



Final Exam

Academic Year 1447 - Second Semester

Exam Information معلومات الامتحان		
Course name	تمثيل المعرفة والاستدلال	اسم المقرر
Course Code	AI 212	رمز المقرر
Exam Date	7 / 6 / 2026	تاريخ الامتحان
Exam Time	8:30 – 10:30	وقت الامتحان
Exam Duration	2 Hours	مدة الامتحان
Classroom No.	GF 1	رقم قاعة الاختبار
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Section No.		رقم الشعبة
Serial Number		الرقم التسلسلي

General Instructions:

تعليمات عامة:

- Your Exam consists of **3 PAGES** (except this paper) (عدد صفحات الامتحان **3** صفحة. (باستثناء هذه الورقة)
- Phones and smart devices are forbidden inside the hall. (يمنع استخدام الهواتف والأجهزة الذكية داخل القاعة.)

هذا الجزء خاص بأستاذ المادة

This section is ONLY for instructors.

#	Course Learning Outcomes (CLOs)	Related Question (s)	Points	Final Score
1	Recognize ideas and techniques underlying the design of knowledge-based systems.	Q1	8	
2	Describe mathematical and logical representations of knowledge-based systems.	Q2	8	
3	Analyze various knowledge representation techniques in the design of knowledge-based systems.	Q3	8	
4	Design and develop knowledge-based systems.	Q4	8	
5	Apply reasoning, logic, web ontology language, and knowledge planning techniques for implementing knowledge-based systems.	Q5	8	

Question 1: Points: 8**CLO #1**

Choose the most appropriate answer for each of the following questions.

1. Given the rule:
 $\text{Allergic}(x, \text{Penicillin}) \rightarrow \text{Avoid}(x, \text{Penicillin})$
and the fact: $\text{Allergic}(\text{Ahmed}, \text{Penicillin})$
The statement $\text{Avoid}(\text{Ahmed}, \text{Penicillin})$ is:
A. Explicit knowledge
B. Data
C. Implicit knowledge derived by reasoning
D. Hard-coded output
2. Which of the following best describes entailment?
A. A likely conclusion
B. A conclusion that must be true if premises are true
C. A stored fact
D. A random assumption
3. In knowledge representation, syntax primarily ensures:
A. Truth of statements
B. Correct interpretation
C. Well-formed structure
D. Logical consequence
4. Semantics in First-Order Logic defines:
A. How symbols are written
B. How inference rules operate
C. What expressions mean in a world
D. How many predicates exist
5. An interpretation in FOL consists of:
A. Syntax rules and inference rules
B. A domain and an interpretation mapping
C. Only a truth assignment
D. Only predicates and constants
6. The statement $S \models \alpha$ means:
A. α is true in every interpretation where S is true
B. α can be syntactically derived from S
C. α is true in some interpretations of S
D. α is explicitly written in S
7. Which of the following correctly expresses “All robots handle some part”?
A. $\forall x \forall y \text{Handles}(x,y)$
B. $\exists x \forall y \text{Handles}(x,y)$
C. $\forall x \exists y \text{Handles}(x,y)$
D. $\exists y \forall x \text{Handles}(x,y)$
8. Which of the following expresses “There is one robot that handles all parts”?
A. $\forall x \exists y \text{Handles}(x,y)$
B. $\exists x \forall y \text{Handles}(x,y)$
C. $\forall x \forall y \text{Handles}(x,y)$
D. $\exists y \exists x \text{Handles}(x,y)$

Question 2: Points: 8**CLO #2**

9. In First-Order Logic, the statement: $\text{Vehicle}(\text{car1})$ represents:
A. A function returning a vehicle
B. A proposition asserting car1 is a vehicle
C. A variable declaration
D. An existential claim?
10. Which expression represents an existential statement?
A. $\forall x (\text{Vehicle}(x) \rightarrow \text{HasEngine}(x))$
B. $\exists x (\text{Vehicle}(x) \wedge \text{Electric}(x))$
C. $\text{Vehicle}(\text{car1})$
D. $\neg \text{Vehicle}(\text{car1})$
11. Which of the following is a function (not a predicate)?
A. $\text{Pedestrian}(x)$
B. $\text{MarriedTo}(x, y)$
C. $\text{MustStop}(x)$
D. $\text{ceoOf}(x)$
12. The statement: $\forall x (\text{Surgeon}(x) \rightarrow \text{Doctor}(x))$ represents:
A. Subtype relationship
B. Disjointness
C. Symmetry
D. Closure assumption

