VIT

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

<u>School of Computer Science and Engineering</u>

FALL Semester – 2023 - 24

Continuous Assessment Test – 2

Exam Duration: 90 Min

Programme Name & Branch: B.Tech & Computer Science and Engineering **Date:** 16-10-2023

Course Name & Code: Artificial Intelligence & CSE3013 **Slot:** B2 + TB2

Class Number(s): VL2023240103690, 3712, 3732 **Maximum Marks:** 50

Sl.	Questions
1.	Represent the following sentences in FOL i. Every student has taken at least one computer science course. ii. A student has taken at most one computer science course. iii. Every student has been in every building on campus. iv. There is a student who has been in every room of at least one building on campus. v. Every student has been in at least one room of every building on campus. vi. Every student has been in every room of every building on campus. Conclusion: iii Does v entail iii? prove it by resolution. Answer 1. Every student has taken at least one computer science course. $\forall x\ Student(x) \Rightarrow \exists y\ CScourse(y) \land Take(x, y)$ 2. A student has taken at most one computer science course. $\exists x\ Student(x)\land[\forall y\ CScourse(y)\land Take(x, y) \Rightarrow [\forall z CScourse(z)\land$ $z\ 6= y \Rightarrow \neg Take(x, z)]]$ or, equivalently, $\exists x\ Student(x)\land[\forall y\ CScourse(y)\land Take(x, y) \Rightarrow [\forall z CScourse(z)\land$ $Take(x, z) \Rightarrow z = y]]$ 3. Every student has been in every building on campus. $\forall x \forall y\ Student(x) \land Building(y) \Rightarrow Visited(x, y)$ 4. There is a student who has been in every room of at least one building on campus. $\exists x\ Student(x) \land \exists y\ Building(y) \land [\forall z\ Room(z, y) \Rightarrow Visited(x, z)]$ 5. Every student has been in at least one room of every building on campus. $\forall x \forall y\ Student(x) \land Building(y) \Rightarrow \exists z\ Room(z, y) \land Visited(x, z)$

6. ∀x∀y∀z Room(z, y) ∧ V isited(x, z) ⇒ V isited(x, y)

(b) transform the expressions you wrote in part (a) to CNF.
1a ¬Student(x) ∨ CScourse(S(x))
1b ¬Student(x) ∨ Take(a, S(x))
2 Student(S0) ∧ ¬CScourse(y) ∨ ¬Take(S0, y) ∨ ¬CScourse(z) ∨
z = y ∨ ¬Take(S0, z)
3 ¬Student(x) ∨ ¬Building(y) ∨ V isited(x, y)
4a Student(S1)
4b Building(S2)
4c ¬Room(z, S2) ∨ V isited(S1, z)
5a ¬Student(x) ∨ ¬Building(y) ∨ Room(S3(x, y), y)
5b ¬Student(x) ∨ ¬Building(y) ∨ Visited(x, S3(x, y))

(c) Does 5 entail 3? If yes, prove it by resolution (adding additional expressions if needed). If not, explain why not.
Answer: to answer we need to negate 3, add it to a knowledge base which contains 5 and any other expression we would have to add, and prove a contradiction.
Given 3. ∀x∀y Student(x) ∧ Building(y) ⇒ Visited (x, y)
we negate it and obtain
3a Student(S4)
3b Building(S5)
3c ¬Visited(S4, S5)
We need to add a new expression
6. ∀x∀y∀z Room(z, y) ∧ Visited(x, z) ⇒ Visited(x, y)
which in CNF is
6 ¬Room(z, y) ∨ ¬Visited(x, z) ∨ Visited(x, y)
We resolve 5a with 3a unifying {x/S4} and obtain
7 ¬Building(y) ∨ Room(S3(S4, y), y)
7 is resolved with 6 using unification {z/S3(S4,y)} and we obtain
8 ¬Visited(x, S3(S4, y)) ∨ Visited(x, y) ∨ ¬Building(y)
which is resolved against 3c with unification {x/S4, y/S5} to obtain
9 ¬Visited(S4, S3(S4, S5)) ∨ ¬Building(S5)
which we resolve with 5b unifying {x/S4, y/S5} to obtain
10 ¬Student(S4) ∨ ¬Building(S5)
We resolve it with 3a to obtain
11 ¬Building(S5)
which, finally, resolved with 3b produces
12 NIL

2. Convert the below sentences in propositional logic and apply resolution rules for propositional logic to find the answer.

    a. If you have the flu, then you miss the final exam.
    b. You do not miss the final exam if and only if you pass the course.
    c. If you miss the final exam, then you do not pass the course.
    d. You have the flu, or miss the final exam, or pass the course.
    e. It is either the case that if you have the flu then you do not pass the course or the case that if you miss the final exam then you do not pass the course.
    f. Either you have the flu and miss the final exam, or you do not miss the final exam and do pass the course.

