Part I. Combinational Logic

1. Specification
2. Implementation

K-map:

Sum of products
Product of sums
Implicant: A product term that has non-empty intersection with on-set $F$ and does not intersect with off-set $R$.

Prime Implicant: An implicant that is not covered by any other implicant.

Essential Prime Implicant: A prime implicant that has an element in on-set $F$ but this element is not covered by any other prime implicants.

Implicate: A sum term that has non-empty intersection with off-set $R$ and does not intersect with on-set $F$.

Prime Implicate: An implicate that is not covered by any other implicate.

Essential Prime Implicate: A prime implicate that has an element in off-set $R$ but this element is not covered by any other prime implicates.
Example

Given $F = \Sigma m (3, 5)$, $D = \Sigma m (0, 4)$

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>2</th>
<th>6</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

Primes: $\Sigma m (3)$, $\Sigma m (4, 5)$

Essential Primes: $\Sigma m (3)$, $\Sigma m (4, 5)$

Min exp: $f(a,b,c) = a'bc + ab'$
Min product of sums

Given \( F = \Sigma m (3, 5), D = \Sigma m (0, 4) \)

Prime Implicates: \( \Pi M (0,1), \Pi M (0,2,4,6), \Pi M (6,7) \)
Essential Primes Implicates: \( \Pi M (0,1), \Pi M (0,2,4,6), \Pi M (6,7) \)
Min exp: \( f(a,b,c) = (a+b)(c')(a'+b') \)
Corresponding Circuit

f(a, b, c, d)
Another min product of sums example

Given \( R = \Sigma m (3, 11, 12, 13, 14) \)
\( D = \Sigma m (4, 8, 10) \)

K-map
Prime Implicates: \( \Pi M (3,11), \Pi M (12,13), \Pi M (10,11), \Pi M (4,12), \Pi M (8,10,12,14) \)

**iClicker:**
How many essential prime implicates do we have in this example?

A. 1  
B. 2  
C. 3  
D. 4  
E. 5
Neighbors of $m_5$ are: minterms 1, 4, 7, 13, and 21
Neighbors of $m_{10}$ are: minterms 2, 8, 11, 14, and 26
Six variable K-map