Quiz 3

Task 1

(a)

In the table, for all the scenarios where KB is true, S1 is also true.

So KB $\models S_1$

(b)

There is at least one scenario where (NOT KB) is true (KB is false) where (NOT S1) is false (S1 is true).

So (not KB) $\not\models$ (not S1)

Task 2

Consider a statement that meets the required scenario

$$\neg\left[(A \wedge \neg B \wedge C \wedge \neg D) \vee (\neg A \wedge \neg B \wedge C \wedge D)\right]$$

Converting to CNF

Apply DeMorgans

$$\neg(A \wedge \neg B \wedge C \wedge \neg D) \wedge \neg(\neg A \wedge \neg B \wedge C \wedge D)$$

$$\left[\neg A \vee \neg(\neg B) \vee \neg C \vee \neg(\neg D)\right] \wedge \left[\neg(\neg A) \vee \neg(\neg B) \vee \neg C \vee \neg D\right]$$

Apply Double negation

$$\left[\neg A \vee B \vee \neg C \vee D\right] \wedge \left[A \vee B \vee \neg C \vee \neg D\right]$$

Task 3

(i) Convert KB to Horn Form

$A \Rightarrow C$

$B \Rightarrow C$

$C \Rightarrow B$

$D \Rightarrow A$

E

$(B \land E) \Rightarrow G$

$B \Rightarrow F$

D

Apply MP,

$$\frac{D \Rightarrow A \qquad D}{A}$$

$$\frac{A \Rightarrow C \qquad A}{C}$$

$$\frac{C \Rightarrow B \qquad C}{B}$$

$$\frac{(B \land E) \Rightarrow G \qquad B, E}{G}$$

So $KB \models G$

(ii) Goal Stack

G.

B
G

C
B
G

A
C
B
G

MP Applications,

~~A~~
C
B
G

$$\frac{D \Rightarrow A \qquad D}{A}$$

$\cancel{C}$
B
G

$$\frac{A \Rightarrow C \qquad A}{C}$$

B̸
G

$$\frac{C \Rightarrow B \qquad C}{B}$$

$\cancel{G}$

$$\frac{(B \land E) \Rightarrow G \qquad B, E}{G}$$

So $KB \models G$

(iii) Convert to CNF,

Remove $\Leftrightarrow$

$$(A \Rightarrow C) \land (B \Rightarrow C) \land (C \Rightarrow B) \land (D \Rightarrow A) \land E$$
$$\land \left[(B \land E) \Rightarrow G\right] \land (B \Rightarrow F) \land D$$

Remove $\Rightarrow$

$$(\lnot A \lor C) \land (\lnot B \lor C) \land (\lnot C \lor B) \land (\lnot D \lor A) \land E$$
$$\land (\lnot(B \land E) \lor G] \land (\lnot B \lor F) \land D$$

Move $\neg$ Inward

$$(\neg A \lor C) \land (\neg B \lor C) \land (\neg C \lor B) \land$$
$$(\neg D \lor A) \land E \land (\neg B \lor \neg E \lor G)$$
$$\land (\neg B \lor F) \land D$$

Which is in CNF

Take CNF of $\neg\alpha$: $\neg G$

Proof of Resolution

$$\frac{\neg G \qquad \neg B \lor \neg E \lor G}{\neg B \lor \neg E}$$

$$\frac{\neg B \lor \neg E \qquad E}{\neg B}$$

$$\frac{\neg B \qquad \neg C \lor B}{\neg C}$$

$$\frac{\neg C \qquad \neg A \lor C}{\neg A}$$

$$\frac{\neg A \qquad \neg D \lor A}{\neg D}$$

$$\frac{\neg D \qquad D}{\text{EMPTY}}$$

so $KB \models G$

TASK 4

CONSTANTS: MON, JOHN, MARY

PREDICATES: RAIN(X): It rains on X

GAVE100T(x,y): x gave y a cheque on Tuesday

MOW(x): x mowed lawn on Wednesday

(a)

RAIN(MON) ⇒ GAVE100T(JOHN, MARY)

GAVE100T(JOHN, MARY) ⇒ MOW(MARY)

(b)

¬RAIN(MON) ∧ GAVE100T(JOHN, MARY) ∧ MOW(MARY)

