# EEM16 Midterm

[redacted]

TOTAL POINTS

**65 / 65**

QUESTION 1

## 1 Problem #1 18 / 18

- ✓ **- 0 a) is Correct**
- ✓ **- 0 b) is correct**
- ✓ **- 0 c) is correct**
- ✓ **- 0 d) is correct**
- ✓ **- 0 e) is correct**
- **- 1** a) added don't cares as minterms
- **- 3** a) is incorrect
- **- 2** b) is partially correct
- **- 5** b) is incorrect
- **- 3** c) is incorrect
- **- 3** d) is incorrect
- **- 2** e) is partially incorrect
- **- 4** e) is incorrect
- **- 1** d) partially incorrect
- **- 2** c) partially incorrect

QUESTION 2

## 2 Problem #2 14 / 14

- ✓ **- 0 all correct**
- **- 2** Part (a): answer other than 2, 3 or 4
- **- 1** Part (b): deduct for wrong demorgan
- **- 0.5** Part(b): partial improper SoP
- **- 1** Part(b): For improper SoP form
- **- 2** Part(b) quite wrong SoP
- **- 4** Part(b): all wrong
- **- 1.5** Part(c): if Not distributive
- **- 2** Pat(c) no 6 SoP
- **- 1** Part(c). For each wrong SoP term
- **- 4** Part(c): all wrong
- **- 0.5** Part(d): Partial wrong reduced expression
- **- 1** Part(d): quite wrong reduced expression
- **- 1** Part(d): For one missing property
- **- 2** Part(d): For two missing properties

QUESTION 3

## 3 Problem #3 22 / 22

- ✓ **- 0 Correct. Good Job.**
- **- 1** (a) math error
- **- 2** (a) incorrect
- **- 1** (a) (b) or (c) math error
- **- 2** (b) incorrect
- **- 2** (c) incorrect = -105
- **- 0.5** (c) negative error for 2's complement
- **- 2** (d) incorrect hex
- **- 2** (e) incorrect BCD
- **- 1** (f) partial credit
- **- 2** (f) incorrect
- **- 2** (g) incorrect bias
- **- 2** (g) incorrect real number
- **- 1** (g) partial credit for error
- **- 6** (h) incorrect
- **- 2** (h) incorrect floating point choice
- **- 1** (h) partially incorrect min bits for mantissa
- **- 2** (h) incorrect min bits for mantissa
- **- 1** (h) partially incorrect min bits for exponent
- **- 2** (h) incorrect min bits for exponent

QUESTION 4

## 4 Problem #5 11 / 11

- ✓ **- 0 (a) Correct. Nice Job!**
- **- 7** (a) incorrect
- **- 5.5** (a) partial for ok attempt
- **- 3** (a) Too much excessive logic
- **- 0** (a) No or incorrect Hit logic
- **- 0.5** (a) Some unnecessary logic
- ✓ **- 0 (b) Correct. Nice Job!**
- **- 4** (b) incorrect
- **- 3.5** (b) Partial credit for attempt
- **- 1** (b) incorrect bit weight (hop and adder cnt)
- **- 1** (b) no or incorrect adder count or hop

- **0.5** (b) Good attempt but slightly too many FA

- **1.5** (b) ok attempt but incorrect design

- **3** (b) partial credit for attempt

# Midterm Exam

Name (Last, First): [redacted]

Student Id #: [redacted]

**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** | | |
| **Question 5** | | |
| **TOTAL** | **100** | |

## Question #1

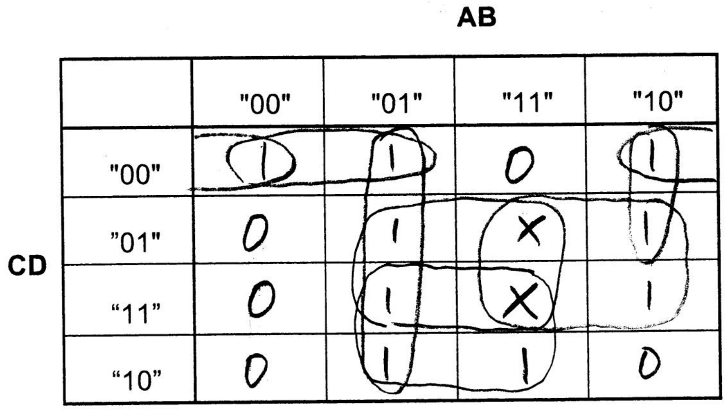
Consider the Boolean function defined by the truth table below where *A, B, C, and D* are inputs, and *Y* is the sole output.

