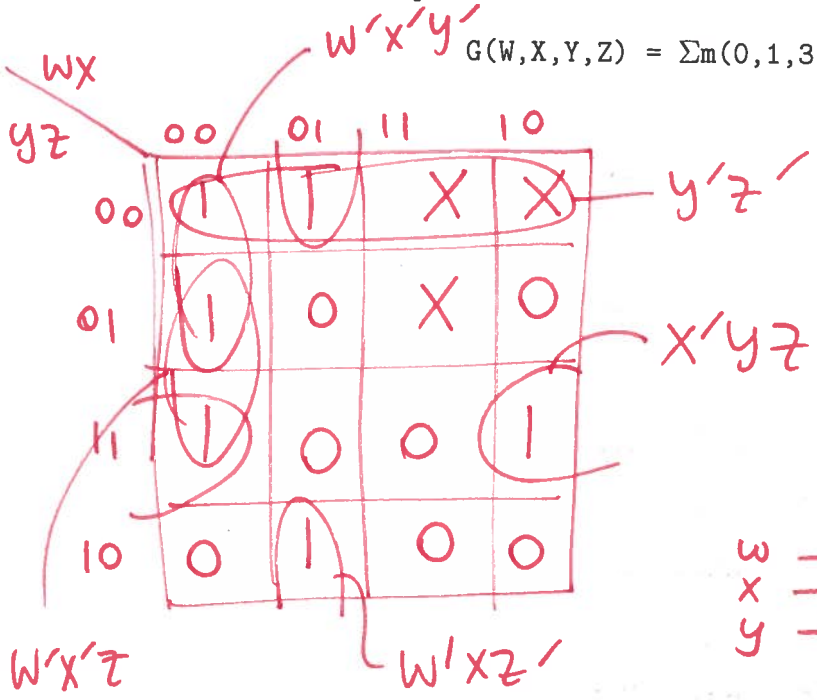
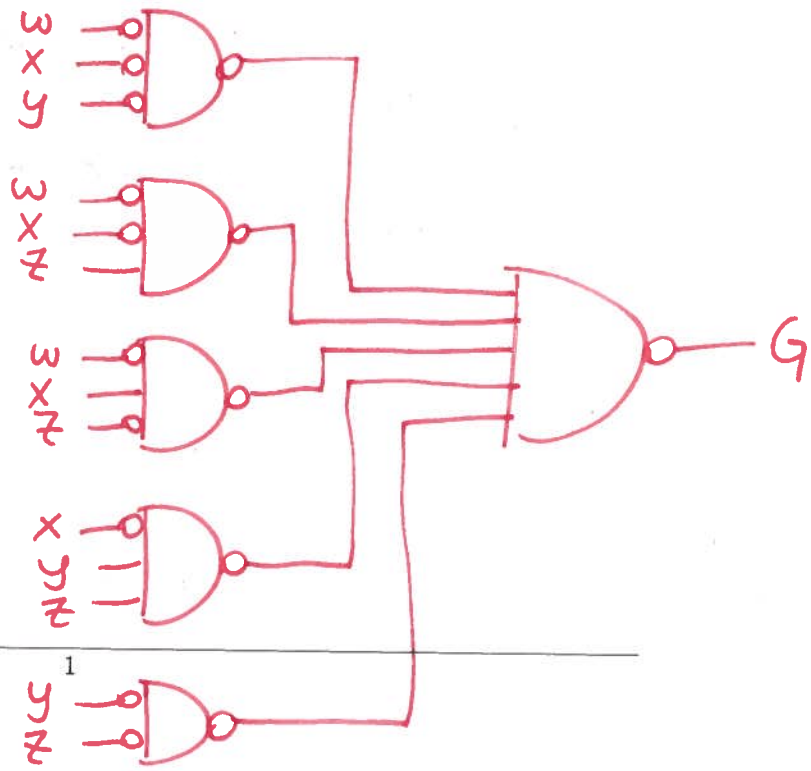
Name: SOLUTIONS

