Midterm 2 Exam

**CSCI 561 Fall 2016: Artificial Intelligence**

Student ID: | | | | | | | | | | |

Last Name: ___________________________________________

First Name: ___________________________________________

USC email: | | | | | | | | | @usc.edu

## Instructions:

1. Date: **11/04/2016 from 3:00 pm – 4:50 pm in SGM-123/124/101**
2. Maximum credits/points/percentage for this midterm: 100
3. The percentages for each question are indicated in square brackets [ ] near the question.
4. **No books** (or any other material) are allowed.
5. **Write down your name, student ID and USC email address.**
6. **Your exam will be scanned and uploaded online.**
7. **Write within the boxes provided for your answers.**
8. **Do NOT write on the 2D barcode.**
9. **The back of the pages will not be graded. You may use it for scratch paper.**
10. No questions during the exam. **If something is unclear to you, write that in your exam.**
11. **Be brief: a few words are often enough if they are precise and use the correct vocabulary studied in class.**
12. When finished, raise completed exam sheets until approached by proctor.
13. **Adhere to the Academic Integrity code.**

| **Problems** | **100 Percent total** |
|---|---|
| 1- English vs Logic | 20 |
| 2- Logic conversion to CNF | 20 |
| 3- Propositional Proof | 10 |
| 4- Fuzzy logic | 15 |
| 5- Planning | 15 |
| 6- FOL resolution proof | 20 |

## 1. [20%] English vs Logic

For each question below, please answer by circling either True (T) or False (F). For sentences in English, make your judgment of the meaning of the sentence, i.e., you may want to translate it to FOL to conclude.

a. [2%] [T] or [**F**]: "Bert and Ernie are brothers" is equivalent to "Bert is a brother and Ernie is a brother"

b. [2%] [T] or [**F**]: “p and q are not both true” is equivalent to “p and q are both not true”

c. [2%] **[T]** or [F]: “Neither p nor q” is equivalent to “both p and q are false”

d. [2%] [**T**] or [F]: “Not all A’s are B’s” is equivalent to “□ x, A(x) □ ¬B(x) ”

e. [2%] [T] or [**F**]: "Men and women are welcome to apply" is equivalent to
“□ x, Man(x)□ Woman(x) □ WelcomeToApply(x)”

f. [2%] [**T**] or [F]: “Every dog chases some cat”, where “some cat” means “some cat or another” (i.e., not a same particular cat that is chased by all dogs), is equivalent to “□ x, Dog(x) □ □ y, Cat(y) □ Chases(x, y)”

**For the following questions, we define the predicate Attract as a relation from x to y, i.e., Attract(x, y) means that x attracts y.**

g. [2%] [**T**] or [F]: “Everything attracts something”, where “something” means “something or other”, is equivalent to “□ x, □ y, Attract(x, y) ”

h. [2%] [T] or [**F**]: “Something is attracted by everything”, where “something” means “something in particular”, is equivalent to “□ y, □ x, Attract( x, y) ”

i. [2%] [**T**] or [F]: “Everything is attracted by something”, where “something” means “something or other”, is equivalent to “□ x, □ y, Attract(x, y) ”

j. [2%] [T] or [**F**]: “Something attract everything”, where “something” means “something in particular”, is equivalent to “□ x, □ y, Attract( x, y) ”

## 2. [20%] Logic conversion to CNF

Convert the sentence $(\forall x)(P(x) \Rightarrow ((\forall y)(P(y) \Rightarrow P(f(x,y))) \wedge \neg(\forall y)(Q(x,y) \Rightarrow P(y))))$ to conjunctive normal form (CNF).

Steps as shown in class lectures (interim steps not shown)

Some common deductions in partial credit include but are not limited to:

1) Not standardized. -2
2) While eliminating existential quantification not putting the variable as function of x. -2
3) ~P(x) missing in last two terms because of wrongly putting the brackets. -3

$$\neg P(x) \vee \neg P(y) \vee P(f(x,y)),\ \neg P(z) \vee Q(z, g(z)),$$
$$\neg P(w) \vee \neg P(g(w))$$

## 3. [10%] Propositional proof

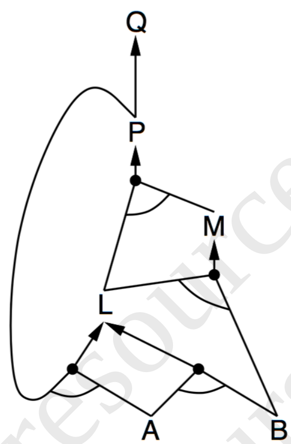
Consider the following propositional logic knowledge base:

$P \Rightarrow Q$
$L \wedge M \Rightarrow P$
$B \wedge L \Rightarrow M$
$A \wedge P \Rightarrow L$
$A \wedge B \Rightarrow L$
$A$
$B$

Using **backward chaining** and **Modus Ponens**, please prove **Q**. Please only use the Modus Ponens inference rule. You will lose points if you use any other rule. Please draw a graph that shows your backward-chaining proof, showing clearly all Modus Ponens steps, to which sentences they apply, and which sentences result.

