IN-CLASS EXERCISE (I3)

Student ID: ..... Duration: 20 mins Date: 24/07/2023

Student name: ..... Score: ...../ 3

Question 1 (1pt) *(A ∧ B) entails (A ↔ B)*. Explain why the given statement is TRUE (or FALSE).

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Question 2 (2pts) Consider the following propositional knowledge base. Please check whether **KB entails Y**.

1. $C \wedge D \rightarrow Y$
2. $R \wedge Z \rightarrow C$
3. $B \rightarrow D$
4. $D \wedge R \rightarrow Z$
5. B
6. $R \leftrightarrow D$

[0.5pt] Convert each sentence in the knowledge base to its CNF form.

1.	5. .....
2.	6. .....
3.	7. .....
4.	

[1.5pt] Perform inference by applying **Resolution Refutation**. Note that, for every step, state clearly which sentences your inference comes from. You don't need to exhaustively consider all pairs of clauses. Add more lines if necessary.

8. ..... From required conclusion
9. ..... From
10. ..... From
11. ..... From
12. ..... From
13. ..... From
14. ..... From

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Question 1 (1pt) *(A ↔ B) entails (A ∧ B)*. Explain why the given statement is TRUE (or FALSE).

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Question 2 (2pts) Consider the following propositional knowledge base. Please check whether **KB entails G**.

[0.5pt] Convert each sentence in the knowledge base to its CNF form.

1.	5. .....
2.	6. .....
3.	7. .....
4.	8. .....

1. $A \wedge B \rightarrow E$
2. $A \wedge D \rightarrow C$
3. $E \rightarrow F$
4. $B \wedge E \rightarrow D$
5. $C \rightarrow F$
6. $D \wedge F \rightarrow G$
7. A
8. B

[1.5pt] Perform inference by applying **Resolution Refutation**. Note that, for every step, state clearly which sentences your inference comes from. You don't need to exhaustively consider all pairs of clauses. Add more lines if necessary.

9. ..... From required conclusion
10. ..... From
11. ..... From
12. ..... From
13. ..... From
14. ..... From
15. ..... From

IN-CLASS EXERCISE (I3)

Student ID: ..... Duration: 20 mins Date: 24/07/2023

Student name: ..... Score: ...../ 3

Question 1 (1pt) *It is always possible to check whether a propositional knowledge base entails a query using forward chaining or backward chaining.* Explain why the given statement is TRUE (or FALSE).

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Question 2 (2pts) Consider the following propositional knowledge base. Please check whether **KB entails Y**.

[0.5pt] Convert each sentence in the knowledge base to its rule form.

1.	5. .....
2.	6. .....
3.	7. .....
4.	

1. $\neg C \vee \neg D \vee Y$
2. $\neg R \vee \neg Z \vee C$
3. $\neg B \vee D$
4. $\neg D \vee \neg R \vee Z$
5. B
6. $R \leftrightarrow D$

[1.5pt] Perform inference by applying **Forward Chaining.** Note that, for every step, state clearly which sentences your inference comes from. If there are multiple rules that are ready to be triggered at a time, process them from top to bottom.

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IN-CLASS EXERCISE (I3)

Student ID: ..... Duration: 20 mins Date: 24/07/2023

Student name: ..... Score: ...../ 3

Question 1 (1pt) *It is always possible to check whether a propositional knowledge base entails a query using resolution refutation.* Explain why the given statement is TRUE (or FALSE).

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Question 2 (2pts) Consider the following propositional knowledge base. Please check whether **KB entails Y**.

[0.5pt] Convert each sentence in the knowledge base to its rule form.

1.	5. .....
2.	6. .....
3.	7. .....
4.	

1. $\neg C \vee \neg D \vee Y$
2. $\neg R \vee \neg Z \vee C$
3. $\neg B \vee D$
4. $\neg D \vee \neg R \vee Z$
5. B
6. $R \leftrightarrow D$

[1.5pt] Perform inference by applying **Backward Chaining.** Note that, for every step, state clearly which sentences your inference comes from. If there are multiple rules that are ready to be triggered at a time, process them from top to bottom.

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SOLUTION

IN-CLASS EXERCISE (I3)

Student ID: ..... Duration: 20 mins Date: 24/07/2023

Student name: ..... Score: ...../ 3

Question 1 (1pt) *(A ∧ B) entails (A ↔ B)*. Explain why the given statement is TRUE (or FALSE).

TRUE. (A ↔ B) ≡ (A ∧ B) ∨ (¬A ∧ ¬B). Every model making (A ∧ B) true also makes (A ↔ B) true.

Question 2 (2pts) Consider the following propositional knowledge base. Please check whether **KB entails Y**.

1. $C \wedge D \rightarrow Y$
2. $R \wedge Z \rightarrow C$
3. $B \rightarrow D$
4. $D \wedge R \rightarrow Z$
5. B
6. $R \leftrightarrow D$

[0.5pt] Convert each sentence in the knowledge base to its CNF form.

1. ¬C ∨ ¬D ∨ Y	5. B
2. ¬R ∨ ¬Z ∨ C	6. ¬R ∨ D
3. ¬B ∨ D	7. ¬D ∨ R
4. ¬D ∨ ¬R ∨ Z	

[1.5pt] Perform inference by applying **Resolution Refutation**. Note that, for every step, state clearly which sentences your inference comes from. You don't need to exhaustively consider all pairs of clauses. Add more lines if necessary.

