Midterm 02B

Graded

Student

Samuel Babak

Total Points

86 / 100 pts

Question 1

Evaluating Formulas **15** / 15 pts

1.1 **Truth Table 1** **5** / 5 pts

✔ **– 0 pts** Correct

– 0.313 pts One item wrong

– 0.625 pts Two items wrong

– 0.938 pts Three items wrong

– 1.25 pts Four items wrong

1.2 **Satisfiable?** **2.5** / 2.5 pts

✔ **– 0 pts** Correct

1.3 **Truth Table 2** **5** / 5 pts

✔ **– 0 pts** Correct

– 0.156 pts One item wrong

– 0.313 pts Two items wrong

– 0.45 pts Three items wrong

– 0.625 pts Four items wrong

– 0.781 pts Five Items wrong

– 1.094 pts Seven items wrong

– 1.5 pts Eight items wrong

– 1.563 pts Ten items wrong

– 1.875 pts Twelve items wrong

1.4 **Valid?** **2.5** / 2.5 pts

✔ **– 0 pts** Correct

– 2.5 pts Incorrect

Question 2

CNF **10** / 10 pts

2.1 **Multiple-Choice** **5** / 5 pts

- ✔ **– 0 pts** Dropped
- **– 0 pts** Dropped
- **– 0 pts** Dropped

2.2 **FOL CNF** **5** / 5 pts

- ✔ **– 0 pts** Correct
- **– 3 pts** Incorrect, multiple errors
- **– 1.5 pts** Incorrect, one error
- **– 0.5 pts** Did not remove quantifiers
- **– 1 pt** Correct, but final answer is not CNF
- **– 2.5 pts** Correct procedure, but answer is a disjunction of ANDs. CNF is a conjunction of ORs.
- **– 3 pts** Incomplete. Final answer is not CNF, and can be progressed further.

Question 3

Knowledge Representation **10** / 15 pts

3.1 **Roses** **5** / 5 pts

- ✔ **– 0 pts** Correct
- **– 5 pts** Incorrect

3.2 **Network Packets** **5** / 5 pts

- ✔ **– 0 pts** Correct
- **– 5 pts** Incorrect

3.3 **Turing Complete** **0** / 5 pts

- **– 0 pts** Correct
- ✔ **– 5 pts** Incorrect

Question 4

Inference **19** / 20 pts

4.1 **Substitutions** **3** / 4 pts

- **– 0 pts** Correct
- **– 1 pt** Incorrect first substitution
- **– 1 pt** Incorrect second substitution
- ✔ **– 1 pt** Incorrect third substitution
- **– 1 pt** Incorrect fourth substitution
- **– 2 pts** Incorrect substitution formatting

4.2 **Proof by Contradiction 1** **6** / 6 pts

- ✔ **– 0 pts** Correct
- **– 0.5 pts** Did not use a line to specify contradiction.
- **– 2 pts** Correct answer but procedure skips over steps.
- **– 2.5 pts** There is some procedure, but contradiction was not reached.
- **– 5 pts** No procedure
- **– 4 pts** No correct procedure past negation of a.
- **– 5 pts** All steps are incorrect
- **– 1 pt** Minor mistakes
- **– 2 pts** Correctly demonstrated contradictions, but did not include the substitutions needed

4.3 **Proof 1 Resolution** **2** / 2 pts

- ✔ **– 0 pts** Correct
- **– 2 pts** Incorrect

4.4 **Proof by Contradiction 2** **6** / 6 pts

- ✔ **– 0 pts** Correct
- **– 3 pts** Error in proof, no contradiction should be found
- **– 1 pt** Small error
- **– 5 pts** No correct expansion beyond negation of query
- **– 2 pts** No conclusion
- **– 2 pts** Incomplete expansion
- **– 2 pts** No negation of the query
- **– 6 pts** Incorrect

4.5 **Proof 2 Resolution** **2** / 2 pts

✔ **– 0 pts** Correct

– 2 pts Incorrect

Question 5

Planning **20** / 20 pts

5.1 **Action - GoTo** **5** / 5 pts

✔ **– 0 pts** Correct

5.2 **Action - GetFood** **5** / 5 pts

✔ **– 0 pts** Correct

5.3 **Action - WorkOut** **5** / 5 pts

✔ **– 0 pts** Correct

– 1 pt Extra, unrequired preconditions

– 1 pt Extra, unrequired effects

– 2.5 pts No effect.

