

IN-CLASS EXERCISE (I3)

Duration: 15 mins

Date: 29/03/2023

Score:/3

Student ID: Student name:

Question 1 (1pt) $(A \wedge B)$ entails $(A \leftrightarrow B)$. 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**.

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

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

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. $R \leftrightarrow D$

[1.5pt] Perform inference by applying **Refutation Resolution**. 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) $(A \leftrightarrow B)$ entails $(A \wedge B)$. 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 F**.

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

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

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

[1.5pt] Perform inference by applying **Refutation Resolution**. 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) Consider a logic with only four propositional variables, A, B, C and D. How many models for this logic satisfy the following sentence, $(A \wedge B) \vee (C \wedge D)$? Give your explanation.

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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 **Refutation Resolution**. 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

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Question 1 (1pt) "This is an inference strategy which begins with known facts and derives new facts using rules whose premises match known facts and continues this process until a goal state (hypothesis) has been reached." Determine which inference technique is mentioned in the given statement. Can you use this inference technique to answer the question of entailment on any propositional KB?

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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 rule form.

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

- | |
|--------------------------------|
| 1. $\neg A \vee \neg B \vee E$ |
| 2. $\neg A \vee \neg D \vee C$ |
| 3. $\neg E \vee F$ |
| 4. $\neg B \vee \neg E \vee D$ |
| 5. $\neg C \vee F$ |
| 6. $\neg D \vee \neg F \vee G$ |
| 7. A |
| 8. B |

[1.5pts] Perform inference by applying **Backward Chaining**. Note that, for every step, state clearly which sentences your inference comes from. Sub-goals at the same levels are processed following the alphabetical order. Add more lines if necessary

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IN-CLASS EXERCISE (I3)

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Student ID: Student name:

Question 1 (1pt) *Conjunctive normal form is a representation in which the KB is a disjunction of clauses and each clause is a conjunction of literals.* 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 rule form.

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

- | | |
|----|-----------------------------|
| 1. | $\neg A \vee \neg B \vee E$ |
| 2. | $\neg A \vee \neg D \vee C$ |
| 3. | $\neg E \vee F$ |
| 4. | $\neg B \vee \neg E \vee D$ |
| 5. | $\neg C \vee F$ |
| 6. | $\neg D \vee \neg F \vee G$ |
| 7. | A |
| 8. | B |

[1.5pts] 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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SOLUTION

IN-CLASS EXERCISE (I3)

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Student ID: Student name:

Question 1 (1pt) $(A \wedge B)$ entails $(A \leftrightarrow B)$. Explain why the given statement is TRUE (or FALSE).

TRUE. $(A \leftrightarrow B) \equiv (A \wedge B) \vee (\neg A \wedge \neg B)$. Every model making $(A \wedge B)$ true also makes $(A \leftrightarrow B)$ true

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 CNF form.

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

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. $R \leftrightarrow D$

[1.5pt] Perform inference by applying **Refutation Resolution**. 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. $\neg Y$ From required conclusion
9. $\neg C \vee \neg D$ From 1 and 8
10. D From 3 and 5
11. $\neg C$ 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. \bullet From 11 and 14

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Question 1 (1pt) $(A \leftrightarrow B)$ entails $(A \wedge B)$. Explain why the given statement is TRUE (or FALSE).

FALSE. $(A \leftrightarrow B) \equiv (A \wedge B) \vee (\neg A \wedge \neg B)$. When $A = B = \text{false}$, $(A \leftrightarrow B)$ is true, yet $(A \wedge B)$ is false. Thus, not every model making $(A \leftrightarrow B)$ true also makes $(A \wedge B)$ true.

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

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

1. $\neg B \vee \neg C \vee A$	5. D
2. $\neg D \vee \neg E \vee B$	6. E
3. $\neg B \vee \neg E \vee G$	7. $\neg A \vee \neg G \vee F$
4. $\neg E \vee C$	

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

[1.5pt] Perform inference by applying **Refutation Resolution**. 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. $\neg F$ From required conclusion
9. B From 2, 5, and 6
10. C From 4 and 6
11. A From 1, 9, and 10
12. G From 3, 6, and 9
13. F From 7, 11, and 12
14. \bullet From 8 and 14

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Question 1 (1pt) Consider a logic with only four propositional variables, A, B, C and D. How many models for this logic satisfy the following sentence, $(A \wedge B) \vee (C \wedge D)$? Give your explanation.

There are a total of $2^4 = 16$ possible tuples. The sentence is true when either $(A \wedge B)$ or $(C \wedge D)$ is true. $(A \wedge B)$ is true in 4 models, similarly for $(C \wedge D)$, yet they share 1 model (when all are true). Thus, there are 7 models satisfying the given sentence.

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. $\neg A \vee \neg B \vee E$	5. $\neg C \vee F$
2. $\neg A \vee \neg D \vee C$	6. $\neg D \vee \neg F \vee G$
3. $\neg E \vee F$	7. A
4. $\neg B \vee \neg E \vee D$	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 **Refutation Resolution**. 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. $\neg G$ | 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. \bullet | From 9 and 13 |

IN-CLASS EXERCISE (I3)

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Student ID: Student name:

Question 1 (1pt) "This is an inference strategy which begins with known facts and derives new facts using rules whose premises match known facts and continues this process until a goal state (hypothesis) has been reached." Determine which inference technique is mentioned in the given statement. Can you use this inference technique to answer the question of entailment on any propositional KB?

Forward chaining. No, forward 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 G**.

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

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

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

[1.5pts] Perform inference by applying **Backward Chaining**. Note that, for every step, state clearly which sentences your inference comes from. Sub-goals at the same levels are processed following the alphabetical order. Add more lines if necessary

The goal G requires D and F from (6)

Subgoal D requires B and E from (4)

Subgoal B is given in (8)

Subgoal E requires A and B from (1) (*)

Subgoals A and B are given in (7) and (8)

Subgoal F requires E from (3)

Subgoal E is proved from the above step (*)

Thus, KB entails G

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Question 1 (1pt) *Conjunctive normal form is a representation in which the KB is a disjunction of clauses and each clause is a conjunction of literals. Explain why the given statement is TRUE (or FALSE).*

Conjunctive normal form is a representation in which the KB is a conjunction of clauses where each clause is a DISJUNCTION of literals.

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 rule form.

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

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

[1.5pts] 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.

From 1, 7, and 8, we have E (9)

From 3 and 9, we have F (10)

From 4, 8, and 9, we have D (11)

From 2, 7, and 11, we have C (12)

From 6, 10, and 11, we have G (13)

Thus, KB entails G