NAME: _____ **SECTION:** _____

L01: Norm Bartley, ST 143
L02: Steve Norman, ST 141

When you start the test, please repeat your name and section, and add your U of C ID number at the bottom of the last page.

SCHULICH School of Engineering
UNIVERSITY OF CALGARY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ENEL 353: Digital Circuits

Midterm Examination

Wednesday, October 24, 2018

Instructions:

- Time allowed is 90 minutes.
- In order to minimize distraction to your fellow students, you may not leave during the last 10 minutes of the examination.
- The examination is closed-book.
- You may use one of the following sanctioned Schulich School of Engineering calculators: Casio FX-260, Casio FX-300MS, TI- 30XIIS.
- The maximum number of marks is 50, as indicated; the midterm examination counts 20% toward the final grade.
- Please use a pen or heavy pencil to ensure legibility.
- Please answer questions in the spaces provided; if space is insufficient, please use the back of the pages.
- Please show your work; where appropriate, marks will be awarded for proper and well-reasoned explanations.

1. Questions about encodings of numbers. **[11 marks total.]**

   (a) **[2 marks.]** Use repeated division to convert 77_{10} to binary representation.

   (b) **[1 mark.]** Use the result of part (a) to find the hexadecimal representation of 77_{10}.

   (c) **[1 mark.]** What is the value of 7064_8 as a decimal number?

   (d) **[2 marks.]** Convert 10101000100011_2 to octal representation.

   (e) **[4 marks.]** Consider the 8-bit pattern 10110011_2. What decimal number does it represent in an unsigned binary system?

   What decimal number does it represent in a 8-bit sign/magnitude system?

   What decimal number does it represent in a 8-bit two's-complement system?

   (f) **[1 mark.]** Find the unsigned 6-bit binary integer corresponding to the Gray code 100101.

2. **[5 marks total.]** Questions about binary integer addition.

   (a) **[2 marks.]** Consider this 16-bit binary addition:

carries:	1	1111 1111 1100 1100
a:		1100 0101 1110 0010
b:		1011 1101 1010 0111
sum:		1000 0001 1000 1001

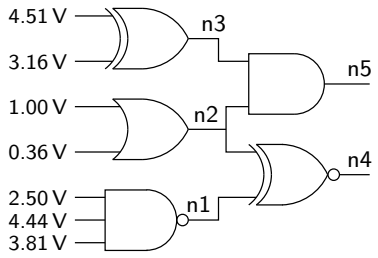
   If a, b and the sum are all interpreted as unsigned numbers, is there overflow in the addition? Give a reason for your answer.

   If a, b and the sum are all interpreted as two's-complement numbers, is there overflow in the addition? Give a reason for your answer.

   (b) **[3 marks.]** Bit patterns 10101_2 and 01101_2 are supplied as inputs to a 5-bit binary adder circuit. What are the values of the sum and overall carry-out? (Give both answers as sequences of one or more bits.)

3. **[3 marks.]** The table below shows some voltage specifications for the Advanced High-Speed CMOS logic family using a power supply voltage of 5.00 V.

parameter	voltage
V_{IH}	3.15 V
V_{IL}	1.35 V
V_{OH}	3.80 V
V_{OL}	0.44 V



   Give ranges of voltages that are as precise as possible for nodes n1, n2, n3, n4, and n5. If for some node(s) it is not possible to give a range of voltages, give a reason for that.

4. **[6 marks.]** Consider the Boolean expression below:

$$Y = \overline{A}\,\overline{C}\,\overline{D} + \overline{A}B\overline{C} + AB\overline{C}D + B\overline{C}D + A\overline{B}\,\overline{C} + AB\overline{C}\,\overline{D}.$$

Use *algebraic manipulation* to simplify Y to a minimal SOP form having three product terms and six literals. You do not have to give names and numbers for theorems you use along the way, but you must clearly show all your steps. *(Do not use a K-map.)*

5. **[15 marks total.]** Questions on K-maps and minimal forms.

   (a) **[10 marks.]** Consider the function Y given in the truth table below. Use the first K-map to derive all minimal SOP expressions for Y, then use the second blank K-map to derive *all* minimum POS expressions for Y. You may add more maps if you need them.