Conclusion: If you have the flu, then you do not pass the course.

Resolution Steps:

    1. Conversion of facts into Propositional logic
    2. Convert FOL statements into CNF
    3. Negate the statement which needs to prove (proof by contradiction)
    4. Draw resolution graph (unification)

p: You have the flu.

q: You miss the final examination.

r: You pass the course.

Step 1: Propositional logic:

a) $p \rightarrow q$: If you have flu then you will miss the final examination.(Implication statement)
b) $\neg q \leftrightarrow r$: You won't miss the final examination if and only if you pass the course. (Bi-conditional statement)
c) $q \rightarrow \neg r$: If you miss the examination then you will be failing the course. (Implication Statement)
d) $p \lor q \lor r$: You have the flu OR you miss the final examination OR you pass the course. (Disjunction Proposition)
e) $(p \rightarrow \neg r) \lor (q \rightarrow \neg r)$: If you have the flu then you'll not pass the course OR If you miss the final examination then you'll fail the course.((P implies not R) OR (Q implies not R))
f) $(p \land q) \lor (\neg q \land r)$: You have the flu and you miss the examination OR You will not miss the final examination and you pass the course.((P and Q) OR (not Q and R))

Step 2: CNF

① $\neg p \vee q$

② $(\neg q \leftrightarrow r)$

$(\neg q \rightarrow r) \wedge (r \rightarrow \neg q)$

$(\neg\neg q \vee r) \wedge (\neg r \vee \neg q)$

$(q \vee r) \wedge (\neg r \vee \neg q)$

2a $q \vee r$ 2b $\neg r \vee \neg q$

③ $\neg q \vee \neg r$

④ $p \vee q \vee r$

⑤ $(\neg p \vee \neg r) \vee (\neg q \vee \neg r)$

⑥ $(p \wedge q) \vee (\neg q \wedge r)$

Goal

$p \rightarrow \neg r$

CNF

$\alpha \rightarrow \beta$

$\neg\alpha \vee \beta$

$\alpha \leftrightarrow \beta$

$(\alpha \rightarrow \beta) \wedge (\beta \rightarrow \alpha)$

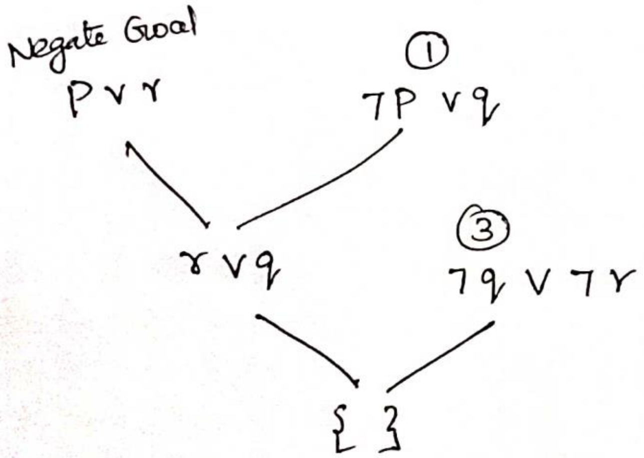
Step 3: Negate Goal

$\neg p \rightarrow r$

$\neg(\neg p) \vee r$

$p \vee r$

Step 4: Resolution Graph



3.a Represent the following sentences in FOL.

a. Anything that is played by any student is tennis, soccer, or chess.
b. Anything that is chess is not vigorous.
c. Anyone who is healthy plays something that is vigorous.
d. Anyone who plays any chess does not play any soccer.
e. (Conclusion) If every student is healthy, then every student who plays any chess plays some tennis.

Use forward chaining algorithm to infer the Conclusion. (6 marks)

Facts to FOL

Apply Forward chaining.

3 b. Construct the Truth table for ((P →Q) →R) →S. (4 marks)

Note: P, Q, R and S are different variables.

