Homework 8

CIS-623 STRUCTURED PROGRAMMING & FORMAL METHODS

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Question 1:

M1:

Does the model M1 and s1 satisfy the following formulas?

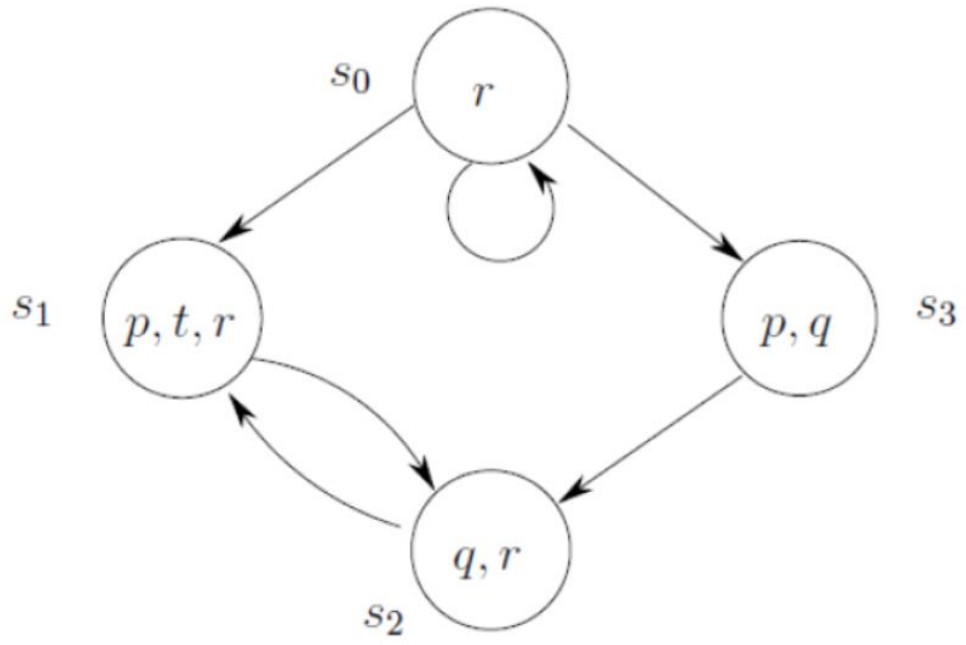
a. AG AF p
b. AG EF p

a. Not satisfied. All possible paths starting from s1 are s1's infinite loop and s1->s2 then s2's infinite loop. G means that every point along these two paths the following must be true: AF(p). S1's infinite loop represents a path where F(p) is not true. Therefore, the answer is "not satisfied".
b. Satisfied. All possible paths starting from s1 are s1's infinite loop and s1->s2 then s2's infinite loop. G means that every point along these two paths the following must be true: EF(p). E means that there must exist a path from the starting point where something must be true. F(p) means that there is a future path where p is true. S1 is connected to s2 and therefore always has the option of transitioning to s2, where p is true. The second path obviously satisfies the condition: EF(p). Therefore, the answer is "satisfied."

Question 2:

Does the model M2 and s0 satisfy the following formulas?

M2:



a. ! EG r
b. AF q
c. AG AF q

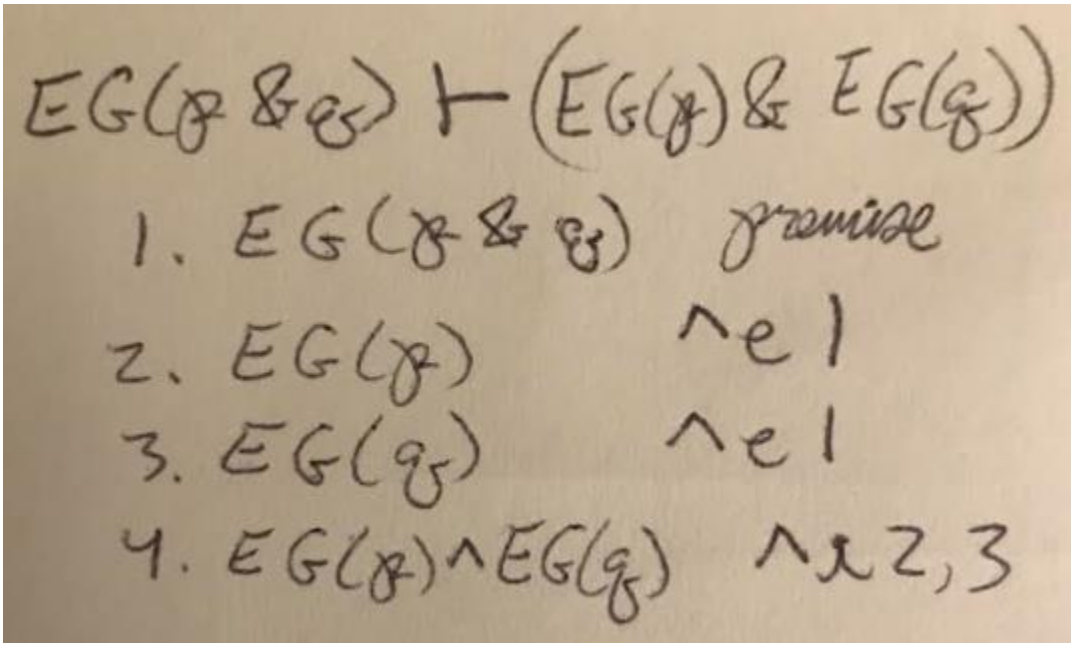
a. False. There is an infinite path where G(r) is true.
b. False. There is an infinite path where F(q) is false.
c. False. There is an infinite path where AF(q) is false (s0 recursive loop).

