ECE2020 A Fall 2021 Test 2

Name: _____

- Only a writing implement may be used on this exam (i.e. no notes or electronics).
- If the meaning of any question is not clear, please ask for clarification.
- Partial credit can only be awarded for work shown.

Honor pledge:

On my honor, I pledge that I will neither receive nor provide improper assistance in the completion of this test. I understand and accept my responsibility as a member of the Georgia Tech Community to uphold the Honor Code at all times, and I know that I have options for reporting honor violations at osi.gatech.edu.

GTID: _____ Signature: _____

Boolean Identities

Identity	$A + 0 = A$	$A \cdot 1 = A$
Dominance	$A + 1 = 1$	$A \cdot 0 = 0$
Idempotence	$A + A = A$	$A \cdot A = A$
Inverse	$A + \overline{A} = 1$	$A \cdot \overline{A} = 0$
Commutative	$A + B = B + A$	$A \cdot B = B \cdot A$
Associative	$A + (B + C) = (A + B) + C$	$A \cdot (B \cdot C) = (A \cdot B) \cdot C$
Distributive	$A \cdot (B + C) = A \cdot B + A \cdot C$	$A + B \cdot C = (A + B) \cdot (A + C)$
Absorption	$A \cdot (A + B) = A$	$A + A \cdot B = A$
DeMorgan's	$\overline{(A + B)} = \overline{A} \cdot \overline{B}$	$\overline{(A \cdot B)} = \overline{A} + \overline{B}$
Double Complement	$\overline{\overline{A}} = A$	
FOIL	$(A + B) \cdot (C + D) = A \cdot C + A \cdot D + B \cdot C + B \cdot D$	
Disappearing opposite	$A + \overline{A} \cdot B = A + B$	

Decimal	Binary	Hex
0	0	0
1	1	1
2	10	2
3	11	3
4	100	4
5	101	5
6	110	6
7	111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

2^{-6}	0.015625
2^{-5}	0.03125
2^{-4}	0.0625
2^{-3}	0.125
2^{-2}	0.25
2^{-1}	0.5
2^{0}	1
2^{1}	2
2^{2}	4
2^{3}	8
2^{4}	16
2^{5}	32
2^{6}	64
2^{7}	128
2^{8}	256
2^{9}	512
2^{10}	1024

8-channel Multiplexer (inputs A_{7-0}, output Q

S2	S1	S0	Q
0	0	0	A_0
0	0	1	A_1
0	1	0	A_2
0	1	1	A_3
1	0	0	A_4
1	0	1	A_5
1	1	0	A_6
1	1	1	A_7

3-to-8 Line Decoder with Enable

A2	A1	A0	EN	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	1	0	0	0	0	0	0	0	1
0	0	1	1	0	0	0	0	0	0	1	0
0	1	0	1	0	0	0	0	0	1	0	0
0	1	1	1	0	0	0	0	1	0	0	0
1	0	0	1	0	0	0	1	0	0	0	0
1	0	1	1	0	0	1	0	0	0	0	0
1	1	0	1	0	1	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0	0	0	0
X	X	X	0	0	0	0	0	0	0	0	0

8-channel Demultiplexer (input A, outputs Q_{7-0})

S2	S1	S0	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0
0	0	0	0	0	0	0	0	0	0	A
0	0	1	0	0	0	0	0	0	A	0
0	1	0	0	0	0	0	0	A	0	0
0	1	1	0	0	0	0	A	0	0	0
1	0	0	0	0	0	A	0	0	0	0
1	0	1	0	0	A	0	0	0	0	0
1	1	0	0	A	0	0	0	0	0	0
1	1	1	A	0	0	0	0	0	0	0

8-to-3 Priority Encoder (Priority A7->A0) with Valid output

A7	A6	A5	A4	A3	A2	A1	A0	E2	E1	E0	V
1	X	X	X	X	X	X	X	1	1	1	1
0	1	X	X	X	X	X	X	1	1	0	1
0	0	1	X	X	X	X	X	1	0	1	1
0	0	0	1	X	X	X	X	1	0	0	1
0	0	0	0	1	X	X	X	0	1	1	1
0	0	0	0	0	1	X	X	0	1	0	1
0	0	0	0	0	0	1	X	0	0	1	1
0	0	0	0	0	0	0	1	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0