8. ¬Y ..... From required conclusion
9. ¬C ∨ ¬D ..... From 1 and 8
10. D ..... From 3 and 5
11. ¬C ..... From 9 and 10
12. R ..... From 7 and 10
13. Z ..... From 4, 10, and 12
14. C ..... From 2, 12, and 13
15. • ..... From 11 and 14

Thus, KB entails Y.

IN-CLASS EXERCISE (I3)

Student ID: ..... Duration: 20 mins Date: 24/07/2023

Student name: ..... Score: ...../ 3

Question 1 (1pt) *(A ↔ B) entails (A ∧ B)*. Explain why the given statement is TRUE (or FALSE).

FALSE. (A ↔ B) ≡ (A ∧ B) ∨ (¬A ∧ ¬B). When A = B = false, (A ↔ B) is true, yet (A ∧ B) is false. Thus, not every model making (A ↔ B) true also makes (A ∧ B) true.

Question 2 (2pts) Consider the following propositional knowledge base. Please check whether **KB entails G**.

[0.5pt] Convert each sentence in the knowledge base to its CNF form.

1. ¬A ∨ ¬B ∨ E	5. ¬C ∨ F
2. ¬A ∨ ¬D ∨ C	6. ¬D ∨ ¬F ∨ G
3. ¬E ∨ F	7. A
4. ¬B ∨ ¬E ∨ D	8. B

1. $A \wedge B \rightarrow E$
2. $A \wedge D \rightarrow C$
3. $E \rightarrow F$
4. $B \wedge E \rightarrow D$
5. $C \rightarrow F$
6. $D \wedge F \rightarrow G$
7. A
8. B

[1.5pt] Perform inference by applying **Resolution Refutation**. Note that, for every step, state clearly which sentences your inference comes from. You don't need to exhaustively consider all pairs of clauses. Add more lines if necessary.

9. ¬G From required conclusion
10. E From 1, 7, and 8
11. F From 3 and 10
12. D From 4, 8, and 10
13. G From 6, 11, and 12
14. • From 9 and 13

Thus, KB entails G.

IN-CLASS EXERCISE (I3)

Student ID: ..... Duration: 20 mins Date: 24/07/2023

Student name: ..... Score: ...../ 3

Question 1 (1pt) *It is always possible to check whether a propositional knowledge base entails a query using forward chaining or backward chaining.* Explain why the given statement is TRUE (or FALSE).

FALSE. Forward chaining and backward chaining can answer any question of entailment only when the KB contains all propositional definite clauses.

Question 2 (2pts) Consider the following propositional knowledge base. Please check whether **KB entails Y**.

1. $\neg C \vee \neg D \vee Y$
2. $\neg R \vee \neg Z \vee C$
3. $\neg B \vee D$
4. $\neg D \vee \neg R \vee Z$
5. B
6. $R \leftrightarrow D$

[0.5pt] Convert each sentence in the knowledge base to its rule form.

1. $C \wedge D \rightarrow Y$	5. B
2. $R \wedge Z \rightarrow C$	6. $R \rightarrow D$
3. $B \rightarrow D$	7. $D \rightarrow R$
4. $D \wedge R \rightarrow Z$	

[1.5pt] Perform inference by applying **Forward Chaining.** Note that, for every step, state clearly which sentences your inference comes from. If there are multiple rules that are ready to be triggered at a time, process them from top to bottom.

The initial fact is B.

From (3) and (5), we have D (8)

From (7) and (8), we have R (9)

From (4), (8), and (9), we have Z (10)

From (6) and (9), we have D again

From (2), (9) and (10), we have C (11)

From (1), (11), and (8), we have Y

Thus, KB entails Y.

IN-CLASS EXERCISE (I3)

Student ID: ..... Duration: 20 mins Date: 24/07/2023

Student name: ..... Score: ...../ 3

Question 1 (1pt) *It is always possible to check whether a propositional knowledge base entails a query using resolution refutation.* Explain why the given statement is TRUE (or FALSE).

TRUE. Resolution refutation can work on any KB of CNF clauses, and any propositional sentence can be normalized to CNF clauses.

Question 2 (2pts) Consider the following propositional knowledge base. Please check whether **KB entails Y**.

1. $\neg C \vee \neg D \vee Y$
2. $\neg R \vee \neg Z \vee C$
3. $\neg B \vee D$
4. $\neg D \vee \neg R \vee Z$
5. B
6. $R \leftrightarrow D$

[0.5pt] Convert each sentence in the knowledge base to its rule form.

1. $C \wedge D \rightarrow Y$	5. B
2. $R \wedge Z \rightarrow C$	6. $R \rightarrow D$
3. $B \rightarrow D$	7. $D \rightarrow R$
4. $D \wedge R \rightarrow Z$	

[1.5pt] Perform inference by applying **Backward Chaining.** Note that, for every step, state clearly which sentences your inference comes from. If there are multiple rules that are ready to be triggered at a time, process them from top to bottom.

The goal Y requires C and D from (1)

Subgoal C requires R and Z from (2)

Subgoal R requires D from (6) (*)

Subgoal D requires B from (3) (**)

B is given in (5)

Subgoal Z requires D and R from (4)

Both subgoals are satisfied from the above steps, (*) and (**)

Subgoal D is satisfied from the above steps (**)

Thus, KB entails Y.