1) Convert number “78” in base 10 to base 8

78 % 8 = 6
78 / 8 = 9 (we don’t need the fraction of the result)
9 % 8 = 1
9 / 8 = 1
1 % 8 = 1
1 / 8 = 0
0 % 8 = 0

We write the result from bottom to top:
0 1 1 6

2) Name three systems for representing sign numbers (that are applicable for binary numbers). Name one advantage and one disadvantage for each system.

1. Sign magnitude:
   Advantage: a human can easily understand the number
   Disadvantage:
   - two versions of zero (+/-)
   - Math is hard

2. Radix system:
   Advantage: easier math
   Disadvantage:
   - two versions of zero (+/-)
   - If math involves going through the zero point, we have to consider two zeros.
   - For humans, it is hard to understand the number

3. Diminished radix system:
   Advantage:
   - easy math
   - One version of zero
   Disadvantage:
   - For humans, it is hard to understand the number
3) Convert 14 and 13 from base 10 to base 2. Subtract 13 from 14 in binary form using Radix (2’s complement) sign number representation.

14 % 2 = 0
14 / 2 = 7
7 % 2 = 1
7 / 2 = 3
3 % 2 = 1
3 / 2 = 1
1 % 2 = 1
1 / 2 = 0

14 (base 10) = 0 1 1 1 0

We need five bits because we use signed numbers.

13 - 8 = 5 \hspace{1cm} (8=2^3 \text{ take the closest and lowest number that is power of 2})
5 % 2 = 1
5 / 2 = 2
2 % 2 = 0
2 / 2 = 1
1 % 2 = 1
1 / 2 = 0

\[
\begin{array}{cccccc}
0 & 1 & 1 & 0 & 1 \\
16 & 8 & 4 & 2 & 1 \\
\end{array}
\]

Convert 13 to -13:
- Compliment of 01101 is 10010
- Add 1: 10010 + 1 = 10011

Add 14 and -13:
01110
+
10011
\[
\begin{array}{c}
100001 \\
\end{array}
\]

We ignore the overflow bit 1, which gives the result: 00001 (14-13=1)
4) What is the order for boolean operators (XOR, NOT, AND, OR)?

1) NOT
2) AND
3) OR, XOR

5) Given the following truth table, express the boolean function $G$ through minterms.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>G</th>
<th>Minterms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>$!A !B !C$</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>$!A !B C$</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>$!A B !C$</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>$!A B C$</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>$A !B !C$</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>$A !B C$</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>$A B !C$</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>$A B C$</td>
</tr>
</tbody>
</table>

$G = !A !B !C + !A !B C + !A B C + A B !C$
6) Implement the following the boolean function $F$ using only NAND gates (do not simplify the function).

$$F = A \cdot B \cdot C + \overline{A} \cdot B \cdot C + \overline{A} \cdot B \cdot C$$

Convert function using double negation:

$$\overline{\overline{F}} = F = \overline{((A \cdot B \cdot C + \overline{A} \cdot B \cdot C + \overline{A} \cdot B \cdot C))} = \overline{((A \cdot B \cdot C) \cdot \overline{((A \cdot B \cdot C) \cdot \overline{(A \cdot B \cdot C))}})$$

7) What is combinational and sequential circuits. To what type of circuits belong Decoder and Multiplexor?

- The combinational circuit is a circuit whose output is defined by its input.
- The sequential circuit is a circuit whose output is defined by both input and the saved state.

A Decoder and a Multiplexor are combinational circuits.
8) Implement the boolean function $F$ through the decoder.

$$F = A \cdot B \cdot C + !A \cdot B \cdot !C + !A \cdot B \cdot C$$

We need to write the truth table:

<table>
<thead>
<tr>
<th>#</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>F</th>
<th>Minterms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>!A !B !C</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>!A !B C</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>!A B !C</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>!A B C</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>A !B !C</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>A !B C</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>A B !C</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>A B C</td>
</tr>
</tbody>
</table>