Your grades for **midterm 2**

Total Score: **95.0**

CSCI561 - Foundations of Artificial Intelligence (20163-CSCI561)

Summary

Class scores distribution

Total (/score/f1036357-b1d3-4607-8153-6a0346e58065)

Q1 (/score/f1036357-b1d3-4607-8153-6a0346e58065/Q1)

Q2 (/score/f1036357-b1d3-4607-8153-6a0346e58065/Q2)

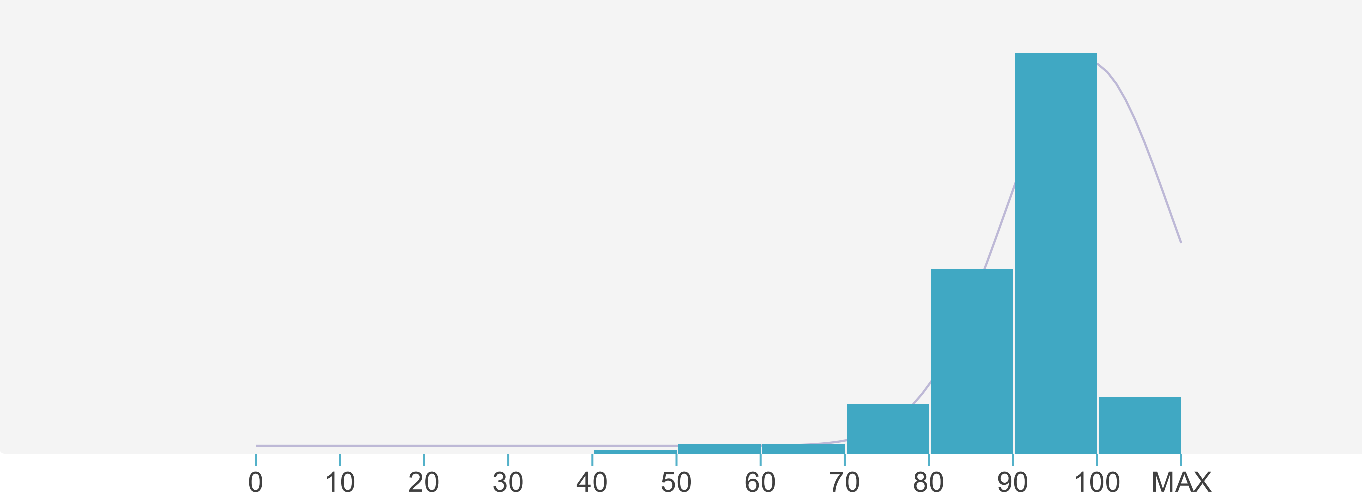
Q3 (/score/f1036357-b1d3-4607-8153-6a0346e58065/Q3)

Q4 (/score/f1036357-b1d3-4607-8153-6a0346e58065/Q4)

Q5 (/score/f1036357-b1d3-4607-8153-6a0346e58065/Q5)

Q6 (/score/f1036357-b1d3-4607-8153-6a0346e58065/Q6)

Students: 521 Median: 92 Mean: 89.89 Std. Dev: 8.938



Q1 Score: **18.0**

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 "$\exists x, A(x) \land \neg B(x)$"

e. [2%] [T] or [F]: "Men and women are welcome to apply" is equivalent to "$\forall x, Man(x) \land Woman(x) \Rightarrow WelcomeToApply(x)$"

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 "$\forall x, Dog(x) \Rightarrow \exists y, Cat(y) \land Chases(x, y)$"

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 "$\forall x, \exists y, Attract(x, y)$"

h. [2%] [T] or [F]: "Something is attracted by everything", where "something" means "something in particular", is equivalent to "$\exists y, \exists x, Attract(x, y)$"

i. [2%] [T] or [F]: "Everything is attracted by something", where "something" means "something or other", is equivalent to "$\exists x, \forall y, Attract(x, y)$"

j. [2%] [T] or [F]: "Something attract everything", where "something" means "something in particular", is equivalent to "$\exists x, \exists y, Attract(x, y)$"

Q2 Score: **18.0**

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).

