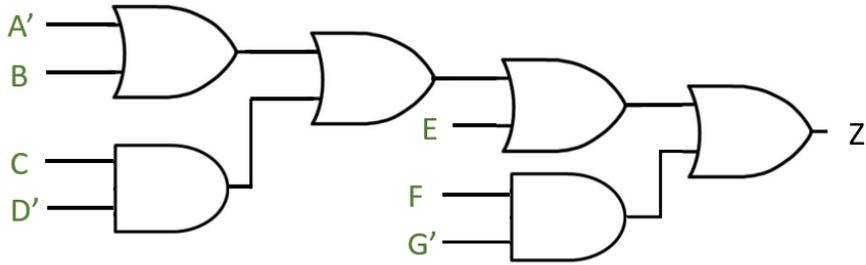
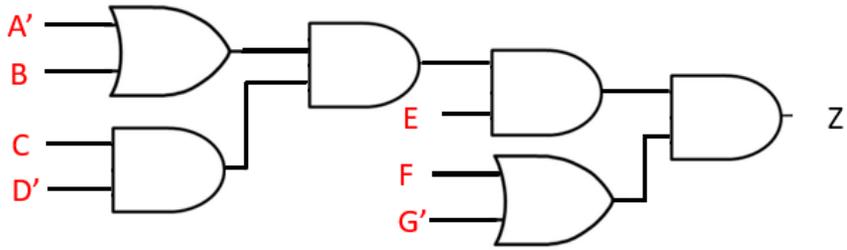


1. (50%) For the following circuit  
 (a) (8%) What is the level of the circuit?

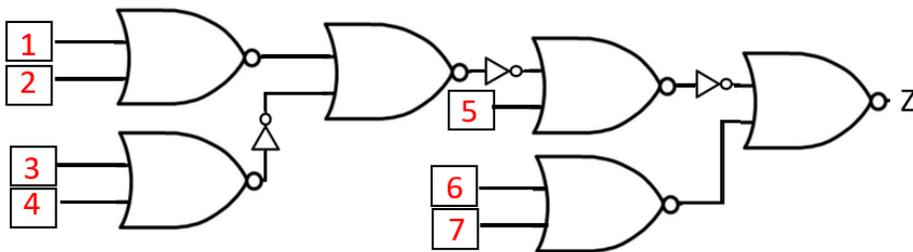


ANS = 4/4

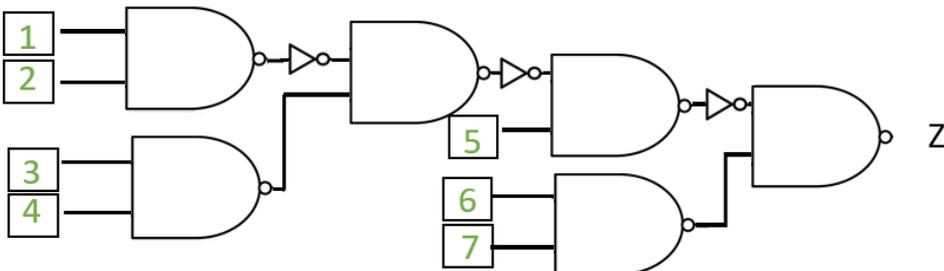
- (b) (42%) The following circuit is the result that uses gate-equivalences to convert the above circuit (shown in 1.a) to a circuit containing only NOR/NAND gates and NOT gates.

However, the information of gate inputs is missing, please choose appropriate literals to fill the following empty frames.

Each correct answer gets 6 points, and wrong answer deducts 4 points as punishment.



ANS = 1. A' 2. B 3. C' 4. D 5. E' 6. F 7. G'



ANS = 1. A 2. B' 3. C 4. D' 5. E' 6. F 7. G'

2. (50%) Considering the following Boolean function F,

$$F(a, b, c, d) = m_0 + m_1 + m_2 + m_3 + m_4 + m_6 + m_7 + m_8 + m_{10} + m_{11} + m_{14}$$

$$F(a, b, c, d) = m_0 + m_1 + m_2 + m_3 + m_4 + m_5 + m_6 + m_8 + m_9 + m_{10} + m_{12}$$

cd \ ab	00	01	11	10
00	1	1	0	1
01	1	0	0	0
11	1	1	0	1
10	1	1	1	1

cd \ ab	00	01	11	10
00	1	1	1	1
01	1	1	0	1
11	1	0	0	0
10	1	1	0	1

(a) (25%) Find a minimum 2-level circuit to realize F with AND and OR gates only. Note that the 2-level circuit needs to be expressed in an algebraic form (instead of actually drawing the circuit with logic gates).

( Hint :5 gates ,16 gate inputs )

$$F = (b' + c + d') (a' + c + d') (a' + b' + c) (a' + b' + d')$$

$$F = (b' + c' + d') (a' + c' + d') (a' + b' + d') (a' + b' + c')$$

Circle 0's will get 5 gates ,16 gate inputs

Circle 1's will get 7 gates ,18 gate inputs

(b) (25%) Find a minimum 3-level circuit to realize F with AND and OR gates only. Note that the 3-level circuit needs to be expressed in an algebraic form.

( Hint :5 gates ,12 gate inputs )

Using  $(X + Y)(X + Z) = X + YZ$  to simplify POS from the last question.

May have many different ways to simplify, but the result will be 5 gates ,12 gate inputs.

$$F = (c + d' + a' b') (a' + b' + c d')$$

$$F = (a' + c + b' d') (b' + d' + a' c)$$

$$F = (a' + d' + b' c) (b' + c + a' d')$$

$$F = (c' + d' + a' b') (a' + b' + c' d')$$

$$F = (a' + c' + b' d') (b' + d' + a' c')$$

$$F = (a' + d' + b' c') (b' + c' + a' d')$$