



0307

THE OPEN UNIVERSITY OF SRI LANKA
BSc (IT) DEGREE PROGRAMME: LEVEL 04

FINAL EXAMINATION: 2026/2027

COU4201: KNOWLEDGE REPRESENTATION & LOGIC PROGRAMMING

DURATION: TWO HOURS ONLY (2 HOURS)

Date: 27.06.2026

Time: 9.30 a.m. – 11.30 a.m.

Answer Four (04) questions only.

Q1.

(i) A smart home system follows the rules given below:

- The alarm will activate if a door is open and the security system is alarmed.
- The user can unlock the house using a fingerprint or a password.
- The lights will turn off if the owner is not at home.
- The heater operates only if the temperature is below 20°C.
- The garage door opens if and only if the correct access code is entered.

- a) Identify the logical connective(s) used in each rule given above.
- b) Represent each rule using **propositional logic** notation.

[10 marks]

(ii) Consider the following statement:

“The door is open if and only if the correct password or fingerprint is entered.”

Let:

D = door is open

P = correct password is entered

F = correct fingerprint is entered

- a) Write the propositional logic expression for the given statement.
- b) Simplify the logical expression obtained in part (ii) a) using logical equivalence laws until it contains only AND, OR, and NOT operators.
- c) Construct the truth table for the **propositional logic** expression obtained in part a).

[15 marks]

Q2.

A university has a system for classifying books in a library.

- (i) The following facts are known, LocatedAbove(X, Y) means item X is placed directly above item Y on a shelf. Rare(X) means item X is a rare book.

The following information is given:

- LocatedAbove(M, N)
- LocatedAbove(N, O)
- LocatedAbove(O, P)
- Rare(M)
- $\neg$ Rare(P)

Using logical reasoning, determine whether there exists a rare item that is directly placed above a non-rare item in the system.

- a) List the given facts in logical form and identify their meaning.
- b) Determine whether the following statement is true or false.

$$\exists X \exists Y (Rare(X) \wedge \neg Rare(Y) \wedge LocatedAbove(X, Y))$$

[15 marks]

- (ii) Consider the following statement:

“In a smart classroom system, a student is allowed to access the online exam system if the student is enrolled in the course and has completed the prerequisite module.”

Let:

Student(x): x is a student

Enrolled(x, c): student x is enrolled in course c

Completed(x, m): student x has completed module m

Allowed(x): student x is allowed to access the online exam system

Course = C

Module = M

- a) Write the **First-Order Logic (FOL)** formula to represent the above statement.
- b) State the **arity** of each predicate used in your formula.

[10 marks]

Q3.

- (i) A knowledge-based system is being developed for an intelligent university admission advisor. The system helps students to check eligibility for different degree programs based on their academic records and subject requirements.

The knowledge engineering process consists of the following steps:

1. Identify the task
2. Assemble relevant knowledge
3. Decide on a vocabulary of predicates, functions, and constants (Ontology design)
4. Encode general knowledge about the domain
5. Encode a description of the specific problem instance
6. Pose queries to the inference system
7. Debug the knowledge base

Scenarios:

- A. The system defines predicates such as Eligible(x, p), HasGrade(x, s), and Requires(p, s).
- B. Rules are written such as: "A student is eligible if they meet all subject requirements."
- C. The system asks: "Is Student X eligible for Program Y?"
- D. The system is designed to determine whether a student is eligible for a selected degree program.
- E. A specific student record is entered into the system.
- F. The system output is checked and corrected if incorrect results occur.
- G. The system designer consults university admission officers to understand entry requirements.

- a) Match each scenario (A - G) with the correct step (1 - 7).
- b) Briefly justify each matching state in part (i) a).

[14 Marks]

- (ii) Consider the following natural language statements:

1. All wealthy professors in a university admire Dr. Silva.
2. In a certain community, all citizens, with the possible exception of John, respect the mayor.