Propositional Logic

p	q	r	s	$p \to q$	$(p \to q) \to r$	$((p \to q) \to r) \to s$
T	T	T	T	T	T	T
T	T	T	F	T	T	F
T	T	F	T	T	F	T
T	T	F	F	T	F	T
T	F	T	T	F	T	T
T	F	T	F	F	T	F
T	F	F	T	F	T	T
T	F	F	F	F	T	F
F	T	T	T	T	T	T
F	T	T	F	T	T	F
F	T	F	T	T	F	T
F	T	F	F	T	F	T
F	F	T	T	T	T	T
F	F	T	F	T	T	F
F	F	F	T	T	F	T
F	F	F	F	T	F	T

4. Suppose a new pet, called Fotik, is delivered in an opaque (non-transparent) box along with two facts about Fotik:

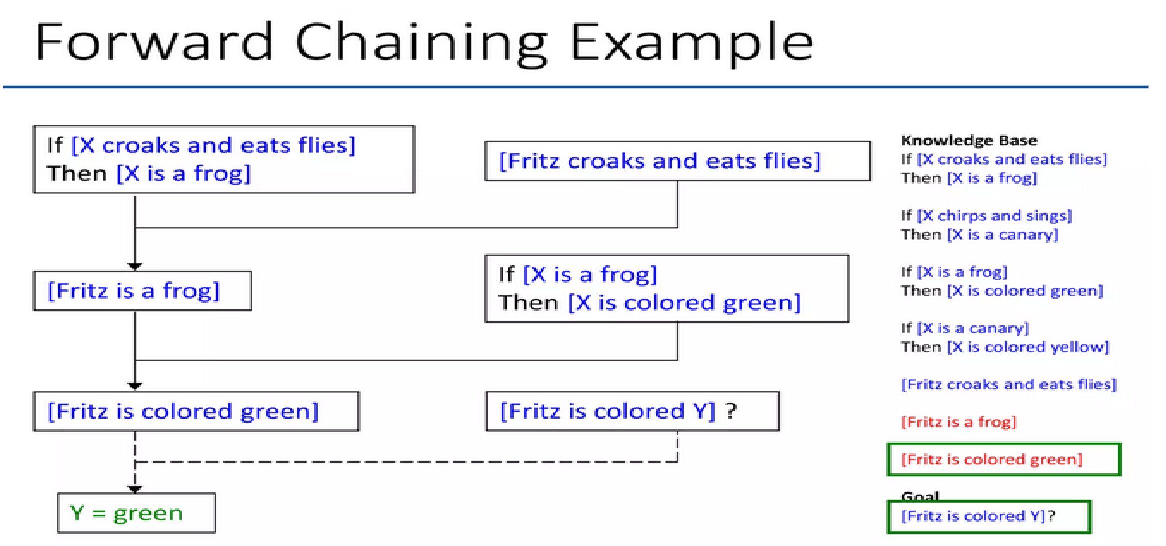
Fact 1: Fotik croaks
Fact 2: Fotik eats flies