(c) You need 15 symbols

S_1: RAIN(MON)

S_2: RAIN(JOHN)

S_3: RAIN(MARY)

S_4: GAVE100T (MON, MON)

S_5: GAVE 100T (MON, JOHN)

S_6: GAVE 100T (MON, MARY)

S_7: GAVE100T (JOHN, MON)

S_8: GAVE 100T (JOHN, JOHN)

S_9: GAVE 100T (JOHN, MARY)

S_{10}: GAVE 100T (MARY, MON)

S_{11}: GAVE 100T (MARY, JOHN)

S_{12}: GAVE100T (MARY, MARY)

S_{13}: MOW(MON)

S_{14}: MOW (JOHN)

S_{15}: MOW (MARY)

Part (a) :

$$S_1 \Rightarrow S_9$$
$$S_9 \Rightarrow S_{15}$$

Part (b) : $\neg S_1 \wedge S_9 \wedge S_{15}$

(d)

In every scenario where events are true ($S_1 = F$, $S_9 = T$, $S_{15} = T$) we can see that the contract is True

So Events $\models$ Contract

& Contract is not violated.

TASK 5

(i) $\{x/Bob, y/John\}$

(ii) $\{y/Bob, x/Bob\}$

(iii) None exists.

(iv) $\{x/y, z/Bob\}$

(v) None exists.

Task 6

Predicates

IsAdj (x, y) : True if x is Adjacent to y.

In (x, y) : True if x is in y

IsBlank (x) : True if x is Blank

Constants

L1, L2, L3, L4, L5, L6, L7, L8, L9, 1, 2, 3, 4, 5, 6, 7, 8

Initial State

In(2, L1) $\wedge$ In(3, L2) $\wedge$ In(6, L3) $\wedge$ In(1, L4)
$\wedge$ IsBlank(L5) $\wedge$ In(7, L6) $\wedge$ In(4, L7) $\wedge$ In(8, L8)
$\wedge$ In(5, L9) $\wedge$ IsAdj(L1, L2) $\wedge$ IsAdj(L2, L1) $\wedge$ IsAdj(L1, L4)
$\wedge$ IsAdj(L2, L3) $\wedge$ IsAdj(L2, L5) $\wedge$ IsAdj(L3, L2) $\wedge$ IsAdj(L3, L6)
$\wedge$ IsAdj(L4, L1) $\wedge$ IsAdj(L4, L5) $\wedge$ IsAdj(L4, L7) $\wedge$ IsAdj(L5, L2)
$\wedge$ IsAdj(L5, L4) $\wedge$ IsAdj(L5, L6) $\wedge$ IsAdj(L5, L8) $\wedge$ IsAdj(L6, L3)
$\wedge$ IsAdj(L6, L5) $\wedge$ IsAdj(L6, L9) $\wedge$ IsAdj(L7, L4) $\wedge$ IsAdj(L7, L8)

$\wedge$ IsADJ(L8, L7) $\wedge$ IsADJ(L8, L5) $\wedge$ IsADJ(L8, L9)
$\wedge$ IsADJ(L9, L6) $\wedge$ IsADJ(L9, L8)

Goal Test

If State Entails

In(1, L1) $\wedge$ In(2, L2) $\wedge$ In(3, L3) $\wedge$ In(4, L4)
$\wedge$ In(5, L5) $\wedge$ In(6, L6) $\wedge$ In(7, L7) $\wedge$ In(8, L8)

Actions

Swap(tile, src, dest)

PRE

In(tile, src) $\wedge$ IsBlank(dest) $\wedge$ IsADJ(src, dest)

EFT

In(tile, dest) $\wedge$ IsBlank(src) $\wedge$ $\neg$ IsBlank(dest)
$\wedge$ $\neg$ In(tile, src)

Task 7

Number of Arguments per predicate : $[1 \quad 4]$

Number of Constants : 5

Possible assignments to each predicate $[5^1 \quad 5^4]$

$[5 \quad 625]$

Total number of possible assignments (atomic sentences)

$[3 \times 5^1 \quad 3 \times 5^4]$

$[15 \quad 1875]$

Since PDDL KBs [State descriptions] are defined by which of the sentences are true,

Num of possible states $[2^{15} \quad 2^{1875}]$