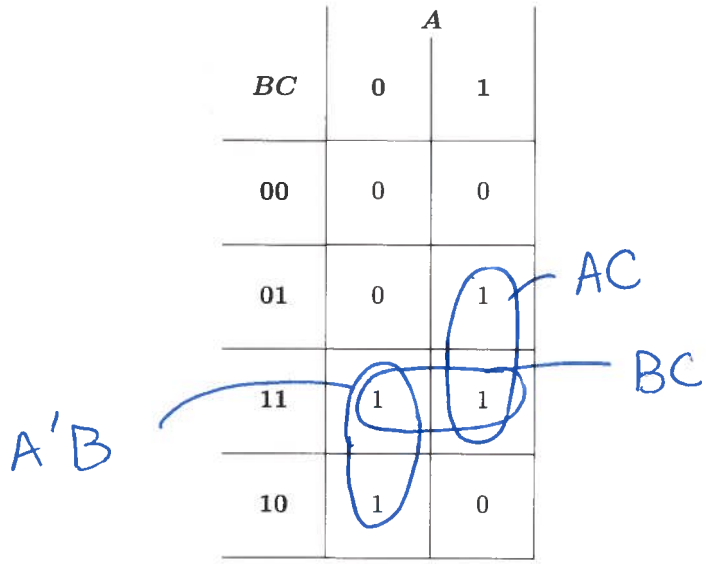
Name: SOLUTIONS 73% CLASS AVG.

Read each question carefully before answering. Answer all parts. Show all work, calculations, and/or reasoning, otherwise no points will be awarded. Properly labeled loops **must be shown** on K-maps to receive credit. Assume that you have access to gates with as many inputs as you need. Point values are as indicated. Usage of XOR and XNOR gates is **not allowed** on this exam!

1. (5 points) Using the following K-map, find the minimum SOP expression for a hazard-free circuit.



$F_{hazard-free}$ = AC+BC+A'B

All prime implicants are required to implement a hazard-free circuit!

2. $F(A,B,C,D) = \Sigma m(2,3,6,7,8,11) + \Sigma d(0,10,12,13)$

(a) (5 points) Using a K-map, find the minimum SOP expression.

CD \ AB	00	01	11	10
00	X	0	X	1
01	0	0	X	0
11	1	1	0	1
10	1	1	0	X

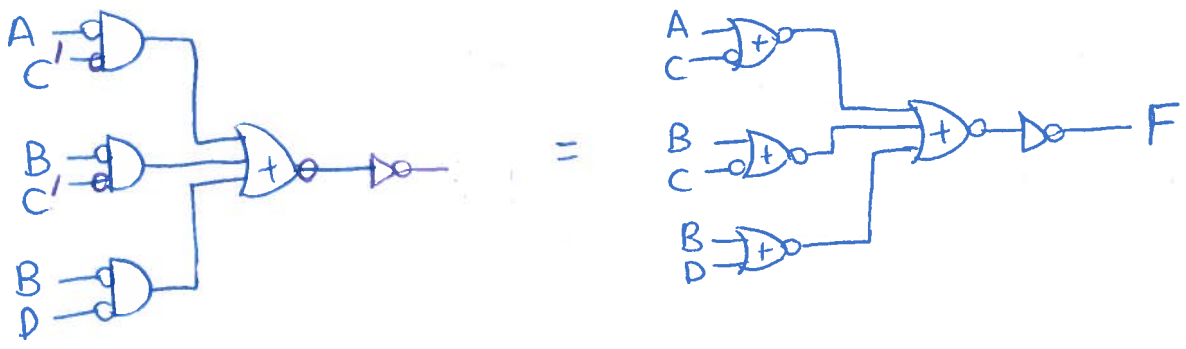
A'C

B'D'

B'C

$F_{SOP} =$ A'C . + B'C + B'D'

(b) (5 points) Draw the circuit diagram as a NOR-only circuit. (Use either the double prime or bubble method and show your work.)



3. $F(A,B,C,D) = \Pi M(1,5,8,9,11,13) + \Pi D(2,3,6,10,14,15)$

(a) (5 points) Using a K-map, find the minimum POS expression.

