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Department of Computing

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CATE

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Exercise Information

Module:	70051 Introduction to Symbolic Artificial Intelligence (MSc AI)	**Issued:**	Tue - 20 Oct 2020
Exercise:	2 (CW)	**Due:**	Tue - 03 Nov 2020
Title:	Logic	**Assessment:**	Individual
FAO:	Craven, Robert (rac101)	**Submission:**	Electronic

Student Declaration - Version 1

- I acknowledge the following people for help through our original discussions:

Zepeng Hu

Signed: (electronic signature) Date: 2020-11-03 16:10:58

For Markers only: (circle appropriate grade)

HU, Zepeng (zh2220)	01797254	t5	2020-11-03 16:10:58	**A* A B C D E F**

1.

i. p: Michel is fulfilled

q: Michel is rich

r: Michel lives another 5 years

$\neg p \wedge \neg q \longrightarrow \neg r$

ii. p: snowstorm arrives

q: Raheem will wear his boots

r: I'm sure it will arrive

$\neg p \vee q \wedge r$

iii. p: Akira and Toshiro are on set

q: filming will begin

r: caterers have cleared out

$p \longrightarrow (q \longleftrightarrow r)$

iv. p: Zrad arrived

q: Sarah arrived

$(p \wedge q) \vee (\neg p \wedge \neg q)$

v. p: Herbert heard the performance

q: Anne-Sophie heard the performance

r: Anne-Sophie answered her phone calls

$\neg(\neg r \longrightarrow (p \wedge q))$

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2.

i. A is satisfiable iff there is some atomic evaluation functions v such that $h_v(A) = t$, where $h_v : fmlas_A \to \{t, f\}$

ii. A, B are logically equivalent iff, for every v, $h_v(A) = h_v(B)$

iii. First assume that $\neg A$ is satisfiable.
That means there is some atomic evaluation functions v such that $h_v(\neg A) = t$, so $h_v(\neg\neg A) = f$, which means that it's not the case that $\neg\neg A \equiv T$, and this is just $\neg\neg A \not\equiv T$.
Then assume that $\neg\neg A \not\equiv T$.
This means that it's not the case that $\neg\neg A \equiv T$, or there is some v, such that $h_v(\neg\neg A) = f$, so $h_v(\neg A) = t$. And this is the definition of the satisfiability of propositional formula $\neg A$.

3.

p	q	r	$(p \wedge \neg q \leftrightarrow \neg(\neg r \vee \neg p)) \rightarrow (\neg\neg q \rightarrow r)$
t	t	t	t f ft f tft fft t tft t t
t	t	f	t f ft t ftf tft f tft f f
t	f	t	t t tf t tft f ft t ftf t t
t	f	f	t t tf f f tf t ft t ftf t f
f	t	t	f f ft t fft t tf t tft t t
f	t	f	f f ft t ftf t tf f tft f f
f	f	t	f f tf t fft t tf t ftf t t
f	f	f	f f tf t ftf t tf t ftf t f

4.

i.

a. CNF b. CNF & DNF c. Not CNF or DNF

d. CNF & DNF e. DNF f. Not CNF or DNF

g. CNF h. DNF

ii. Let S be in CNF.

$S \vdash_{res(PL)} \emptyset$ iff $S \models \perp$

It ~~shows that if~~ implies that S is satisfiable iff $S \nvdash_{res(PL)} \emptyset$, which means that if it is impossible to derive $\emptyset$ from S by a resolution derivation, then S is satisfiable. This property gives a good way to show the satisfiability.

iii. a. $\{\{p,s\},\{q,r\},\{\neg s,q\},\{\neg p,\neg r,\neg s\}\}$

$\Rightarrow \{\{p,s\},\{\neg p,\neg r,\neg s\}\}$ q was pure

$\Rightarrow \{\{p,s\}\}$ $\neg r$ was pure

$\Rightarrow \{\ \}$ p was pure

b. $\{\{\neg p, q, r\}, \{\neg q\}, \{p, r, q\}, \{\neg r, q\}\}$

$\Rightarrow \{\{\neg p, r\}, \{p, r\}, \{\neg r\}\}$ unit propagation by $\{\neg q\}$

$\Rightarrow \{\{\neg p\}, \{p\}\}$ unit propogation $\{\neg r\}$

$\Rightarrow \{\{\}\}$ unit propogation $\{\neg p\}$

5. p: I'm going

q: You're going

r: Tara is going

$p \rightarrow \neg q$, $\neg q \rightarrow \neg r$, $(r \wedge p) \vee (\neg r \wedge \neg p)$, $\neg p \rightarrow r$,

therefore q

$(r \wedge p) \vee (\neg r \wedge \neg p) = (\neg r \vee p) \wedge (r \vee \neg p)$

