NOTE: All the answers need to be written down into answer sheets, not into the question sheet.

Problem 1 (10 points, 2.5 pts each question))

You are a map-coloring robot assigned to the task of coloring the following map (see Figure 1). Each region must be colored one of Red (R), Green(G) or Blue(B). Adjacent regions must be a different color. The map (left) and the constraint graph (right) are shown below.

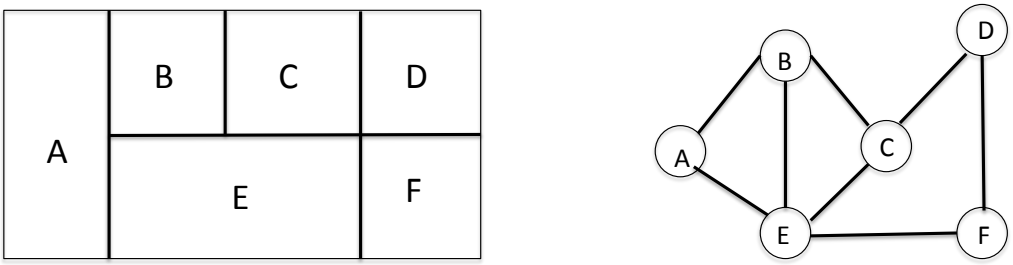

Figure 1: Map coloring problem

a) Consider the partial assignment in Figure 2 below where variable A and E have been assigned values as shown in the figure. Cross out all values that should be eliminated by Arc Consistency (using AC-3 in the textbook.)

Regions in the map

A	B	E	C	D	F
Blue	R G B	Red	R G B	R G B	R G B

Figure 2: Partial assignment for Region A= Blue and E= Red

ANSWER: See Figure 3

Regions in the map

A	B	E	C	D	F
Blue	R G B X X	Red	R G B X X	R G B X	R G B X

Figure 3: Answer to (a)

b) Minimum Remaining Values Heuristics. Consider the partial assignment in Figure 4 where B is assigned value Green and constraint propagation has been done. Write down all unassigned variables (just the letters that correspond to these variables) that might be selected by Minimum Remaining Values Heuristic (MRV)

Regions in the map

A	B	E	C	D	F
R B	Green	R B	R B	R G B	R G B

Figure 4: Partial assignment for Region B= Green

Answer: A, E, C

c) Degree Heuristic. Consider the partial assignment in Figure 4 where B is assigned Green and constraint propagation has been done. Write down all unassigned variables that might be selected by the Degree Heuristics

Answer: E

d) Consider the following complete but inconsistent assignment in Figure 6. E has been selected to be assigned a value during local search for a complete and consistent assignment. What new value would be chosen for E by the MINIMUM-CONFLICT heuristic?

Regions in the map

A	B	E	C	D	F
R B	Green	R B	R B	R G B	R G B

Figure 5: Partial assignment for Region B= Green

Regions in the map

A	B	E	C	D	F
B	G	?	G	G	G

Figure 6: Complete assignment where the value of Region E needs to be changed, and to be found.

Answer: R

Problem 2 (10 points)

Assume the following knowledge base KB:

$\forall$ x allergies(x) $\implies$ sneeze(x)

$\forall$ x $\forall$ y cat(y) $\wedge$ allergicToCats(x) $\implies$ allergies(x)

cat(Felix)

allergicToCats(Mary)

The Goal/Query: Does Mary sneeze?, I.e., sneeze(Mary)?

Perform Resolution Refutation (RR) and find out if the query has a positive (True) or negative (False) answer for this KB? Answer the question with True (Yes) or False (No), and show how you derived this answer through RR. Show also unifications if any. T/F answers without the poof/refutation of the query will not be given any point. Partial points will be given to the proof.

ANSWER: See (Figure 7)Result of Resolution is {}, i.e, Mary sneezes. i.e., sneeze(Mary) is true. 1 point for unification. No point reduction for lack of standardization (i.e., variable w in the figure)