13. In a hospital robot system, we declare:
 $\forall x (\text{Robot}(x) \rightarrow \neg \text{Human}(x))$
 This represents:
 A. Disjointness
 B. Subtype relationship
 C. Symmetry
 D. Closure assumption
14. What is the primary motivation for procedural control of reasoning?
 A. To make knowledge bases smaller
 B. To compensate for the computational intractability of blind theorem proving
 C. To eliminate the need for backward chaining
 D. To replace first-order logic with procedural languages
15. What is the key advantage of the four-place Fibonacci formulation $F(n, y, z, v)$ over the naive two-place $\text{Fibo}(n, v)$?
 A. It produces different (more accurate) Fibonacci numbers
 B. It avoids redundant subgoal computation, requiring only a linear number of steps
 C. It uses less memory by storing only one number at a time
 D. It converts the recursive definition to an iterative one automatically
16. For the goal $\text{AmericanCousin}(x, \text{sally})$, which goal ordering in PROLOG is more efficient when Sally has far fewer cousins than there are Americans?
 A. $\text{american}(X), \text{cousin}(X, \text{sally})$ — find Americans, then test if cousin
 B. $\text{cousin}(X, \text{sally}), \text{american}(X)$ — find Sally's cousins, then test if American
 C. Both orderings have identical performance
 D. The ordering does not matter because PROLOG tries all combinations

Part B: Points 8

Use only the predicates, constants, and logical symbols provided below. - Do not introduce new predicate names. - Use standard First-Order Logic notation with quantifiers ($\forall, \exists$), implication ($\rightarrow$), negation ($\neg$), and conjunction ($\wedge$).	
Constant: R5 Predicates: Robot(x) PassedInspection(x) FailedInspection(x) AllowedToOperate(x) A. In an automated factory: - Every robot that is allowed to operate must have passed inspection. $\forall x ((\text{Robot}(x) \wedge \text{AllowedToOperate}(x)) \rightarrow \text{PassedInspection}(x))$ - Any robot that fails inspection is not allowed to operate. $\forall x (\text{FailedInspection}(x) \rightarrow \neg \text{AllowedToOperate}(x))$ - R5 failed inspection. $\text{FailedInspection}(\text{R5})$	Constant: DrAli Predicates: LicensedDoctor(x) Cardiologist(x) MayPrescribe(x) B. In a hospital: - Every cardiologist is a licensed doctor. $\forall x (\text{Cardiologist}(x) \rightarrow \text{LicensedDoctor}(x))$ - Only licensed doctors may prescribe medication. $\forall x (\text{MayPrescribe}(x) \rightarrow \text{LicensedDoctor}(x))$ - DrAli is a cardiologist. $\text{Cardiologist}(\text{DrAli})$

Choose the most appropriate answer for each of the following questions.

17. The statement:

$$\forall x (\text{MayPrescribe}(x) \rightarrow \text{LicensedDoctor}(x))$$

means:

- A. All licensed doctors may prescribe
- B. Only licensed doctors may prescribe
- C. All doctors are cardiologists
- D. Some doctors may prescribe

18. Which of the following correctly represents:

"Only robots with authorization may operate"

- A. $\forall x (\text{Authorized}(x) \rightarrow \text{Operate}(x))$
- B. $\forall x (\text{Operate}(x) \rightarrow \text{Authorized}(x))$
- C. $\exists x (\text{Operate}(x) \wedge \text{Authorized}(x))$
- D. $\forall x (\text{Robot}(x) \rightarrow \text{Authorized}(x))$

19. Given:

$$\forall x (\text{LicensedDoctor}(x) \rightarrow \text{MayPrescribe}(x))$$

$\text{LicensedDoctor}(\text{DrAli})$

What follows?