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. (10 points) Draw the following as a hazard-free NAND-only circuit. Assume that you have access to gates with as many inputs as you need. **You may use bubbles on inputs, but not as output inverters!**

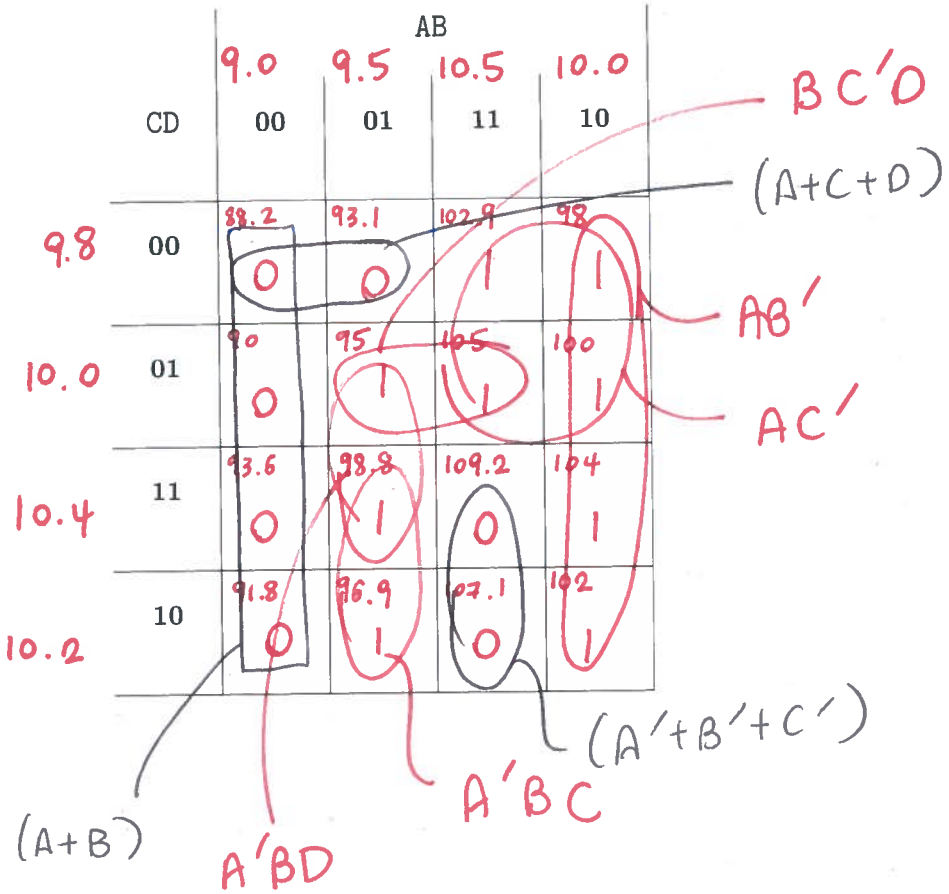
$G(W,X,Y,Z) = \Sigma m(0,1,3,4,6,11) + \Sigma d(8,12,13)$





2. (10 points) A sensor measures the length and width of a piece of machined metal. AB corresponds to the length, and CD corresponds to the width, as indicated in the table below. Use the K-map below to solve for F, which indicates if the area of the piece of metal is between 95 cm^2–105 cm^2 (inclusive). Ensure that F is hazard-free. All loops must be labeled to receive credit for this problem.

AB	Length (cm)	CD	Width (cm)
00	9.0	00	9.8
01	9.5	01	10.0
10	10.0	10	10.2
11	10.5	11	10.4



SOP → F= A'BD + A'BC + AC' + AB' + BC'D

POS → (A+B)(A+C+D)(A'+B'+C')

3. (2 points) Explain what ROM is and why it is useful in digital electronics.