Solution:

$P \Rightarrow Q$
$L \wedge M \Rightarrow P$
$B \wedge L \Rightarrow M$
$A \wedge P \Rightarrow L$
$A \wedge B \Rightarrow L$
$A$
$B$




Rubric and partial credit:

Backward chaining can be viewed as a search on an and-or tree.
1. Attempted to prove Q by using the correct rule with or without a finished proving on this node (proposition symbol), 2 points. No partial credit.
2. Attempted to prove P, M, A, B by using the correct rule with or without a finished proving on this node (proposition symbol), 1 point each. No partial credit.
3. Avoid loop in the process of proving L, or correctly marked it as an infinite loop and use the correct rule instead, 2 points.
   Partial credits:
      Proved L in the correct way but claimed the infinite loop is true, 1 point.
4.. Expressed the idea of AND search. 2 points. Expressing AND search includes using standard graph notation, citing the rules, and all other forms of expressing AND search.

Special circumstances:
1. Pointed out the infinite loop issue, but did not give any alternative ways yield the solution, 8 points. But if did not express the idea of AND search, 6 points.
2. Used Forward Chaining and finished proving, 5 points. No partial credits for incomplete proving.
3. Used Resolution and finished proving, 3 points. No partial credits for incomplete proving.
4. Cannot be recognized as forward chaining, backward chaining, and resolution algorithms. 0 point.

# 4. [15%] Fuzzy logic

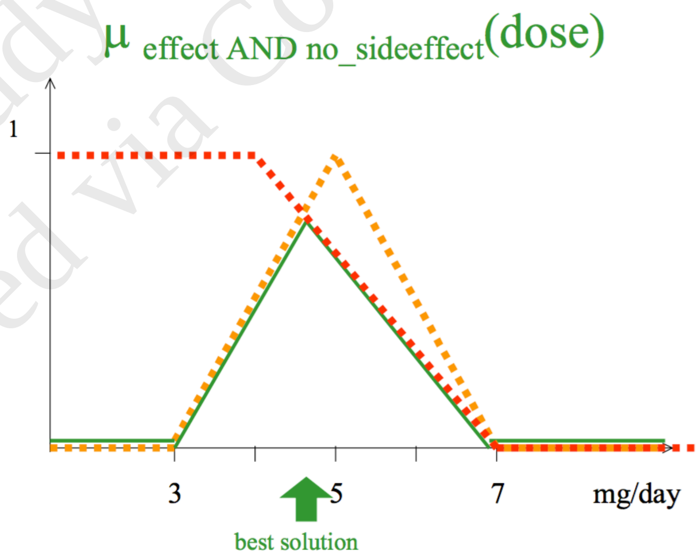
Solve the following problem
using fuzzy logic:

A certain drug is found to be effective only when given in doses between 3 and 7 mg per day with maximum efficiency at 5 mg per day. Unfortunately, it has some harmful side-effects. Side-effects never appear at doses below 4 mg/day, sometimes appear between 4 and 7 mg/day, and are always present at doses above 7 mg/day.

**Which dose is the best compromise between effect and side-effects?**

Please draw your answer approximately by defining fuzzy concepts and operating on them. Please indicate clearly which curve correspond to which concept, or you will lose points. It is not necessary to be very accurate, but your answer should be logically correct.

*Hint: This question is quite simple and does not require you to apply all of the steps of fuzzy logic studied in class. You should be able to provide an answer simply by defining fuzzy concepts for **effect** and **side-effect**, then drawing a fuzzy set that combines these logically to represent the question, finally deriving your answer from the point of highest membership in that set.*




Partial credit may be awarded for partially correct answers.
In general, two lines should be put together into one drawing, if not -5 points.

## 5. [15%] Planning

Consider the following partial order planning (POP) problem: We have a robot that tries to fill bins with packages. Each bin holds at most one package.

- $F(x, y)$: True if and only if package $x$ **fits** into bin $y$.
- $E(y)$: True if and only if bin $y$ is **empty**.
- $P(x)$: True if and only if package $x$ is **packed** into some bin.
- $In(x, y)$: True if and only if package $x$ is **in** bin $y$.

Let us now consider two packages, A and B, and two bins, 1 and 2.
The initial state of our problem is **{ F(A, 1), F(A, 2), F(B, 2), In(A, 2), P(A), E(1) }.**

The following actions are available to our robot:

$Place(x, y)$: This places package $x$ into bin $y$, and so it must update $E$, $P$ and $In$. This action can occur only if $x$ fits into $y$, $x$ is not in any bin and $y$ is empty.

