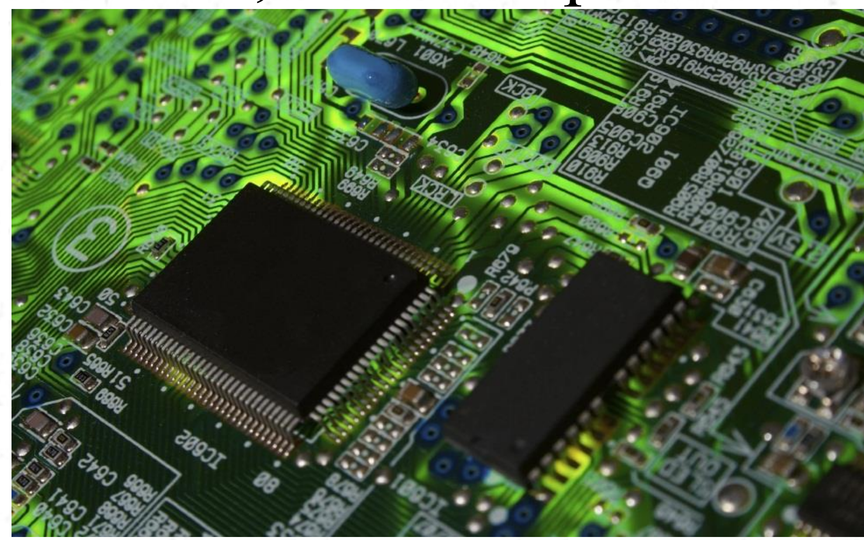
Mathematics for Computing (IT1030)

Lecture 2
Logic Gates

Logic Gates

- A computer, or other electronic device, is made up of a number of circuits.



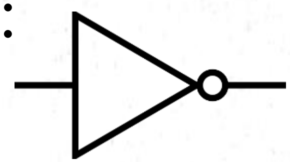
- The components in a logical circuit takes 0 and 1 as inputs.
- 1 is the state where there is a voltage on the input and 0 is the state where there is no voltage on the input.

Logic Gates (cont'd.)

- Therefore, boolean algebra is used to model the circuitry in electronic devices.
- The absence of a voltage is usually denoted as 0 (zero) and the presence of a voltage is denoted by 1 (one).
- As mentioned earlier, concepts of boolean algebra can be used to simplify logical circuitry.
- There are a set of components that matches the boolean operators discussed earlier.
- These components are called **Logic Gates**.

Basic Logic Gates (NOT Gate)

- **Complement** → NOT Gate.
- Also known as *inverter* or *complementer*.
- Consists of a single input and a single output.
- As in the complement, the input gets inverted.
- Symbol:

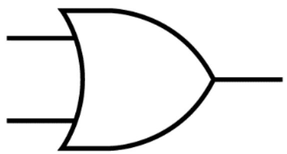


- Truth Table:

Input (A)	Output ($\bar{A}$)
0	1
1	0

Basic Logic Gates (OR Gate)

- **Boolean Sum** → OR Gate.
- Consists of two inputs and a single output.
- As in the sum, the output is 1 if at least one input is 1.
- Symbol

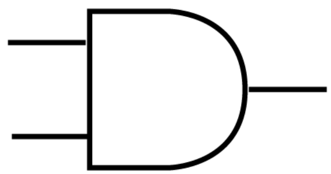


- Truth Table:

Input (A)	Input (B)	Output (A + B)
0	0	0
0	1	1
1	0	1
1	1	1

Basic Logic Gates (AND Gate)

- **Boolean Product** → AND Gate.
- Consists of two inputs and a single output.
- As in the product, the output is 0 if at least one input is 0.
- Symbol:

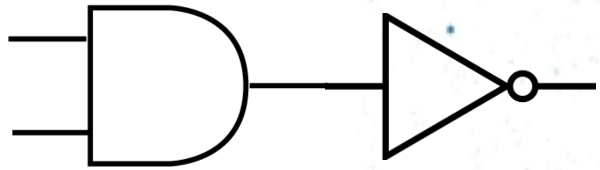


- Truth Table:

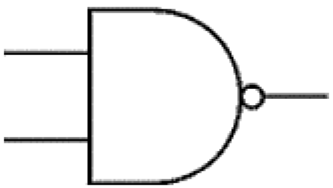
Input (A)	Input (B)	Output (A · B)
0	0	0
0	1	0
1	0	0
1	1	1

Derived Logic Gates (NAND Gate)

- Created by combining an AND gate with a NOT gate.