$(\forall x)\Big(P(x) \Rightarrow \big((\forall y)(\sim P(y) \vee P(f(x,y))) \wedge \sim(\forall y)(\sim Q(x,y) \vee P(y))\big)\Big)$

$\therefore$ (~~impl~~ implication removed)

$(\forall x)\big(P(x) \Rightarrow ((\forall y)(\sim P(y) \vee P(f(x,y))) \wedge (\forall y)(Q(x,y) \wedge \sim P(y)))\big)$

($\therefore$ inwarding negation)

$(\forall x)\big(P(x) \Rightarrow ((\forall y)(\sim P(y) \vee P(f(x,y))) \wedge (\forall z)(Q(x,z) \wedge \sim P(z)))\big)$

(generalization.

$(\forall x)\Big(\sim P(x) \vee \big[(\forall y)(\sim P(y) \vee P(f(x,y))) \wedge (\forall z)(Q(x,z) \wedge \sim P(z))\big]\Big)$

(other ($\Rightarrow$) removed.

$(\forall x)\Big(\sim P(x) \vee \big((\forall y)(\forall z)(\sim P(y) \vee P(f(x,y))) \wedge (Q(x,z) \wedge \sim P(z))\big)\Big)$

$\forall x, \forall y, \forall z\ (\sim P(x) \vee \sim P(y) \vee P(f(x,y))) \wedge (\sim P(x) \vee (Q(x,z) \wedge \sim P(z)))$

$\forall x, \forall y, \forall z\ (\sim P(x) \vee \sim P(y) \vee P(f(x,y))) \wedge (\sim P(x) \vee Q(x,z)) \wedge (\sim P(x) \vee \sim P(z))$

$(\sim P(x) \vee \sim P(y) \vee P(f(x,y))) \wedge (\sim P(x) \vee Q(x,z)) \wedge (\sim P(x) \vee \sim P(z))$

(removing universal ~~quantifier~~ quantifier)

z should be a function of x

1. $\sim P(x) \vee \sim P(y) \vee P(f(x,y))$
2. $\sim P(x) \vee Q(x,z)$
3. $\sim P(x) \vee \sim P(z)$

(removing 'and' ~~conjn~~)