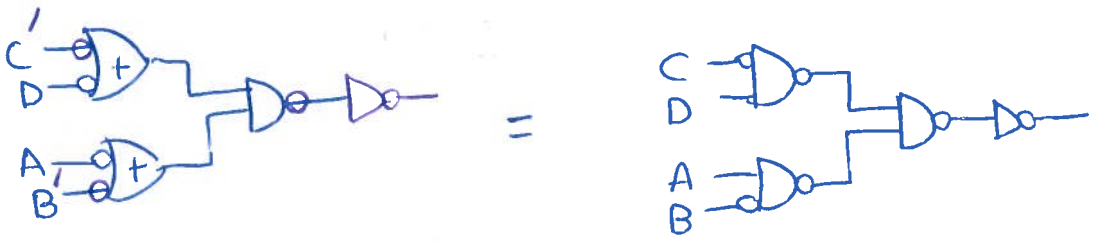
CD \ AB	00	01	11	10
00	1	1	1	0
01	0	0	0	0
11	X	1	X	0
10	X	X	X	X

(A'+B)

(C+D')

$F_{POS} =$ (C+D')(A'+B)

(b) (5 points) Draw the circuit diagram as a NAND-only circuit. (Use either the double prime or bubble method and show your work.)

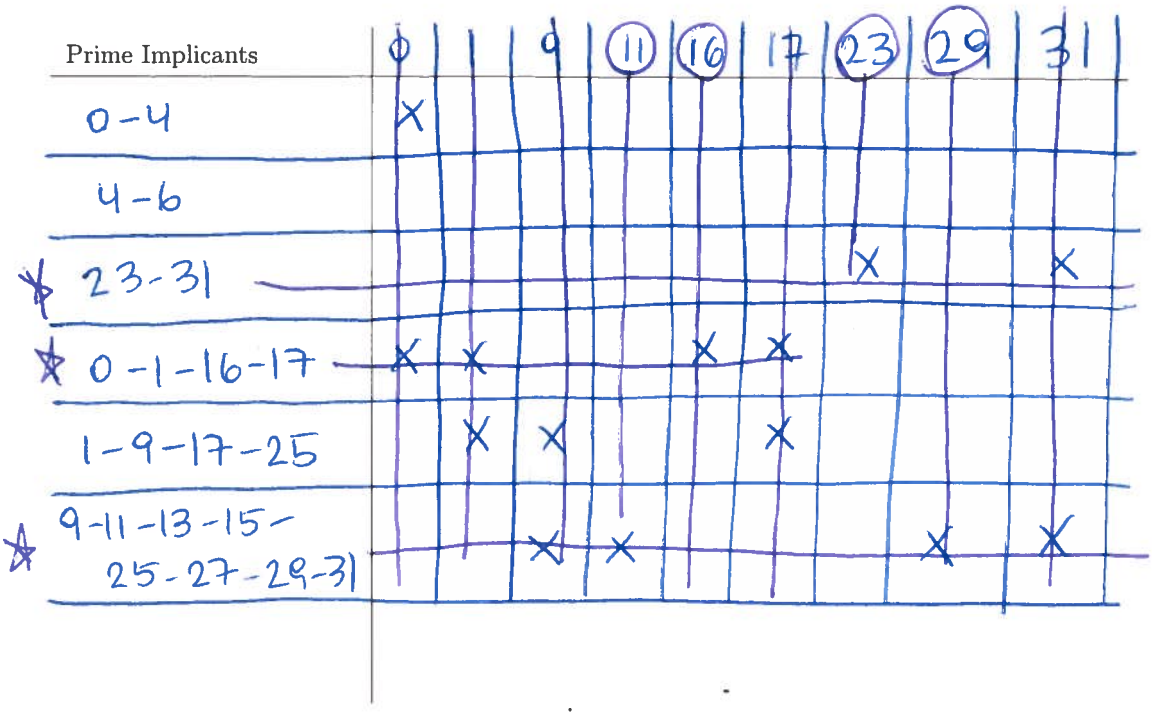


3. Use the Quine-McCluskey method to find the minimum SOP expression for the following expression. Each column containing implicants is worth 5 points. Circle all of the prime implicants in each column. This question continues on the next page.