| A | B | C | D | Y | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 | 1 | X |
| 0 | 1 | 1 | 0 | 1 | 1 |
| 0 | 1 | 1 | 1 | 1 | X |
| 1 | 0 | 0 | 0 | 1 | |
| 1 | 0 | 0 | 1 | 1 | |
| 1 | 0 | 1 | 0 | 0 | |
| 1 | 0 | 1 | 1 | 1 | |
| 1 | 1 | 0 | 0 | 0 | |
| 1 | 1 | 0 | 1 | X | |
| 1 | 1 | 1 | 0 | 1 | |
| 1 | 1 | 1 | 1 | X | |

(a) Complete the following statements

$$Y = \sum m( 0, 4, 5, 6, 7, 8, 9, 11, 14 )$$

(b) Complete the Karnaugh Map shown below, **circle** the prime implicants.



**AB**

**CD**

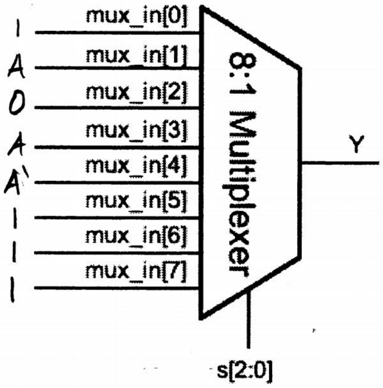
| | "00" | "01" | "11" | "10" |
|---|---|---|---|---|
| "00" | 1 | 1 | 0 | 1 |
| "01" | 0 | 1 | X | 1 |
| "11" | 0 | 1 | X | 1 |
| "10" | 0 | 1 | 1 | 0 |

How many prime implicants are there? 7

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

EssentialPrimeImplicants = $(B \wedge C) \vee (A \wedge D)$

(d) Implement the function *Y* using an 8-input multiplexer. The select signal is *s[2:0]={B,C,D}* where *s=3'b100* is *B*=1 and *C=D*=0 selecting the input *mux_in*[4]. *A* or ~*A* are permissible as inputs, *mux_in*[7:0]. Write the desired inputs on the figure below.

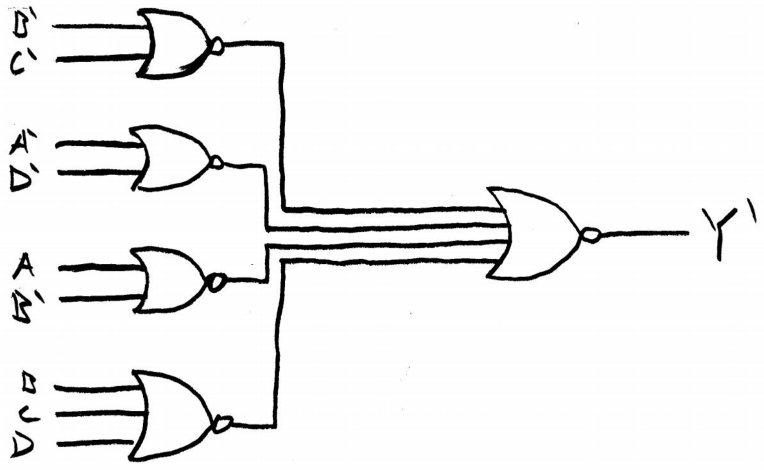


(e) Implement ¬*Y* using the minimum # of NOR gates with fewest # of inputs (minimize literals and terms).

POS

$$Y = (B \wedge C) \vee (A \wedge D) \vee (\bar{A} \wedge B) \vee (\bar{B} \wedge \bar{C} \wedge \bar{D})$$

$$\bar{Y} = (\bar{B} \vee \bar{C}) \wedge (\bar{A} \vee \bar{D}) \wedge (A \vee \bar{B}) \wedge (B \vee C \vee D)$$



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

$\uparrow$

$\overline{(\bar{a}\vee b)\vee(c\wedge\bar{d}\wedge\bar{e})}$

## Question #2

$\uparrow\uparrow$

$$Y = \neg\left(\neg(a\wedge\neg b)\vee\left(c\wedge\neg(d\vee e)\right)\right) \rightarrow \overline{\overline{(a\wedge\bar{b})}\vee(c\wedge\bar{d}\wedge\bar{e})}$$

(a) For the above Boolean function, if you were to convert the above expression into a sum-of-product representation, how many times did you have to apply DeMorgan's theorem?
3

(b) For part (a), what is the resulting function?