$\therefore$ These statement are in CNF

Q3 Score: **10.0**

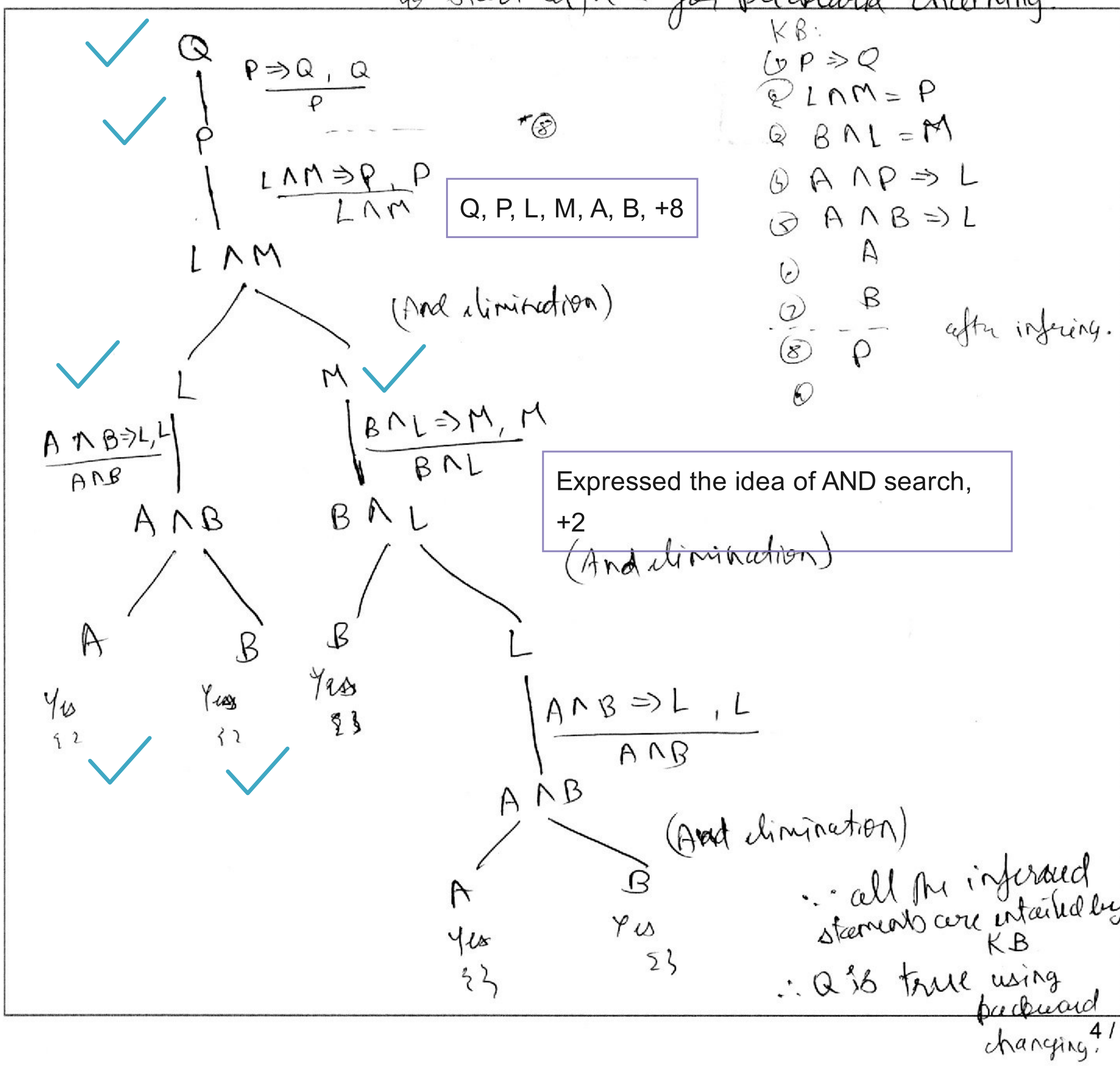
3. [10%] Propositional proof

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.

we start with Q for backward chaining.



Q, P, L, M, A, B, +8

Expressed the idea of AND search, +2

Q4 Score: **15.0**

4. [15%] Fuzzy logic

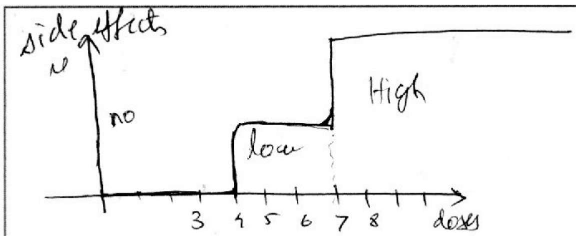
Solve the following problem using fuzzy logic:

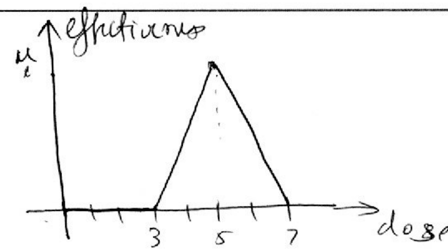
A certain drug is found to be effective only when given in doses between 3 and 7 mg per day with maximum efficiency at 5 mg per day. Unfortunately, it has some harmful side-effects. Side-effects never appear at doses below 4 mg/day, sometimes appear between 4 and 7 mg/day, and are always present at doses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

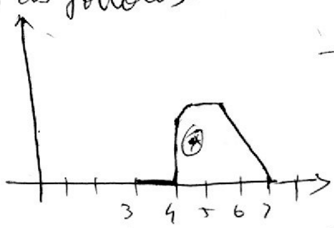




no side effect from 0 - 4 mg/day
low side effects from 4-7 mg/day
high sid effects from 7+ mg/day.

effectiveness b/w 3 - 7 mg/day
no effectiveness b/w 0-3
& 7+ mg/day

* so the aggregated graph with both effects & side effects between 3 - 7 mg/day is as follows. (∵ 3-7 is effective)



Thus defuzzification (ie center of mass of this figure will give us the best compromise between effect & side effect.
∴ The best dose would be between 4-5 mg/day leaning towards 5
eg: 4.9 mg/day would be ideal.

