

1- General Concepts:

1- T 2- T 3- F 4- F 5- F 6- F 7- F 8- T 9- F 10- T 11- F 12- T
 13- part of 14- does not infer false statements 15- derives any sentence that is entailed
 16- valid 17- $a \wedge \neg b$ 18- horn 19- backward 20- tautology

2- Truth tables:

a)

A	B	C	$A \wedge B$	$\alpha = (A \wedge B) \vee C$	$\neg C$	$A \vee \neg C$	$B \vee C$	$KB = (A \vee \neg C) \wedge (B \vee C)$
T	T	T	T	T	F	T	T	T
T	T	F	T	T	T	T	T	T
T	F	T	F	T	F	T	T	T
T	F	F	F	F	T	T	F	F
F	T	T	F	T	F	F	T	F
F	T	F	F	F	T	T	T	T
F	F	T	F	T	F	F	T	F
F	F	F	F	F	T	T	F	F

Rubrics: each row one point.

b) No, in the colored row, the KB is true but α is not. So KB does not entail α .

Rubrics: no partial credit.

3- Propositional logic

a) $\neg((A \Rightarrow B) \Rightarrow (((P \wedge B) \Rightarrow Q) \vee R))$

$\neg(\neg(A \Rightarrow B) \vee (\neg(P \wedge B) \vee Q \vee R))$

$\neg(\neg(\neg A \vee B) \vee (\neg P \vee \neg B \vee Q \vee R))$

$(\neg A \vee B) \wedge P \wedge B \wedge \neg Q \wedge \neg R$

b)

● Modus tollens on 3,4 $\Rightarrow \neg \text{study}$ (2 points)

● And Introduction on 6,7 $\Rightarrow \text{HomeworkDueNextWeek} \wedge \text{HighWeightageOfHomework}$ (11)

Modus Ponens on 2,11 $\Rightarrow \text{WorkOnHW}$ (4 points)

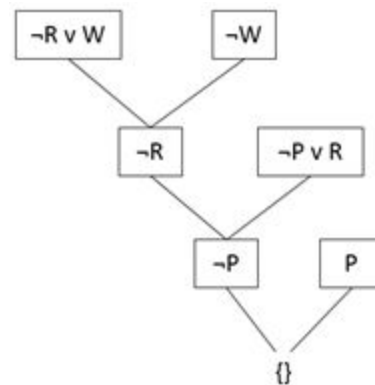
● Modus tollens on 1,8 $\Rightarrow \neg \text{ExamNextWeek}$ (12)

Modus tollens on 5,12 $\Rightarrow \neg \text{StudyBreak}$ (4 points)

Rubrics: every method except using inference rules got half points. Not mentioning the name of the inference rule is -1 in each part.

c) To prove W , we add $\neg W$ to the KB :

KB : $\neg W, P, \neg Q, \neg P \vee R, \neg Q \vee W, \neg W \vee P, \neg R \vee W$



Rubrics: other solutions also exist.

4- First Order Logic

1- (blue texts are the answer with this assumption that fails(x,y,z) also implies that takes(x,y,z)

a) $\forall x,z ((\text{Student}(x) \wedge \text{Semester}(z)) \Rightarrow \exists y,t (\text{Course}(y) \wedge \text{Course}(t) \wedge \text{Takes}(x,y,z) \wedge \text{Takes}(x,t,z) \wedge y \neq t))$

b) $\exists x (\text{Student}(x) \wedge \text{takes}(x, \text{History}, \text{S2015}) \wedge \text{Failed}(x, \text{History}, \text{S2015}) \wedge \forall y (\text{Student}(y) \wedge \text{takes}(y, \text{History}, \text{S2015}) \wedge \text{Failed}(y, \text{History}, \text{S2015}) \Rightarrow x = y))$

$\exists x (\text{Student}(x) \wedge \text{Failed}(x, \text{History}, \text{S2015}) \wedge \forall y (\text{Student}(y) \wedge \text{Failed}(y, \text{History}, \text{S2015}) \Rightarrow x = y))$

$\exists x (\text{Student}(x) \wedge \text{Failed}(x, \text{History}, \text{S2015}) \wedge \forall y (x \neq y \wedge \text{Student}(y) \Rightarrow \neg \text{Failed}(y, \text{History}, \text{S2015})))$

c) $\neg \exists x (\text{Student}(x) \wedge \text{takes}(x, \text{Chemistry}, \text{S2015}) \wedge \text{Failed}(x, \text{Chemistry}, \text{S2015})) \wedge \exists y (\text{Student}(y) \wedge \text{takes}(y, \text{History}, \text{S2015}) \wedge \text{Failed}(y, \text{History}, \text{S2015}))$

$\neg \exists x (\text{Student}(x) \wedge \text{Failed}(x, \text{Chemistry}, \text{S2015})) \wedge \exists y (\text{Student}(y) \wedge \text{Failed}(y, \text{History}, \text{S2015}))$

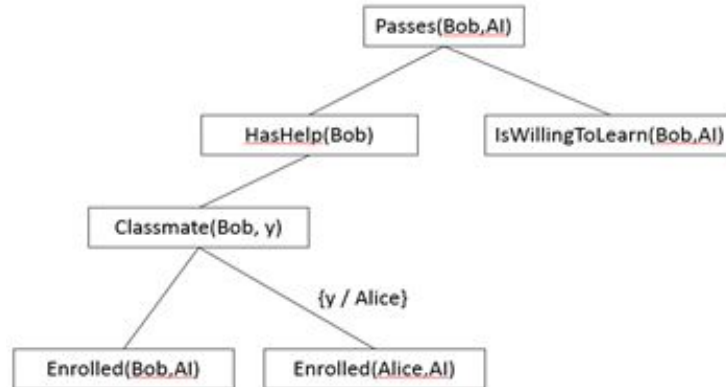
d) $\forall x, z (\text{Student}(x) \wedge \text{Semester}(z) \wedge \text{Takes}(x, \text{Analysis}, z) \Rightarrow \text{Takes}(x, \text{Geometry}, z))$

$\forall x, z (\text{Student}(x) \wedge \text{Semester}(z) \wedge \text{Takes}(x, \text{Analysis}, z) \Rightarrow \exists y (\text{Semester}(y) \wedge \text{Takes}(x, \text{Geometry}, y)))$

e) $\neg \exists x, z (\text{Student}(x) \wedge \text{Semester}(z) \wedge \text{takes}(x, \text{Analysis}, z) \wedge \text{takes}(x, \text{History}, z))$

Rubrics: Every subquestion is 3 pts. Making at most 1 error in predicate or parameter or quantifier or logical connectives, especially Student() Course() Semester(), can only get 1 pt. (more than 1 error will get 0 since it's required basic knowledge of FOL)

2-



Rubrics: Didn't use backward chaining method -4. Missing unification -2. Missing any box -2. Parameter error -1. Up to -10.

3- not complete due to infinite loops. When a loop is detected, suspend the loop branch and try other branches until getting this subgoal or no solution.

Rubrics: NO is 1pt. Explain 2pts. You can get full points if you explain it right without say No.

4- Algorithms exist that return YES to every entailed sentence, but no algorithm exists that also returns NO to every nonentailed sentence

Rubrics:no partial

5-Planning

1- 4

2- E, F

3- E

4- If we add an ordering constraint to F, so that it occurs before B. (Multiple possible answer, like add one more B between EC, but no change order of BEC and no remove any steps)

Rubrics:no partial Q1-Q4

5- No, For example if we go to finish from F, g will not be true.

Rubrics:NO is 1pt. Good justification 1pt