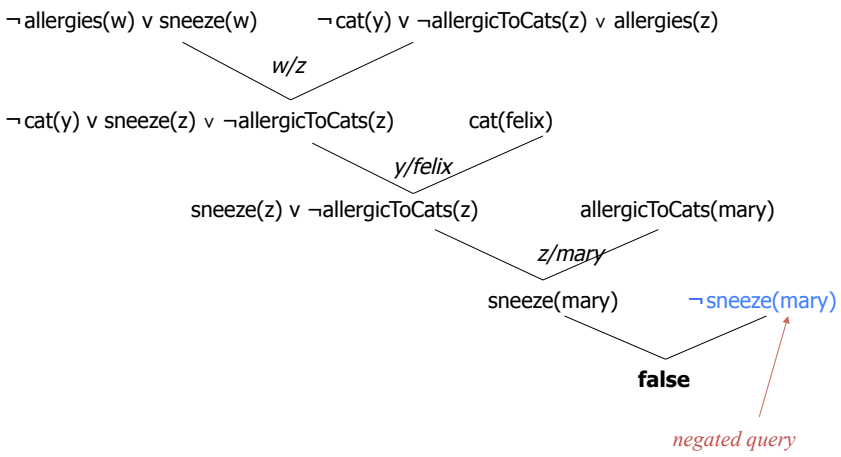

Figure 7: ANSWER to Resolution Refutation Problem.

Problem 3 (10 points, division: 3-3-4 pts)

In the following adversarial game (see Figure 8) it is MAX's turn to play. The numbers at each leaf node is the estimated score of that position. Check nodes from left to right order.

a) Perform mini-max search and label each branch node with its value. Draw the figure on your answer sheet and fill the squares above the leaf nodes. You don't need to draw the nodes at the leaf level.

ANSWER: See Figure 9

b) What is Max's best move, i.e., which node it is and which utility does it give?

ANSWER: Node B, value 5

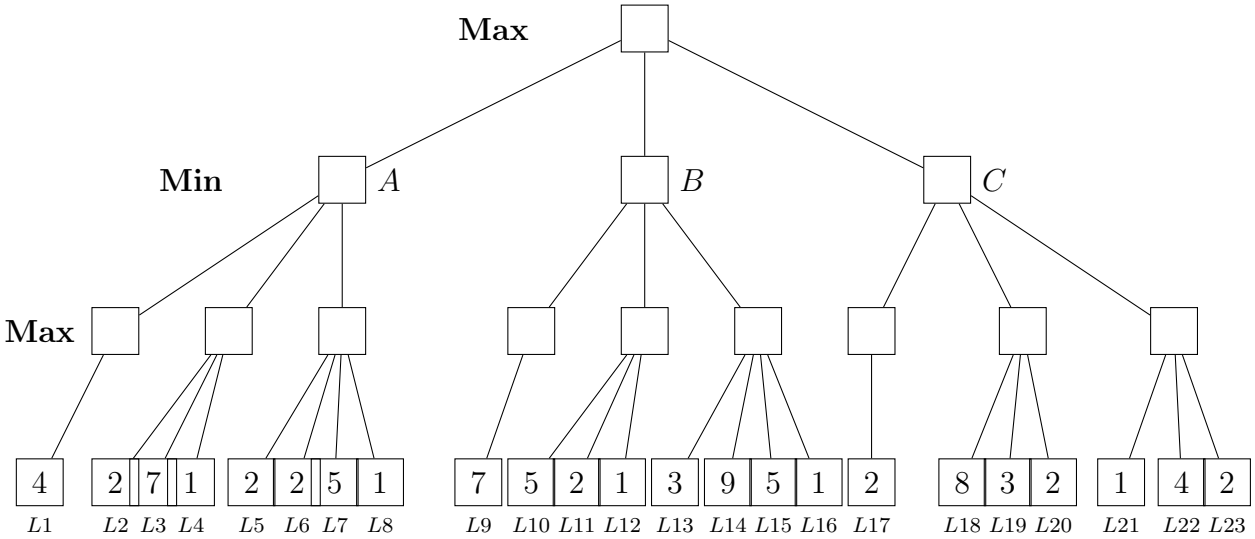

Figure 8: Adversarial game problem.

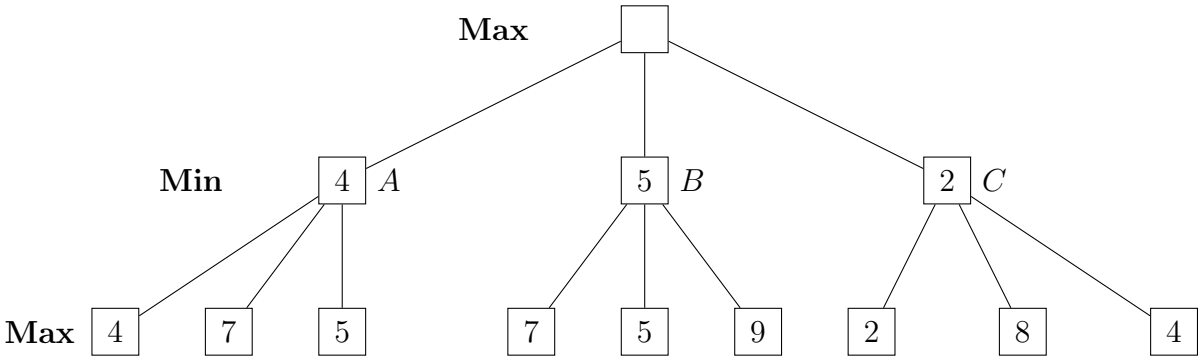

Figure 9: M

inimax. ANSWER: Adversarial game problem.

c) Write down all leaf nodes that the alpha-beta algorithm would prune. Your answer will be a list of L_i labels .