Q5 Score: **14.0**

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) }.**

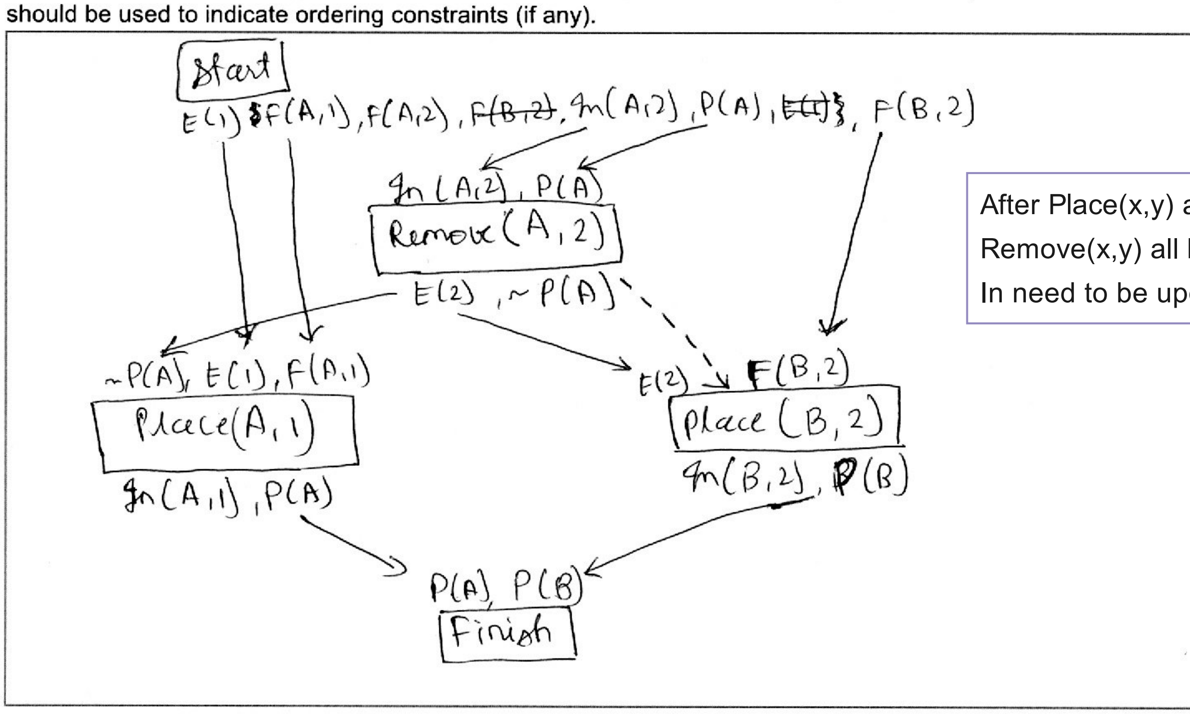
The following actions are available to our robot:

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).



After Place(x,y) and Remove(x,y) all E,P and In need to be updated.

Q6 Score: **20.0**

6. [20%] FOL Resolution Proof

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

1. $\forall x, y, On(x, y) \Rightarrow Above(x, y)$
2. $\forall x, y, z, On(x, y) \land Above(y, z) \Rightarrow Above(x, z)$
3. $\exists x, On(A, x) \land On(x, C)$

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:

① $\sim On(x, y) \lor Above(x, y)$

② $\sim On(x, y) \lor \sim Above(y, z) \lor Above(x, z)$

③ ⓐ $On(A, B)$

ⓑ $On(B, C)$

(B is a skolem constant to remove existential quantifier)

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.

we have to prove Above(A, C) ∴ we add $\sim Above(A, C)$ to KB.

$\sim Above(A, C)$ + $\sim On(x, y) \lor \sim Above(y, z) \lor Above(x, z)$ ②

$\{x/A, z/C\}$

$\sim On(A, y) \lor \sim Above(y, C)$ + $On(A, B)$ (3a)

$\{y/B\}$

$\sim Above(B, C)$ + $\sim(On(x, y)) \lor (Above(x, y))$ ①

$\{x/B, y/C\}$

$\sim On(B, C)$ + $On(B, C)$ (3b)

Null
{}

∴ We get null at end
∴ our assumption of $\sim Above(A, C)$ was wrong ∴ $\boxed{Above(A, C)}$