- Symbol:

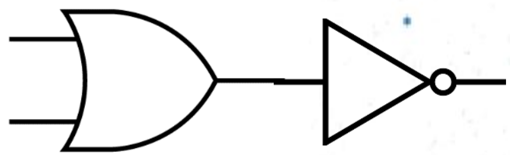


- Truth Table:

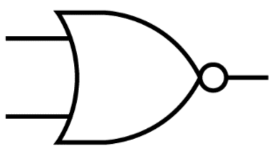
Input (A)	Input (B)	Output ($\overline{A \cdot B}$)
0	0	1
0	1	1
1	0	1
1	1	0

Derived Logic Gates (NOR Gate)

- Created by combining an OR gate with a NOT gate.



- Symbol

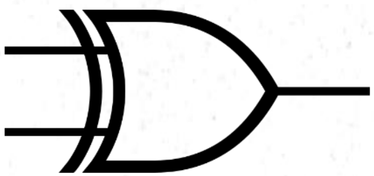


- Truth Table:

Input (A)	Input (B)	Output ($\overline{A + B}$)
0	0	1
0	1	0
1	0	0
1	1	0

Derived Logic Gates (XOR Gate)

- Similar to the OR Gate.
- Consists of two inputs and a single output.
- The output is 1 if **ONLY ONE** input is 1.
- Symbol:

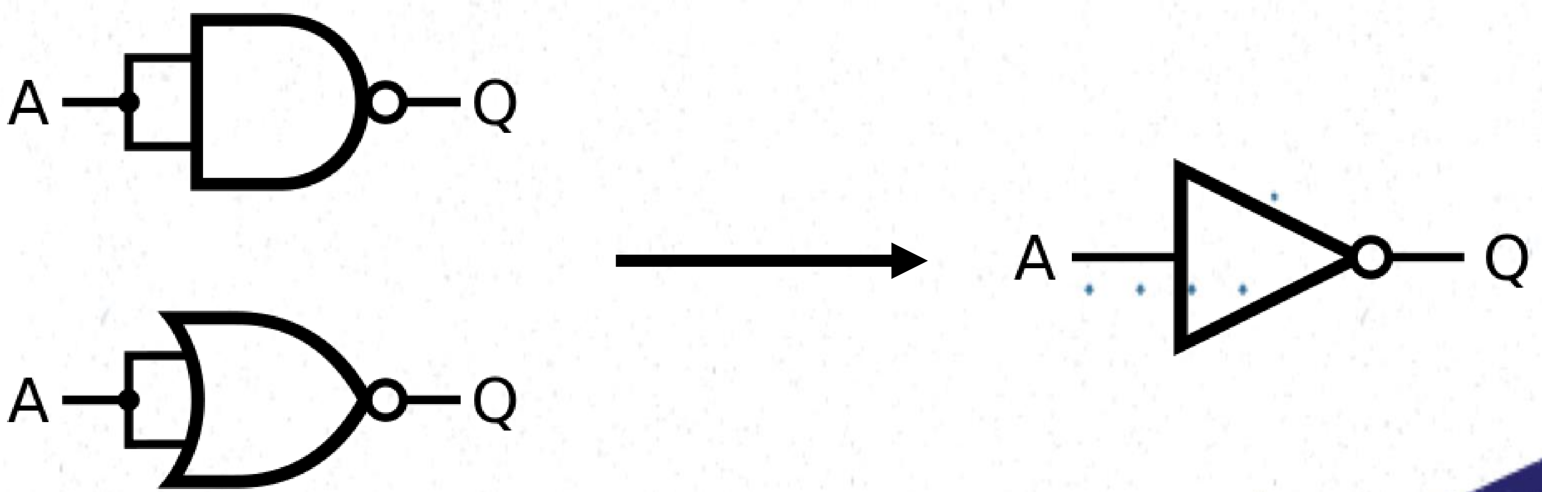


- Truth Table:

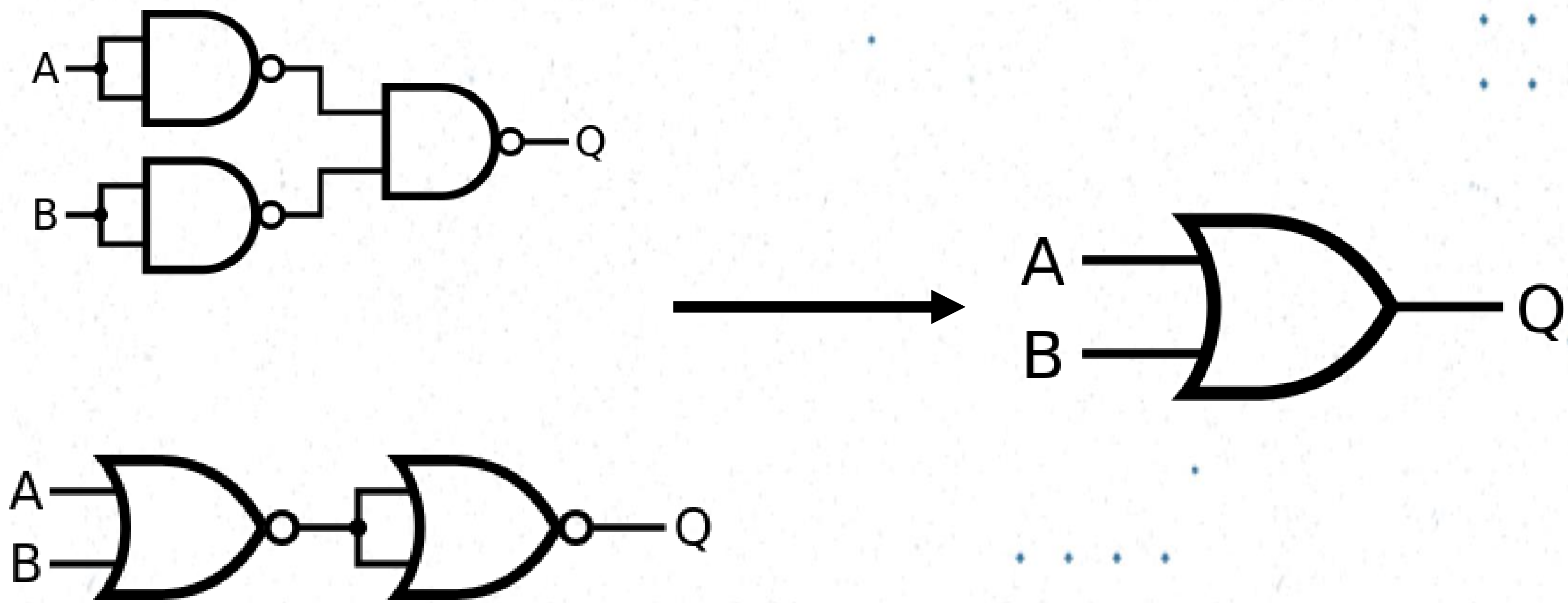
Input (A)	Input (B)	Output ($A \oplus B$)
0	0	0
0	1	1
1	0	1
1	1	0

Universality of NAND and NOR Gates

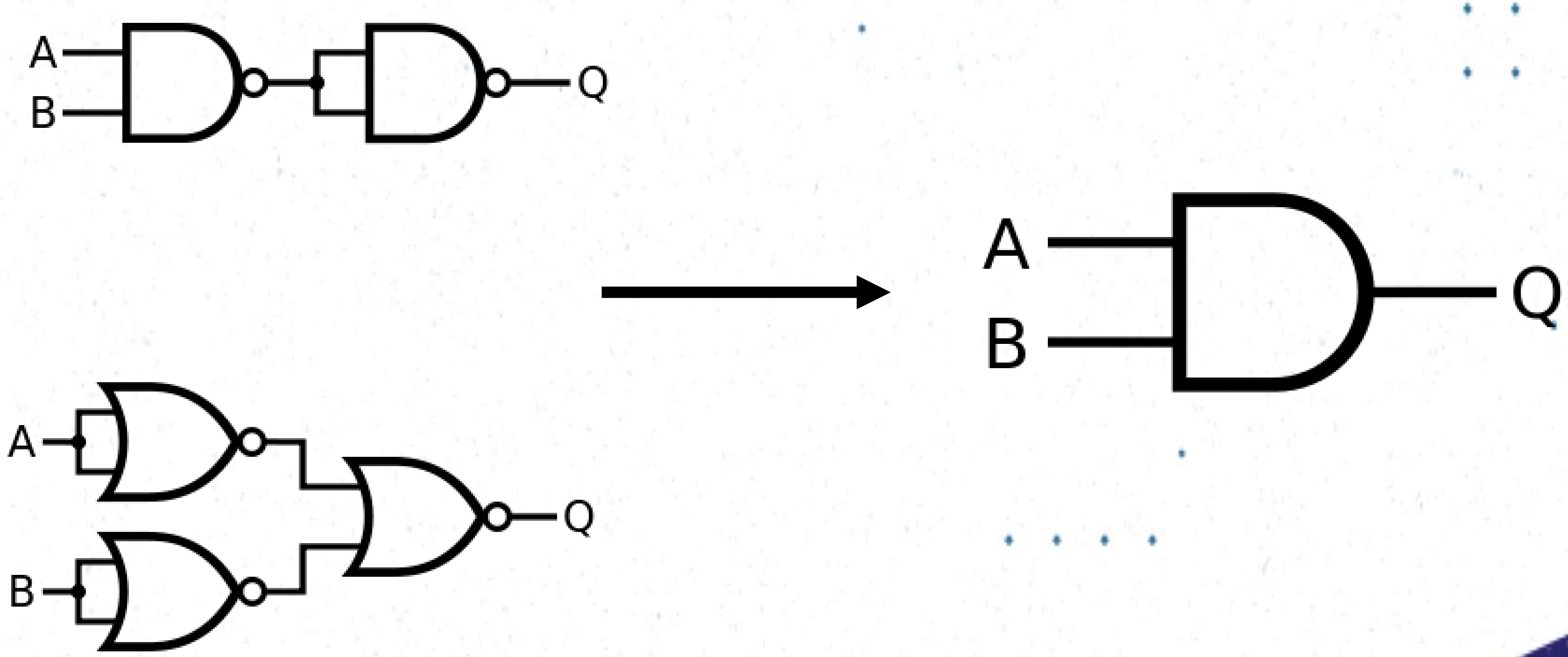
- Basic gates can be derived using the NAND and NOR gates.
- It has been identified that NAND can be replaced by NOR or otherwise



