THE OPEN UNIVERSITY OF SRI LANKA
BSc (IT) DEGREE PROGRAMME: LEVEL 04
FINAL EXAMINATION: SEMESTER 1: 2024/2025
COU4201: KNOWLEDGE REPRESENTATION & LOGIC PROGRAMMING
DURATION: **TWO HOURS (2 HOURS)**

Date: **12.06.2025** Time: **9.30 am – 11.30 am**

Answer FOUR Questions ONLY.

Q1.

(a) Explain all five (05) **logical connectives** using an example.

[10 Marks]

(b) Consider the following propositional expression involving three propositions P, Q, and R;

$\neg((P \vee Q) \wedge \neg R) \rightarrow ((\neg P \wedge R) \vee Q)$

(i) Construct a complete truth table for the above expression.

[08Marks]

(ii) Clearly explain which rows represent model assignments, counterexamples, contradictions, and tautologies.

[02 Marks]

(c) Prove the following equation using the laws of propositional logic. Clearly state the name of each law in front of the step where it is applied.

$\neg[(P \rightarrow (Q \wedge R)) \vee (\neg Q \rightarrow \neg P)] \equiv P \wedge (\neg Q \vee \neg R) \wedge \neg Q$

[05 Marks]

Q2.

(a) Assume the following explicit beliefs about blocks a, b, c, and d:

- O(a,b) — Block a is on top of block b
- O(b,c) — Block b is on top of block c
- O(c,d) — Block c is on top of block d
- G(a) — Block a is green
- $\neg$G(d) — Block d is not green

Using logical reasoning and the given facts above, determine if a green block is directly on top of a non-green block.

[10 Marks]

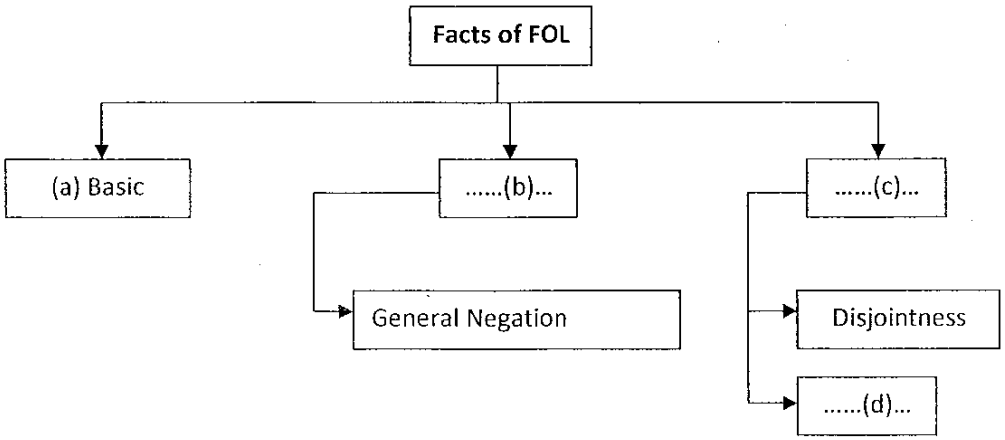
(b) (i) Explain what **arity** means in the context of First-Order Logic (FOL).

(ii) Write the FOL formula representing this statement. Then, state the arity of each function and predicate used in your formula.

"The sum of one and the negation of one is zero."

[06 Marks]

(c) (i) Write the appropriate terms for (b), (c), and (d) of the following chart.



[03 Marks]

(ii) Define the terms (a), (b), and (c) mentioned in the above question (i).

[06 Marks]

Q3.

(a) What is a **Knowledge Base** in the context of Artificial Intelligence? Explain your answer with a suitable example.

[05 Marks]

(b) Explain four (04) steps in the Knowledge Engineering Process.

[08 Marks]

(c) *"Three friends – **Nina**, **Oscar**, and **Priya** – are suspected of stealing a rare artifact from a museum. It is known that exactly one of them is the thief. Suppose that, if a person visits the museum, that person definitely sees the artifact."*

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Each of them makes a statement during interrogation:

- **Nina** says: *"Oscar was at the museum during the theft, but Priya was not."*
- **Oscar** says: *"I didn't even know about the artifact, and Priya is innocent."*
- **Priya** says: *"Nina and I were both at a café during the time of the theft."*

You may assume that everyone is telling the truth—except possibly for the thief.

(i) Formalize each person's statements as propositional logic.

(ii) Assume that exactly one of them is guilty, and only the guilty party might lie. Use logical contradiction (resolution) to identify who must be lying, and conclude who the thief is.

[12 Marks]

Q4.

(a) (i) Define what **Resolution** is in knowledge representation, and write the 3 steps in resolution.

(ii) Explain the three special types of clauses

(iii) Convert to CNF

$((p \supset q) \supset r)$

[06 Marks]

(b) Go through the given scenario and write a detailed answer using First-Order Logic (FOL).
In a knowledge-based system, the following ontology about vehicles is defined:

- All electric vehicles are vehicles.
- Some vehicles run on fossil fuel, while others run on electricity.
- Trucks are vehicles that run on fossil fuel.
- Every vehicle that runs on electricity is quiet.
- Tesla cars are electric vehicles and are quiet.

(i) Given the above ontology, is it possible for a Tesla car to be noisy? Why or why not?

(ii) If a new rule states, "All vehicles must have wheels," how does this impact the existing ontology?

(iii) A researcher discovers a new model of electric vehicle that is not quiet. What changes must be made to the ontology to resolve any contradictions?

(iv) Suppose an AI system is reasoning with this knowledge. If a new entity called "RoboRider" is introduced as a vehicle, what additional information is needed to determine whether it is quiet?

[13 Marks]

(c) Consider the following statement:

Every employee who works overtime receives a bonus.

(i) Express the above statements using First-Order Logic (FOL).

(ii) Provide the negation of the above statement in FOL.

(iii) Interpret the negation in natural English.

[06 Marks]

Q5.

(a) List three key characteristics of the **Prolog programming language.**

[03 Marks]

(b) Identify and explain three built-in predicates in Prolog.

[06 Marks]

(c) Write a Prolog program to store facts indicating that apple, banana, and lemon are fruits, and that two of them (apple and banana) are sweet, while one (lemon) is sour.

(i) Create a file named `fruits.pl` store your facts in the file.

(ii) Show how to load the file into SWI-Prolog using the methods we have discussed in class.

(iii) Show how to use the `listing/0` command to verify that the database was loaded correctly.

[08 Marks]

(d) Write the correct Prolog queries for the following goals.

(i) Is there a fruit named banana in the database?
(ii) Are apple and lemon both listed as fruits?
(iii) Is apple a fruit and also sweet?
(iv) Is lemon a fruit and also sweet?

[08 Marks]

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Q6.

(a) Write the output of the following prolog queries.

(i) `?- write('Great job!'), nl.`

(ii) `?- 5 is 10 / 2.`

(iii) `?- 25 is 5 * 5.`

(iv) `?- X is 3 + 7.`

[04 Marks]

(b) What are the three (03) types of operators in Prolog? Explain with examples.

[06 Marks]

(c) Write short notes on the following topics. Include suitable examples for each.

(i) Operator precedence in Prolog programming.

(ii) Control structures in Prolog.

(iii) Logical connectives in Prolog.

[06 Marks]

(d) Define and test a predicate which takes two arguments, both numbers, and calculates and outputs the following values:

(i) Their average.

(ii) The square root of their product.

(iii) The larger value of (i) and (ii).

[09 Marks]