Assignment - 3

ANGAD MANJUNATHA
1001718335

Task - 1

a. By looking at the table given to us, we can see that in all rows where KB is true, S1 is also true.
So therefore $KB \models S1$.

b. By looking at the table again we can see that there is atleast 1 row where KB is false (not (KB) is true) but S1 is true (not (S1) is false)
So therefore

$$\text{not}(KB) \not\models \text{not}(S1)$$

Task - 2

Consider the sentence:

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

This is false in both given scenarios and true otherwise.

Converting to CNF

Demorgan Law

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

Demorgan Law

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

Double Negation

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

Which is in CNF

Task - 3

Converting to Horn Form

$A \Rightarrow B$

$B \Rightarrow A$

$B \Rightarrow F$

$C \wedge E \Rightarrow G$

E

D

$B \Rightarrow C$

$D \Rightarrow A$

i $\dfrac{D \Rightarrow A \quad D}{A}$

$\dfrac{A \Rightarrow B \quad A}{B}$

$\dfrac{B \Rightarrow C \quad B}{C}$

$\dfrac{C \wedge E \Rightarrow G \quad C, E}{G}$

So $KB \models \alpha$

ii

A
B
C
G

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

$$\frac{A \Rightarrow B \quad A}{B}$$

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

$$\frac{C \wedge E \Rightarrow G \quad C, E}{G}$$

So $KB \models \alpha$

iii Converting to CNF

$(A \Leftrightarrow B) \wedge (B \Rightarrow F) \wedge (B \Rightarrow C) \wedge (D \Rightarrow A) \wedge (C \wedge E \Rightarrow G) \wedge E \wedge D$

Remove $\Leftrightarrow$

$(A \Rightarrow B) \wedge (B \Rightarrow A) \wedge (B \Rightarrow F) \wedge (B \Rightarrow C) \wedge (D \Rightarrow A) \wedge (C \wedge E \Rightarrow G) \wedge E \wedge D$

Remove $\Rightarrow$

$(\neg A \vee B) \wedge (\neg B \vee A) \wedge (\neg B \vee F) \wedge (\neg B \vee C) \wedge (\neg D \vee A) \wedge (\neg C \vee \neg E \vee G) \wedge E \wedge D$

Move ¬ inwards

$(\neg A \vee B) \wedge (\neg B \vee A) \wedge (\neg B \vee F) \wedge (\neg B \vee C) \wedge (\neg B \vee A) \wedge$
$((\neg C \vee \neg E) \vee G) \wedge E \wedge D$

Distribute and Flatten

$(\neg A \vee B) \wedge (\neg B \vee A) \wedge (\neg B \vee F) \wedge (\neg B \vee C) \wedge (\neg D \vee A) \wedge$
$(\neg C \vee \neg E \vee G) \wedge E \wedge D$

Clauses in $KB \wedge \neg \alpha$

$\neg A \vee B$ $\quad \neg B \vee A$ $\quad \neg B \vee F$ $\quad \neg B \vee C$ $\quad \neg D \vee A$
$\neg C \vee \neg E \vee G$ $\quad E$ $\quad D$ $\quad \neg G$

Applying Resolution and adding results

$$\frac{\neg G \quad \neg C \vee \neg E \vee G}{\neg C \vee \neg E}$$

$$\frac{\neg C \vee \neg E \quad E}{\neg C}$$

$$\frac{\neg C \quad \neg B \vee C}{\neg B}$$

(6)

$$\frac{\neg B \qquad \neg A \vee B}{\neg A}$$

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

$$\frac{\neg D \qquad D}{\square}$$

Resolution ends in Empty clause

So $KB \models \alpha$.

Task - 4

a. Constants

John, Mary, Day

Predicates

Rain(z) - Rained on day z

Given(x, y, z) - x gives cheque of 10K to y on day z.

Mow(x, y) - x mow lawn on day z

Contract

Rain(May 1st, 2017) → Given(John, Mary, May 2nd 2017)

Given(John, Mary, May 2nd 2017) → Mow(Mary, May 3rd 2017)

b. Events

¬Rain(May 1st, 2017) ∧ Given(John, Mary, May 2nd 2017)

∧ Mow(Mary, May 3rd 2017)

c. The contract did not get violated. The statement says if it rains then John must give the cheque to Mary. So if it does not rain it is upto John whether if he wants to given the 10K cheque to Mary or not. But once John gives the cheque to Mary, everything is suppose to happen as per the contract.

d.

