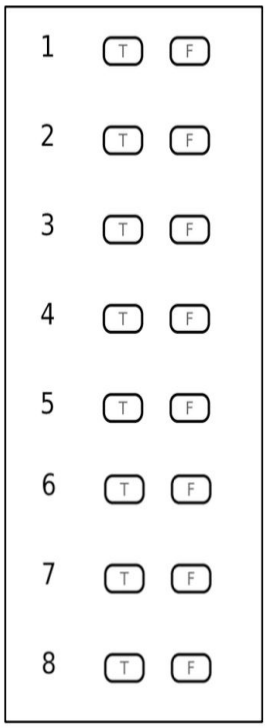
1. [8%] General AI Knowledge and Application.



F, 1). [1%] $\neg(A \Leftrightarrow B) = (A \wedge (\neg B)) \vee (B \wedge A)$.

T, 2). [1%] Every definite clause is a Horn clause.

T, 3). [1%] KB *entails* α if and only if $KB \Rightarrow \alpha$.

T, 4). [1%] $A \vee B$ is satisfiable.

F, 5). [1%] $(A \Leftrightarrow B)$ *entails* $(A \vee B)$.

T, 6). [1%] $\neg \forall x\ Likes(x,\ IceCream) \equiv \exists x\ \neg Likes(x,\ IceCream)$.

F, 7). [1%] Skolemization is the process of removing universal quantifiers by elimination.

T, 8). [1%] $\neg\ \exists x$ (F(x) $\wedge$ P(x)) is the logical translation of the statement: "None of my friends are perfect."

2.[16%] Multiple Choice

1. (b)
2. (b)
3. (a)
4. (f)
5. (g)
6. (c)
7. (c)
8. (d)

3.[8%] First-Order Logic (FOL)

3A. [2%]

$\exists x\ (IsWorker(x) \wedge \neg IsHardworking(x))$

3B. [2%]

$\forall x\ (IsWorker(x) \wedge IsHardworking(x) \Rightarrow \exists y (IsEvaluation(y) \wedge \neg Baffles(y,x)))$

Or

$\forall x\ (\neg IsWorker(x) \vee \neg IsHardworking(x) \vee \exists y (IsEvaluation(y) \wedge \neg Baffles(y,x)))$

3C. [2%]

$\forall x\ ((IsEvaluation(x) \Rightarrow \exists y\ (IsWorker(y) \wedge Baffles(x,y)))$

Or

$\forall x\ (\neg IsEvaluation(x) \vee \exists y\ (IsWorker(y) \wedge Baffles(x,y)))$

3D. [2%]

$(\exists x)\ (\exists y)\ isWorker(x) \wedge isHardworking(x) \wedge isWorker(y) \wedge isHardworking(y) \wedge \neg(x = y) \wedge (\forall z)\ (isWorker(z) \wedge isHardworking(z)) \Rightarrow ((x = z)\ OR\ (y = z))$

Or

$(\exists x)\ (\exists y)\ isWorker(x) \wedge isHardworking(x) \wedge isWorker(y) \wedge isHardworking(y) \wedge \neg(x = y) \wedge (\exists z)\ (\neg isWorker(z) \vee \neg isHardworking(z)) \vee (x = z) \vee (y = z)$

4.[20%] Inference in First Order Logic

4A.[10%]

Rule 4: Halfling(Frodo)

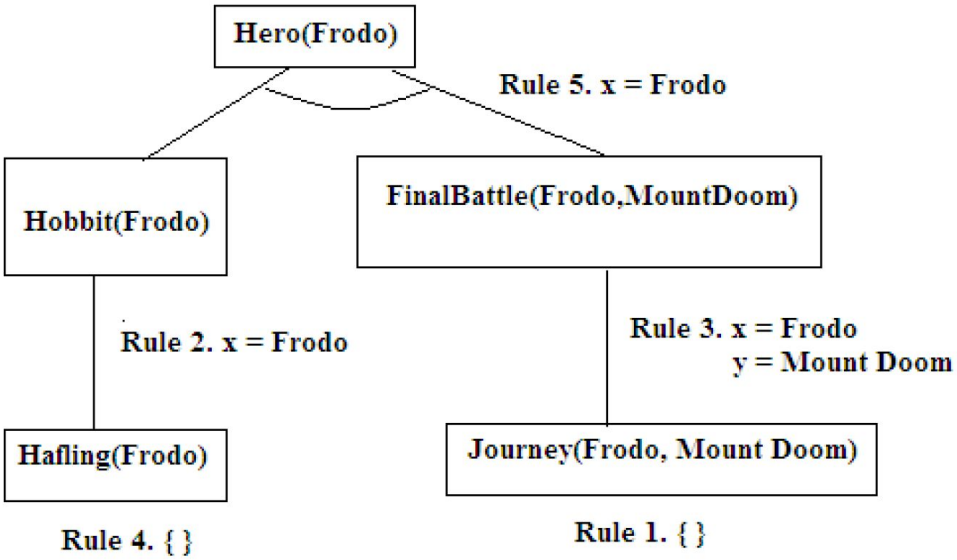
Rule 2: Halfling(Frodo) → Hobbit(Frodo) x = Frodo

Rule 1: Journey(Frodo, Mount Doom)