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

Find all minimal SOP expressions

CD \ AB	00	01	11	10
00				
01				
11				
10				

Find all minimal POS expressions

CD \ AB	00	01	11	10
00				
01				
11				
10				

(b) **[5 marks.]** Use the 5-variable K-map for the function Z given below to derive a minimal SOP expression. Indicate all distinguished 1-cells in the map, and identify all essential prime implicants.

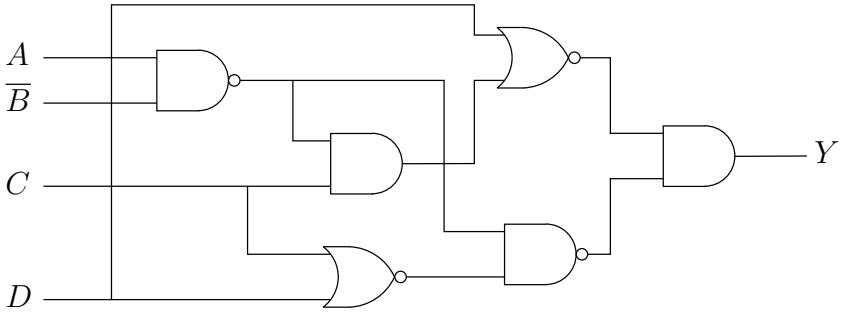
DE \ BC	00	01	11	10
00				1
01	X	1	1	
11	X	1	1	
10				1

$A = 0$

DE \ BC	00	01	11	10
00				1
01		1	1	1
11				1
10				1

$A = 1$

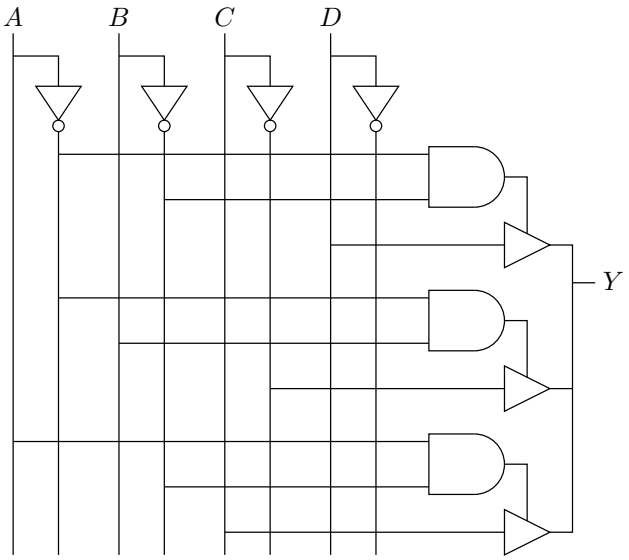
6. **[4 marks.]** Consider schematic below:



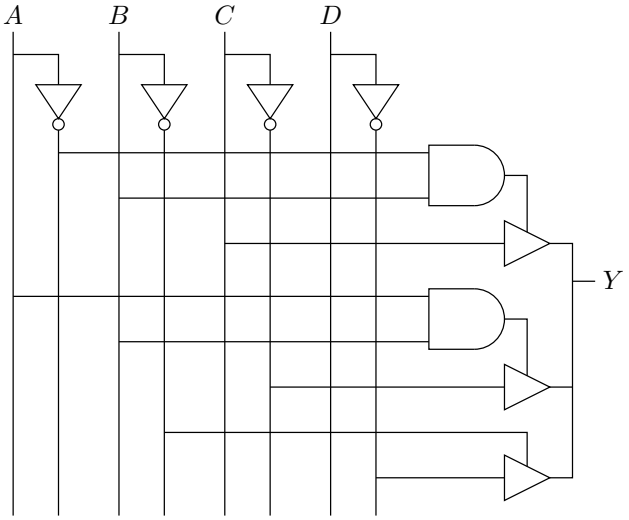
Use "bubble-pushing" and/or Boolean algebra to find an SOP expression for Y as a function of A, B, C, and D.

7. **[6 marks total.]** For each of the given schematics, either determine an SOP expression for Y as a function of A, B, C and D, or explain clearly why it is impossible to find such an expression.

   (a) **[3 marks.]**



   (b) **[3 marks.]**



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Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	TOTAL
/ 11	/ 5	/ 3	/ 6	/ 15	/ 4	/ 6	/ 50