– 1 pt Incorrect precondition format

– 5 pts Incorrect

5.4 **Action Plan** **5** / 5 pts

✔ **– 0 pts** Correct

– 0.714 pts One step missing

– 1.429 pts Two steps missing

– 2.143 pts Three steps missing.

– 5 pts Blank

– 2 pts Incorrect format

– 5 pts Incorrect

Question 6

Conditional Probability

12 / 20 pts

– **0 pts** Correct

✔ – **4 pts** First item is incorrect.

– **4 pts** Second item is incorrect.

✔ – **4 pts** Third item is incorrect.

– **4 pts** Fourth item is incorrect.

– **4 pts** Fifth item is incorrect.

– **4 pts** Answers are fractions_

.ame: Samuel Babak UnityID: Sababak

CSC 411 Midterm 02B Spring 2024

Time Allowed: 75 minutes

Instructions:

DO NOT OPEN THE EXAM UNTIL GIVEN THE INSTRUCTION TO DO SO.

NOT EVEN TO FILL IN YOUR NAME AT THE TOP EACH PAGE.

You are allowed one (1) sheet of paper (8"x11") with handwritten notes and a calculator. You may be required to wipe the memory of your calculator before the exam. No other review materials are permitted.

Make sure that you have 19 questions on 10 pages. The last page contains logic equivalences for reference.

Handwriting must be legible to be considered for grading.

If the grader is unable to decipher your handwriting, they will mark the question as incorrect.

No answers will be accepted on the back of a sheet of paper. Please write small, but legibly within the space given.

Your exam must be turned in before the end of the exam time, or your exam will not be graded and you will receive a 0%.

If you are caught violating these rules by the teaching staff, you will receive a -100% on the exam.

Section	Possible Points
Evaluating Formulas	15
CNF	10
Knowledge Representation	15
FOL Inference	20
Planning	20
Conditional Probability	20
TOTAL	100

ame: _____ UnityID: _____

Evaluating Formulas

1. [5 points] Provide a truth table for the following formula.

$$(a \vee b) \rightarrow (a \vee c)$$

a	b	c	$(a \vee b)$	$(a \vee c)$	$(a \vee b) \rightarrow (a \vee c)$
T	T	T	T	T	T
T	T	F	T	T	T
T	F	T	T	T	T
T	F	F	T	T	T
F	T	T	T	T	T
F	T	F	T	F	F
F	F	T	F	T	T
F	F	F	F	F	T

2. [2.5 points] True or False: This formula is satisfiable? True

3. [5 points] Provide a truth table for the following formula.

$$(\neg r \rightarrow s) \wedge (t \rightarrow s)$$

r	s	t	$\neg r$	$(\neg r \rightarrow s)$	$(t \rightarrow s)$	$(\neg r \rightarrow s) \wedge (t \rightarrow s)$
T	T	T	F	T	T	T
T	T	F	F	T	T	T
T	F	T	F	T	F	F
T	F	F	F	T	T	T
F	T	T	T	T	T	T
F	T	F	T	T	T	T
F	F	T	T	F	F	F
F	F	F	T	F	T	F

4. [2.5 points] True or False: This formula is valid? False

ame: _____ UnityID: _____

NF

[5 points] Circle the option below that converts $\neg(u \rightarrow v) \vee (w \rightarrow \neg x)$ into CNF.

a. $(\neg u \vee \neg w \vee \neg x) \wedge (v \vee \neg w \vee \neg x)$ $\neg(\neg u \vee v) \vee (\neg w \vee \neg x)$

$(u \wedge \neg v) \vee (\neg w \vee \neg x)$

b. $(u \vee \neg v \vee \neg w \vee \neg x)$ $(u \vee (\neg w \vee \neg x)) \wedge (\neg v \vee (\neg w \vee \neg x))$

c. $(u \vee \neg w \vee \neg x) \wedge (\neg v \vee \neg w \vee \neg x)$

d. $(u \vee \neg v \vee \neg w) \wedge (u \vee \neg v \vee \neg x)$

6. [5 points] Convert the following First Order Logic sentence into CNF. Circle the final CNF conversion.

