variable denotes the difficulty of the exam and has two values (0 for easy and 1 for difficult) and IQ Level (i) – This represents the Intelligence Quotient level of the student and is also discrete in nature having two values (0 for low and 1 for high) Additionally, the IQ level of the student also leads us to another variable, which is the Aptitude Score of the student (s). Now, with marks the student has scored, he can secure admission to a particular university. The probability distribution for getting admitted (a) to a university is also given below.



e^0	e^1
0.7	0.3

i^0	i^1
0.8	0.2

	m^0	m^1
i^0, e^0	0.6	0.4
i^0, e^1	0.9	0.1
i^1, e^0	0.5	0.5
i^1, e^1	0.8	0.2

	s^0	s^1
i^0	0.75	0.25
i^1	0.4	0.6

	a^0	a^1
m^0	0.6	0.4
m^1	0.9	0.1

4

i. Calculate the probability that in spite of the exam level being difficult, the student having a low IQ level and a low Aptitude Score, manages to pass the exam and secure admission to the university.

ii. Calculate the probability that the student has a High IQ level and Aptitude Score, the exam being easy yet fails to pass and does not secure admission to the university. 4

(4+4)

b. Assume that there are two batsmen - B1 and B2. We want to compare their performance in 2020 - 2021 by their average number of centuries per innings. B1 made 12 centuries in 48 innings in 2020 and 183 centuries in 582 innings in 2021 whereas B2 made 104 centuries in 411 innings in 2020 and 45 centuries in 140 innings in 2021. Show how this can be considered as a case for Simpson's paradox. 3

18/10000

(3)

c. Suppose a person belongs to the "tall" class with membership 0.4 and "thin" class with membership 0.2. Following fuzzy logic, find his/her membership in class "tall and thin".

(2)

2