$Y =$ $(a\wedge\bar{b}\wedge\bar{c})\vee(a\wedge\bar{b}\wedge d)\vee(a\wedge\bar{b}\wedge e)$

(c) The following expression can be written as a 6-term sum-of-product, $((a\vee b)\wedge a)\vee$

$$Y = (a\vee b)\wedge(a\vee\neg b\vee\neg c)$$

What Boolean property do you need to apply to do this?

Distributive Property

Without reducing, what are the 6 product terms?

$(a\wedge a)\vee(a\wedge\bar{b})\vee(a\wedge\bar{c})\vee(b\wedge a)\vee(b\wedge\bar{b})\vee(b\wedge\bar{c})$

$a\vee(a\wedge\bar{b})\vee(a\wedge b)$
$\vee(a\wedge\bar{c})\vee(b\wedge\bar{c})$

$a\vee(a\wedge\bar{c})\vee(b\wedge\bar{c})$

$a\vee(b\wedge\bar{c})$

(d) The 6-term sum-of-product of part (c) can obviously be reduced.
What is the reduced expression?

$a\vee(b\wedge\bar{c})$

What Boolean axioms or properties are needed for the reduction?

$(a\wedge b)\vee(a\wedge\bar{b})$

$= a$

convergence?

Absorption, idempotence, convergence

9 7

1101001
64 32 8 1 105

144+7 = 151

## Question #3

(a) The following 8 bits can be used to represent different numbers depending on the encoding
8b'10010111
If this was unsigned, what is the corresponding integer? 151
$1+2+4+16+128 = 151$

(b) If the 8 bits in (a) was sign magnitude, what is the corresponding integer? -23
$-(16+4+2+1) = -23$

(c) If the 8 bits in (a) was 2's complement, what is the corresponding integer? - 105
$(-128) + 23 = -105$

(d) If the 8 bits in (a) was hexadecimal, what is the corresponding hexadecimal? $97_{Hex}$
1001 = 9 , 0111 = 7

(e) If the 8 bits in (a) was binary coded decimal, what is the corresponding integer? 97

(f) If the 8 bits is fixed point 1001.0111, what is the corresponding number? 9.4375
$1001 = 9$, $.0111 = 2^{-2}+2^{-3}+2^{-4} = 0.4375$

(g) If the 8 bits in (a) was a 4E3 floating point number (IEEE format S+EEE+MMMM),
$-1 \cdot 2^{1-3} \cdot (1+2^{-2}+2^{-3}+2^{-4})$

What is the bias? 3

What is the corresponding real number? -0.359375

(h) Military temperature range is -55°C to +125°C with 1% accuracy. min. mag. 0.25°C

Would you choose floating point or fixed point? floating point

If you are to represent this in floating point,
what is the minimum # of bits for mantissa? 6