	$\forall e\, P(e) \rightarrow \forall d\, (\neg Q(d) \wedge R(d))$
remove $\rightarrow$	$\forall e \neg P(e) \vee \forall d\, (\neg Q(d) \wedge R(d))$
move universal identifiers to left	$\forall e d\ \neg P(e) \vee (\neg Q(d) \wedge R(d))$
remove universal iden.	$\neg P(e) \vee (\neg Q(d) \wedge R(d))$
distributive law	$(\neg P(e) \vee \neg Q(d)) \wedge (\neg P(e) \vee R(d))$

ame: _____ UnityID: _____

Knowledge Representation

7. [5 points] Circle the formula that appropriately converts the sentence into FOL:

   "Every Rose (R) has (H) its thorns (T)."

   a. $\forall x \exists y\, R(x) \rightarrow T(y) \wedge H(x,y)$

   b. $\exists x \forall y\, T(x) \rightarrow R(y) \vee H(x,y)$

   c. $\forall x \forall y\, R(x) \rightarrow T(y) \wedge H(x,y)$

   d. $\forall x \forall y\, R(x) \wedge H(x,y) \rightarrow T(y)$

8. [5 points] Circle the formula that appropriately converts the sentence into FOL:

   "Every packet (P) is transmitted using either of the TCP or UDP protocols."

   a. $\exists q\, P(q) \rightarrow UDP(q) \vee TCP(q)$

   b. $\forall q \exists r\, P(q) \rightarrow TCP(r) \vee UDP(r)$

   c. $\forall p\, TCP(p) \vee UDP(p)$

   d. $\forall q\, P(q) \rightarrow TCP(q) \vee UDP(q)$

9. [5 points] Circle the formula that appropriately converts the sentence into FOL:

   "A machine (M) is Turing Complete (TC) if it can be simulated (S) by another TC machine."

   a. $\exists a \forall b\, M(a) \wedge TC(a) \rightarrow M(b) \wedge TC(b) \wedge S(a,b)$

   b. $\forall a \exists b\, M(a) \wedge M(b) \wedge TC(b) \wedge S(a,b) \rightarrow TC(a)$

   c. $\forall a \exists b\, M(a) \wedge TC(a) \rightarrow M(b) \wedge TC(b) \wedge S(a,b)$

   d. $\exists a \forall b\, M(a) \wedge M(b) \wedge TC(b) \wedge S(a,b) \rightarrow TC(a)$

ame: _____ UnityID: _____

FOL Inference

10. [4 points] Given p and q, write the substitutions σ in the right column that unify p and q. Write the word "fail" if a substitution cannot be made.

p	q	σ
$Friends(x, Abdul)$	$Friends(Joseph, y)$	{x \ Joseph, Abdul \ y}
$Guitarrist(Luca)$	$Guitarrist(h)$	{Luca \ h}
$Likes(a, Flowers)$	$Likes(b, Chocolate)$	{a \ b, Flowers \ Chocolate}
$Float(x) \rightarrow Real(x)$	$Float(Pi) \rightarrow Real(Pi)$	{x \ Pi}

11. [6 points] Given the KB below, use resolution through contradiction to determine whether the query is true.

$$\alpha = Defeats(Jotaro, Dio)$$

Make sure to indicate the premise's line number you are referencing and substitutions necessary at each step in the right column. More rows than necessary were included.