READ ONLY MEMORY

SAVES ON GATES WHEN MULTIPLE OUTPUT AND/OR MANY INPUT VARIABLES EXIST

4. (2 points) Explain the difference between UV-erasable EPROM and one-time programmable EPROM.

UV-ERASABLE - CONTENTS CAN BE ERASED & RE-PROGRAMMED

OTP - CONTENTS CANNOT BE ERASED & RE-PROGRAMMED

5. (2 points) In what situations would you use UV-erasable EPROM?

PROTOTYPING

6. (2 points) In what situations would you use one-time programmable EPROM?

FINAL DESIGN / IMPLEMENTATION

7. (2 points) You are interested in using the 27C512 EPROM chip, which has 8 bit words and 16 address pins. What is the memory capacity of this chip in bytes?

$2^{16} = 65,536$ BYTES

8. The following codes are used by a vending machine to determine the item being purchased (represented by the variables DE) and the amount of money inserted into the machine (represented by the variables ABC). The machine has an output, V, which is 1 if enough money has been inserted to pay for the item.

ABC	Money Inserted	DE	Item & Cost
000	\$0.20	00	Snickers – \$0.70
001	\$0.30	01	Coke – \$0.60
010	\$0.40	10	Water – \$0.50
011	\$0.50	11	Chips – \$0.85
100	\$0.60		
101	\$0.70		
110	\$0.80		
111	\$0.90		

(a) (10 points) Find the minterms of V. (Hint: feel free to use a truth-table or a K-map if it will help you here.)

$\Sigma m(14, 17, 18, 20, 21, 22, 24, 25, 26, 28, 29, 30, 31)$

THIS QUESTION CONTINUES ON THE NEXT PAGE

(b) (20 points) Use the Quine-McCluskey method to derive an equation for V.

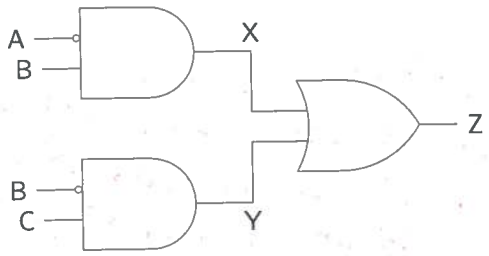
Column 1	Column 2	Column 3
TWO. 17. 10001	17-21 10-01	17-21-25-29 1--01
18. 10010	17-25 1-001	18-22-26-30 1--10
20. 10100	18-22 10-10	20-21-28-29 1-10-
24. 11000	18-26 1-010	20-22-28-30 1-1-0
THREE 14. 01110	20-21 1010-	24-25-28-29 11-0-
21. 10101	20-22 101-0	24-26-28-30 11--0
22. 10110	20-28 1-100	28-29-30-31 111--
25. 11001	24-25 1100-	
26. 11010	24-26 110-0	
28. 11100	24-28 11-00	
	14-30 -1110	
FOUR 29. 11101	21-29 1-101	
30. 11110	22-30 1-110	
FIVE 31. 11111	25-29 11-01	
	26-30 11-10	
	28-29 1110-	
	28-30 111-0	
	29-31 111-1	
	30-31 1111-	

