1. (10 points) Express \(-36_{10}\) as an **8-bit twos-complement** binary number.

   Answer: \[
   \begin{array}{cccccccc}
   \text{msb} & 1 & 1 & 0 & 1 & 1 & 1 & 0 \\
   \text{lsb} & & & & & & & \\
   \end{array}
   \]

2. (10 points) Find the complement of \(F\). Do not simplify the expression.

   \[
   F = (A + B')(A'D' + E) + (AC' + BD)[(C+E')(B' + D) + 0]
   \]

   Using the set of rules for complement, this turns out to be a one-step process. We get

   \[
   F' = [A'B' + (A+D)E'][(A' + C)(B' + D') + (C'E+BD')]1
   \]

3. (10 points) Find the dual of \(F\). Do not simplify the expression.

   \[
   F = AB + (A' + C)(B+E')[D'E(A' + B) + 1]
   \]

   Using the set of rules for duals, this turns out to be a one-step process. We get

   \[
   F_D = (A+B)[A'C + BE' + (D'+E+A'B)0]
   \]
4. A leading medical electronics company is designing a logic network that will perform preliminary diagnosis on patients based on the presence or absence of four symptoms ABCD. The diseases to be diagnosed are XYZ, and their relationship with the symptoms is as follows —

<table>
<thead>
<tr>
<th>ABCD</th>
<th>XYZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td>000</td>
</tr>
<tr>
<td>0001</td>
<td>110</td>
</tr>
<tr>
<td>0010</td>
<td>000</td>
</tr>
<tr>
<td>0011</td>
<td>100</td>
</tr>
<tr>
<td>0100</td>
<td>110</td>
</tr>
<tr>
<td>0101</td>
<td>001</td>
</tr>
<tr>
<td>0110</td>
<td>011</td>
</tr>
<tr>
<td>0111</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ABCD</th>
<th>XYZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>010</td>
</tr>
<tr>
<td>1001</td>
<td>110</td>
</tr>
<tr>
<td>1010</td>
<td>111</td>
</tr>
<tr>
<td>1011</td>
<td>111</td>
</tr>
<tr>
<td>1100</td>
<td>010</td>
</tr>
<tr>
<td>1101</td>
<td>011</td>
</tr>
<tr>
<td>1110</td>
<td>000</td>
</tr>
<tr>
<td>1111</td>
<td>100</td>
</tr>
</tbody>
</table>

a) (15 points) Draw the K-maps for X, Y and Z to implement this network as a 4-input 3-output system:

b) (15 points) Find the minimum 2-level AND-OR expressions to implement this system:

\[
X = CD + AB'C + A'BC'D' + B'C'D
\]

\[
Y = A'C + AB' + A'BD + B'CD
\]

\[
Z = AB' + A'BC'D + BCD
\]
5. Given the function: \( F(a, b, c, d) = \sum m(0,2,8,9,11,15) + D(1,3,6,7) \)

a) (10 points) Draw and label a K-Map of the function and circle the elements of the on-set that correspond to a minimized expression for \( F \)

b) (15 points) Find the minimum SOP form of the function.

\[ A'B' + B'C' + CD \quad \text{or} \quad A'C + B'C' + CD \]

c) (15 points) Write a verilog module that implements your SOP form:

```verilog
module somename (X,A,B,C,D);
  input A,B,C,D;
  output X;
  assign X = ~A&~B|~B&~C|C&D;
endmodule
```

or

```verilog
module somename (X,A,B,C,D);
  input A,B,C,D;
  output X;
  assign X = ~A&C|~B~C|C&D;
endmodule
```