ANSWER: L4, L8, L15, L16,L18, L19,L20, L21, L22, L23)

Problem 4 (15 points total, 4 points for each of the first questions. The sum will not be negative for this problem.)

This is a mixture of multiple choice (b) , Classical "writing the answer" (a and c), and

True/False type of tasks.

a) Assume the following problem represented as a graph (see Figure 10) where the numbers on the edges represent the cost of traveling between the nodes connected by the edge. You will apply A* graph search algorithm and the nodes in the graph have the following h-values:

h(S)= 7
h(A)= 6
h(B)= 2
h(C)= 1
h(G)= 0

Write down the to-be expanded node and the content of the priority queue at each step. Ties break alphabetically. Write down the generated solution path - you will not get any points if you dont show how the solution is generated (i.e., the queue and the currently expanding node). Is this an optimal solution? Why or why not, explain very briefly.

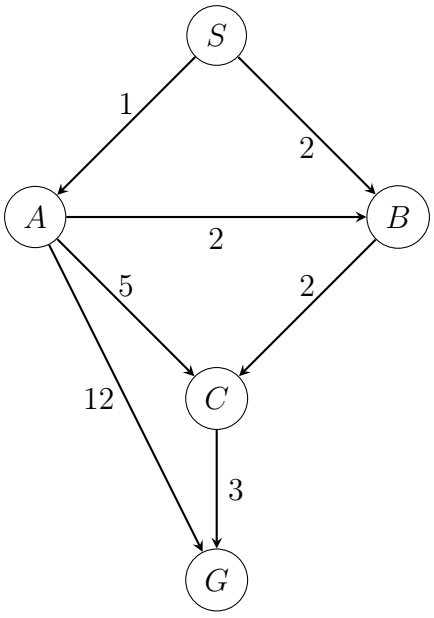

Figure 10: A* Problem

REMOVE ANSWER: The solution is S B C G. Optimal. Because cost for this solution is 7 and there is no other path with less cost. SEE FIGURE 11 for expansion and Queu.

- Expanding — Queue
  S(7)
- S (7) -→ A(1+6,S), **B(4,S)**
- B(4,S) A(7,S), **C(5,SB)**
- C(5,SB) **A(7, S)** , G(7+0,SBC)
- A(7,S) **G(7,SBC)**, G(13, SA),B&C are already in Closed
- G(7,SBC) goal

Soluton path: S B C G

Figure 11: ANSWER A:STAR question(a).

b) Which of the following set of heuristic values provide a consistent heuristic for this problem (Figure 10)? Choose one of the options below.

1. $\{h(S) = 7, h(A) = 6, h(B) = 2, h(C) = 1, h(G) = 0\}$
2. $\{h(S) = 7, h(A) = 6, h(B) = 2, h(C) = 2, h(G) = 0\}$
3. $\{h(S) = 7, h(A) = 6, h(B) = 4, h(C) = 2, h(G) = 0\}$
4. $\{h(S) = 7, h(A) = 4, h(B) = 4, h(C) = 4, h(G) = 0\}$
5. None of the above. IMPORTANT: Note that for consistency, every pair of adjacent nodes (node that have direct connection) schould be checked. Not only between S–>A or A–B but all pairs, and all nodes must be used in these pairs (including G, which is also "a node". Those answers which make part of the Figure consistent but not the entire one will not be accepted as correct.

(ANSWER: 5, None of the above. For example $\{h(S) = 7, h(A) = 6, h(B) = 2, h(C) = 1, h(G) = 0\}$ is not consistent because for example h(A)-h(B)=4 is not $\leq$ C(A,B)=2). Remember that for consistency, h(n)-h(n«) $\leq$ C(n, n«), should be true throughout the graph

c) Write down a consistent heuristic set and apply A* graph search with it on the same graph (Figure 10). What is the solution path with this heuristic set? You don't get any points by writing only the optimal solution if it is not accompanied with a consistent set of heuristics. One consistent set is: $\{h(S) = 7, h(A) = 6, h(B) = 5, h(C) = 3, h(G) = 0\}$.