<u>This is for scratch work and will not be graded unless you tell me that something on here needs to be graded.</u>

0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

Numbers (35 points total)

1) Convert from the given number to the other two bases:

Decimal	Binary	Hexadecimal
20		
	0b11011	
		0x1A

2) Which of these **unsigned binary** numbers represents the largest magnitude (circle one):

101111000010 001111000010 100111000010

3) Which of these **two's complement** numbers represents the largest magnitude (absolute value) (circle one):

100011000010 101111000010 000011000010

4) Perform the following **binary additions**, assuming that the numbers are the type specified. Maintain five bits for the results.

unsigned	**signed-magnitude** representation	**two's complement** representation
00101 +10111	00101 +10111	00101 +10111

5) Write an unsigned 5-bit binary addition problem that results in overflow. You don't need to write the result.

6) Write a 5-bit two's complement binary addition problem that results in overflow. You don't need to write the result.

Multiple choice / short answer (35 points total)

1) The following two numbers are 100-digit two's complement numbers. Keeping the result as 100 digits, mark all of the answers that are true about this subtraction.

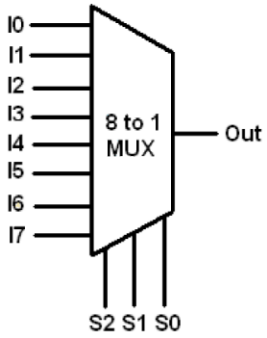
```
 00101[insert 90 random digits here]10100
-01011[insert 90 random digits here]11011
```

a) The value of the "90 random digits" affects whether the most-significant digit of the result is '1' or '0'.
b) The result will represent a negative number.
c) Adding the two numbers instead of subtracting would give the same result.
d) The result will have a '1' in the most-significant digit.
e) The operation will result in overflow.

2) If you add two 16-digit two's complement numbers, how many digits do you need in your result to guarantee that overflow does not occur?

_____

3) You have an 8-input multiplexer with signal names as follows:



Which one of the following best describes what would happen if all three "S" inputs were connected together and treated as a single input (so they are either all 0 or all 1)?

a) The device would always output 0.
b) The device would implement the same input-output behavior as a priority encoder.
c) The device could still be used as a multiplexer, but not an 8-input multiplexer.
d) The device would not function at all because multiplexers cannot have the same value on all of their control signals.

4) If the following hexadecimal number is converted to binary, what will be the most-significant three digits of the resulting binary number?

```
A7F5F44D98ABF423009F429C
```

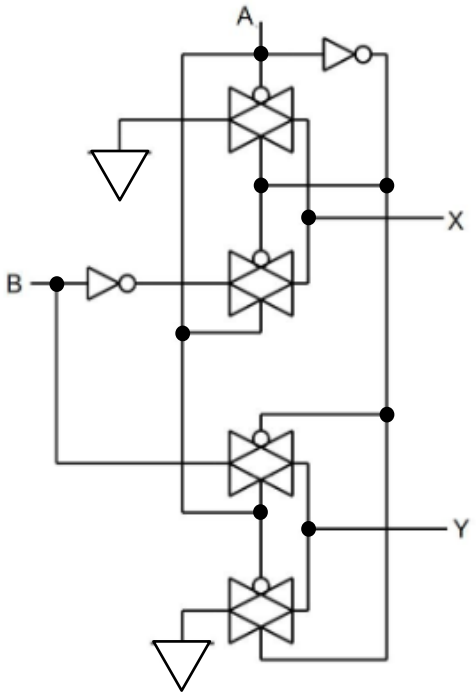
_____

5) What is the result of the following operation on these 14-digit signed-magnitude numbers? Digits that differ between the two numbers are bold to make sure you notice them. Enter your answer in signed-magnitude binary

011101110001**0**1

+**1**11101110001**1**1

6) Consider the following circuit. Note that dots on wire intersections indicate connection, and the down-facing triangle is ground as usual. Make no assumptions about signals A, B, X, and Y other than what is forced to be true by the circuit or what is stated in each answer.

