HW6

Graded

Student

SAMUEL PHAM

Total Points

100 / 100 pts

Question 1

Q1

25 / 25 pts

✔ **– 0 pts** Correct

Question 2

Q2

75 / 75 pts

✔ **– 0 pts** Correct

Question 3

Points Adjustments

0 / 0 pts

✔ **– 0 pts** N/A

Question assigned to the following page: 1

1. (25 pts) For each pair of atomic sentences, provide the most general unifier if it exists:

(a) P(A, A, B), P(x, y, z)
(b) Q(y, G(A, B)), Q(G(x, x), y)
(c) R(x, A, z), R(B, y, z)
(d) Older(Father(y), y), Older(Father(x), John)
(e) Knows(Father(y), y), Knows(x, x)

a) $\theta = \{x/A, y/A, z/B\}$

b) A can't be unified w/ B → Fail to unify

c) $\theta = \{x/B, y/A\}$

d) $\theta = \{y/John, x/John\}$

e) Knows(Father(y), y) Knows(x, x)

$x/Father(y)$ — Fail here

→ Fail to unify

Question assigned to the following page: 2

2. (75 pts) Consider the following sentences:

1. • John likes all kinds of food.
2. • Apples are food.
3. • Chicken is food.
4. • Anything someone eats and isn't killed by is food.
5. • If you are killed by something, you are not alive.
6. • Bill eats peanuts and is still alive.*
7. • Sue eats everything Bill eats.

(a) Translate these sentences into formulas in first-order logic.
(b) Convert the formulas of part (a) into CNF (also called clausal form).
(c) Prove that John likes peanuts using resolution.
(d) Use resolution to answer the question, "What does Sue eat?"
(e) Use resolution to answer (d) if, instead of the axiom marked with an asterisk (*) above, we had:
- If you don't eat, you die.
- If you die, you are not alive.
- Bill is alive.

a)

1) $\forall x \; Food(x) \Rightarrow Likes(John, x)$
2) $Food(Apples)$
3) $Food(Chicken)$
4) $\forall x \; [\exists y \; Eats(y, x) \wedge \neg Killed(y, x)] \Rightarrow Food(x)$
5) $\forall x \; [\exists y \; Killed(y, x)] \Rightarrow \neg Alive(y)$
6) $Eats(Bill, Peanuts) \wedge Alive(Bill)$
7) $\forall x \; [Eats(Bill, x)] \Rightarrow Eats(Sue, x)$

b)

① Eliminate $\Rightarrow$

1) $\forall x \; \neg Food(x) \vee Likes(John, x)$
4) $\forall x \; \neg[\exists y \; Eats(y, x) \wedge \neg Killed(y, x)] \vee Food(x)$
5) $\forall x \; \neg[\exists y \; Killed(y, x)] \vee \neg Alive(y)$
7) $\forall x \; \neg[Eats(Bill, x)] \vee Eats(Sue, x)$

② Move $\neg$

4) $\forall x \; [\forall y \; \neg Eats(y, x) \vee Killed(y, x)] \vee Food(x)$
5) $\forall x \; [\forall y \; \neg Killed(y, x)] \vee \neg Alive(y)$

③ Standardize variables

None

④ Skolemize

None

⑤ Drop universal quantifier

1) $\neg Food(x) \vee Likes(John, x)$
4) $\neg Eats(y, x) \vee Killed(y, x) \vee Food(x)$
5) $\neg Killed(y, x) \vee \neg Alive(y)$
7) $\neg Eats(Bill, x) \vee Eats(Sue, x)$

⑥ Distribute

None

Question assigned to the following page: 2

c)

Query α: John likes Peanuts

Likes (John, Peanuts)

PROVE: $\neg\alpha$

1) ~~$\neg$ Food(x) $\vee$ Likes (John, x)~~
2) Food (Apple)
3) Food (Chicken)
4) ~~$\neg$ Eats(y, x) $\vee$ Killed(y, x) $\vee$ Food(x)~~
5) ~~$\neg$ Killed(y, x) $\vee$ $\neg$ Alive (y)~~
6) ~~Eats(Bill, Peanuts)~~
7) ~~Alive(Bill)~~
8) $\neg$ Eats (Bill, x) $\vee$ Eats(Sue, x)
9) $\neg$ Likes (John, Peanuts)] $\neg\alpha$

~~10)~~	$\neg$ Killed (Bill, x)	$\theta = \{x/Bill\}$	5, 7
~~11)~~	$\neg$ Eats (Bill, x) $\vee$ Food(x)		4, 9
~~12)~~	Food (Peanuts)	$\theta = \{x/Peanuts\}$	6, 10
13)	Likes (John, Peanuts)		1, 11
14)	Empty clause → contradiction		0, 12

→ $\Delta \not\models \neg\alpha$ is unsat

→ $\Delta \models \alpha$

→ Query α is true

d) What does Sue eat?

1) $\neg$ Food(x) $\vee$ Likes (John, x)
2) Food (Apple)
3) Food (Chicken)
4) $\neg$ Eats(y, x) $\vee$ Killed(y, x) $\vee$ Food(x)
5) $\neg$ Killed(y, x) $\vee$ $\neg$ Alive (y)
6) ~~Eats(Bill, Peanuts)~~
7) Alive(Bill)
8) ~~$\neg$ Eats (Bill, x) $\vee$ Eats(Sue, x)~~

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9) Eats (Sue, Peanuts) $\theta = \{x/Peanuts\}$ 6, 8

→ Sue eats Peanuts

e)

If you don't eat, you die

$\forall x \neg[\exists y\ Eat(x, y)] \Rightarrow Die(x)$

$\forall x [\exists y\ Eat(x, y)] \vee Die(x)$

$\forall x\ Eat(x, Fox)) \vee Die(x)$

$Eat(x, Fox)) \vee Die(x)$

If you die, you are not alive

$\forall x\ Die(x) \Rightarrow \neg Alive(x)$

$\neg\forall x\ Die(x) \vee \neg Alive(x)$

$\exists x\ \neg Die(x) \vee \neg Alive(x)$

$\neg Die(x) \vee \neg Alive(x)$

Bill is alive

Alive (Bill)

1) $\neg$ Food(x) $\vee$ Likes (John, x)
2) Food (Apple)
3) Food (Chicken)
4) $\neg$ Eats(y, x) $\vee$ Killed(y, x) $\vee$ Food(x)
5) $\neg$ Killed(y, x) $\vee$ $\neg$ Alive (y)
6) ~~Eat (x, Fox)) $\vee$ Die(x)~~
7) ~~$\neg$ Die(x) $\vee$ $\neg$ Alive(x)~~
8) Alive(Bill)
9) ~~$\neg$ Eats (Bill, x) $\vee$ Eats(Sue, x)~~

~~10)~~	$\neg$ Die(Bill)	$\theta = \{x/Bill\}$	7, 8
~~11)~~	Eat(Bill, Fox))	$\theta = \{x/Fox\}$	6, 10
12)	Eats (Sue, Fox))		9, 11

→ No longer able to derive

→ Unable to answer what Sue eats