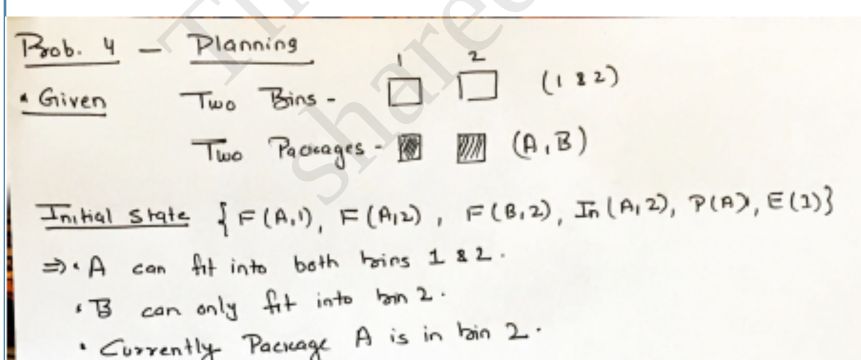
$Remove(x, y)$: This removes package $x$ from bin $y$, and so it must update $E$, $P$ and $In$. This action can occur only if $x$ is in bin $y$.

In the final state, **both packages should be packed** (in bins).

Using the same conventions as we used in the lectures, please draw a plan that takes us from the initial state to the final state. Make sure that you clearly mark: each action (plan step) in a box, with all preconditions listed above it and all effects listed below it. Solid arrows should point from an effect to precondition to indicate causal links (you will lose points if your arrows only loosely point from one step to another). Dashed arrows should be used to indicate ordering constraints (if any).

Partial Credit Criteria:

1) All Plan actions correct - 6 Marks(2 each)
2) 4.5 marks for precondition(1.5 for each action)
3) Effect/Postcondition - All E, P ,In must be updated after Place and Remove. For each missing update for E, P, In - deduct 0.5 marks.


Prob. 4 — Planning
• Given Two Bins - 1 2 (1 & 2)
Two Packages - (A, B)
Initial state {F(A,1), F(A,2), F(B,2), In(A,2), P(A), E(1)}
⇒ • A can fit into both bins 1 & 2.
• B can only fit into bin 2.
• Currently Package A is in bin 2.

Solution on next page.

Solution:- We have three simple steps.

(1) Remove A from bin 2 so that 2 gets empty.

(2) Place B into bin 2. (Steps 2 & 3 can follow any order).

(3) Place A into bin 1.

With Precondition, Action, Postcondition/Effects :-

(1) Precondition:- P(A), In(A,2), !E(2)

Action → Remove(A,2)

Effect → !P(A), E(2), !In(A,2)

(2) Precondition:- F(B,2), !P(B), E(2)

Action:- Place(B,2)

Postcondition:- P(B), In(B,2), !E(2),

(3) Precondition:- F(A,1), !P(A), E(1)

Action – Place(A,1)

Effect – P(A), !E(1), In(A,1)

Plan Diagram

P(A), In(A,2), !E(2), F(A,1), F(B,2), !P(B)

↓

$\boxed{\text{Remove(A,2)}}$

↓

!P(A), E(2), !In(A,2), F(A,1), F(B,2), !P(B)

↓

$\boxed{\text{Place(B,2)}}$

↓

P(B), In(B,2), !E(2), F(A,1), !P(A), E(1)

↓

$\boxed{\text{Place(A,1)}}$

↓

P(A), P(B), In(A,1), In(B,2), !E(1), !E(2).

## 6. [20%] FOL Resolution Proof

Given the following sentences in first-order logic (FOL):

1. □ x, y, On(x, y) □ Above(x, y)
2. □ x, y, z, On(x, y)□ Above(y, z) □ Above(x, z)
3. □ x, On(A, x) □ On(x, C)

we wish to prove **Above(A, C)** using the **resolution** inference rule and a **proof by contradiction** (refutation).

a. [9%] Convert sentences 1, 2 and 3 to CNF (partial credit 2 pts for 1, 3 pts for 2, 2 pts for 3a and 2 pts for 3b):

$$1.\ \neg On(x,y) \lor Above(x,y)$$
$$2.\ \neg On(x,y) \lor \neg Above(y,z) \lor Above(x,z)$$
$$3a.\ On(A,F)$$
$$3b.\ On(F,C)$$

b. [11%] Draw your resolution proof. Only use the resolution inference rule, as you will lose points if you use any other rule. Please clearly show which sentences are resolved and what results. If unification is used at any step, please show the substitution, or you will lose points for each missing substitution.

(partial credit 2 pts for 4, 2 pts for 5, 2 pts for 6 and 3 pts for 7):

$$4.\ \neg Above(A,C)$$
$$5 = 2 + 4.\ \neg On(A,y) \lor \neg Above(y,C)$$
$$6 = 3a + 5.\ \neg Above(F,C)$$
$$7 = 1 + 3b.\ Above(F,C)$$
$$8 = 6 + 7.\ false$$