$$F(A,B,C,D,E) = \Sigma m(0,1,9,11,16,17,23,29,31) + \Sigma d(4,6,13,15,25,27)$$

	Column 1	Column 2	Column 3	Column 4
zero	0. 00000 ✓	0-1 0000- ✓	0-1-16-17 -000-	9-11-13-15-25-27-29-31
		0-4 00-00	~~0-16-1-17~~	-1--1
one	1. 00001 ✓	0-16 -0000 ✓		
	4. 00100 ✓		1-9-17-25 --001	all others are redundant
	16. 10000 ✓	1-9 0-001 ✓	~~1-17-9-25~~	
		1-17 -0001 ✓		
two	6. 00110 ✓	4-6 001-0	9-11-13-15 01--1 ✓	
	9. 01001 ✓	16-17 1000- ✓	9-11-25-27 -10-1 ✓	
	17. 10001 ✓		~~9-13-11-15~~	
three	11. 01011 ✓	9-11 010-1 ✓	9-13-25-29 -1-01 ✓	
	13. 01101 ✓	9-13 01-01 ✓	~~9-25-11-29~~	
	25. 11001 ✓	9-25 -1001 ✓	~~9-25-13-29~~	
		17-25 1-001 ✓		
four	15. 01111 ✓	11-15 01-11 ✓	11-15-27-31 -1-11 ✓	
	23. 10111 ✓	11-27 -1011 ✓	~~11-27-15-31~~	
	27. 11011 ✓	13-15 011-1 ✓	13-15-29-31 -11-1 ✓	
	29. 11101 ✓	13-29 -1101 ✓	~~13-29-15-31~~	
		25-27 110-1 ✓	25-27-29-31 11--1 ✓	
five	31. 11111 ✓	25-29 11-01 ✓	~~25-29-27-31~~	
		15-31 -1111 ✓		
		23-31 1-111		
		27-31 11-11 ✓		
		29-31 111-1 ✓		

(a) (5 points) Fill out the prime implicant table.



(b) (5 points) Identify all of the essential prime implicants.

ACDE (23-31)

$B'C'D'$ (0-1-16-17)

BE (9-11-13-15-25-27-29-31)

(c) (5 points) Write the minimum SOP expression.

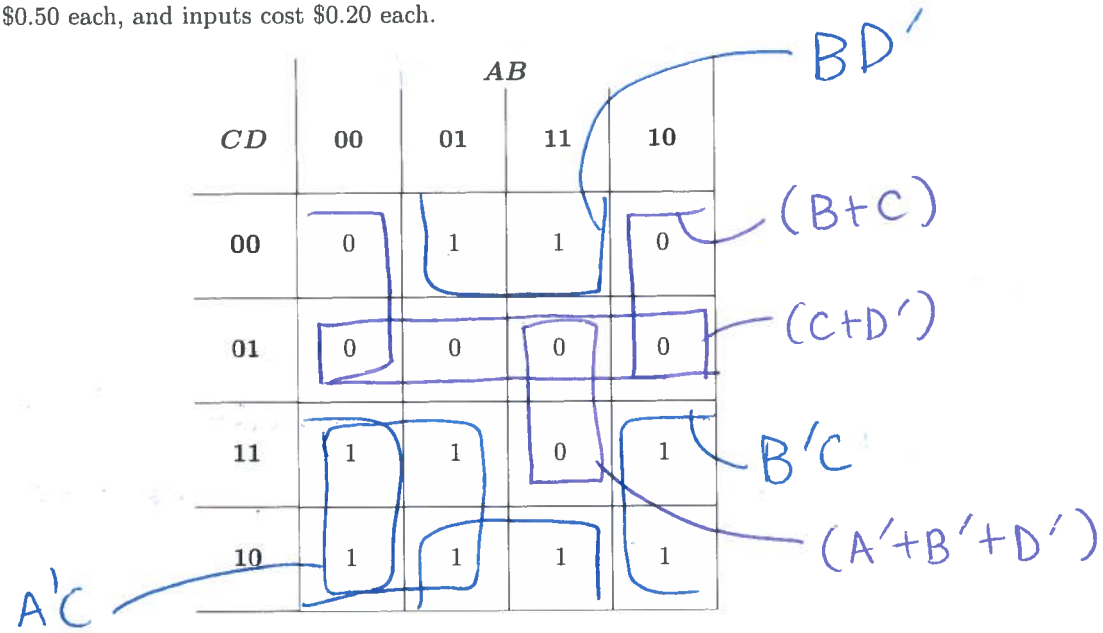
$F_{SOP} =$ $ACDE + B'C'D' + BE$

(d) (5 points) If this had to be implemented as a **hazard-free** circuit, write the corresponding circuit equation.