$125-(-55) = 180$

$256 = 2^8$

And, what is the minimum # of bits for exponent? 4

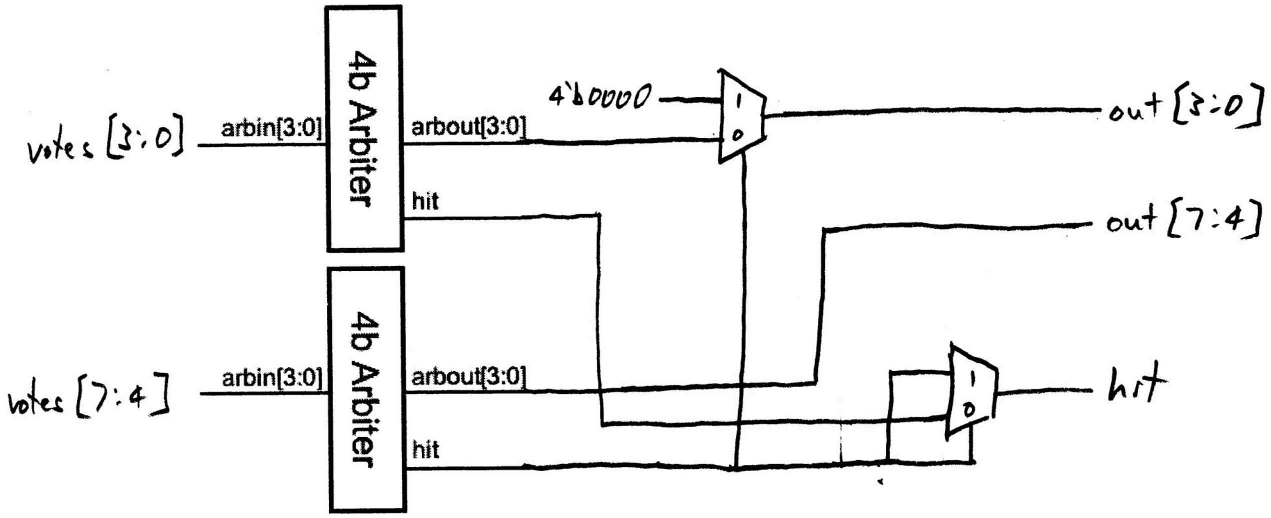
9 bits => 7,

$15-7 = 8$

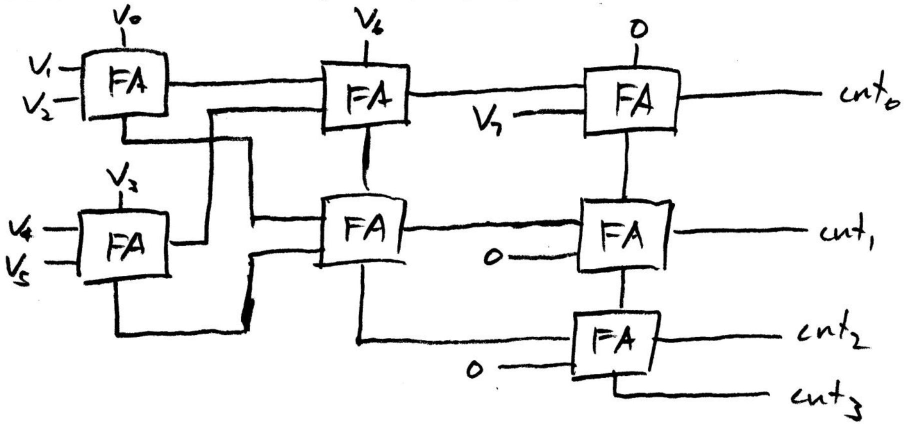
$0.01 \approx 2^{-7}$

## Question #5

(a) Given 8-bit input, *votes*[7:0], in which any number of the inputs can be a 1'b1. Build an **arbiter** that provides an 8-bit output, *arbout*[7:0], that is 1-hot. The hot signal corresponds to the position with the highest priority. Note that votes[7] has higher priority than votes[6] etc. You have available to you a module ARB that is a 4-bit arbiter already built that you **must** use. ARB accepts as inputs *arbin*[3:0] and outputs *arbout*[3:0] and a *hit* signal to indicate that one or more of the signals is a 1'b1. You also have available to you INV (inverters), and 2-input MUX (multiplexers). Recall that you can implement considerable arbitrary logic with 2-input MUXs.



(b) Now, the *votes*[7:0] need to be counted. You have available Full Adders (FA) as building blocks for implementing a design. If the delay of the logic is determined by the number of hops where each hop is the traversal of a Full-Adder from any input (*a,b,and c*) to any output (*sum, carry*). Design your block to minimize this delay. Note that your design should output 4 bits to indicate the binary count, *cnt*[3:0].