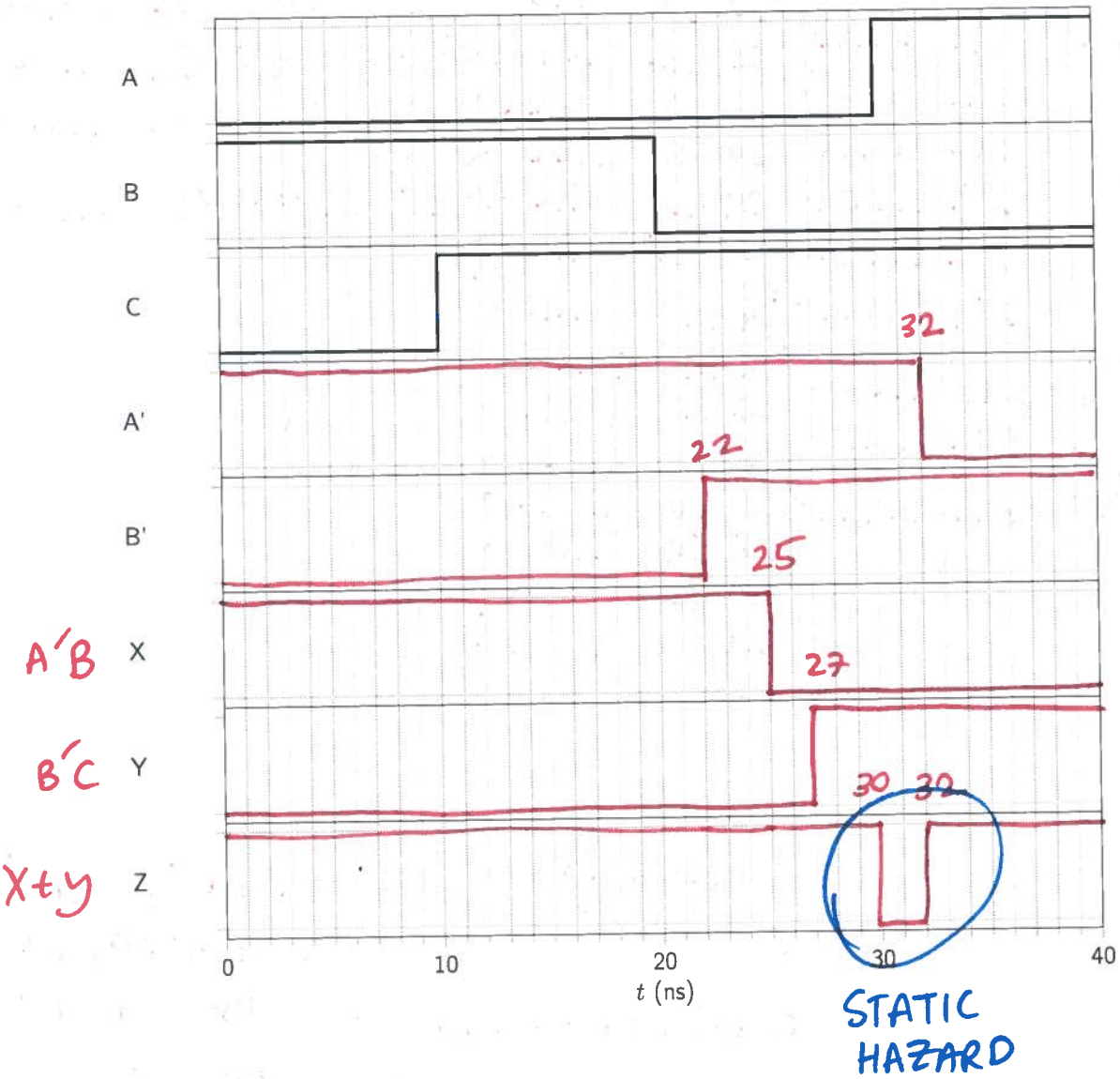
PI's

essential

V= $BCDE' + AD'E + ADE' +$ { $ACD' + ABD'$; $ACE' + ABD'$; $ABE' + ACD'$; $ABE' + ACE'$ }

9. (20 points) Draw a timing diagram for the following circuit, given gate delays of 2 ns for NOT gates, and 5 ns for AND and OR gates. Indicate any static hazards in the output signal

