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Assignment 2

I. Propositional Logic (8 marks)

a. Knowledge representation with propositional logic. (1 marks)

1a)

i) $ok_{1,1}$

ii) $\neg st_{1,1}$

iii) $\neg br_{1,1}$

iv) $\neg wp_{1,1}$

v) $br_{1,1} \leftrightarrow (pt_{1,2} \vee pt_{2,1})$

vi) $st_{1,2} \leftrightarrow (wp_{1,1} \vee wp_{2,2} \vee wp_{1,3})$

vii) $br_{2,1} \leftrightarrow (pt_{1,1} \vee pt_{3,1} \vee pt_{2,2})$

viii) $ok_{2,2} \leftrightarrow (\neg pt_{2,2} \wedge \neg wp_{2,2})$

ix) $ok_{2,1} \leftrightarrow (\neg pt_{2,1} \wedge \neg wp_{2,1})$

x) $ok_{1,2} \leftrightarrow (\neg pt_{1,2} \wedge \neg wp_{1,2})$

xi) $st_{1,2}$

xii) $\neg br_{1,2}$

xiii) $\neg br_{1,2} \rightarrow \neg pt_{1,3}$

xiv) $\neg br_{1,2} \rightarrow \neg pt_{2,2}$

xv) $\neg br_{1,2} \rightarrow \neg pt_{1,1}$

xvi) $\neg st_{2,1}$

xvii) $\neg st_{2,1} \rightarrow \neg wp_{1,1}$

xviii) $\neg st_{2,1} \rightarrow \neg wp_{2,2}$

xix) $\neg st_{2,1} \rightarrow \neg wp_{3,1}$

xx) $br_{2,1}$

xxi) $\neg br_{1,1} \rightarrow \neg pt_{1,2}$

xxii) $\neg br_{1,1} \rightarrow \neg pt_{2,1}$

xxiii) $\neg st_{1,1} \rightarrow \neg wp_{1,2}$

xxiv) $\neg st_{1,1} \rightarrow \neg wp_{2,1}$

xxv) $(br_{2,1} \wedge ok_{2,2} \wedge ok_{1,1}) \rightarrow pt_{3,1}$

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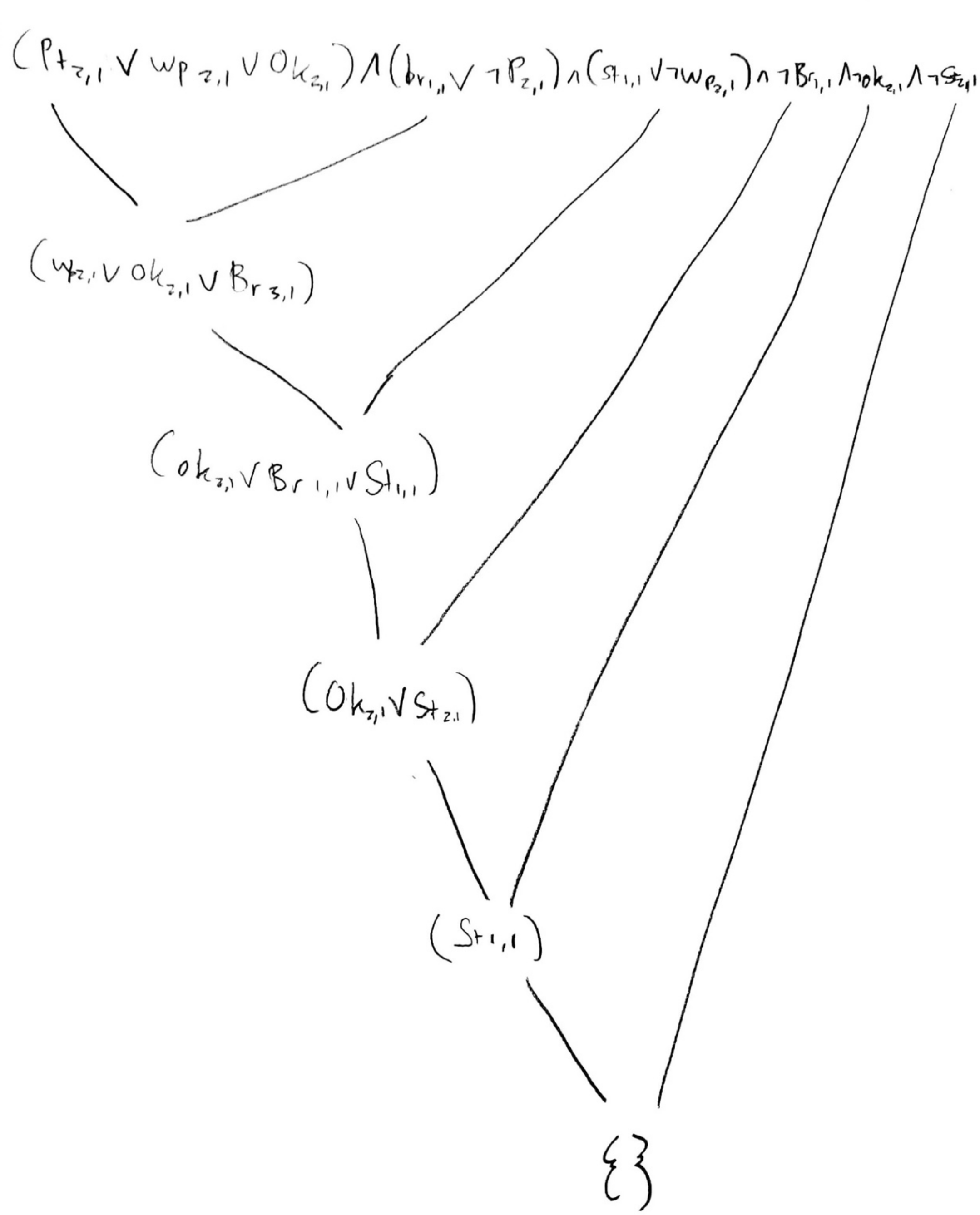
b. Consider above Wumpus Knowledge base KB: (6 marks)

bi)