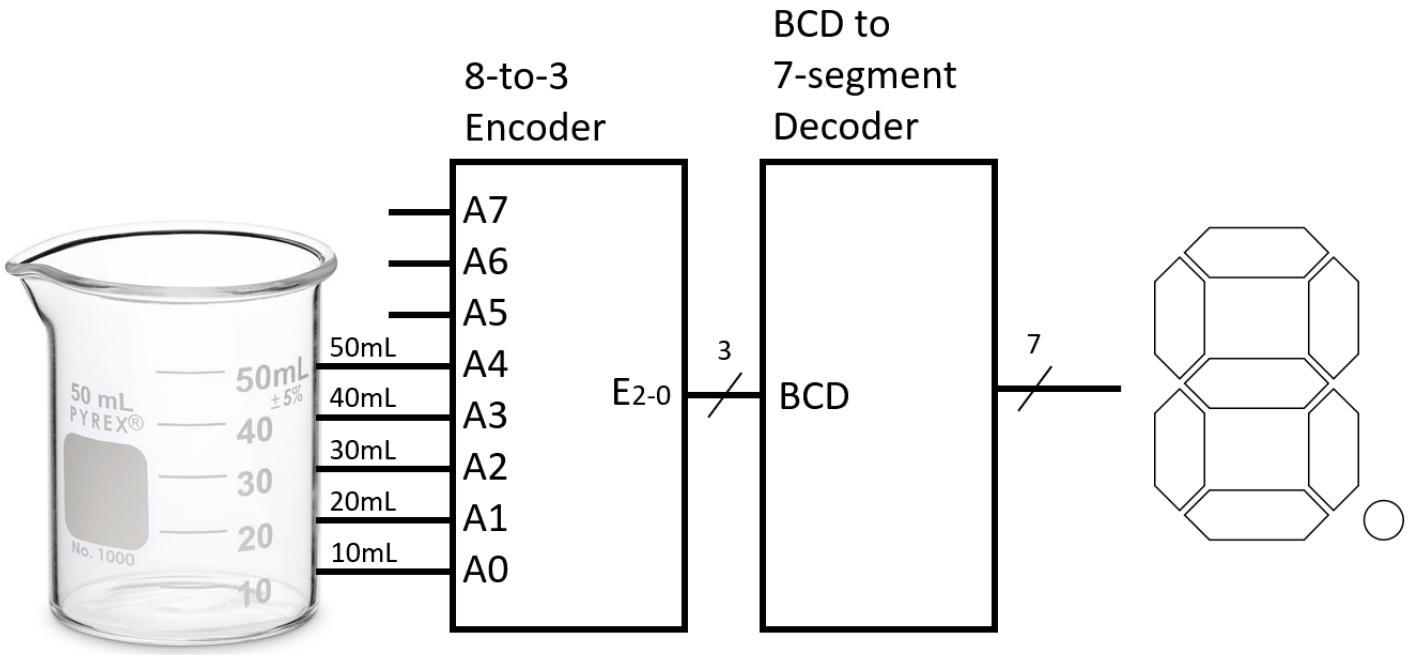


Mark all of the following that are true.

a) If A is driven '1', Y will be the same value as B.
b) This circuit can be driven backwards; i.e. X and Y can be driven, and A and B used as outputs.
c) If A and B are both driven '0', X and Y will both be '0'.
d) If A and B are both driven '1', X and Y will both be '1'.
e) It is possible to put X into a high-impedance state (i.e. not driven).
f) It is possible to put Y into a high-impedance state (i.e. not driven).

Building Blocks Circuit (30 points total)

Below is a system that is supposed to display the number of centiliters of liquid in a beaker. Assume that five sensors are attached the beaker at the specified levels, and each sensor outputs an active signal when the liquid is at or above that level. Assume that the encoder is connected to the decoder in a sensible way, and the display is connected to the decoder as required.



1) For this system to work, what should the priority of the encoder be?

2) What should the unconnected inputs of the encoder be driven with?

3) In the current system, what will the 7-segment display show when the beaker has 35 mL of liquid in it?

4) The previous answer should have demonstrated a mistake in the design. Propose a solution to the mistake.