

# EEM16 Midterm

AURORA BEVERLEY YEH

TOTAL POINTS

**74 / 80**

QUESTION 1

Problem 1 20 pts

4.3 (c) 7 / 7

✓ - 0 pts Correct

1.1 (a-c) 8 / 12

✓ - 1 pts Question1 (b): 4 pts. Missing or having extra essential prime implicant, or incorrect term

✓ - 3 pts Question1 (c): 4 pts. Wrong terms

1 "AB" is not an essential prime implicant, since if without it, all the 1s are already covered by the rest terms.

2 It starts from 0, not 1

1.2 (d-f) 7 / 8

✓ - 1 pts Question1 (f): 3 pts. Incorrect term to remove the risk.

QUESTION 2

2 Problem 2 20 / 20

✓ - 0 pts Correct

QUESTION 3

3 Problem 3 19 / 20

✓ - 2 pts (f) incorrect real number or bias

+ 1 Point adjustment

☞ (f) partial

QUESTION 4

Problem 4 20 pts

4.1 (a) 8 / 8

✓ - 0 pts Correct

4.2 (b) 5 / 5

✓ - 0 pts Correct

# Midterm Exam

Name (Last, First): Yeh, Aurora

Student Id #: 305110110

**Do not start working until instructed to do so.**

1. You must answer in the **space provided** for answers after every question. We will ignore answers written anywhere else in the booklet. **All pages in this booklet must be accounted** for otherwise it will not be graded.
2. You are permitted 1 page of notes 8.5x11 (front and back).
3. You may not use any electronic device.

Following table to be filled by course staff only

	Maximum Score	Your Score
Question 1		
Question 2		
Question 3		
Question 4		
<b>TOTAL</b>	<b>100</b>	

Question #1

Consider the following Karnaugh Map for the Boolean function, Y. A blank truth table is provided for your convenience.

		AB		A		
		"00"	"01"	"11"	"10"	
CD	D	"00"	0	0	1	1
	1	"01"	1	1	X	X
	0	"11"	0	0	1	1
	C	"10"	1	1	X	0

	A	B	C	D	Y	Dual
1	0	0	0	0	0	0
2	0	0	0	1	1	X
3	0	0	1	0	1	X
4	0	0	1	1	0	0
5	0	1	0	0	0	0
6	0	1	0	1	1	1
7	0	1	1	0	1	X
8	0	1	1	1	0	0
9	1	0	0	0	1	1
10	1	0	0	1	X	0
11	1	0	1	0	0	0
12	1	0	1	1	1	1
13	1	1	0	0	1	1
14	1	1	0	1	X	0
15	1	1	1	0	X	0
16	1	1	1	1	1	1

(a) Circle the prime implicants on the map.

How many prime implicants are there? 6

(b) Write the Boolean (sum-of-product) expression of the essential prime implicants of (b) (if any).

$$\text{EssentialPrimeImplicants} = (\sim C \wedge D) \vee (A \wedge B) \vee (A \wedge \sim C) \vee (A \wedge D) \vee (\sim A \wedge C \wedge \sim D)$$

(c) Complete the following statement

$$\neg Y = \prod M(2, 3, 6, 7, 9, 12, 13, 16)$$

$$(\sim C \vee \sim D) \wedge (\sim A \vee \sim B) \wedge (\sim A \vee C) \wedge (\sim A \vee \sim D) \wedge (A \vee \sim C \vee D)$$

- (d) Express as a minimal sum of product,  $\neg Y$ .  
The K-map is provided for your convenience.

		AB		B	A		
		"00"	"01"	"11"	"10"	}	
CD	d	0	0	1	1		this is Y
	c	1	1	X	X		
	b	0	0	1	1		
	a	1	1	X	0		

$\neg Y = (\sim A \sim C \sim D) \vee (\sim A C \sim D) \vee (A C \sim D)$

- (e) Is the dual of this function itself? Circle one:  Yes  No

Justify your answer:

when you invert the truth table and reverse the terms, everything except the 'don't cares' match, but we don't care about those

- (f) If the logic is implemented using its minimal sum-of-product expression, is there a risk of a static hazard?

Circle one:  Yes  No

uh what?

