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**Class Group:** COMP1D-X

# Lab 5 – De Morgan's Theorem and Basic Circuits

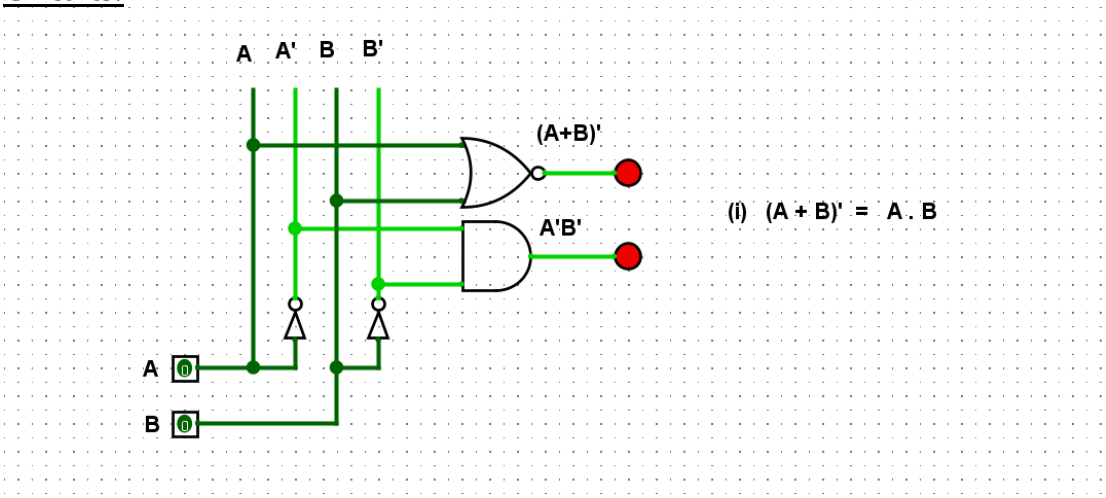
1. Prove the following theorems of De Morgan by completing the following tables. Verify this theorem in Logisim using appropriate circuits:

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

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

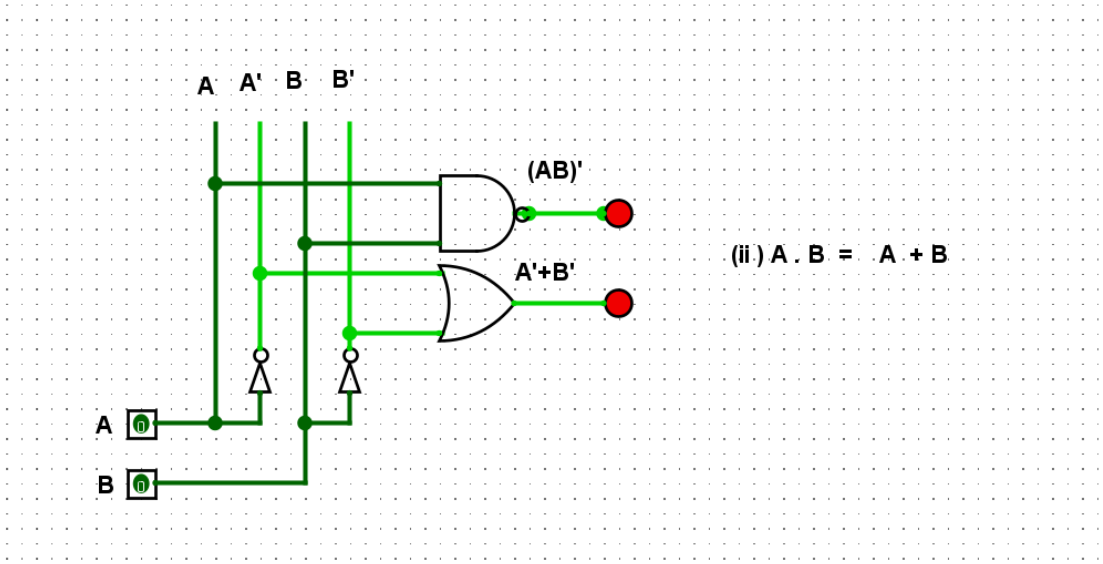
| A | B | A+B | $\overline{A}$ | $\overline{B}$ | $\overline{A+B}$ | $\overline{A} \cdot \overline{B}$ |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 |