Rule 3: Journey(Frodo, Mount Doom) → FinalBattle(Frodo, Mount Doom) x = Frodo, y = Mount Doom

Rule 5: Hobbit(Frodo) ^ FinalBattle(Frodo, Mount Doom) → Hero(Frodo)

4B.[10%]



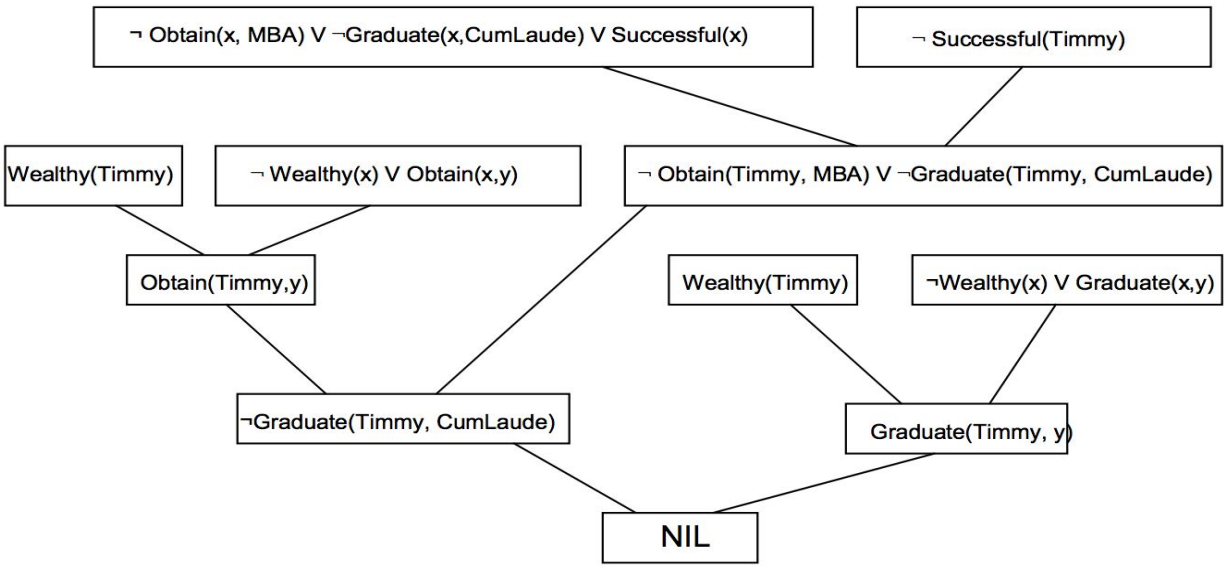
5.[23%] CNF and Resolution with FOL

5A.[10%]

1. Eliminate implication
   $\forall x\ [\neg\ (\forall y\ P(x, y)) \vee (\neg\forall y\ (\neg Q(x, y) \vee R(x, y)))\ ]$
2. Reduce scope of negation
   $\forall x\ [(\ \exists y\ \neg P(x, y)) \vee (\ \exists y\ (Q(x, y) \wedge \neg R(x, y)))\ ]$
3. Standardize variables
   $\forall x\ [(\ \exists y\ \neg P(x, y)) \vee (\ \exists z\ (Q(x, z) \wedge \neg R(x, z)))\ ]$
4. Eliminate existential quantification
   $\forall x\ [\neg P(x, f(x)) \vee (Q(x, g(x)) \wedge \neg R(x, g(x)))\ ]$
5. Drop universal quantification symbols
   $\neg P(x, f(x)) \vee (Q(x, g(x)) \wedge \neg R(x, g(x)))$
6. Convert to conjunction of disjunctions
   $[\neg P(x, f(x)) \vee Q(x, g(x))] \wedge [\neg P(x, f(x)) \vee \neg R(x, g(x))]$
7. Create separate clauses
   * $\neg P(x, f(x)) \vee Q(x, g(x))$
   * $\neg P(x, f(x)) \vee \neg R(x, g(x))$
8. Standardize variables
   * $\neg P(x, f(x)) \vee Q(x, g(x))$
   * $\neg P(y, f(y)) \vee \neg R(y, g(y))$

Once the answer ends at step 6 or 7 or 8, then full credit!

5B. [13%]



Step 1: substitution { x/Timmy }
Step 2: add substitution { y/MBA }
Step 3: add substitution { y/CumLaude }

6.[17%] Planning

6A. [5%]

InHole1(B), InHole2(D), On(C, Table), On(A, Table), Clear(C), Clear(A), Clear(B), Clear(D)

6B. [6%]

MoveToHole2(X) Move a block and place it inside Hole 2

PRECONDITIONS:
Empty(Hole2)
{¬ InHole2(X)} -->optional
Clear(X)

EFFECTS:
(Clear(X)) -->optional
InHole2(X)

6C. [6%]

MoveOntoA(X) move a block inside Hole 1 and put it on top of A

PRECONDITIONS:
InHole1(X)
Clear(X)
Clear(A)

EFFECTS:
Empty(Hole1)
¬InHole1(X)
{Clear(X)} -->optional
¬ Clear(A)
On(X, A)

7.[8%] Partial Order Plan

The threat is: Go(Home, Safeway) deletes the At(Home) which is the prediction of Make(Omelette). The resolution is to add the operator Go(Safeway, Home) before Make(Omelette).