LE/EECS 4401/5326 3.0 Artificial Intelligence — Dept. of Electrical Eng. & Computer Sci.
GS/EECS 5326 3.0 Topics in Artificial Intelligence — York University — Winter 2022

Deferred Final Examination — May 13, 2022

Duration: 120 minutes
No Aids Allowed
Total marks: 75

Name:

Student Number:

1)	/5
2)	/5
3)	/5
4)	/5
5)	/5
6)	/15
7)	/10
8)	/10
9)	/15
Total	/75

1. [5 points] Is entailment under the closed-world assumption *monotonic*? Justify your answer.

2. [5 points] Explain how STRIPS deals with the *frame problem*.

3. [5 points] A popular fragment of first-order logic is *Horn clauses*. What is a Horn clause? What are the expressive limitations of Horn clauses knowledge bases? That is, what kind of knowledge cannot be expressed using Horn clauses?

4. [5 points] Consider an undiscounted MDP with states s_0, s_1, s_2, s_3, and s_4, where s_0 is the starting state, and s_3 and s_4 are terminal states. The reward in s_4 is $+1$, in s_3 it is -1, and in all other states it is 0. Action a is only possible in s_0 and leads to s_1 with probability 0.6 and to s_2 with probability 0.4. Action b is possible in s_1 and leads to s_3 with probability 0.8 and to s_4 with probability 0.2; it is also possible in s_2 and leads to s_3 with probability 0.1 and to s_4 with probability 0.9. Action c is possible in s_1 and leads to s_3 with probability 0.3 and to s_4 with probability 0.7; it is also possible in s_2 and leads to s_3 with probability 0.6 and to s_4 with probability 0.4. (No actions are possible in the terminal states.)

   What is the expected value of the policy π where $\pi(s_0) = a$, $\pi(s_1) = c$, and $\pi(s_2) = b$? Show how you compute this value.

5. [5 points] Show using logical interpretations that $\exists x.(P(x) \vee Q(x))$ does *not* logically entail $\exists x.P(x)$. Give a detailed argument.

6. [15 points] Assume the following facts:

(1) John likes all desserts.

(2) Chocolate cake is a dessert.

(3) Apple pie is a dessert.

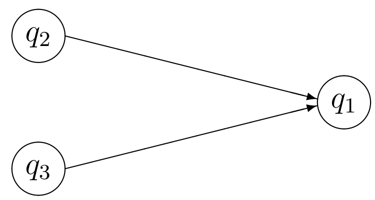
(4) Mary does not like chocolate cake.

(a) For each fact, give its translation in first-order logic.

(b) Convert all of the above facts into clausal form.

(c) Use resolution to answer the question “What dessert does John like that Mary does not like?”. Indicate clearly which clauses are resolved and what substitutions are used.

7. [10 points] Suppose that we have the following belief network (or Bayes net):



(a) Give an example of an independence assumption that is implicit in this network (write it formally).

(b) What are the 6 conditional probabilities that need to be specified to fully determine the joint probability distribution?

(c) Express $Pr(q_1|q_3)$ in terms of the 6 conditional probabilities given in your answer to the previous question.

8. [10 points] Consider the following STRIPS actions:

Action Name	Preconditions	Add Effects	Delete Effects
A	p	r	-
B	-	p	-
C	o	-	o
D	p	q	r

Suppose that the start state is $S_0 = \{o\}$ and the goal is $G = \{p, q, r, o\}$.

(a) Which actions are applicable in the start state S_0? What is the new state for each of the applicable actions?

(b) Suppose we want to do backward/regression planning. Which actions are consistent with the goal G? What is the regressed goal for all the consistent actions?

(c) Give a sequence of actions that achieves the goal G when executed in the starting state S_0.

9. [15 points] Consider the following dynamic domain, to be specified in the situation calculus. Suppose that we have a fluent $IsOpen(x, s)$ that is true if and only if door x is open in situation s and another fluent $IsLocked(x, s)$ that is true if and only if door x is locked in situation s. Suppose also that we have an action $open(x)$ whose only effect is to open a closed (i.e., not open) door x provided that x is not locked, as well as an action $close(x)$ whose only effect is to close an open door x. $open(x)$ can be executed whenever door x is open and $close(x)$ can be executed whenever door x is closed. Performing $open(x)$ when door x is locked has no effect. Finally, assume that these are the only actions that affect the fluent $IsOpen$.

a) Write effect axioms for the actions $open$ and $close$; your axioms should capture all the effects of the actions.

b) Write frame axiom(s) for the action $open$ and the fluent $IsOpen$; your axioms should handle all cases where the fluent does not change when $open$ is performed.

c) Write a successor state axiom for the fluent $IsOpen(x, s)$.

d) Suppose that the that doors $D1$ and $D2$ are both closed (i.e., not open) and unlocked initially. Write a sentence in the situation calculus that represents the *planning task* for the goal of having both $D1$ and $D2$ open.

e) Write a ground situation term that represents a plan that is achieves the goal of having both $D1$ and $D2$ open in an initial situation as described above.

f) This domain cannot be represented directly in STRIPS. Briefly explain why. Also describe how you could change the language to allow the domain to be represented in STRIPS.