- A. $\neg \text{MayPrescribe}(\text{DrAli})$
- B. $\text{MayPrescribe}(\text{DrAli})$
- C. Nothing can be concluded
- D. DrAli is not licensed

20. Which of the following is logically equivalent to:

$$\text{MayPrescribe}(x) \rightarrow \text{LicensedDoctor}(x)$$

$$\text{A. } \text{LicensedDoctor}(x) \rightarrow \text{MayPrescribe}(x)$$

$$\text{B. } \neg \text{MayPrescribe}(x) \rightarrow \neg \text{LicensedDoctor}(x)$$

$$\text{C. } \text{MayPrescribe}(x) \wedge \text{LicensedDoctor}(x)$$

$$\text{D. } \neg \text{LicensedDoctor}(x) \rightarrow \neg \text{MayPrescribe}(x)$$

21. The empty clause [] represents:

- A. TRUE
- B. UNKNOWN
- C. FALSE (contradiction)
- D. A unit clause

22. Which pair of clauses can be resolved?

- A. $[p, q]$ and $[\neg p, r]$
- B. $[p, q]$ and $[r, s]$
- C. $[p]$ and $[q]$
- D. $[\neg p]$ and $[\neg q]$

23. Resolving the clauses $[p, q]$ and $[\neg p, r]$ produces:

- A. $[q, r]$
- B. $[p, r]$
- C. $[p, q, r]$
- D. []

24. A clause that contains exactly one literal.

- A. Empty Clause
- B. Unit Clause
- C. Horn Clause
- D. Resolvent

25. A logical form where a formula is expressed as a conjunction of clauses, and each clause is a disjunction of literals.

- A. Disjunctive Normal Form
- B. Implication Form
- C. Conjunctive Normal Form (CNF)
- D. Predicate Logic Form

26. A resolution derivation that ends with the empty clause, proving unsatisfiability.

- A. Contradiction Rule
- B. Logical Collapse

C. Refutation

D. Entailment

27. A property of an inference procedure where all derived conclusions are logically correct.

- A. Completeness
- B. Soundness
- C. Consistency
- D. Validity

28. The process of eliminating existential quantifiers by introducing new constants or functions.

- | | |
|---|---|
| <p>A. Generalization
 B. Unification
 C. Skolemization
 D. Resolution</p> <p>29. Backward chaining starts reasoning from:
 A. Facts in the KB
 B. All clauses simultaneously
 C. The goal (query)
 D. Random clause</p> <p>30. If a clause is:
 $[Girl \vee \neg Child \vee \neg Female]$
 Then solving Girl generates subgoals:
 A. Girl
 B. Child only
 C. Female only
 D. Child and Female</p> | <p>31. Which language was designed specifically to give users fine-grained control over theorem-proving, using if-needed, if-added, and if-removed procedures?
 A. PROLOG
 B. LISP
 C. PLANNER
 D. CONNIVER</p> <p>32. Which design choice most clearly indicates a knowledge-based approach?
 A. Writing many if-else statements
 B. Encoding facts and general rules separately
 C. Using object-oriented programming
 D. Storing values in arrays</p> |
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Part B: 8 Points

A company wants to automate its decision-making system for approving business loans. The following rules are used:

- If a customer has a high income and a good credit score, then the customer is eligible for a loan.
- If a customer is eligible for a loan and has no outstanding debts, then the loan is approved.
- If a customer has a stable job, then the customer has a high income.
- If a customer has a good payment history, then the customer has a good credit score.

Facts:

- The customer has a stable job.
- The customer has a good payment history.
- The customer has no outstanding debts.

Tasks

1. Represent the above knowledge using Horn clauses.
2. Convert the rules into clausal form.
3. Using backward chaining (SLD resolution), determine whether the loan is approved.
4. Draw the goal reduction steps (or goal tree).

Representation using Horn Clauses

Let:

- $Income(x)$ = high income
- $Credit(x)$ = good credit score
- $Eligible(x)$ = eligible for loan
- $Approved(x)$ = loan approved
- $StableJob(x)$
- $History(x)$ = good payment history
- $NoDebt(x)$

Rules

1. $Income(x) \wedge Credit(x) \Rightarrow Eligible(x)$
 2. $Eligible(x) \wedge NoDebt(x) \Rightarrow Approved(x)$
 3. $StableJob(x) \Rightarrow Income(x)$
 4. $History(x) \Rightarrow Credit(x)$
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Facts

- $StableJob(Customer)$
- $History(Customer)$
- $NoDebt(Customer)$

2. Clausal Form

1. $[Eligible, \neg Income, \neg Credit]$
2. $[Approved, \neg Eligible, \neg NoDebt]$
3. $[Income, \neg StableJob]$
4. $[Credit, \neg History]$
5. $[StableJob]$
6. $[History]$
7. $[NoDebt]$

