THE OPEN UNIVERSITY OF SRI LANKA
BSc (IT) DEGREE PROGRAMME: LEVEL 04
FINAL EXAMINATION: 2023/2024
COU4201 – KNOWLEDGE REPRESENTATION AND LOGIC PROGRAMMING
DURATION: TWO HOURS (2 HOURS)

0019

Date: 26th August 2024 **Time:** 1.30 pm – 3.30 pm

Answer FOUR (04) questions only.

1)

a. "Reasoning is the formal manipulation of the symbols representing a collection of believed propositions to represent new ones." Explain what is meant by the term **knowledge** in the context of knowledge representation and reasoning. [04 marks]

b. Explain the following terms in your own words.
   i. Syntax
   ii. Semantics
   iii. Pragmatics [06 marks]

c. In the First Order Logic (FOL) there are two types of symbols that have been used to express *Syntax*. Explain each of them. [06 marks]

d. *Alice, Bob, and Carol are part of the Art Society. Every member of the Art Society who does not enjoy painting is a sculptor. Sculptors do not enjoy loud music, and anyone who does not enjoy classical music is not a painter. Bob dislikes whatever Alice enjoys and likes whatever Alice dislikes. Alice enjoys classical music and painting.*

   Prove, using First Order Logic (FOL), that there is a member of the Art Society who is a sculptor but not a painter. [09 marks]

2)

a. Explain the following terms in expressing knowledge.
   i. Ontology
   ii. Knowledge Engineering [04 marks]

b. Explain the steps in the procedure of converting any propositional formula to Conjunctive Normal Form (CNF). [03 marks]

c. Consider the following sentences and prove by resolution that: **Sarah likes coffee.**

i. Sarah likes all beverages.
ii. Coffee and tea are beverages.
iii. Anything that anyone drinks and is not expired is a beverage.
iv. Tom drinks coffee and is not expired.
v. Alex drinks everything that Tom drinks.

Hint: The steps for resolution are,

- **Convert the facts into first-order logic.**
- **Convert the FOL statement into CNF.**
- **Negate the statement that needs to be proven (proof by contradiction).**
- **Draw resolution graph (unification).** [10 marks]

d. Consider the following set of FOL expressions

employee(e)∧department(d)∧works_in(e, d)→eligible_for_bonus(e)
eligible_for_bonus(e) ∧ achieved_target(e, t) → receives_bonus(e,t)
achieved_target(alice, sales)
achieved_target(bob, marketing)
works_in(alice, finance)
works_in(bob, sales)
department(finance)
department(sales)
department(marketing)
employee(alice)
employee(bob)

Step by step explain how you conclude that **receives_bonus(bob, marketing)** is true with the use of,

i. Forward chaining
ii. Backward chaining [08 marks]

3)

a. Write the outputs of the following PROLOG codes.

i. ? X is 10, Y is X*(2*X).
ii. ? X is mod(9,3).
iii. ? sqrt(81)-11=:=12*6-2.
iv. checkodd(N):-M is N mod 2, M=:=1.

?-checkodd(5).

v. ?- X=fred,read(X).
|: felix. [08 marks]

b. Suppose *test1.pl* contains the lines;

```
alpha.
delta.
male(john).
male(ross).
male(raj).
female(penny).
female(monica).
```

and *test2.pl* contains the lines

```
theta.
male(joey).
parent(samson).
parent(jess).
```

With the use of query **?- consult('test1.pl'),consult('test2.pl').** both files are consulted in the presented order. Answer the following queries.

i. ?- alpha.
ii. ?- male(john).
iii. ?- parent(jess). [06 marks]

c. Suppose you are given the following Prolog program file *animals.pl*:

```
?- dynamic(dog/1).
dog(bella).
dog(max).
dog(rocky).
```

Suppose this file is consulted into the Prolog database and then the following queries are executed:

```
?- retract(dog(max)).
?- assertz(dog(luna)).
?- retractall(dog(_)).
?- assertz((cat :- write('hello kitty'), nl)).
```

i. What will be the state of the Prolog database regarding the **dog/1** predicate after executing all the queries?
ii. What happens when you execute the **?- cat.** query after the final query? [06 marks]

d.

i. Define a Prolog predicate **add_person/1** that adds a person to the database by user (e.g.: alice, bob, charlie) only if the person is not already present. Use a cut to ensure that once a person is found, no further actions are taken.

ii. Write a Prolog predicate **show_people/0** that prints each person in the database on a new line. Ensure that the predicate handles cases where there are no people in the database.

iii. Define a Prolog predicate **delete_person/1** that removes a person from the database if it exists. Use a cut to ensure that the predicate only performs the removal once and does not attempt further actions. [05 marks]

4)

a. Explain the *cons* notation in the Lists using an example. [04 marks]

b. What will be the output of the following PROLOG codes.

i. ?- X=yellow,Y=100,Z=[green,red,blue],write('List is'),write([X,Y,Z]),nl.

ii. ?- write([red,green|[blue|[yellow|[]]]]), nl. [06 marks]

c. Consider the following Prolog list: [1, 2, 3, 4, 5, 6].

i. Use the **member/2** predicate to check if 3 is an element of this list.

ii. Use the **length/2** predicate to determine the length of the list.

iii. Reverse the list using the **reverse/2** predicate.

iv. Use the **append/3** predicate to split the list into two parts where the first part contains the first three elements. [08 marks]

d. Write predicates for the following scenarios.

i. **join3/4**: Join three strings String1, String2, and String3 to form a new string Newstring.

ii. **readline_from_file/2**: Read the first line from a given text file and output it as an atom. (Hint: You need to implement a helper predicate readline/1 to read a line from the terminal, which you can then adapt to read from a file.) [07 marks]

5)

a. Provide brief answers to the following.

i. What is a production rule?

ii. What are the key phases of operation in a production system?

iii. Provide a simple example for production rule. [06 marks]

b. Briefly explain the Structure of a WME. [07 marks]

c. Describe the concept of conflict resolution in a production system and give an example of a conflict resolution approach. [06 marks]

d. Three bricks, each a different size, are piled up and you wish to use a robotic "hand" to place the bricks in one of three clearly defined places refer as position 1, 2, and 3. The largest brick should go in position 1 and the smallest in position : Position 1, Position 2, and Position 3. The goal is to arrange the bricks such that:

The largest brick is placed in Position 1.
The medium brick is placed in Position 2.

The smallest brick is placed in Position 3.

The robotic hand can only move one brick at a time, and it can only place a brick onto an empty position or on top of a larger brick.

Describe the sequence of events from the initial state to the final configuration of the bricks according to production system principles. Include the production rules that would guide each step of the process. [06 marks]

e.

Write the sequence of events from the initial state to the final configuration of the bricks according to the production principles. [06 marks]

6)

a. What are **slots** and **fillers** in the context of frames used in object-oriented representation systems? How are they utilized? [06 marks]

b. Explain the concept of inheritance networks and discuss how they are used to represent knowledge in artificial intelligence. [06 marks]

c. Compare and contrast strict inheritance and defeasible inheritance, providing examples to illustrate your answer. [06 marks]

d. Explain the concept of inferential distance and how it differs from the shortest path heuristic. Provide examples to support your explanation. [07 marks]