Name: _____

Read each question carefully before answering. Answer all parts. Show all work, calculations, and/or reasoning, otherwise no points will be awarded. K-maps may be used to double check your work, but may NOT be used as your actual work. Point values are as indicated.

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1. Express the following as 5-bit signed binary numbers and **add the binary numbers together** (i.e. do not add the two decimal numbers together and convert the result to binary). Use 2's complement to represent negative numbers. Indicate if there is an overflow in any of the answers, and, if so, how you know there was an overflow situation.

   (a) (5 points) $-14_{10} + 7_{10}$

___ ___ ___ ___ ___

   (b) (5 points) $11_{10} + 9_{10}$

___ ___ ___ ___ ___

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2. Express the following as 4-bit signed binary numbers and **multiply the binary numbers together with all overflow bits present from the start** (i.e. do not multiply the two decimal numbers together and convert the result to binary). Use 2's complement to represent negative numbers. Indicate if there is an overflow in any of the answers, and, if so, how you know there was an overflow situation.

   (a) (5 points) $2_{10} \times -4_{10}$

— — — — — — — —

   (b) (5 points) $-6_{10} \times 3_{10}$

— — — — — — — —

3. (10 points) Determine if the following expressions are equivalent. Explain your reasoning.

$$F = A \oplus BC$$
$$G = A'BC + AB' + AC'$$

4. (15 points) Express the following as a minimum **sum-of-products** equation. Show and label all steps in your minimization process.

$$F = (A + B + C)(B' + C + D)(A' + B + D')(A' + C' + D)$$

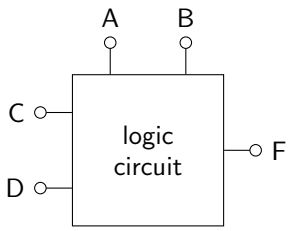
5. (20 points) Express F as a minimum **sum-of-products** equation. Show and label all steps in your minimization process.

$$F = (W \equiv Z)(YZ \oplus X)$$

6. (20 points) Express F as a minimum **sum-of-products** equation. Show and label all steps in your minimization process.

$$F(A, B, C, D) = \Sigma m(5, 7, 10, 13) + \Sigma d(0, 11, 15)$$

7. (25 points) You receive two 2-bit numbers designated as AB and CD. If $AB \geq CD$, an LED should turn on. Otherwise, the LED will remain off. Derive a minimum **product-of-sums** expression to control the LED, where $F = 0$ means the LED is off, and $F = 1$ means the LED is on. Show and label all steps in your minimization process.



A	**B**	**C**	**D**	**F**
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	