Question 3:

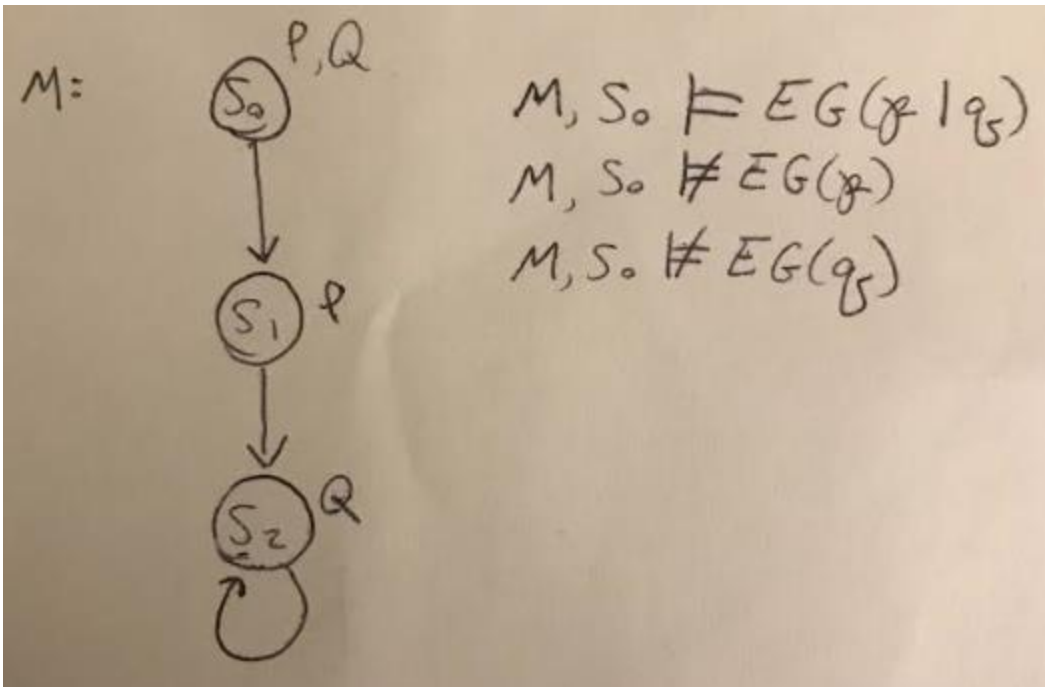
Prove or construct counterexamples for the following CTL formulas

a. EG (p & q) → (EG p & EG q)
b. EG (p | q) → (EG p | EG q)

a. True. See proof below.



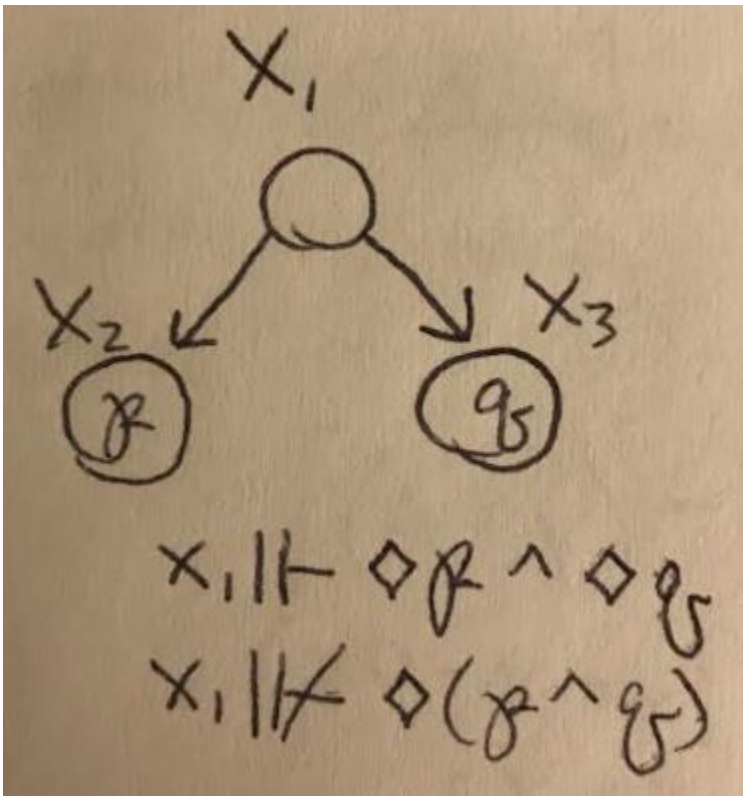
b. False. See counterexample below.


M:
P, Q
s_0
s_1
P
s_2
Q
$M, s_0 \models EG(\varphi \mid q_5)$
$M, s_0 \not\models EG(\varphi)$
$M, s_0 \not\models EG(q_5)$

Question 4:

Give a model and a world in which only one of the following two formulas is true while the other is false.

$\Diamond(p \wedge q)$ and $\Diamond p \wedge \Diamond q$



Question 5:

Find natural deduction proofs for the following sequent over the basic modal logic K.

$$\Diamond(p \to q) \vdash \Box p \to \Diamond q$$