Concordia University
Department of Computer Science & Software Engineering

SOEN331/W- Winter 2017
Introduction to Formal Methods for Software Engineering

Midterm 1 (15%)

Date: 24/01/2017

Instructor: Dr. Ormandjieva
Duration: 70 minutes

Name: _____

Student ID: _____

Notes:

1. **This is a closed book and notes exam.**
2. Write your answers in this exam paper
3. Write clearly your assumptions in the exam paper, if needed.

Special Instructions:

- Answer ALL questions
- Keep your answers short and precise
- Total 15 points

Total # of pages (including this cover page): 5

Question 1 (6 points)

Consider the argument given by the following sentences.

P1. *Either the computer is not intelligent or the program does not terminate*

P2. *If the computer is not intelligent then the computer runs forever*

P3. *If the program does not terminate then the alarm rings forever*

Q. *Therefore, either the alarm rings forever or the computer runs forever.*

1.1 Formalize the statement in propositional logic

1.2 Prove that Q is a logical consequence of the premises P1, P2, P3 using proof by contradiction technique seen in class

Question 2 (4 points)

The following statements relate to computer accounts for students. Translate each sentence into a predicate logic formula:

2.1 *Every student owns 200 MB of disk space.*

2.2 *No student can have two different disk spaces.*

2.3 *A student may give the disk space to some other student, but not to two students simultaneously.*

Question 3 (2 points. Circle the right answer(s))

3.1 Which of the following predicates are valid formalizations of ***"some cats are sleepy"***?

Note: ***isAcat(x)*** is true if x is a cat.

(a) $\exists\, x : Animal \bullet isAcat(x) \rightarrow sleepy(x)$	**(d)** $isAcat(c)\ \&\ sleepy(c)$ ∀, ∃, ∃! ?	**(g)** $\exists\, c : Cat \bullet sleepy(c)$
(b) $\exists\, c : Cat \bullet isAcat(c) \rightarrow sleepy(c)$ ∀ sleepy	**(e)** $isAcat(x) \rightarrow sleepy(x)$ ∀, ∃, ∃! ?	**(h)** $\exists\, x : Animal \bullet sleepy(x)$
(c) $\exists\, x : Animal \bullet isAcat(x)\ \&\ sleepy(x)$	**(f)** $isAcat(x)\ \&\ sleepy(x)$ ∀, ∃, ∃! ?	**(i)** None of the previous.

3.2 Which of the following predicates are valid formalizations of "***Somebody likes somebody***"?

(a) $\exists\, q : Person \bullet likes(p, q)$	**(c)** $\forall\, p : Person \bullet \exists\, q : Person \bullet likes(p, q)$	**(f)** None of the previous.
(b) $\exists\, p : Person \bullet likes(p, q)$	**(d)** $\exists\, p : Person \bullet \exists\, q : Person \bullet likes\ (p, q)$	
	(e) $\exists\, p : Person \bullet \neg\, \exists\, q : Person \bullet likes\ (p, q)$	

Question 4 (2 points)

Is Propositional Logic sound (consistent)? complete? Explain your answer.

Question 5 (1 points)

Given the following well-formed formulas:

5.1 $(P \Rightarrow Q) \Rightarrow (Q \vee \neg P)$
5.2 $(P \vee Q) \wedge P$
5.3 $((P \Rightarrow Q) \vee P) \wedge \neg P$

Which are tautologies? Use truth tables to prove your answer