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bii) $ok_{1,1}$

$\neg st_{1,1}$

$\neg br_{1,1}$

$\neg st_{1,1} \rightarrow \neg w_{1,2}$

$\neg br_{1,1} \rightarrow \neg p_{1,2}$

$ok_{1,2} \leftrightarrow (\neg pt_{1,2} \wedge \neg w_{1,2}$

biii)

$br_{2,1} \wedge ok_{2,2} \wedge ok_{1,1} \rightarrow pt_{3,1}$

$ok_{1,1}$

$ok_{2,2} \leftrightarrow (\neg pt_{2,2} \wedge \neg wp_{2,2})$

$\neg st_{2,1} \rightarrow \neg wp_{2,2}$

$\neg st_{2,1}$

$\neg br_{1,2} \rightarrow \neg pt_{2,2}$

$\neg br_{1,2}$

$br_{2,1}$

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c. Convert to CNF. (1 mark)

c) convert to CNF $\neg[(\neg a \leftrightarrow b) \vee d] \rightarrow [(c \wedge b) \vee a \vee d]$

$\neg[(\neg a \leftrightarrow b) \vee d] \rightarrow [(c \wedge b) \vee a \vee d]$

$\neg[(\neg a \rightarrow b) \wedge (b \rightarrow \neg a) \vee d] \rightarrow [(c \wedge b) \vee a \vee d]$

$\neg[(a \vee b) \wedge (\neg b \vee \neg a) \vee d] \rightarrow [(c \wedge b) \vee a \vee d]$

Cancel

$\neg d \rightarrow [(c \wedge b) \vee a \vee d]$

$d \vee [(c \wedge b) \vee a \vee d]$

$d \vee ((a \vee c) \wedge (a \vee b) \vee d)$

Cancel

$d \vee (a \vee c) \wedge (a \vee b)$

$(d \vee c) \vee a \wedge (a \vee b)$

$(d \vee c) \vee a$

$d \vee c \vee a$

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II. First Order Logic (8 marks)

1. Unification. (2 mark)

For each pair of sentences find the unifier. Lower case letters are variables.

II. 1) Unification

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

b) $\{F(x)/y, B/z\}$

c) $\{F(y)/x, x/F(B))\}$

d) $\{\}$ $\therefore$ c cannot be z and y

e) $\{x/y, y/x\}$

F) $\{x/A\}$

g) $\{x/B, A/y\}$

h) $\{\}$ $\therefore$ x cannot be both $P(F(v))$ and $P(v)$

i) $\{y/x\}$

J) $\{y/z, P(y)/P(x)\}$

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2. Consider a FOL Knowledge base KB: (6 marks)

a. Prove by resolution

2a) $\forall x_1 \exists y_1\, P(x) \rightarrow Q(y_1, x_1)$

$\neg \forall x_1 \exists y_1\, P(x_1) \vee Q(y_1, x_1)$

$\exists x_1 \neg \exists y_1\, P(x_1) \vee Q(y_1, x_1)$

$\exists x_1 \forall y\, \neg P(x_1) \vee Q(y_1, x_1)$

$\neg P(g) \vee Q(y_1, g)$

$\forall x_2 \exists y_2\, Q(y_2, x_2) \rightarrow P(x_2)$

$\neg \forall x_2 \exists y_2\, Q(y_2, x_2) \vee P(x_2)$

$\exists x_2 \neg \exists y_2\, Q(y_2, x_2) \vee P(x_2)$

$\exists x_2 \forall_2\, \neg Q(y_2, x_2) \vee P(x_2)$

$\neg Q(y_2, g) \vee P(g)$

KB:

$\neg P(g) \vee Q(y_1, g)$

$P(g) \vee \neg Q(y_2, g)$

$R(g) \vee \neg Q(g, e)$

$R(e) \vee \neg Q(g, c)$

$P(A)$

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Prove : $KB \models R(A)$

$\neg R(A)$

$P(A) \wedge (\neg P(g) \vee Q(y_1, g)) \wedge (\neg Q(g, e) \vee R(e)) \wedge \neg R(A)$

$\{A/g\}$

$Q(y_1, g)$

$\{Y/g, g/e\}$

$R(e)$

$\{e/A\}$

$\{\}$

b. Prove by forward chaining

c) Prove $KB \models R(A)$ by backward chaining

$F_1 : P(A)$

$R_1 : Q\{A, y_3\} \rightarrow R(A)$

$\sigma = \{x_3/A\}$

$R_2 : P(A) \rightarrow Q(y_1, A)$

$\sigma = \{x_1/A\}$

$\therefore KB \models R(A)$ by backward chaining

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c. Prove by Backward chaining

2.b) Prove $KB \models R(A)$ by forward chaining

$F_1: P(A)$

$R_1: P(A) \rightarrow Q(y_1, A)$ with F_1

$\sigma = \{x_1/A\}$

$R_2: Q(A, y_3) \rightarrow R(A)$ with R_1

$\sigma = \{x_3/A\}$

$\therefore KB \models R(A)$ by Forward chaining