SOLUTIONS

CSC 384 Test 5 on KR

Wednesday, December 7, 2022

Last Name: ______________________________

First Name: ______________________________

Email: ______________________________

1. Conceptual Questions (12 marks total)

1.1 Circle all of the following statements that are true: **(5 marks)**

a) A proof procedure that is sound is also complete

b) A proof procedure that is complete is also sound

c) A sound proof procedure will always generate true conclusions

d) A complete proof procedure can generate all true statements

e) Unsound proof procedures could generate true statements.

1.2 Circle the words that are syntactic symbols in KR: **(5 marks)**

conjunctions	**methods**	**relations**
descriptors	**functions**	**predicates**
variables	**interpretations**	**constants**

1.3 True or False? Refutation proofs are sound but not complete.

(1 mark)

True **False**

1.4 What does the abbreviation MGU stand for? **(1 mark)**

Most General Unifier

2. KB Conversion (18 marks total)

Convert the formulae below into Clausal Normal Form, using the steps on the right. Label the steps that you use with the step number, and only use the steps that you need.

1. Eliminate Implications.
2. Move Negations inwards.
3. Standardize Variables.
4. Skolemize.
5. Convert to Prenix Form.
6. Distribute conjunctions over disjunctions.
7. Flatten nested conjunctions and disjunctions.
8. Convert to Clauses.

2.1 **(4 marks)** $\exists X\,(\,rich(X) \rightarrow smart(X)\,)$

1. $\exists X\,(\,\neg rich(X) \vee smart(X)\,)$
4. $(\,\neg rich(a) \vee smart(a)\,)$
8. $(\,\neg rich(a), smart(a)\,)$

2.2 **(6 marks)** $\neg\exists X\,(\,rich(X) \rightarrow \exists Y\, happy(Y)\,)$

1. $\neg\exists X\,(\,\neg rich(X) \vee \exists Y\, happy(Y)\,)$
2. $\forall X\,(\,rich(X) \wedge \forall Y\,(\neg happy(Y)\,)$
5. $\forall X \forall Y\,(\,rich(X) \wedge \neg happy(Y)\,)$
8. $(\,rich(X)\,)$

   $(\,\neg happy(Y)\,)$

2.3 **(8 marks)** $\forall X \forall Y \exists Z\;(\,(friends(X,Z) \wedge friends(Z,Y)) \rightarrow friends(X,Y)\,)$

1. $\forall X \forall Y \exists Z\;(\neg(friends(X,Z) \wedge friends(Z,Y)) \vee friends(X,Y)\,)$
2. $\forall X \forall Y \exists Z\;(\neg friends(X,Z) \vee \neg friends(Z,Y)) \vee friends(X,Y)\,)$
4. $\forall X \forall Y\;(\neg friends(X,g(X,Y)) \vee \neg friends(g(X,Y),Y)) \vee friends(X,Y)\,)$
7. $\forall X \forall Y\;(\neg friends(X,g(X,Y) \vee \neg friends(g(X,Y),Y) \vee friends(X,Y)\,)$
8. $(\neg friends(X,g(X,Y)\,,\; \neg friends(g(X,Y),Y)\,,\; friends(X,Y)\,)$

3. Resolution (10 marks total)

3.1 Use the following statements (listed here in English and Clausal Normal Form) to prove that **babies can manage crocodiles**.

Use the **Forward Chaining** technique, present your proof as a sequence of statements in the table provided. **(4 marks)**

Statement	Clausal Form
Babies are illogical	[1] (¬baby(X) , illogical(X))
Nobody is despised who can manage a crocodile *	[2] (manage(X,crocodile), ¬despised(X))
Illogical persons are despised.	[3] (¬illogical(X) , despised(X))

Clause #	Clauses to Combine	Resulting Clause
[4]	**1 & 3**	(¬baby(X) , despised(X))
[5]	**2 & 4**	(¬baby(X) , manage(X,crocodile))
[6]		logically equivalent to baby(x) → manage(X,crocodile)
[7]		

* For anyone who is curious about the source and interpretation of this statement, it originates from a collection of Lewis Carroll syllogisms and is loosely interpreted to facilitate the answering of this question.

3.2 Use the following statements (listed here in English and Clausal Normal Form) to prove that **you missed class** (in clausal form: **missClass(you)**). Using the **Refutation** technique, present your proof as a sequence of statements in the table provided. **(6 marks)**

Statement	**Clausal Form**
People who oversleep miss their bus.	[1] (¬oversleep(X), missBus(X))
If you miss your bus and can't get a ride, you will miss your class	[2] (¬missBus(X), hasRide(X), missClass(X))
You overslept and nobody can give you a ride.	[3] (oversleep(you)) [4] (¬hasRide(you))

Clause #	**Clauses to Combine**	**Resulting Clause**
[5]	*Refutation Clause*	(¬missClass(you)) (X = you)
[6]	**2 & 5**	(¬missBus(you), hasRide(you))
[7]	**4 & 6**	(¬missBus(you))
[8]	**1 & 7**	(¬oversleep(you))
[9]	**3 & 8**	( ) ← empty clause, proof complete
[10]		

***This page is intentionally left blank for answer overflows*.**