Under what input conditions?

the last term  $(\sim A C \sim D)$

it's not overlapping any other essential prime implicant

What product term(s) would you add to remove the risk?  $(B C \sim D)$

Question #2

(a) Rewrite the following Boolean equation as a sum-of-products or product-of-sum. Hint: apply DeMorgan's theorem.

$$W = \neg(\neg(c \vee \neg(a \wedge \neg b)) \vee (d \wedge \neg e))$$

Answer:

$$= \sim(\sim(c \vee \sim a \vee b) \vee (d \wedge \sim e))$$

$$= \sim(\sim(c \vee \sim a \vee b) \vee \sim(\sim d \vee e))$$

$$= \sim\sim((c \vee \sim a \vee b) \wedge (\sim d \vee e))$$

$$W = \underline{(c \vee \sim a \vee b) \wedge (\sim d \vee e)}$$

(b) Rewrite the following Boolean equation as a sum-of-products or product-of-sum.

$$X = (c \vee (a \wedge b)) \vee (d \wedge e)$$

Answer:

$$(c) \vee (a \wedge b) \vee (d \wedge e) \quad \text{?? ?}$$

$$\sim(\sim(c \vee (a \wedge b)) \wedge \sim(d \wedge e))$$

$$\sim((c \vee \sim(a \wedge b)) \wedge (\sim d \vee \sim e)) \rightarrow \text{??}$$

$$X = \underline{(c) \vee (a \wedge b) \vee (d \wedge e)}$$

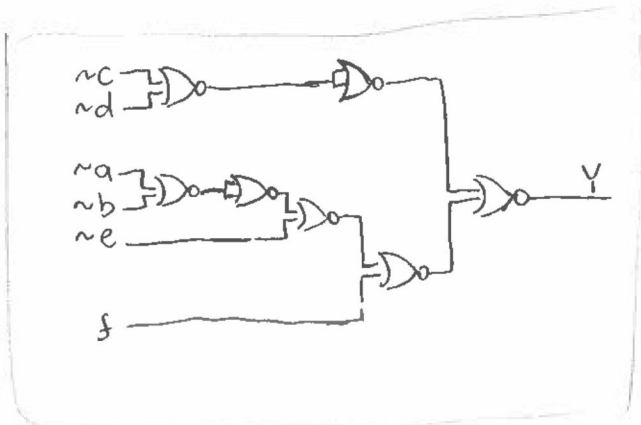
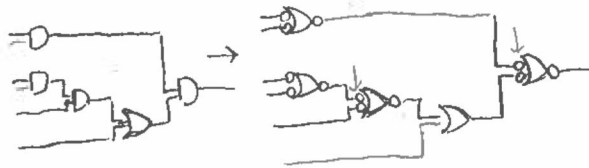
2-input

(c) Implement the following function using NOR gates only and the fewest NOR gates possible. You may use true and complemented versions of the a-f inputs,

$$Y = (a \wedge b \wedge c \wedge d \wedge e) \vee (c \wedge d \wedge f)$$

$$(a \wedge b) = \sim(\sim a \vee \sim b)$$

$$Y = (c \wedge d) \wedge ((a \wedge b \wedge e) \vee f)$$



check:

$$\sim\sim(\sim c \vee \sim d) \rightarrow \sim(c \wedge d)$$

$$\sim\sim(\sim a \vee \sim b) \rightarrow \sim(a \wedge b)$$

$$\sim(\sim(a \wedge b \wedge e) \vee \sim f) \rightarrow a \wedge b \wedge e$$

$$\sim((a \wedge b \wedge e) \vee f)$$

$$\sim(\sim(c \wedge d) \vee \sim((a \wedge b \wedge e) \vee f))$$

$$(c \wedge d) \wedge ((a \wedge b \wedge e) \vee f) \quad \checkmark$$

Question #3

The following 12-bit word can be used to represent different numbers depending on the encoding

12b' <sup>30 29 28 27 26 25 24 23 22 21 20 19</sup> 1011\_1101\_0110

(a) If the word is 2's complement, what is the corresponding integer? -1066

(b) If we convert the word into base-4, what is the represented number?

233112

(c) If we take answer in (b), write the 3's complement of the base-4 number.

100221

(d) If the word is unsigned fixed point 6.6, what is the corresponding number?

47.34375

What is the absolute accuracy of this representation? 1/128

(e) What is this word in Hexadecimal? bd6

(f) If the word is 6E5 floating point number (IEEE format S+EEEE+MMMMM),

What is the bias? 15

What is the corresponding real number? -1.010110

(g) In base-20 system and using 3 "vigits" (base-20 digits) in 20's complement:

How would one represent a base-10 integer -1616? 15.19.4

What is the most positive value in base-10 integer that can be represented?

