1. In the Markov network below, what is the probability of the setting with A true, B false, and C true?
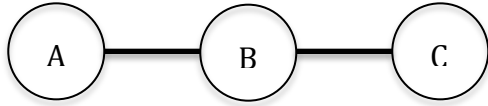
A	B	
F	F	1
F	T	2
T	F	3
T	T	4

B	C	
F	F	1
F	T	1
T	F	2
T	T	1

2. Consider a Markov logic program whose only constant is *A* and whose two rules are:

R1: $\forall x\ P(x) \rightarrow Q(x)$
R2: $\forall x\ Q(x) \rightarrow P(x)$

Draw the Markov logic network. Given the data set below, what are the weights of these rules after a single step of gradient ascent maximum likelihood parameter learning, assuming our learning rate parameter is 0.1 and weights are initialized to 0.

Data:

P(A)	Q(A)
T	T
T	F
F	F
T	T

3. What is the OLS regression line given the following data, where *Y* is the response (dependent) variable?

X	Y
1.0	2.1
1.5	2.8
0.4	1.0

4. Given the following background knowledge B, positive examples P, and negative examples N, suppose we are in FOIL's Learn-Rule procedure to learn a single rule. Furthermore suppose our current rule is *Can_reach(x,y)*. What is the FOIL-Gain of adding the literal *Linked_to(x,z),* to yield the rule *Can_reach(x,y) ← Linked_to(x,z)*?

B:
Linked_to(1,2)
Linked_to(2,3)
Linked_to(3,4)

P:
Can_reach(1,2)
Can_reach(1,3)
Can_reach(1,4)
Can_reach(2,3)
Can_reach(2,4)
Can_reach(3,4)

N:
Can_reach(1,1)
Can_reach(2,1)
Can_reach(3,1)
Can_reach(4,1)
Can_reach(2,2)
Can_reach(3,2)
Can_reach(4,2)
Can_reach(3,3)
Can_reach(4,3)
Can_reach(4,4)

Solution

Before adding the literal, the current rule $Can\_reach(x,y)$ covers:
- Positive bindings: $p_0 = 6$
- Negative bindings: $n_0 = 10$

After adding $Linked\_to(x,z)$, a new variable z is introduced. Only examples whose x appears as the first argument of a $Linked\_to$ fact survive (i.e. $x \in \{1,2,3\}$):

- Positive bindings: $p_1 = 6$ (all positives have $x \in \{1,2,3\}$)
- Negative bindings: $n_1 = 6$ (the four negatives with $x=4$ are dropped)

The number of positive bindings still covered is $t = 6$.

$$
\text{FOIL-Gain} = t \left(\log_2 \frac{p_1}{p_1+n_1} - \log_2 \frac{p_0}{p_0+n_0} \right)
$$

$$
= 6 \left(\log_2 \frac{6}{12} - \log_2 \frac{6}{16} \right)
= 6 \left(-1 - (-1.415) \right)
= 6 (0.415) \approx 2.49
$$