Check for h(n)-h(n′) ≤ C(n, n′) condition for consistency. Solution is SBCG.

d) Uniform cost Seach is a special case of A-star. True or False?

ANSWER: True, the case where (h = 0)

e) Simulated annealing is a stochastic optimization method. True or False?

ANSWER: True

Problem 5 (15 points. Division: 3-2-2-3-2-3, and -1 for each wrong answer. Sum of the points will not be negative for the whole problem.)

This is a combination of multiple-choice and True/False types of task. Choose the correct answer for each question.

a) "Men and women are welcome to apply." is equivalent to

$\forall(x)$ [(M(x) $\wedge$ W(x)) $\implies$ Apply(x)]

ANSWER: False. The FOL sentence says that everything that is both a man and a woman is welcome to apply, obviously not what is meant. The disjunction would give a correct one

b) Which of the following represents the sentence "Some person plays every game"?

1. $\exists x \forall y[Person(x) \wedge Game(y) \rightarrow Plays(x, y)]$
2. $\exists x \forall y[Person(x) \wedge Game(y) \wedge Plays(x, y)]$
3. $\forall x \forall y[Person(x) \wedge [Game(y) \rightarrow Plays(x, y)]]$
4. $\exists x \forall y[Person(x) \wedge [Game(y) \rightarrow Plays(x, y)]]$
5. None of the above.
   ANSWER: 4. $\exists x \forall y[Person(x) \wedge [Game(y) \rightarrow Plays(x, y)]]$.

c) Which of the following is the Skolemized version of this sentence:
$\forall x[(\neg P(x) \wedge Q(x)) \vee \exists y(R(x, y) \wedge T(y)))]$

1. $\forall x[\neg P(x) \wedge Q(x) \vee (R(f(x), y) \wedge T(y)))]$
2. $\forall x[P(x) \wedge \neg Q(x) \vee (R(x, f(x)) \wedge T(f(x)))]$
3. $\forall x[\neg P(x) \wedge Q(x) \vee (R(x, f(x)) \wedge T(f(x)))]$
4. $\forall x[\neg P(x) \wedge Q(x) \vee (R(x, x) \wedge T(x)))]$
5. None of the above.

ANSWER: 3.

$\forall x[\neg P(x) \wedge Q(x) \vee (R(x, f(x)) \wedge T(f(x)))]$.

d) For the sentence below, write V=valid if the sentence is valid, U=unsatisfiable if the sentence is unsatisfiable and S=satisfiable if the sentence is satisfiable but not valid.

1. $\forall x[[Student(x) \wedge \neg Student(x)] \rightarrow BornOn(x, Moon)]$

ANSWER: Valid. Because the antecedent is false.

e) Apply one step resolution to the following clauses: $p \vee q$ and $\neg p \vee \neg q$. Which of the below is the correct result of the resolution step.

1. $\{p, \neg p\}$ and $\{q, \neg q\}$
2. $\{\}$

(ANSWER: $\{p, \neg p\}$ and $\{q, \neg q\}$ is correct. Because when two clauses have multiple pairs of complementary literals, only one pair of literals may be resolved at a time.)

f) You will convert the folllowing sentence into Conjunctive Normal form.
$(A \wedge B) \vee (C \wedge D) \vee (E \implies F)$

Which one is the resultant CNF?

1. $(A \vee C) \wedge (B \vee C) \wedge (A \vee D) \wedge (B \vee D \vee \neg E \vee F)$
2. $(A \vee C) \vee (B \vee C) \vee (A \vee D) \wedge (B \vee D \vee \neg E \vee F)$
3. $(A \vee C) \wedge (B \vee C) \wedge (A \vee D) \wedge (B \vee D \vee E \vee F)$
4. $(A \vee C \vee \neg E \vee F) \wedge (A \vee D \vee \neg E \vee F) \wedge (B \vee D \vee E \vee F) \wedge (B \vee C \vee E \vee F)$
5. none of the above

ANSWER: None of the above. Cot«rrect answer: $(A \vee C \vee \neg E \vee F) \wedge (A \vee D \vee \neg E \vee F) \wedge (B \vee D \vee \neg E \vee F) \wedge (B \vee C \vee \neg E \vee F)$

Problem 6 (20 points. Each question is 2 points. -1 for each wrong answer but the total points will not be negative.)

True/False type of questions. Answer with either True(T) or False(F)

a) Randomized behaviour may be rational in competitive multi-agent environments.