We need to check:

$p \rightarrow \neg q, \neg q \rightarrow \neg r, (\neg r \vee p) \wedge (r \vee \neg p), \neg p \rightarrow r \models q$

That is to check:

$(p \rightarrow \neg q) \wedge (\neg q \rightarrow \neg r) \wedge (\neg r \vee p) \wedge (r \vee \neg p) \wedge (\neg p \rightarrow r) \wedge \neg q$ is

satisfiable

Convert to CNF:

$\{\{\neg p, \neg q\}, \{q, \neg r\}, \{\neg r, p\}, \{r, \neg p\}, \{p, r\}, \{\neg q\}\}$

DP:

$\{\{\neg p, \neg q\}, \{q, \neg r\}, \{\neg r, p\}, \{r, \neg p\}, \{p, r\}, \{\neg q\}\}$

$\Rightarrow \{\{\neg r\}, \{\neg r, p\}, \{r, \neg p\}, \{p, r\}\}$ unit propogation $\{\neg q\}$

$\Rightarrow \{\{\neg p\}, \{p\}\}$ unit propogation $\{\neg r\}$

$\Rightarrow \{\{\}\}$ unit propogation $\{\neg p\}$

$\Rightarrow$ Unsatisfiable since $\emptyset$ is in the set.

6.

i. $C = \{Andrea\}$

$P_2 = \{cupcake, aunt, \cancel{same}\}$

cupcake(X, Y): X gives a cupcake to Y

aunt(X, Y): Y is X's aunt

~~same(X, Y): X is the same with Y~~

~~∀X∀Y∃Z(cupcake(aunt(aunt(Andrea, X), Y), Z) ∧ ¬same(Andrea, Z))~~

$\forall X \forall Y \exists Z$

$(aunt(Andrea, X) \land aunt(X, Y) \land cupcake(Y, Z)$

$\land \neg(Andrea = Z))$

ii. $P_1 = \{computer\}$ computer(X): X is a computer

$P_2 = \{connect\}$ connect(X, Y): X connects to Y

$$\exists X \forall Y \, (computer(X) \wedge computer(Y) \wedge connect(X, Y) \wedge \neg connect(Y, Y))$$

iii. $C = \{\text{Paul Klee}, \text{Kandinsky}\}$

$P_1 = \{gallary, room, British\}$

$P_2 = \{painting, in, hang\}$

gallary(X): X is a gallary

room(X): X is a room

British(X): X is in British

painting(X, Y): X is Y's painting

in(X, Y): X is in Y

hang(X, Y): X hangs in Y

$$\exists Y \exists S \forall X \forall Z$$

$$(gallary(Y) \wedge British(Y) \wedge room(S) \wedge in(S, Y) \wedge painting(X, \text{Paul Klee}) \wedge in(X, Y) \wedge in(Z, Y) \wedge painting(Z, \text{kandinsky}) \wedge hang(X, S) \wedge hang(Z, S))$$

iv. $P_2 = \{love\}$

$love(X, Y)$: X loves Y

$\exists X \exists Y \forall Z \, (\neg love(X,Y) \rightarrow \neg love(Z,X))$

7.

i. $\forall X \, (a(k,X) \rightarrow \neg(X=j))$

This means that for everything that there is a directed arrow from k to it, it is not j. It's not true, since the ~~arr~~ directed from k is connected to j.

ii. $c(l) \rightarrow \exists X \, (b(X) \wedge c(X) \wedge a(l,X))$

X can be chosen as j or k, it is true.

iii. $\exists X \neg \exists Y \, (\neg(X=Y) \wedge a(X,Y))$

It is true. It means that there is an X, that we cannot find something ~~conne~~ connected by an arrow from X except itself. X can be chose as ■ (black square).

iv. $\forall X \, (\neg s(X) \rightarrow \exists Y \, (c(Y) \wedge b(Y) \wedge a(X,Y)))$

It is faulse, we can chose X as j.

j is not square, ~~but there is nothing~~ and j only has an directed arrow to l, who is not black.

~~circle~~

v.

$\forall x \, (\exists y \, (\neg(x=y) \wedge a(x,y)) \rightarrow \exists y \, (a(x,y) \wedge a(y,x)))$

It's faulse.

If x is k, then the y satisfies $\neg(x=y) \wedge a(x,y)$ only is j, but there is no arrow from j to k.

vi.

$\forall x \forall y \, (a(x,j) \wedge a(y,j) \longrightarrow (a(x,y) \vee a(y,x)))$

It's faulse.

If x and y are both k, there is no arrow from k to k.