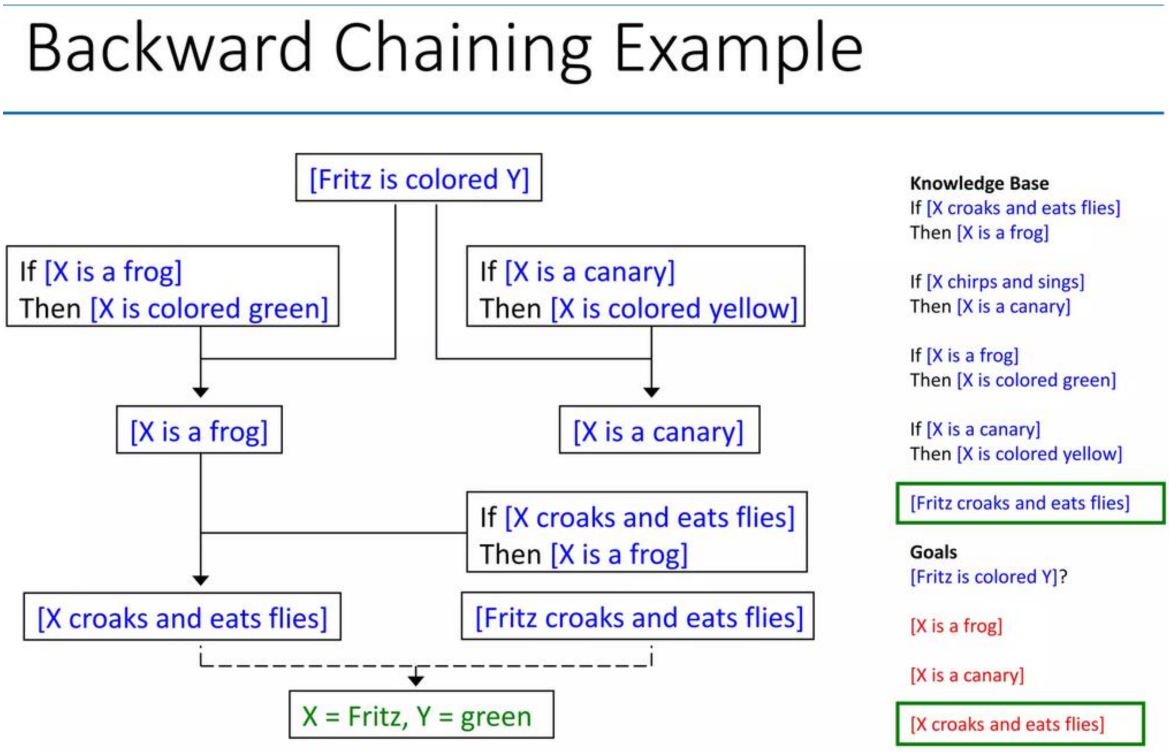
Suppose you have a rule base containing the following four rules:) You can replace X with Fotik wherever applicable)

Rule 1: If X croaks and X eats flies - Then X is a frog
Rule 2: If X chirps and X sings - Then X is a canary
Rule 3: If X is a frog - Then X is green
Rule 4: If X is a canary - Then X is yellow

a. Using both forward chaining and backward chaining processes to decide whether Fotik is green. (3+3 marks)
b. Explain which is the more appropriate technique to use in this scenario. (2 marks)

c. Also draw the AND-OR graph that demonstrates the process of forward chaining. (2 marks)





5 Consider the Wumpus world shown below

Stench (1,5)	(2,5)	(3,5)	Breeze (4,5)	(5,5)
Wumpus (1,4)	Stench (2,4)	Breeze (3,4)	Pit (4,4)	Breeze (5,4)
Stench (1,3)	Breeze (2,3)	Pit (3,3)	Breeze (4,3)	Pit (5,3)
(1,2)	(2,2)	Breeze Gold (3,2)	(4,2)	Breeze (5,2)
Agent (1,1)	Breeze (2,1)	Pit (3,1)	Breeze (4,1)	(5,1)

Assume the following knowledge base of the agent. (4 marks)

(1,1) → (2,1) → (1,1) → (1,2) → (1,3) → (1,2) → (2,2) → (3,2)

Convert the Knowledge base into propositional logic sentences.

Show by resolution that, in the given situation, cell (1,4) contains a Wumpus and (3,2) contains a Gold. (3+3 marks)

Knowledge base of the agent -Propositional logic – Resolution

R1. $\neg S_{11} \rightarrow \neg W_{11} \wedge \neg W_{12} \wedge \neg W_{21}$

R2. $\neg S_{21} \rightarrow \neg W_{11} \wedge \neg W_{21} \wedge \neg W_{22} \wedge \neg W_{31}$

R3. $\neg S_{12} \rightarrow \neg W_{11} \wedge \neg W_{12} \wedge \neg W_{22} \wedge \neg W_{13}$

R4. $\neg S_{13} \rightarrow \neg W_{12} \wedge \neg W_{13} \wedge \neg W_{23} \wedge \neg W_{14}$

R5. $S_{13} \rightarrow W_{12} \vee W_{13} \vee W_{23} \vee W_{14}$

Resolution :

Rules: $S_{13} \rightarrow W_{12} \vee W_{13} \vee W_{23} \vee W_{14}$

$W_{12} \vee W_{13} \vee W_{23} \vee W_{14}$ $\quad$ $\neg W_{12}$

$W_{13} \vee W_{23} \vee W_{14}$ $\quad$ $\neg W_{13}$

$W_{23} \vee W_{14}$ $\quad$ $\neg W_{23}$

W_{14}

Wumpus in (1, 4)

Same way Gold in (3, 2)