1	$Friend(Jotaro, Polnareff)$	Jotaro is friends with Polnareff
2	$\neg Friend(a, b) \vee HasFriends(a)$	A person has friends if they have at least a friend (converted to CNF)
3	$\neg HasFriends(x) \vee Defeats(x, y)$	A person X can defeat another if they have friends (converted to CNF)
4	¬Defeats(Jotaro, Dio)	Negation of α
5	Friend(J,P) ∨ (¬Friend(J,P) ∨ hasfriend(J))	1, 2, {a \ Jotaro, b \ Polnareff}
6	hasfriends(Jotaro)	5, Simplified
7	hasfriends(J) ∧ (¬hasfriends(J) ∨ Defeats(J,D))	3, 6 {x \ Jotaro, y \ Dio}
8	Defeats(Jotaro, Dio)	7, Simplified
9	{}	4, 8 Contradiction
10		

12. [2 points] Based on the resolution above, α is:

(a) True

b. False

ame: _____ UnityID: _____

13. [6 points] Given the KB below, use resolution through contradiction to determine whether the query is true.

$$\alpha = Equals(P, NP)$$

Make sure to indicate the premise's line number you are referencing and substitutions necessary at each step in the right column. More rows than necessary were included.

1	$Problem(TSP)$	Traveling Salesman is a Problem
2	$Problem(LP)$	Linear Programming is a Problem
3	$\neg Problem(p) \vee \neg Problem(q) \vee \neg Similar(p, q) \vee Reducible(p, q)$	A problem is reducible to another if they have a similar solution (converted to CNF)
4	$\neg In(a, x) \vee \neg In(b, y) \vee \neg Reducible(x, y) \vee Equals(a, b)$	Two complexity classes are equal if a problem from one is reducible to the other (converted to CNF)
5	$Problem(SAT)$	Boolean Satisfiability is a Problem
6	$Similar(SAT, TSP)$	SAT and TSP have similar solutions
7	$In(NP, TSP)$	TSP is on the NP class
8	$In(P, LP)$	LP is on the P class
9	$\neg$ Equals(P, NP)	Negation of α
10	$\neg$Reducible(TSP, LP) $\vee$ Equals(P, NP)	4, 7, 8 {a\NP, b\P, x\TSP, y\LP}
11		1, 2, 3 {P\TSP, q\LP}
12	NO contradiction	10, 11
13		9, 12 (contradiction)
14		

14. [2 points] Based on the chaining above, α is:

a. True

(b) False

ame: _____ UnityID: _____

Planning

Given the following initial and goal states,

Initial State: `At(Bruce, House) ∧ Hungry(Bruce)`

Goal State: `At(Bruce, House) ∧ ¬Hungry(Bruce) ∧ Pumped(Agent)` Bruce

15. [5 points] Design **`Action(GoTo(person, source, destination))`**, such that an agent can only go to `destination` if they are at `source` and not at `destination`. The result is that the agent is no longer at `source`, and they are now at the `destination`.

`Action(GoTo(agent, source, destination))`

Preconditions: AT(agent, source) ∧ ¬AT(agent, destination)

Effect: ¬AT(agent, source) ∧ AT(agent, Destination)

16. [5 points] Design **`Action(GetFood(agent))`**, such that an `agent` can get food if they are at a restaurant and they are hungry. The result is that the `agent` is no longer hungry. You may use `Restaurant` to represent this action.

`Action(GetFood(person))` agent

Preconditions: AT(agent, Restaurant) ∧ Hungry(agent)

Effect: ¬Hungry(agent)

ame: _____ UnityID: _____

17. [5 points] Design **`Action(WorkOut(agent))`**, such that an **`agent`** can only work out if they are at the gym and not hungry. The result is that the **`agent`** is now pumped and hungry. You may use `Gym` to represent this action.

`Action(WorkOut(agent))`

Preconditions: $At(agent, gym) \land \neg Hungry(agent)$

Effect: $Pumped(agent) \land Hungry(agent)$

18. [5 points] What is the plan for reaching the goal state? Consider the number beside each action is meant to denote when it would occur. For example, "Action 1" means this would be the first action. Note more rows were provided than need to be filled.

