

## Practical Session – Week 1A

### Objectives

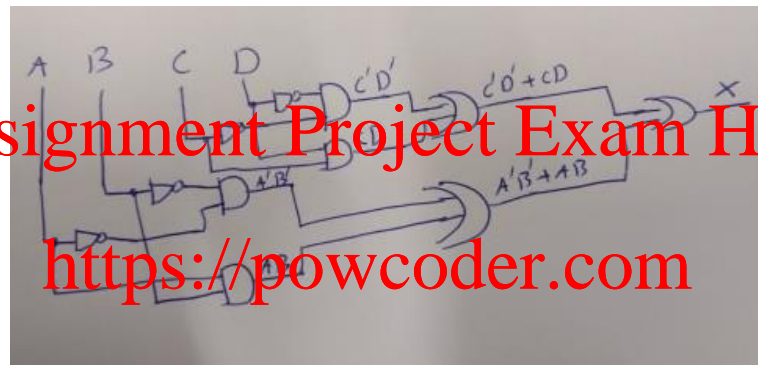
1. To draw the logic gate circuits of Boolean expressions
2. To write down the Boolean expressions of given circuit diagrams
3. To find Boolean expressions

### Tasks

1. Draw the logic gate circuit corresponding to the following Boolean expression

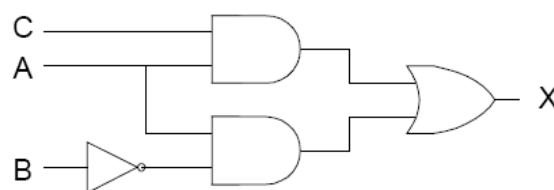
$$F = (A' \cdot B' + A \cdot B) + (C' \cdot D' + C \cdot D)$$

**Answer:**



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2. Write the Boolean expression of the following circuit diagram. Set up the truth table



**Answer:  $X = C.A + A.B'$**

Table 1. Truth Table for Task 2

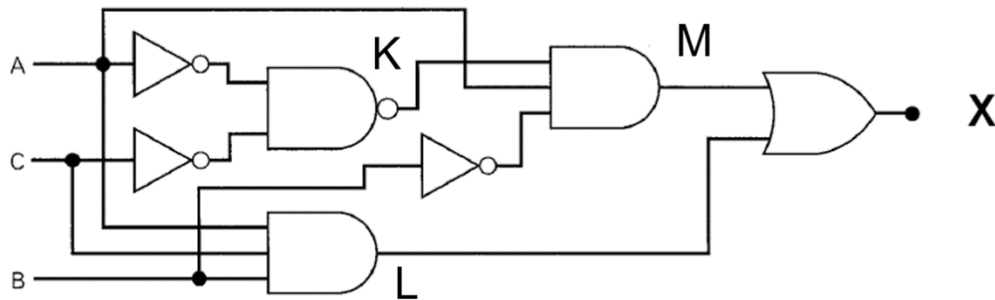
A	B	C	B'	C . A	A . B'	X
0	0	0	1	0	0	0
0	0	1	1	0	0	0
0	1	0	0	0	0	0
0	1	1	0	0	0	0
1	0	0	1	0	1	1
1	0	1	1	1	1	1
1	1	0	0	0	0	0
1	1	1	0	1	0	1

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3. Write the Boolean expression of the following circuit diagram. Set up the truth table



Answer:  $X = (A' \cdot C')' \cdot A \cdot B' + A \cdot C \cdot B$

or equivalently,  $X = M + L$ , where  $M = K \cdot A \cdot B'$ ,  $L = A \cdot C \cdot B$ ,  $K = (A' \cdot C')'$

Table 2. Truth Table for Task 3

A	B	C	A'	B'	C'	K	L	M	X
0	0	0	1	1	1	0	0	0	0
0	0	1	1	1	0	1	0	0	0
0	1	0	1	0	1	0	0	0	0
0	1	1	1	0	0	1	0	0	0
1	0	0	0	1	1	1	0	1	1
1	0	1	0	1	0	1	0	1	1
1	1	0	0	0	1	0	1	0	0
1	1	1	0	0	0	1	1	0	1

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4. Compare X of exercise 2 and exercise 3. Keep in mind that the Boolean expression of X in exercise 3 can be simplified to the one of exercise 2.

Answer (not assessed):

$$\begin{aligned}
 (A' \cdot C')' \cdot A \cdot B' + A \cdot C \cdot B &= \quad // \text{Apply DeMorgan Theorem: } (A \cdot B)' = A' + B' \text{ and } (A + B)' = A' \cdot B' \\
 &= (A + C) \cdot A \cdot B' + A \cdot C \cdot B = \quad // \text{Distributive Law – permits the factoring out of an expression} \\
 &= A \cdot A \cdot B' + C \cdot A \cdot B' + A \cdot C \cdot B = \quad // \text{Idempotent Rule} \\
 &= A \cdot B' + C \cdot A \cdot B' + A \cdot C \cdot B = \quad // \text{Absorptive Law – absorbing like terms} \\
 &= A \cdot B' + C \cdot A(B' + B) = \quad // \text{complement Rule} \\
 &= A \cdot B' + C \cdot A
 \end{aligned}$$

5. Find the Boolean expression of function  $f(x,y,z)$  with three inputs and one output;  $f(x,y,z)$  produces 1 when at least two of the inputs are 1, otherwise it produces 0

**Step1:** set up the truth table

x	y	z	$f(x, y, z)$
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

**Step2:** Find all the Boolean sub-expressions only when  $f(x,y,z)=1$ , e.g., when  $(x=0,y=1,z=1)$ . The sub-expression is generated by inverting the inputs with zero and keeping the rest as they are, e.g., the subexpression for  $(x=0,y=1,z=1)$  is  $x'yz$ .

**Answer:**  $x'yz, xy'z, xyz', xyz$

**Step3:**  $f(x,y,z)$  is given by summing (applying logical OR) all the sub-expressions found in step2.

**Answer:**  $f = x'yz + xy'z + xyz' + xyz$

**Step4** (this step is optional and will **not be assessed**): Simplify  $f(x,y,z)$  using Boolean algebra. For those who are interested in how to simplify Boolean expressions, they can read the following link (Karnaugh maps) <https://www.geeksforgeeks.org/k-mapkarnaugh-map/>

**Answer:** this is out of the scope of this lab session

6. Revisit and study the 4-bit ripple carry adder shown in the slides. Draw the circuit for an 8-bit ripple carry adder