Backward Chaining (SLD Resolution)

Goal:

$Approved(Customer)$

Start with:

$[\neg Approved]$

Step 1

Use rule:

$$[Approved, \neg Eligible, \neg NoDebt]$$

→ Subgoals:

[$\neg Eligible$, $\neg NoDebt$]

Step 2

Resolve with fact:

[NoDebt]

→ Remaining:

[$\neg Eligible$]

Step 3

Use rule:

$$[Eligible, \neg Income, \neg Credit]$$

→ Subgoals:

$[\neg Income, \neg Credit]$

Step 4

Use rule:

$$[Income, \neg StableJob]$$

→ Subgoal:

$[\neg StableJob, \neg Credit]$

Step 5

Resolve with fact:

[StableJob]

→ Remaining:

[¬Credit]

Step 6

Use rule:

$[Credit, \neg History]$

→ Subgoal:

[¬History]

Step 7

Resolve with fact:

[History]

→ Result:

[]



Final Result

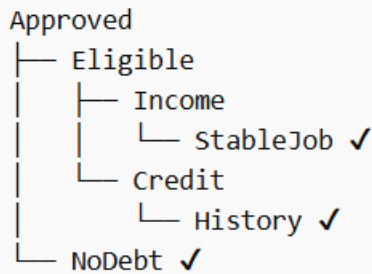
$KB \models Approved(Customer)$



The loan is approved



4. Goal Tree



Question 5: Points: 8

CLO #5

33. A Horn clause is defined as a clause that contains:

- A. At least one positive literal
- B. Only negative literals
- C. Only positive literals
- D. At most one positive literal

34. Which of the following is a positive (definite) Horn clause?

- A. $[\neg A, \neg B]$
- B. $[A, B]$
- C. $[\neg A, \neg B, C]$
- D. $[\neg A, \neg B, C, D]$

35. A negative Horn clause contains:

- A. Exactly one positive literal
- B. More than one positive literal
- C. No positive literals
- D. Only one literal

36. Which of the following is a **negative Horn clause**?

- A. $[\neg A, \neg B]$
- B. $[\neg A, B]$
- C. $[A]$
- D. $[A, B]$

37. Which of the following correctly represents:

$$A \wedge B \Rightarrow C$$

- A. $[A, B, C]$
- B. $[\neg A, \neg B, C]$
- C. $[\neg A, B, C]$
- D. $[A, \neg B, C]$

38. In SLD resolution, negative Horn clauses are typically used to represent:

- A. Facts
- B. Rules
- C. Goals (queries)
- D. Functions

39. Horn clauses are commonly used to represent:

- A. Images and graphics
- B. Rules and logical inference
- C. Sorting algorithms only
- D. Numerical computations only

40. In Horn clause reasoning, a negative clause is commonly interpreted as:

- A. A fact
- B. A theorem
- C. A goal/query
- D. A function

Best Wishes

Dr. Mostafa Elhosseini

NAME :
EXAM :
DATE :

Roll No 0 ☐ ☐ 1 ☐ ☐ 2 ☐ ☐ 3 ☐ ☐ 4 ☐ ☐ 5 ☐ ☐ 6 ☐ ☐ 7 ☐ ☐ 8 ☐ ☐ 9 ☐ ☐ Question 01 A B C D 1 ☐ ☐ ☐ ☐ 2 ☐ ☐ ☐ ☐ 3 ☐ ☐ ☐ ☐ 4 ☐ ☐ ☐ ☐ 5 ☐ ☐ ☐ ☐ A B C D 6 ☐ ☐ ☐ ☐ 7 ☐ ☐ ☐ ☐ 8 ☐ ☐ ☐ ☐	Question 02 A B C D 9 ☐ ☐ ☐ ☐ 10 ☐ ☐ ☐ ☐ 11 ☐ ☐ ☐ ☐ 12 ☐ ☐ ☐ ☐ 13 ☐ ☐ ☐ ☐ A B C D 14 ☐ ☐ ☐ ☐ Question 03 A B C D 15 ☐ ☐ ☐ ☐ 16 ☐ ☐ ☐ ☐ 17 ☐ ☐ ☐ ☐ 18 ☐ ☐ ☐ ☐ 19 ☐ ☐ ☐ ☐ A B C D 20 ☐ ☐ ☐ ☐
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