Action 1	GoTO(Bruce, House, restaurant)
Action 2	getfood(Bruce)
Action 3	GoTo(Bruce, restaurant, Gym)
Action 4	workout(Bruce)
Action 5	GoTO(Bruce, Gym, restaurant)
Action 6	getfood(Bruce)
Action 7	GoTo(Bruce, restaurant, House)
Action 8	

ame: _____ UnityID: _____

Conditional Probability

Consider the following truth table:

A	B	C	$P(A,B,C)$
T	T	T	0.15
T	T	F	0.20
T	F	T	0.05
T	F	F	0.20
F	T	T	0.10
F	T	F	0.15
F	F	T	0.05
F	F	F	0.10

19. [20 points, 4 points each] Answer the following conditional probability formulas. Please round your answers to the nearest thousandths.

$P(B = false, C = true \mid A = true)$	$\frac{0.10}{0.60} = 0.167$
$P(B = false \mid A = false, C = true)$	$\frac{0.05}{0.15} = 0.333$
$P(A = true, C = false \mid B = true)$	$\frac{0.05}{0.60} = 0.083$
$P(C = true \mid A = false)$	$\frac{0.15}{0.40} = 0.375$
$P(A = true \mid B = false, C = false)$	$\frac{0.20}{0.30} = 0.667$

Name: _____ UnityID: _____

This page contains logic equivalences for propositional and First-order logic.

THIS SHEET WILL NOT BE CONSIDERED FOR GRADING

$$(\alpha \wedge \beta) \equiv (\beta \wedge \alpha) \quad \textbf{commutativity of } \wedge$$
$$(\alpha \vee \beta) \equiv (\beta \vee \alpha) \quad \textbf{commutativity of } \vee$$
$$((\alpha \wedge \beta) \wedge \gamma) \equiv (\alpha \wedge (\beta \wedge \gamma)) \quad \textbf{associativity of } \wedge$$
$$((\alpha \vee \beta) \vee \gamma) \equiv (\alpha \vee (\beta \vee \gamma)) \quad \textbf{associativity of } \vee$$
$$\neg(\neg\alpha) \equiv \alpha \quad \textbf{double-negation elimination}$$
$$(\alpha \Rightarrow \beta) \equiv (\neg\beta \Rightarrow \neg\alpha) \quad \textbf{contraposition}$$
$$(\alpha \Rightarrow \beta) \equiv (\neg\alpha \vee \beta) \quad \textbf{implication elimination}$$
$$(\alpha \Leftrightarrow \beta) \equiv ((\alpha \Rightarrow \beta) \wedge (\beta \Rightarrow \alpha)) \quad \textbf{biconditional elimination}$$
$$\neg(\alpha \wedge \beta) \equiv (\neg\alpha \vee \neg\beta) \quad \textbf{De Morgan}$$
$$\neg(\alpha \vee \beta) \equiv (\neg\alpha \wedge \neg\beta) \quad \textbf{De Morgan}$$
$$(\alpha \wedge (\beta \vee \gamma)) \equiv ((\alpha \wedge \beta) \vee (\alpha \wedge \gamma)) \quad \textbf{distributivity of } \wedge \textbf{ over } \vee$$
$$(\alpha \vee (\beta \wedge \gamma)) \equiv ((\alpha \vee \beta) \wedge (\alpha \vee \gamma)) \quad \textbf{distributivity of } \vee \textbf{ over } \wedge$$
$$\neg\forall x\, p \equiv \exists x\, \neg p$$
$$\neg\exists x\, p \equiv \forall x\, \neg p$$

Instructions for Converting FOL to CNF

a. Eliminate →, ↔
b. Drive in negations using De Morgan's Laws and remove double negation
c. Standardize variables (rename duplicate variables)
d. Move all quantifiers left
e. Skolemization
f. Drop universal quantifiers
g. Applying the distributive laws