Important

In order to receive credit for this exam you must comply with the policies stated on this page, and you must be able to sign the integrity commitment at the bottom of this page.

You are permitted to use the textbook for this course during the exam.

You are permitted to use your own personal course notes for ECE 2060 during the exam.

You are permitted to use the ECE 2060 Carmen site for this course (the lecture section Carmen site - Class Number 9487) during the exam.

You are permitted to use the equation sheet that is provided with the exam.

You are permitted to use a calculator.

Integrity Commitment: By signing below I attest that:

1. I will not obtain help from any other person, by any means. The work and answers I submit for the exam will be the product of my effort alone.
2. I will not use any resources other than those stated above (no other books, no other notes, no other online materials or resources, etc.)
3. I will not share my work with anyone else by any means until after the solutions to the exam have been posted on Carmen.

Signature:	Date: 2/7/23
Print Name: Gage Farmer	

1. [6 points] Convert the decimal number **−501** to a **10-bit 2's complement** binary number.

$2^{10} - 501 = 523$

2/523
2/261 1
2/130 1
2/65 0
2/32 1
2/16 0
2/8 0
2/4 0
2/2 0
0

$\boxed{1110100000_2}$

2. [7 points]
   a) (6 pts) Perform 2's complement binary addition on the following 10-bit numbers. Explicitly show all carries above the upper number.

```
 1 1 1 1 1 1 1
  0111110101
 +0000001100
 01000000001
```

↑ if can add a bit to num

if can't, wrong answer ↓

$\boxed{1000000001}$

   b) (1pt) Is there an overflow? Briefly explain how you know.

Yes, because the answer requires 11 bits (including sign) so it overflows to being -1 instead

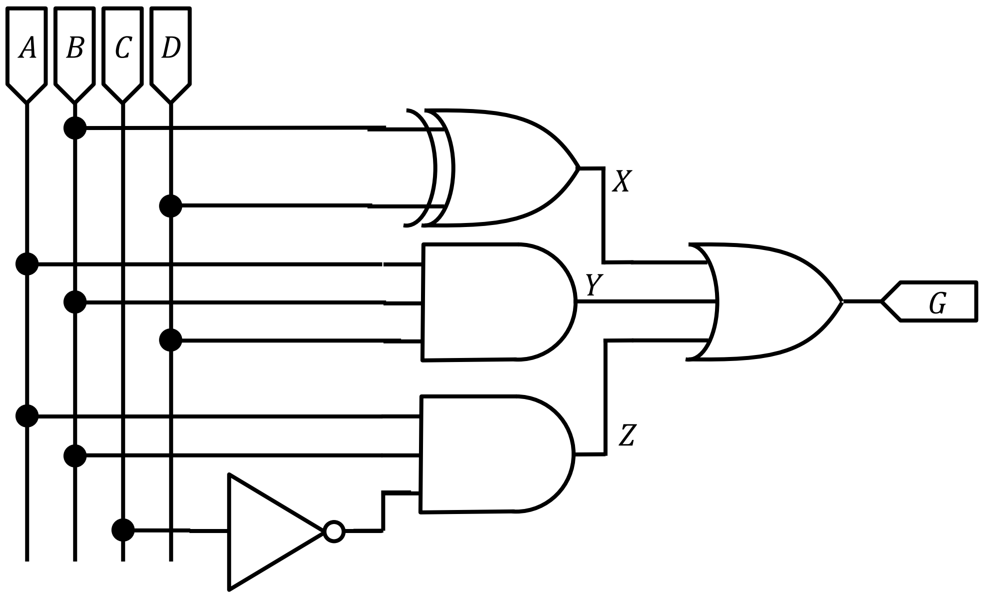
3. [7 points]
   a) (6 pts) Perform 1's complement binary addition on the following 10-bit numbers. Explicitly show all carries above the upper number.

```
1 1 1 1 1 1 1 1 1 1
  0001011111
 +1110100001
  0000000000
           1
  0000000001
```

   b) (1 pt) Is there an overflow? Briefly explain how you know.

No, because the carry bit is moved and added to the rightmost bit.

4. [12 points]



a) (6 pts) Find the Boolean expression for G in terms of AND, OR, and NOT operations. Do not otherwise reduce the expression – leave it in the un-simplified form found from the circuit.

(B XOR D) OR (A AND B AND D) OR (A AND B AND NOT C)

$(B\bar{D}+\bar{B}D)+(ABD)+(AB\bar{C})$

b) (4 pts) Complete the truth table for the circuit. Do not change any headings or values typed into the table.