Let the predicates be defined as follows:

Wealthy(x): x is wealthy

Professor(x): x is a professor

Admires(x, y): x admires y

Citizen(x): x is a citizen

Respects(x, y): x respects y

Constants:

s = Dr. Silva

m = mayor

j = John

- a) Write the **First-Order Logic (FOL)** representation for each statement given above.
- b) Identify and explain the use of quantifiers and logical connectives used in each formula state in part (ii) a).

[11 Marks]

Q4.

- (i) A smart hospital management system is designed to automatically assign patients to treatment units based on medical conditions and resource availability.

The system follows the rules given below:

- If a patient has a contagious disease, they must be isolated before receiving treatment.
- A patient can be admitted to the ICU only if a ventilator is available and the patient's condition is critical.
- A patient receives treatment only if they are admitted to a treatment unit.
- If a patient is isolated, they cannot be assigned to a general ward.

- a) Translate the above rules into **First-Order Logic (FOL)** or **propositional logic** using suitable predicates.
- b) Using logical reasoning, determine whether a patient with a contagious but non-critical condition can be assigned to the ICU. Justify your answer.

- c) Assume a patient is contagious and is not admitted to ICU. Determine whether the patient can still receive treatment in a general ward. Justify your answer.

[15 Marks]

- (ii) *Negate the following statements:*

“Every employee works on at least one project.”

- Express this statement in First-Order Logic (FOL).
- Write the negation of the statement in FOL.
- Interpret the negation in plain English.

[05 Marks]

- (iii) *Negate the following statements:*

“There exists at least one student who mentors another student.”

- Express this statement in First-Order Logic (FOL).
- Write the negation of the statement in FOL.
- Interpret the negation in plain English.

[05 Marks]

Q5.

- (i) Identify and explain the following built-in predicates used in Prolog. Provide the purpose and a simple example for each predicate.

- `write/1`
- `read/1`
- `nl/0`
- `consult/1`
- `is/2`

[10 Marks]

- (ii) Create a simple Prolog knowledge base file named ‘family.pl’ using the following facts:

- John is the parent of Mary.
- Mary is the parent of Sam.
- David is the parent of Mary.

- a) Write the Prolog facts for the above information.

[04 Marks]

b) Write and execute the following queries and state the expected output for each.

- i. Is John the parent of Mary?
- ii. Who is the parent of Mary?
- iii. Is Sam the parent of Mary?

[06 Marks]

c) Extend your Prolog program with the following rule:

- A person X is an ancestor of Y if X is a parent of Y OR X is a parent of someone who is an ancestor of Y.

Write the recursive rule for ancestor/2.

Then execute the following queries and state whether how backtracking produces multiple answers:

- i. Who are all the ancestors of Sam?
- ii. State all possible ancestor relationships in the database using backtracking.

[05 Marks]

Q6.

(i) Consider the following Prolog program:

```
calc(A, B) :- B is A + 2.
```

```
calc(A, B) :- A > 3, B is A * 2.
```

```
calc(A, B) :- A =< 3, B is A - 1.
```

Using the above program, determine the output of the following queries. State all possible results using backtracking where applicable.

- a) ?- calc(2, X).
- b) ?- calc(5, X).

[08 Marks]

- (ii) Consider the following Prolog program:

```
odd_loop(0).  
odd_loop(N) :-  
    N > 0,  
    (N mod 2 == 1 -> write(N), nl ; true),  
    M is N - 1,  
    odd_loop(M).
```

- a) Describe the functionality of the above program in your own words.

[05 Marks]

- b) Write the output of the following query:

```
?- odd_loop(5).
```

[04 Marks]

- c) Trace the execution step by step for `odd_loop(4)` and show what is printed at each recursive call.

[04 marks]

- d) Modify the above program, so that it prints even numbers from 1 to 10 in ascending order.

[04 marks]

**** *All Rights Reserved* ****