CSE440, Fall 2025, Sec-2

Assignment-02

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1. $\neg S11 \Rightarrow \neg W12 \wedge \neg W21 \wedge \neg W11$

2. $\neg S12 \Rightarrow \neg W13 \wedge \neg W22 \wedge \neg W11 \wedge \neg W12$

3. $S13 \Rightarrow W23 \vee W12 \vee W13$

4. $\neg S11$

5. $\neg S12$

6. $S13$

7. $\neg W12 \wedge \neg W21 \wedge \neg W11$

8. $\neg W13 \wedge \neg W22 \wedge \neg W11 \wedge \neg W12$

9. $W23 \vee W12 \vee W13$

10. $\neg W12$

11. $\neg W13$

12. $W23 \vee W13$ [Res.(9,10)]

13. $W23$ [Res.(11,12)] Proved.

Therefore, wumpus is in square(2, 3).

2/

Forward chaining.

1. $B \Rightarrow C$
2. $B \Rightarrow D$
3. $G \Rightarrow H$
4. $A \Rightarrow E$
5. $G \Rightarrow I$
6. $(A \land F) \Rightarrow G$
7. $(C \land D) \Rightarrow A$
8. $E \Rightarrow F$
9. $(H \land F) \Rightarrow J$
10. B
11. $(C \land D)$ [AND Intro (1,2)]
12. A [Modus Ponens(7, 11)]
13. E [Modus Ponens (4, 12)]
14. F [Modus Ponens (8, 13)]
15. $(A \land F)$ [AND Intro (12,14)]
16. G [Modus Ponens (15, 6)]

17. H [Modus Ponens (3, 16)]

18. (H ∧ F) [And Intro (14, 17)]

19. J [Modus Ponens (9, 18)]

Backward chaining.

1. $B \Rightarrow C$
2. $B \Rightarrow D$
3. $G \Rightarrow H$
4. $A \Rightarrow E$
5. $G \Rightarrow I$
6. $(A \wedge F) \Rightarrow G$
7. $(C \wedge D) \Rightarrow A$
8. $E \Rightarrow F$
9. $(H \wedge F) \Rightarrow J$
10. B
11. J (goal)
12. $(H \wedge F)$ [subgoal (9)]
13. H [subgoal (12)]

14. G [subgoal (13)]

15. (A ∧ F) [subgoal (14)]

16. A [subgoal (15)]

17. (C ∧ D) [subgoal (16)]

18. C [subgoal (17)]

19. B [subgoal (18), True (10), proven]

20. C [using (19), subgoal is proven]

21. D [subgoal (17)]

22. B [subgoal (21), True (10), proven]

23. D [using (22), subgoal is proven]

24. C ∧ D [using (20, 23), subgoal is proven]

25. A [using (24), subgoal is proven]

26. F [subgoal (17)]

27. E [subgoal (26)]

28. A [subgoal (27); True (25), proven]

29. E [using (28), subgoal is proven]

30. F [using (29), subgoal is proven]

31. $(A \wedge F)$ [using (25, 30), subgoal is proven]

32. G [using (31), subgoal is proven]

33. H [using (32), subgoal is proven]

34. F [subgoal (33), True (30), proven]

35. $H \wedge F$ [using (33, 34), subgoal is proven]

36. J [using (35), subgoal is proven]

QED

3.

(1) Every student in the university takes at least one course.

$\Rightarrow$ $\forall x\,(\text{student}(x) \Rightarrow \exists y\,(\text{course}(y) \wedge \text{takes}(x, y)))$

(2) If a person studies hard, then they will pass the exam.

$\rightarrow$ $\forall x\,(\text{person}(x) \wedge \text{studiesHard}(x) \Rightarrow \text{PassesExam}(x))$

(3) There exists a professor who teaches all students.

$\rightarrow$ $\exists x\,\forall y\,(\text{professor}(x) \wedge \text{student}(y) \Rightarrow \text{teaches}(x, y))$

(4) All students are friendly

$\rightarrow$ $\forall x\,(\text{student}(x) \Rightarrow \text{friendly}(x))$

(5) Every books in the library is written by some author.

$\rightarrow \forall x\,(\text{Books}(x) \wedge \text{InLibrary}(x)) \Rightarrow \exists y\,(\text{Author}(y) \wedge \text{writtenBy}(x,y))$

4/

1. $(\forall x)\ \text{bird}(x) \Rightarrow \text{hasWings}(x)$
2. $(\forall x)\ (\text{bird}(x) \wedge \text{hasWings}(x)) \Rightarrow \text{canFly}(x)$
3. $\text{bird}(\text{Tweety})$
4. $\text{hasWings}(\text{Tweety})$ [$\theta = x/\text{Tweety}$, GMP (1, 3)]
5. $\text{canFly}(\text{Tweety})$ [$\theta = x/\text{Tweety}$, GMP (2, 3, 4)]

QED.

Therefore, Tweety has the ability to fly. (Proved)

5/

(A) $P(R, I, W, G)$

$= P(R) \cdot P(I) \, P(W \mid R, I) \, P(G \mid W)$

$= 0.2 \times 0.6 \times 0.99 \times 0.95.$

$= 0.11286.$

(B)

$P(W, G) = ?$

We know,

$$P(R, I, W, G) = P(R) \, P(I) \, P(W \mid R, I) \, P(G \mid W)$$

Applying enumeration method,

$$P(W, G) = \sum_{r=R} \sum_{i=I} P(R) \, P(I) \, P(W \mid R, I) \, P(G \mid W)$$

$$= [P(r) \, P(i) \, P(W \mid r, i) + P(r) \, P(\neg i) \, P(W \mid r, \neg i) + P(\neg r) \, P(i) \, P(W \mid \neg r, i) + P(\neg r) \, P(\neg i) \, P(W \mid \neg r, \neg i)] \times P(G \mid W)$$

$$= [(0.2 \times 0.6 \times 0.99) + (0.2 \times 0.4 \times 0.90) + (0.8 \times 0.6 \times 0.80) + (0.8 \times 0.4 \times 0.10)] \times 0.95$$

$$= (0.1188 + 0.072 + 0.384 + 0.032) \times 0.95$$

$$= 0.6068 \times 0.95 = 0.57646.$$

(c)

(a) Yes, conditioning on W blocks the path. So, R is independent of G given W

(b) Yes, R and I both are independent as both are root nodes with no direct edge between them.

(c) No, R and I are not independent given W because conditioning on W opens the path rather than blocking the path which creates dependence between R and I.