ANSWER: TRUE, in competitive multi-agent environments it can avoid the pitfalls of predictability

b) There exists a task environment in which every agent is rational.

ANSWER: True. Consider a task environment in which all actions (including no action) give the same, equal reward

c) Philosopher John Searle suggests that any physical symbol system has necessary and sufficient means for general intelligent action. True or False?

ANSWER: False. This is suggested by Alan Newel and Herbert Simon. Searle suggested the opposite

d) If h is a consistent heuristic, then h is also an admissible heuristic. True or False? ANSWER: True.

e) Purely reactive agents use semantic networks for planning. True or False?

ANSWER: False .

f) Backgammon is a fully observable, sequential, deterministic, static, dicrete and multi-agent environment. True or False?

ANSWER: False not deterministic .

g) Circumscription allows the entailed sentences to be removed after new sentences added to the knowledge base. ANSWER: True

h) "Multiple inheritance" is one of the reasons that leads to undecidability problem in first order logic. True or False?

ANSWER: False. It is not in logic but semantic networks

i) "Closed world assumption" is the assumption that atomic sentences not known to be true are in fact false.

ANSWER: True

j) Two agents participate in a game which is defined as follows:

Agents. {Agent-i, Agent-j}
Actions: {0,100,200,300} - these actions can be thought as giving bid in an auction for

Agent i \ Agent j	0	100	200	300
0	**300,0**	**200,0**	**0,100**	**0,0**
100	200,0	200,0	200,100	0,300
200	0,0	0,200	0,0	0,0
300	-100,0	-100,0	-100,0	-100,0

Figure 12: Game theory question

example.
The Payoff matrix is shown in Figure 12 .

Which of the options below is the strongly dominant equilibrium in this game? Each option shows the pair of actions, (action of agent-i, action of agent-j):

1. (0, 100)
2. (200, 200)
3. (300,0)
4. (300,100)
5. None of the above

ANSWER: None of the above. There is no strongly dominan equilibrium in this payoff matrix .

Problem 7 (20pts- division of points: 3-3-3-3-2-2-2-2. Minus point: -1 for each wrong answer)

Multiple Choice or True/False type of tasks. .

a) In situation calculus, something true in one situation may not be true in another situation. True or False?

ANSWER: True

b) The following plan describes the process of withdrawing money from an ATM. Which of the representations is written in STRIPS?

1. Action (withdraw(cash),
   PRECOND: At(ATM) ∧ Sells(ATM, cash, person) ∧ hasMoneyOnAccount (person)
   DELETE-LIST: hasMoneyOnAccount (person)
   ADD-LIST: have (cash))
2. Action (withdraw(cash),
   PRECOND: At(ATM) ∧ Sells(ATM, cash, person) ∧ hasMoneyOnAccount (person)
   EFFECT: ¬ hasMoneyOnAccount (person) ∧ have (cash))

ANSWER: 1

c) Which statements about partial order planning are true?

1. Search in plan space and use least commitment when possible.
2. Make only choices that are relevant to solving the current part of the problem.
3. Both of the above.
4. None of the above.

ANSWER: 3

d) Progression planners reason from the goal state, trying to find the actions that will lead to the start state. True or False?

ANSWER: False. That is regression planner.

e) In Medieval Europe, Latin worked as the Lingua Franca. Today English has taken over that role, obviously giving an advantage to persons who have it as mother tongue. There have been attempts to create artificial human languages (e.g., Esperanto and Interlingua) that would not give anybody such an advantage, but those languages have not been very successful. Suppose you were given the task of creating such as language. Which of the following would say say would be most important to try to restrict:

1. The lexicon.
2. The grammar.
3. Ambiguity.
4. Redundancy

ANSWER: 2 or 3

f) Two search engines were evaluated on a web search query. Engine A returned 27 web pages, 18 of which were deemed relevant to the query. Engine B returned 9 pages, all of which were relevant to the query. Which of the following statements is definitely correct?

1. System A had a higher recall than system B.
2. System B had a higher precision than system A.
3. System B had a higher F1-score than system A.
4. System A had a better performance than system B.

ANSWER: 2

g) When performing sentiment analysis, it is normally important to find out:

1. Who the opinion holder is.
2. What object the opinion is expressed on.
3. If the opinion is positive, negative or neutral.
4. All of the above.

ANSWER: 3

h) Which of the following statements is not correct?

1. The distributional hypothesis assumes that words with similar usage have similar meanings.
2. The bag of words model ignores the grammatical structure of the language.
3. An n-gram model is an example of a language model.
4. Grounding means that a speaker defines the basis for a dialogue.

ANSWER: 4

LYKKE TIL!