$F_{hazard-free} =$ $A'B'D'E' + ACDE + B'C'D' + C'D'E + BE$

4-6 is not necessary because it consists only of don't care terms!

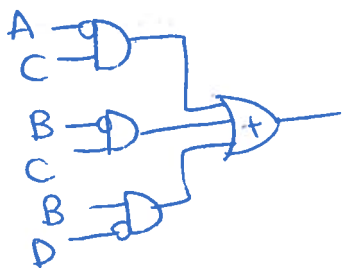
4. Use the following K-map to answer the following questions. In addition, assume that logic gates cost \$0.50 each, and inputs cost \$0.20 each.



(a) (5 points) Find the minimum SOP expression.

$A'C + B'C + BD'$

(b) (5 points) What is the cost of this circuit? (Show how many gates and inputs are needed, then calculate the cost.)



4 gates * \$0.50 = \$2.00

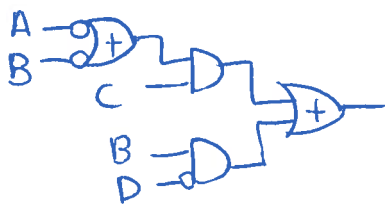
9 inputs * \$0.20 = \$1.80

\$3.80

(c) (5 points) Find the factored SOP expression.

$(A'+B')+BD'$

(d) (5 points) What is the cost of this circuit? (Show how many gates and inputs are needed, then calculate the cost.)



4 gates * \$0.50 = \$2.00

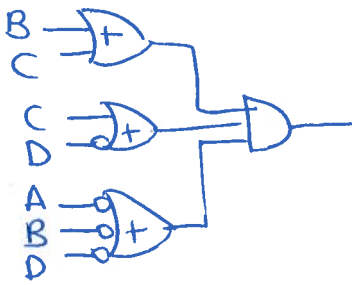
8 inputs * \$0.20 = \$1.60

\$3.60

(e) (5 points) Find the minimum POS expression.

$(B+C)(C+D')(A'+B'+D')$

(f) (5 points) What is the cost of this circuit? (Show how many gates and inputs are needed, then calculate the cost.)



4 gates * \$0.50 = \$2.00

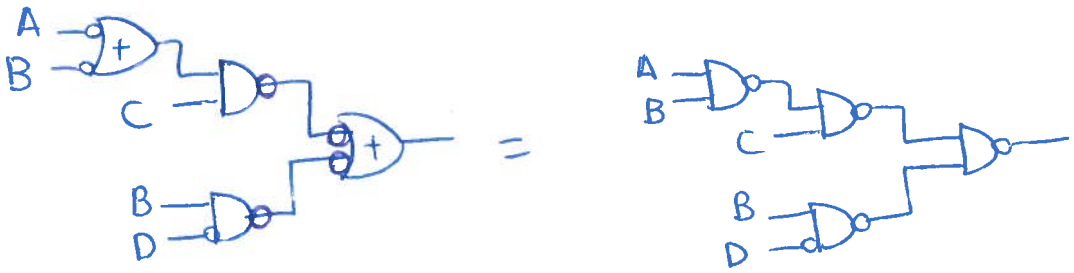
10 inputs * \$0.20 = \$2.00

\$4.00

(g) (5 points) Identify the lowest cost implementation of this circuit.

Factored SOP

(h) (5 points) Draw the lowest cost circuit diagram as a NAND-only circuit. (Use either the double prime or bubble method and show your work.)



(i) (5 points) Draw the lowest cost circuit diagram as a NOR-only circuit. (Use either the double prime or bubble method and show your work.)