How many Full Adders to you need? 7

How many hops is your design? 4

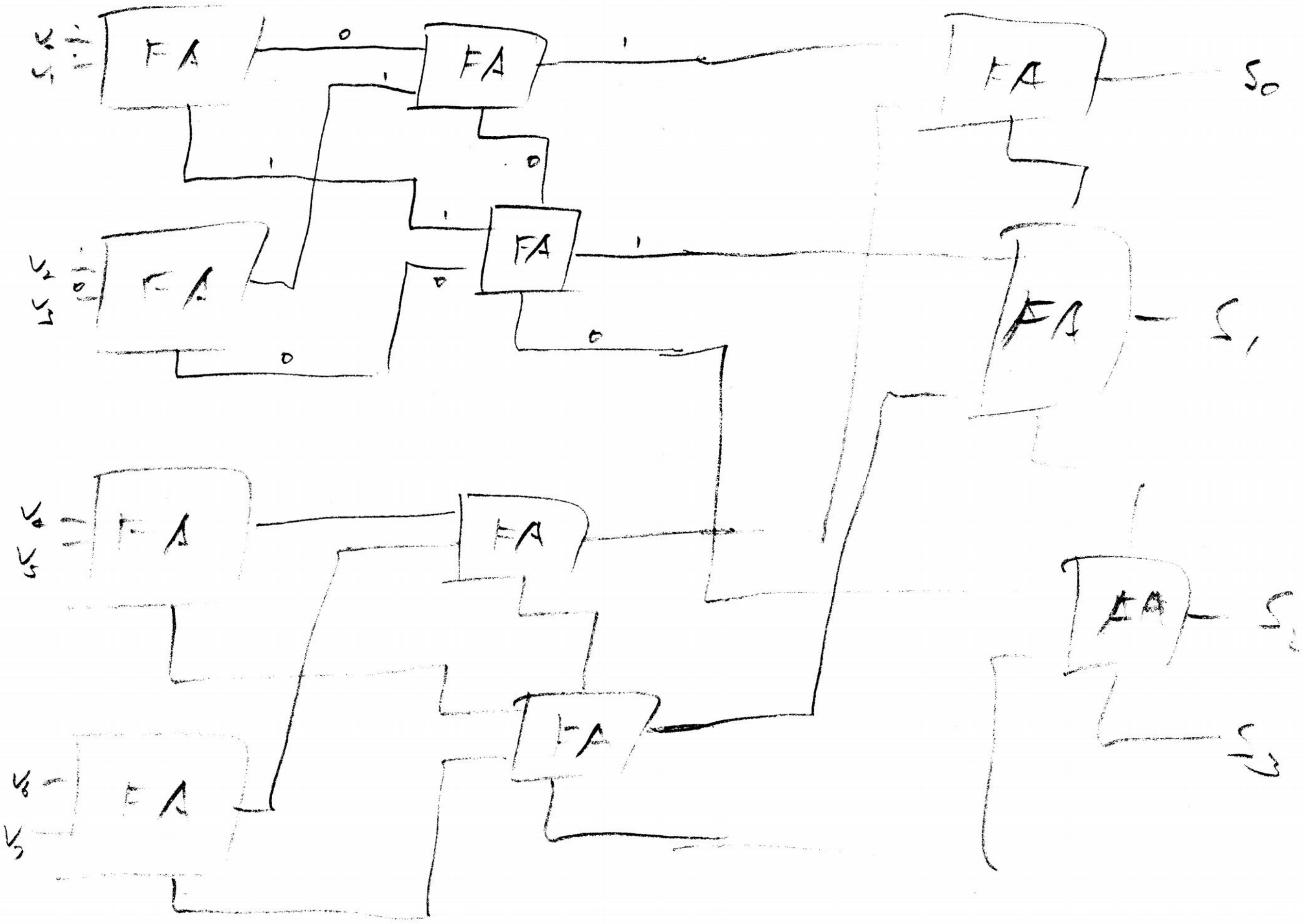
11 10 01 11

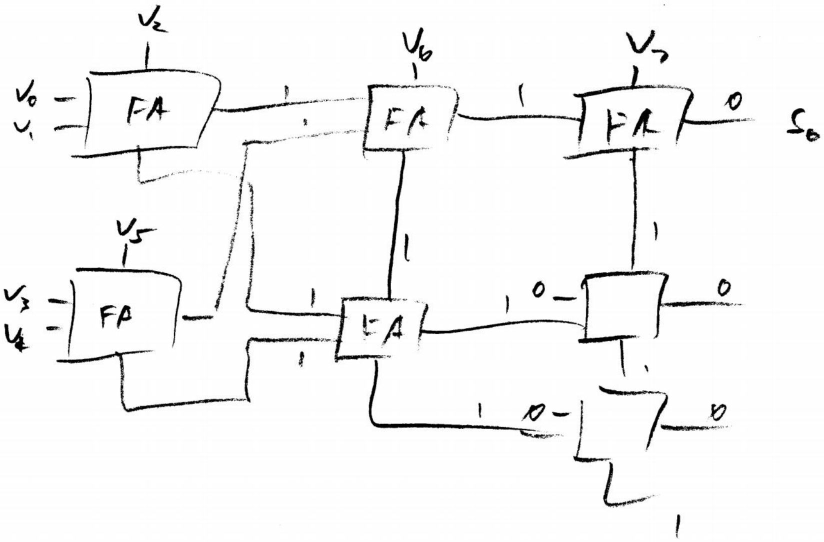
111 111 11 10 01 01 10

11 11

011 011

## Blank page for scratch work





Blank page for scratch work