**Circuits:**



| A | B | $\overline{A}$ | $\overline{B}$ | A.B | $\overline{A.B}$ | $\overline{A} + \overline{B}$ |
|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 | 1 | 0 | 0 |

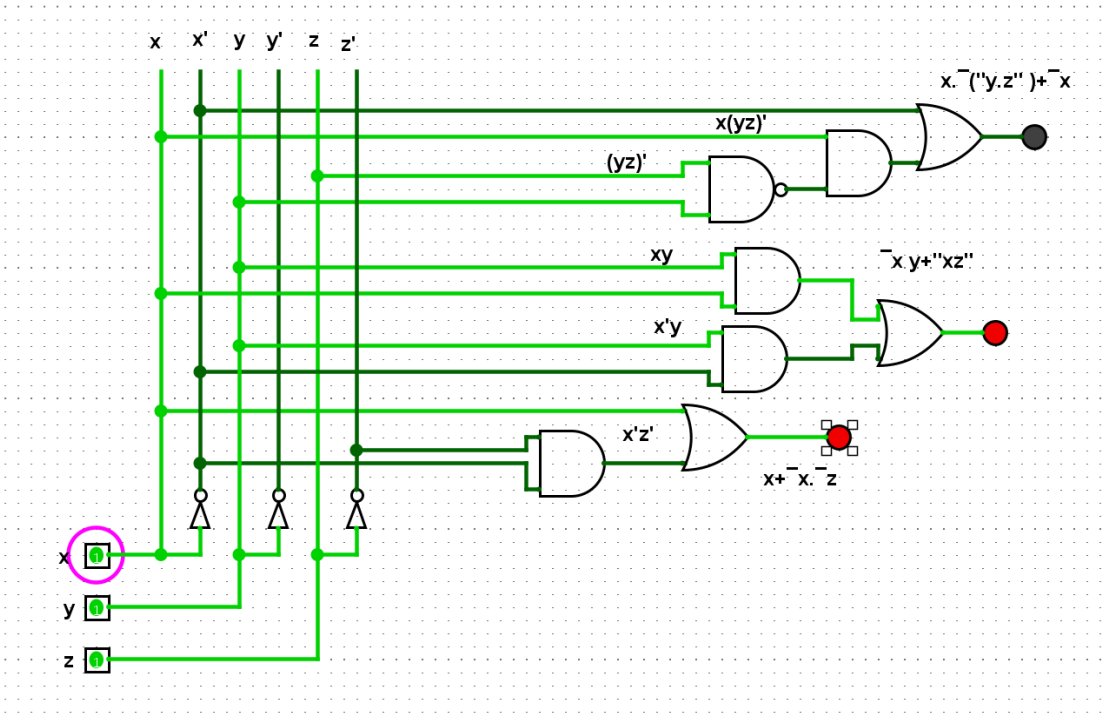
**Circuits**:



2. Draw circuits for the Boolean expressions outlined below. Complete the truth tables for these expressions and verify the truth tables using your circuits,

   i. $x.\overline{y.z} + \overline{x}$
   ii. $\overline{x}y + xz$
   iii. $x + \overline{x}.\overline{z}$

| x | y | z | x’ | y’ | z’ | xz | (yz)’ | x’y | x’z’ | x*(yz)’ | $x.\overline{y.z} + \overline{x}$ | $\overline{x}y + xz$ | $x + \overline{x}.\overline{z}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |



3. Using the Sum of Products technique, design a circuit which implements the following truth table. The inputs are A, B, and C. The output is X

**Truth Table:**

| A | B | C | X |
|---|---|---|---|
| 0 | 0 | 0 | **1** |
| 0 | 0 | 1 | **0** |
| 0 | 1 | 0 | **1** |
| 0 | 1 | 1 | **0** |
| 1 | 0 | 0 | **1** |
| 1 | 0 | 1 | **0** |
| 1 | 1 | 0 | **1** |
| 1 | 1 | 1 | **0** |

**Circuit:**

**X =** (ABC)' + ABC' + AB'C + A'BC