

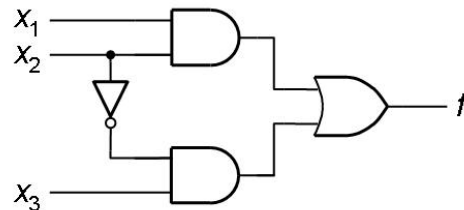
For this homework, the cost of a circuit is considered to be the total number of gates plus the total number of inputs.

P1. (15 points) How many transistors are required to implement the following functions/circuits using CMOS technology?

(a) $C = YZ + XZ + XY$

(b) $S = \bar{X}\bar{Y}Z + \bar{X}Y\bar{Z} + X\bar{Y}\bar{Z} + XYZ$

(c) The circuit shown here



P2. (15 points) Find the minimum SOP expression for the following functions.

(a) $F(A,B,C) = \sum m(3,5,6) + D(0,7)$

(b) $F(W,X,Y,Z) = \sum m(0,2,4,5,8,14,15) + D(7,10,13)$

(c) $F(A,B,C,D) = \sum m(4,6,7,8,12,15) + D(2,3,5,10,11,14)$

P3. (a) (10 points) Find the minimum-cost circuit consisting only of two-input NAND gates for the function $f(x_1, \dots, x_4) = \sum m(0, 1, 2, 3, 4, 6, 8, 9, 12)$. Assume that the input variables are available in both uncomplemented and complemented forms. How many NAND gates did you use?

(b) (10 points) Find the minimum-cost circuit consisting only of two-input NOR gates for the function $f(x_1, \dots, x_4) = \sum m(6, 7, 8, 10, 12, 14, 15)$. Assume that the input variables are available in both uncomplemented and complemented forms. How many NOR gates did you use?

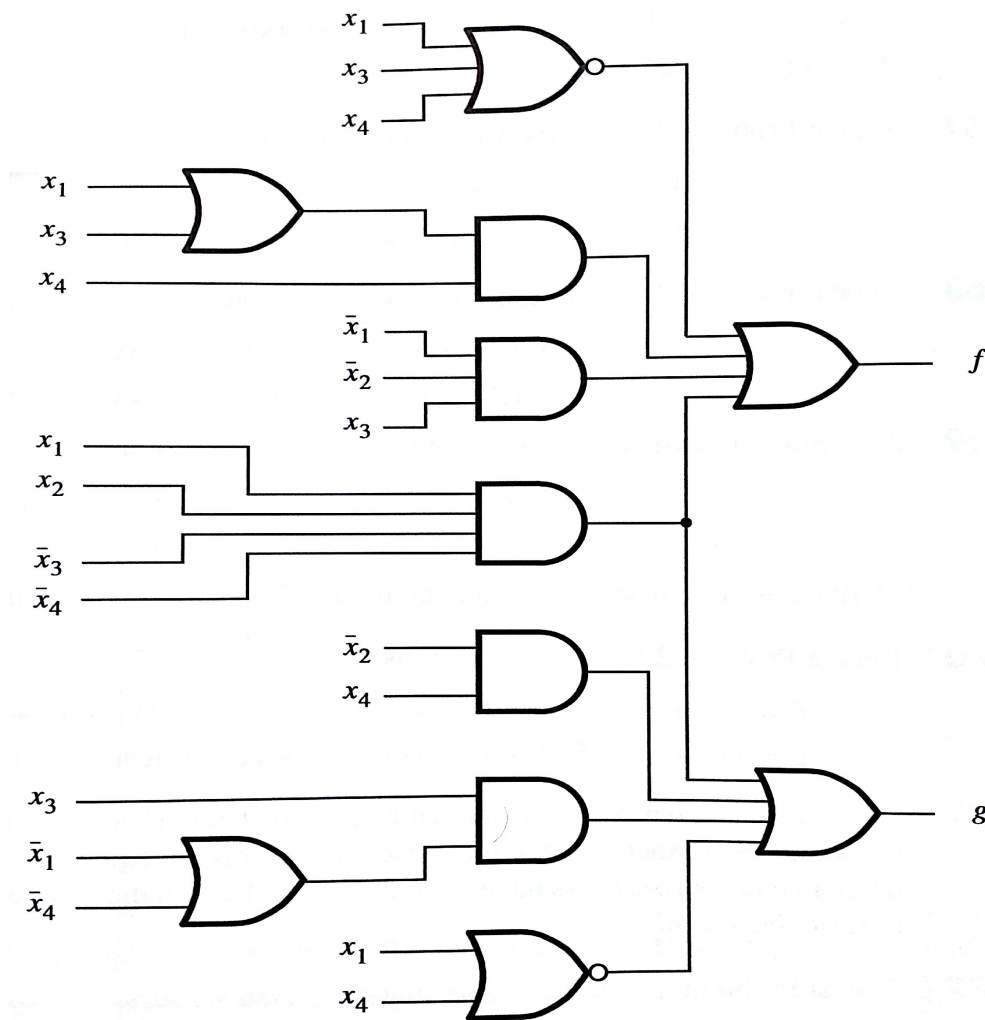
P4. (20 points) A circuit has two outputs, f and g, which are specified as follows:

$f(x_1, x_2, x_3, x_4) = \sum m(0, 2, 4, 6, 7, 9) + D(10, 11)$

$g(x_1, x_2, x_3, x_4) = \sum m(2, 4, 9, 10, 15) + D(0, 13, 14)$

Design the minimum-cost circuit and compare its cost with the combined costs of the two circuits that implement f and g separately. Assume that the input variables are available in both uncomplemented and complemented forms.

- P5. (20 points) The circuit in the figure below implements two functions f and g .
- What is the cost of this circuit? Assuming that the input variables are available in both uncomplemented and complemented forms.
 - Redesign the circuit to implement the same functions, but the cost should be as low as possible. What is the cost of your circuit?



- P6. (10 points) Jointly minimize the functions for segments F and G when displaying digits from 0 to 9 in a 7-segment display. Use W, X, Y, and Z as your variables.