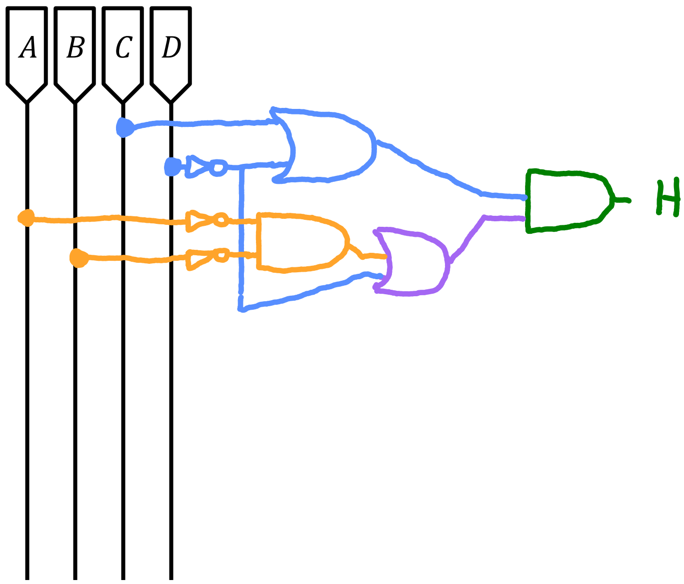
A	*B*	*C*	*D*	*X*	*Y*	*Z*	*G*
0	0	0	0	0	0	0	0
0	0	0	1	1	0	0	1
0	0	1	0	0	0	0	0
0	0	1	1	1	0	0	1
0	1	0	0	1	0	0	1
0	1	0	1	0	0	0	0
0	1	1	0	1	0	0	1
0	1	1	1	0	0	0	0
1	0	0	0	0	0	0	0
1	0	0	1	1	0	0	1
1	0	1	0	0	0	0	0
1	0	1	1	1	0	0	1
1	1	0	0	1	0	1	1
1	1	0	1	0	1	1	1
1	1	1	0	1	0	0	1
1	1	1	1	0	1	0	1

c) (2 pts) Express the function $G(A,B,C,D)$ in compact m-notation

$G(A,B,C,D)=\sum m(1,3,4,6,9,11,12,13,14,15)$

5. [6 points] Implement the following Boolean expression with AND, OR, and NOT gates. Do not simplify or re-arrange the expressions before drawing the logic circuit. The only variables available as inputs to your circuit are A, B, C, and D (not their complements), and they are each available only at the wires shown below. Use the fewest number of inverters possible to generate any complements that you need.

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



6. [6 points] Find the Boolean dual of the following expression.

$$K = (A + B + C')(A + B' + C)(A' + B' + C')$$

$\overline{(A+B+C')}+\overline{(A+B'+C)}+\overline{(A'+B'+C')}$

$\boxed{DUAL(K)=(A B C')+(A B'C)+(A'B'C')}$

7. [6 points] For the following function L, use DeMorgan's theorems to find $\bar{L}$ in sum of products (SOP) form.

$$L = (A + B + \bar{C})(A + \bar{B} + C)(\bar{A} + \bar{B} + \bar{C})$$

$\overline{(A+B+\bar{C})}+\overline{(A+\bar{B}+C)}+\overline{(\bar{A}+\bar{B}+\bar{C})}$

$\boxed{\bar{L}=(\bar{A}\bar{B}C)+(\bar{A}B\bar{C})+(ABC)}$

Equation Sheet

$$X + 0 = X$$
$$X + 1 = 1$$
$$X \cdot 1 = X$$
$$X \cdot 0 = 0$$

$$X + X = X$$
$$X \cdot X = X$$

$$(X')' = X$$

$$X + X' = 1$$
$$X \cdot X' = 0$$

$$XY = YX$$
$$X + Y = Y + X$$

$$(XY)Z = X(YZ) = XYZ$$

$$(X + Y) + Z = X + (Y + Z) = X + Y + Z$$

$$X(Y + Z) = XY + XZ$$
$$X + YZ = (X + Y)(X + Z)$$

$$\overline{X + Y} = \bar{X}\bar{Y}$$
$$\overline{XY} = \bar{X} + \bar{Y}$$

Half Adder

$$S = X'Y + XY' = X \oplus Y$$
$$C = XY$$

Full Adder

$$S = X \oplus Y \oplus C_{in}$$
$$C_{out} = XY + XC_{in} + YC_{in}$$

$$Q^+ = S + R'Q \; (SR = 0)$$
$$Q^+ = D$$
$$Q^+ = JQ' + K'Q$$
$$Q^+ = TQ' + T'Q$$

Q	Q^+	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

Q	Q^+	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0