CIS 301: Logical Foundations of Programming

Spring 2023

Exam 1 – 100 points

**This test is closed-notes and closed-computers.**

There are 9 questions worth 8-15 points each.

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Score: \_\_\_\_\_\_\_\_\_\_\_\_

1. (15 pts) Consider the following questions about logical analysis of conditional statements.

a) (7 pts) Consider the following code fragment:

num = 4;

if (x < 10 || (y > 100 && y < 200)) {

if (x >= 10) {

num = 18;

}

}

// 🡨 suppose we are right here

Suppose *num* has the value 18 immediately after the above code fragment finishes (i.e., at the point marked with the 🡨 just after the brackets). What can we conclude about *x* and *y*? Explain as concisely as you can.

b) (8 pts) Consider the following code fragment:

num = 4;

if (val1 > 0 || val2 < 10) {

num = 7;

}

else if (val1 < 0) {

num = 10;

}

else {

num = 20;

}

// 🡨 suppose we are right here

Suppose *num* has the value 20 immediately after the above code fragment finishes (i.e., at the point marked with the 🡨 just after the brackets). What can we conclude about *val1* and *val2*? Explain as concisely as you can.

1. (8 pts) Draw a circuit for the following logical formula: **(p OR NOT q) AND (NOT p OR Q).** Use only a combination of AND, OR, and NOT gates.
2. (8 pts) Draw a parse tree for the following logical formula:

p → q V ¬r ∧ p

1. (13 pts) Use two truth tables to demonstrate that the following two statements are logically equivalent:

(p → q) ∧ (q → p)

(p V ¬q) ∧ (q V ¬p)

Afterwards, give a brief explanation about why your truth tables demonstrate that the statements are equivalent.

1. (8 pts) Apply DeMorgan's laws to write an if-statement whose condition is the negation of the condition in the if-statement below. Write your if-statement in such a way that it does not use any ! (not) symbols.

if ((total >= 100 && Character.isDigit(ch) == false) || num < 10) {

//statements

}

Write your negated if-statement below:

1. (8 pts) Is the statement (p V ¬q) ∧ (¬p V ¬q) ∧ (p → q) satisfiable? How do we know?
2. (11 pts) Consider the following (invalid) argument:

**Premises:**

If I order fries, then I get ketchup.

If I get ketchup, then I get a cheeseburger.

I don’t get ketchup.

**Conclusion**:

I don’t get a cheeseburger.

a) (4 pts) Translate each premise and conclusion to propositional logic. Start by identifying each propositional atom.

b) (7 pts) Provide a truth assignment for your translations in (a) that demonstrates that the argument is NOT valid. How do you know that truth assignment makes the argument invalid? Explain.

1. (15 pts) Complete the following natural deduction proof:

(c ∨ a) ∧ b ⊢ (a ∧ b) ∨ (b ∧ c)

1. (14 pts) Complete the following natural deduction proof:

q → (p ∧ r), r → s ⊢ q → (s ∧ p)