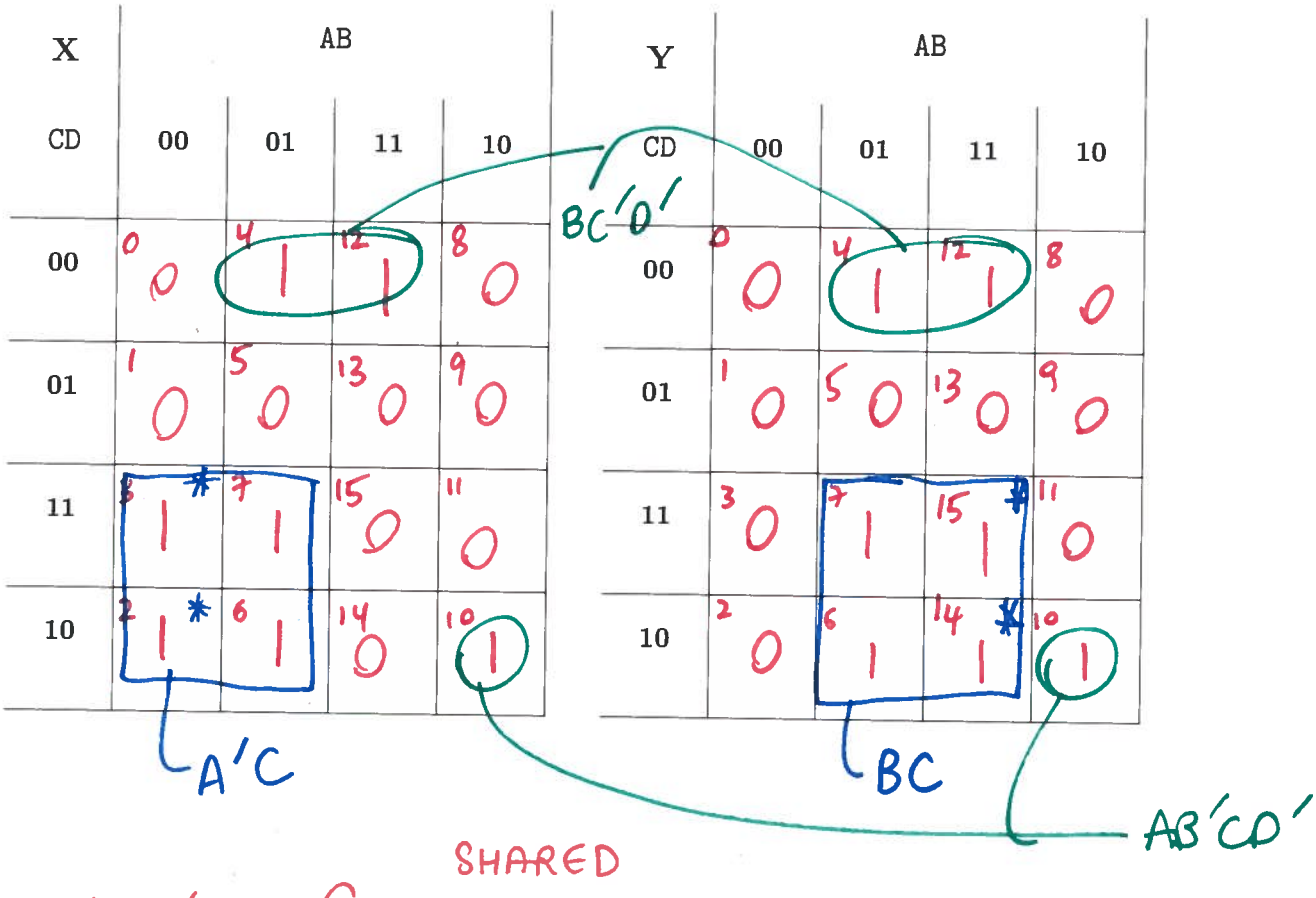




10. (25 points) Find the optimized implementation of the following two circuits. Show all work. How many gates and/or inputs do you save by implementing circuits together rather than individually?

$$X(A,B,C,D) = \Sigma m(2,3,4,6,7,10,12)$$

$$Y(A,B,C,D) = \Sigma m(4,6,7,10,12,14,15)$$



SHARED

$X = A'C + \{BC'D' + AB'CD'\}$

$Y = BC + \{BC'D' + AB'CD'\}$