3999

$9.19.19 \rightarrow 9 \cdot 400 + 19 \cdot 20 + 19 = 3600 + 380 + 19 =$

$20^3 - 1 = 4000 - 1 \checkmark$

check

-2048	1024
+512	+32
+256	+8
+128	+1
+64	
+16	
+4	1065
+2	
<hr/>	
-2048	
+982	1066
<hr/>	
-1066	

$-x = \sim x + 1$

1011 = 11  
1101 = 13  
0110 = 6

S = 1  
E = 01111 = 15  
M = 010110

1616 → 4.0.16

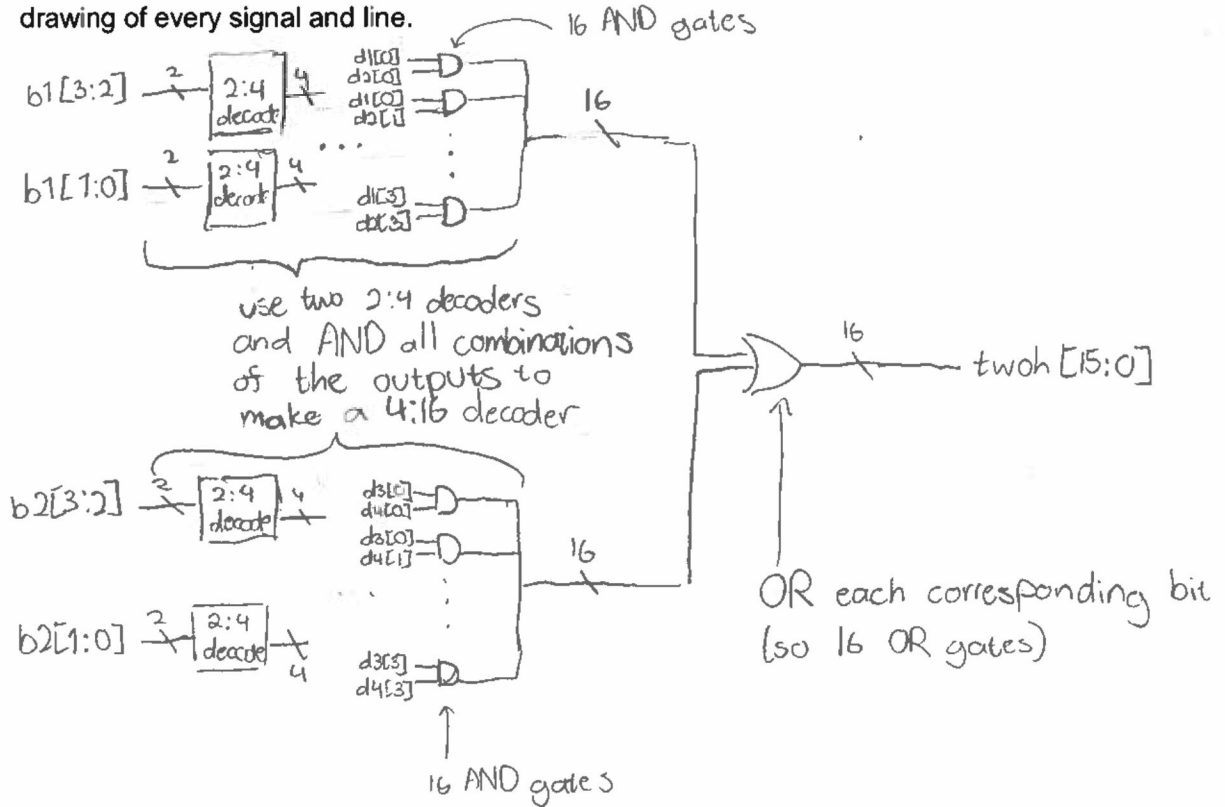
0 1 2 3 4 5 6 7 8 9  
19 18 17 16 15 14 13 12 11 10

15.19.3 → 1

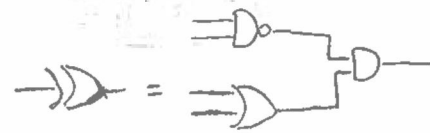
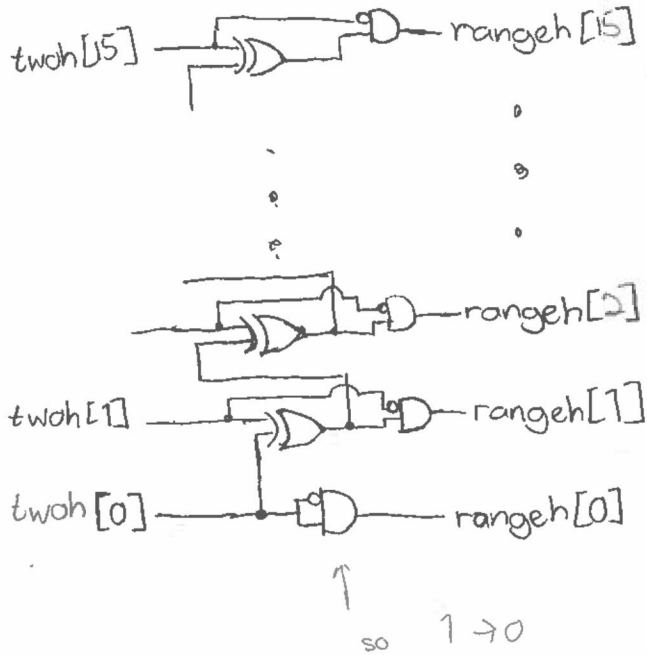
$-5 \cdot 400 + 19 \cdot 20 + 4$   
 $= -2000 + 380 + 4$   
 $= -1616$

