1) Write the first and second canonical forms of f.

1st canonical form: Sum of Products

"True" (1) combinations

Sum of Minterms:

$$F(a,b,c,d) = \sum_{a'b'c'd + a'bc'd + a'bc'd + a'bcd' + a'bcd + ab'c'd + abc'd' + abc'd + abcd' + abcd'}$$

$$= a'b'c'd + a'bc'd' + a'bcd' + a'bcd + ab'c'd + abc'd' + abc'd$$

2nd canonical form: Product of Sums

"False" (0) combinations

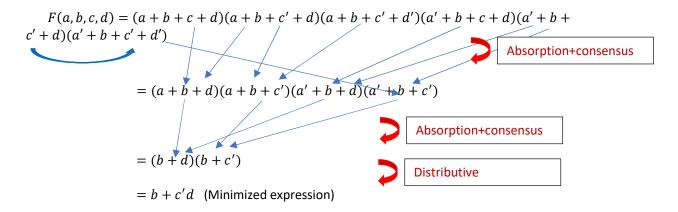
Product of Maxterms:

$$F(a,b,c,d) = \prod M(0,2,3,8,10,11)$$

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

$$\cdot (a'+b+c'+d)(a'+b+c'+d')$$

2) Convert the second canonical form expression to first canonical form expression using axioms and theorems of Boolean algebra



Need to expand this to get first canonical form:

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

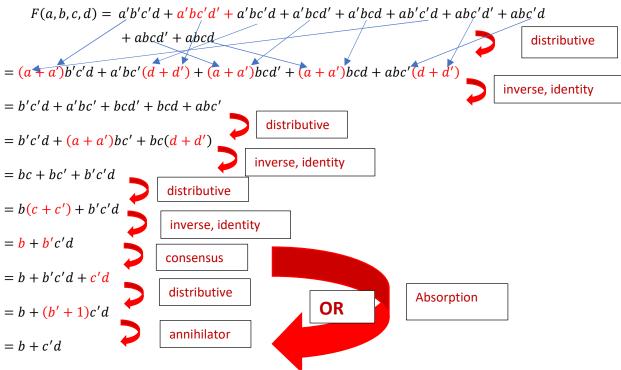
$$= abcd + abcd' + abc'd + abc'd' + a'bcd + a'bcd' + a'bc'd + a'bc'd'$$

$$+ abc'd + ab'c'd + a'bc'd + a'bc'd + a'bcd' + a'bc'd + abc'd' + abc'd$$

$$= a'b'c'd + a'bc'd' + a'bc'd + a'bcd' + a'bcd + ab'c'd + abc'd' + abc'd$$

$$+ abcd' + abcd$$
expand by ANDing with both forms of missing literals

3) Minimize the expression for f(a,b,c,d) in the <u>first canonical form</u> using axioms and theorems of Boolean algebra. <u>Show all steps</u> in your minimization and <u>write the name of the axiom/theorem/property</u> you use on the right-hand side of the expression <u>at each step.</u>



4) Draw the circuit for the <u>minimized</u> expression you found in Question 3 above using <u>2-input NAND gates only</u>. Show all steps, and explain your work leading up to the final circuit.

$$F(a,b,c,d) = \overline{\overline{F(a,b,c,d)}} = \overline{\overline{b+c'd}} = \overline{\overline{b}\ \overline{(c'd)}}$$

