

Numbers (35 points total)

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

Decimal	Binary	Hexadecimal
20	10100	14
27	0b11011	1B
26	11010	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
$\begin{array}{r} 111 \\ 00101 \\ +10111 \\ \hline 11100 \end{array}$	$\begin{array}{r} 00101 \quad 5 \\ +10111 \quad +-7 \\ \hline 10010 \quad -2 \end{array}$	$\begin{array}{r} 111 \\ 00101 \\ +10111 \\ \hline 11100 \end{array}$

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

11111
+11111

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

01111
+01111

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.

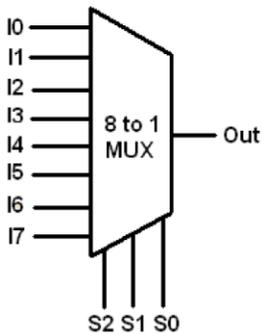
00101[insert 90 random digits here]10100
-01011[insert 90 random digits here]11011

- 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?

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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?

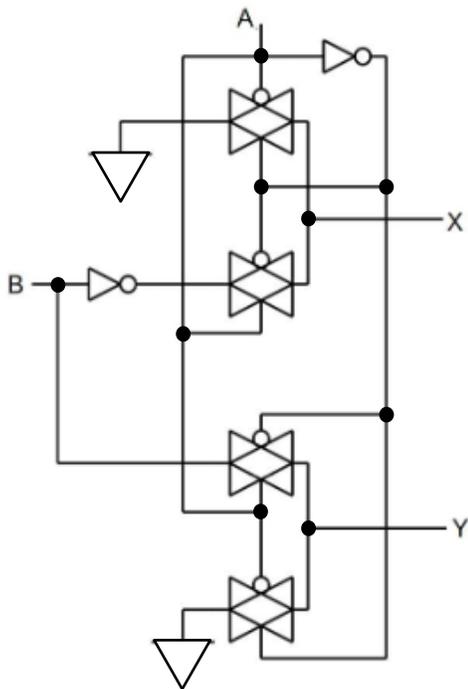
A7F5F44D98ABF423009F429C

101

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

$$\begin{array}{r}
 01110111000101 \\
 +11110111000111 \\
 \hline
 10000000000010
 \end{array}$$

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.

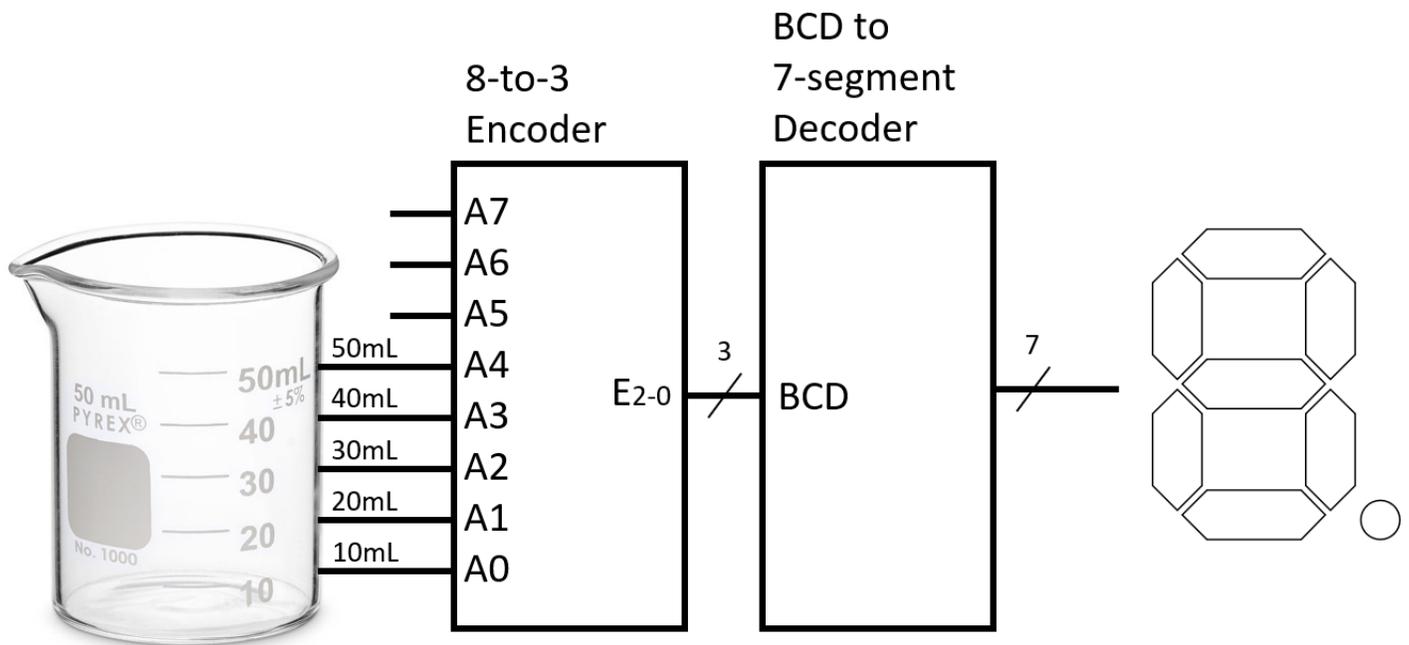


Mark all of the following that are true.

- 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?

A7 highest, A0 lowest

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

0 (ground)

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

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

Connect the sensors starting at A1, and drive A0 with 1.