Question #4

- (a) Two 4-bit binary inputs,  $b1[3:0]$  and  $b2[3:0]$ , are needed to be decoded into a single 2-hot output vector,  $twoh[15:0]$ . This 2-hot vector has up to two positions of 1's and the remainder are 0's. If  $b1$  is the same as  $b2$ , then only a single 1 is asserted. Design this logic. You may use 2:4 Decoders as building blocks and any number of AND, OR, or INV gates. Try to minimize the amount you use. You may describe connections to avoid an overly complex drawing of every signal and line.



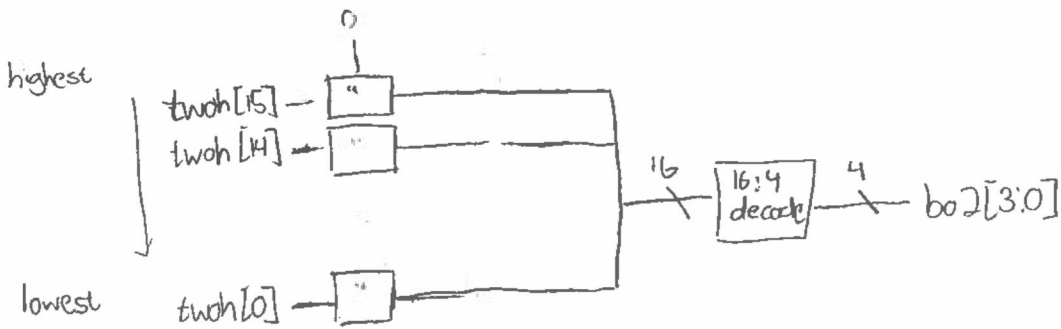
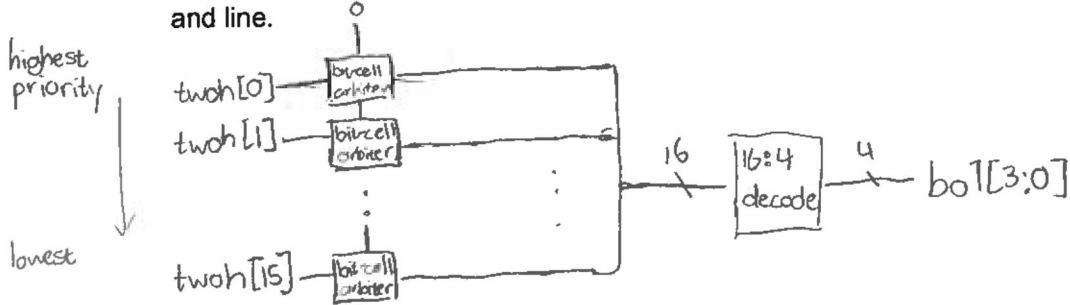
(b) Next, you are tasked to code the  $twoh[15:0]$  signals into a vector that indicates a range, similar to a thermometer code. The 16-bit input,  $twoh[15:0]$ , produces 16-bit outputs,  $rangeh[15:0]$ , whereby the positions in between the 2 asserted signals of the  $twoh[15:0]$  are all 1's. For instance, with  $b1[3:0]=4'b0110$  and  $b2[3:0]=4'b0010$ ,  $rangeh[15:0]=16b'0000_0000_0011_1110$ . You may use any building block we have covered in lecture as well as any number of AND, OR, or INV gates. Again you can describe connections to avoid drawing every signal and line.



XOR acts like a toggle



(c) Finally, encode inverse the function of (a) by accepting the  $twoh[15:0]$  signal as input and output 2 binary values  $bo1[3:0]$  and  $bo2[3:0]$  to indicate the binary position of the two hot bits. You may use any building block we have covered in lecture as well as any number of AND, OR, or INV gates. Again you can describe connections to avoid drawing every signal and line.



top half - let most significant 1 from right pass through, then decode

bottom - let least sig. 1 from left pass through, then decode

