***QUESTION 1:***

***a-)***  Write the expressions of 𝑓 in the first and second canonical forms.

***First canonical form:***

a’b’cd + a’bc’d’ + a’bcd’ + a’bcd + abc’d’ + abcd’

***Second canonical form:***

(a+b+c+d)(a+b+c+d’)(a+b+c’+d)(a+b’+c+d’)(a’+b+c+d)(a’+b+c+d’)(a’+b+c’+d)(a’+b+c’+d’)(a’+b’+c’+d’)

***b-)*** Minimize the expression in the first canonical form using axioms and theorems of the Boolean algebra.

---> a’bcd’ + a’bcd = a’bc(d+d’) = a’bc(1) = a’bc

* a’b’cd + a’bc’d’ + a’bcd’ + a’bcd + abc’d’ + abcd’ = a’b’cd + a’bc’d’ + a’bc + abc’d’ + abcd’ (Consensus)
* ---> abc’d’ + abcd’ = abd’(c + c’) = abd’(1) = abd’
* a’b’cd + a’bc’d’ + a’bc + abc’d’ + abcd’ = a’b’cd + a’bc’d’ + a’bc + abd’ (Inverse)

---> a’bc’d’ + abd’ = a’bc’d’ + abd’ + bc’d’ because of the consensus theorem.

* a’b’cd + a’bc’d’ + a’bc + abd’ = a’b’cd + a’bc’d’ + a’bc + abd’ + bc’d’ (Consensus)
* a’b’cd + a’bc’d’ + a’bc + abd’ + bc’d’ = a’b’cd + a’bc + abd’ + bc’d’ (Absorption)

---> a’bc + bc’d’ = a’bc + bc’d’ + a’bd’ because of the consensus theorem.

* a’b’cd + a’bc + abd’ + bc’d’ = a’b’cd + a’bc + abd’ + bc’d’ + a’bd’ (Consensus)

---> abd’ + a’bd’ = bd’(a+a’) = bd’(1) = bd’

* a’b’cd + a’bc + abd’ + bc’d’ + a’bd’ = a’b’cd + a’bc + bc’d’ + bd’ (Inverse)
* a’b’cd + a’bc + bc’d’ + bd’ = a’b’cd + a’bc + bd’ (Absorption)----> a’b’cd + a’bc = a’b’cd + a’bc + a’cd because of the consensus theorem
* a’b’cd + a’bc + bd’ = a’b’cd + a’bc + bd’ + a’cd (Consensus)
* a’b’cd + a’bc + bd’ + a’cd = a’bc + bd’ + a’cd (Absorption)
* a’bc + bd’ + a’cd = bd’ + a’cd (a’bc is the consensus term so redundant)
* ((bd’)’ . (a’((cd)’)’)’)’

***c-)*** Draw the circle for the minimized expression in b by using only 2-input NAND gates.

***a b c d***



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