S1: Rain(John)
S2: Rain(Mary)
S3: Rain(May 1st)
S4: Rain(May 2nd)
S5: Rain(May 3rd)
S6: Given(John, John, May 1st)
S7: Given(John, John, May 2nd)
S8: Given(John, John, May 3rd)
S9: Given(John, Mary, May 1st)
S10: Given(John, Mary, May 2nd)
S11: Given(John, Mary, May 3rd)
S12: Given(Mary, John, May 1st)
S13: Given(Mary, John, May 2nd)
S14: Given(Mary, John, May 3rd)
S15: Given(Mary, Mary, May 1st)
S16: Given(Mary, Mary, May 2nd)
S17: Given(Mary, Mary, May 3rd)
S18: Mow(John, May 1st)
S19: Mow(John, May 2nd)
S20: Mow(John, May 3rd)
S21: Mow(Mary, May 1st)
S22: Mow(Mary, May 2nd)
S23: Mow(Mary, May 3rd)

$S_3 \rightarrow S10$
$S10 \rightarrow S23$
} contract

$\neg S_3 \wedge S10 \wedge S23$ } Events which actually happened.

Task - 5

Predicates

left (u) - u is on left bank.
right (u) - u is on right bank
ischild (u) - u is a child
is adult (u) - u is an adult
is boat (u) - u is a boat

constants - 3 children - C_1, C_2, C_3
3 adults - A_1, A_2, A_3
Boat - B

Initial State

is adult $(A1) \wedge$ isadult $(A2) \wedge$ is adult $(A_3) \wedge$ ischild(c_1) $\wedge$ ischild $(c_2) \wedge$ ischild $(c_3) \wedge$ isboat $(B) \wedge$ left (A_1) $\wedge$ left $(A_2) \wedge$ left $(A_3) \wedge$ left $(c_1) \wedge$ left $(c_2) \wedge$ left (c_3) $\wedge$ left (B)

Goal state

right $(A_1) \wedge$ right $(A_2) \wedge$ right $(A_3) \wedge$ right $(c_1) \wedge$ right $(c_2) \wedge$ right $(c_3) \wedge$ right (B)

Actions

two_move_right (u, v, z)

Pre-conditions = is child (u) ∧ [is adult (y) ∨ is child (y)]
∧ is boat (z) ∧ left (u) ∧ left (v) ∧
left (z)

effect = right (u) ∧ right (v) ∧ right (z) ∧ ¬left (u)
∧ ¬left (u) ∧ ¬left (v) ∧ ¬left (z)

one - move : left (u, y)

pre-condition = is child (u) ∧ is boat (y) ∧ right (u)
∧ right (v)

effect = left (u) ∧ left (y) ∧ ¬right (u)
∧ ¬right (y)

Plan:

two_move_right (C1, A1, B)
one_move_left (C1, B)
two_move_right (C1, A2, B)
one_move_left (C1, B)
two_move_right (C1, A3, B)
one_move_left (C1, B)

two_move_right (c1, c2, B)
one_move_left (c1, B)
two_move_right (c1, c3, B)

Task 7

In case of execution monitoring / online replanning the action would be made as it is and no changes would be made. If the state is different from the expected state. then current plan would be discarded and new plan would be generated.

Conditional Planning

Two_move right

Precondition: ischild (u) ∧ [isadult (y) ∨ ischild (y)]
∧ isboat (z) ∧ left (u) ∧ left (y) ∧ left (z)

effect : right (u) ∧ right (y) ∧ right (z) ∧ ¬left (u)
∧ ¬left (y) ∧ ¬left (z)

one_move_left
Pre : ischild (u) ∧ isboat (y) ∧ right (u) ∧ right (y)

eff : [left(x) $\wedge$ left(y) $\wedge$ right(x) $\wedge$ $\neg$ right(y)]

$\vee$

[right(x) $\wedge$ right(y) $\wedge$ $\neg$ left(x) $\wedge$ $\neg$ left(y)]

Task - 6

Number of predicates: 4
Number of constants: 5
Number of arguments per predicate: 1-4

So number of possible assignments
$[4 \times 5^1 - 4 \times 5^4]$
$[20 - 2500]$

A state is described by which of these assignments is true
So possible number of states
$[2^{20} - 2^{2500}]$