Universality of NAND and NOR Gates



Universality of NAND and NOR Gates



Exercises

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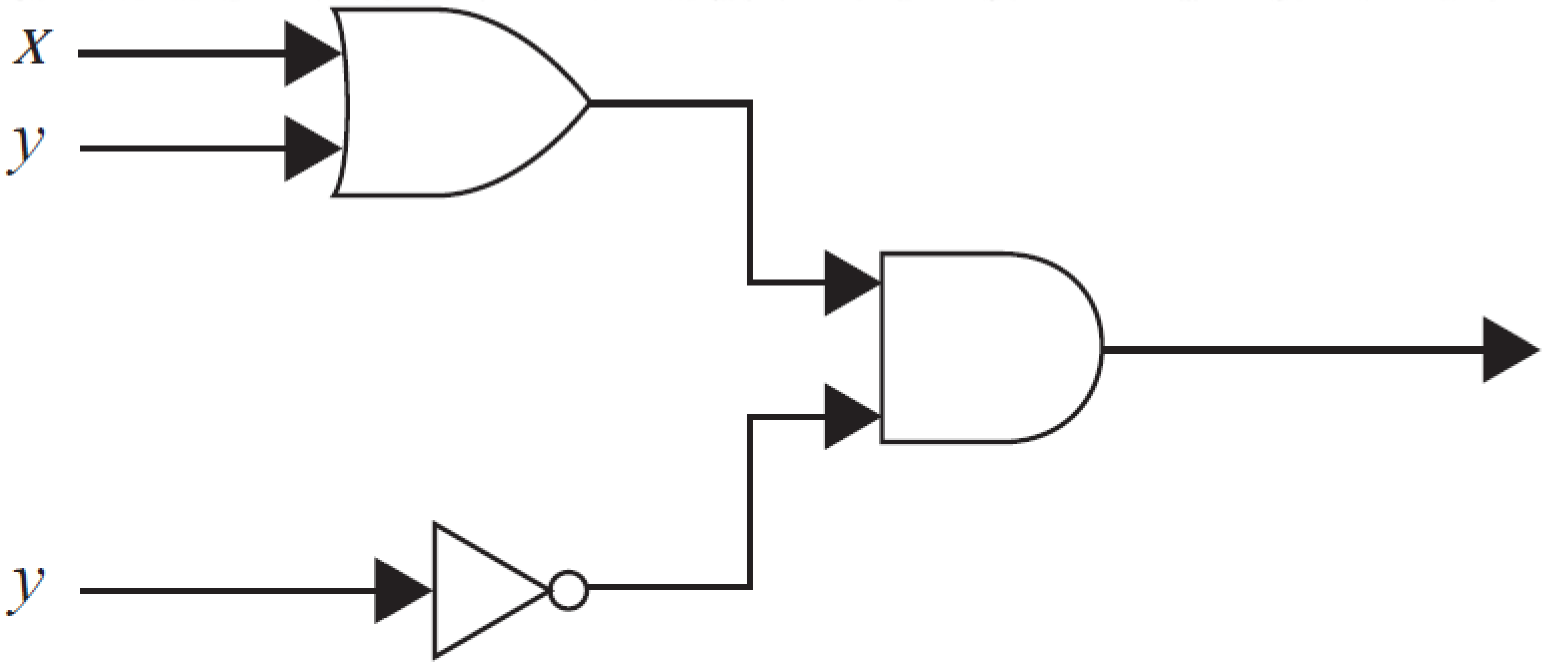
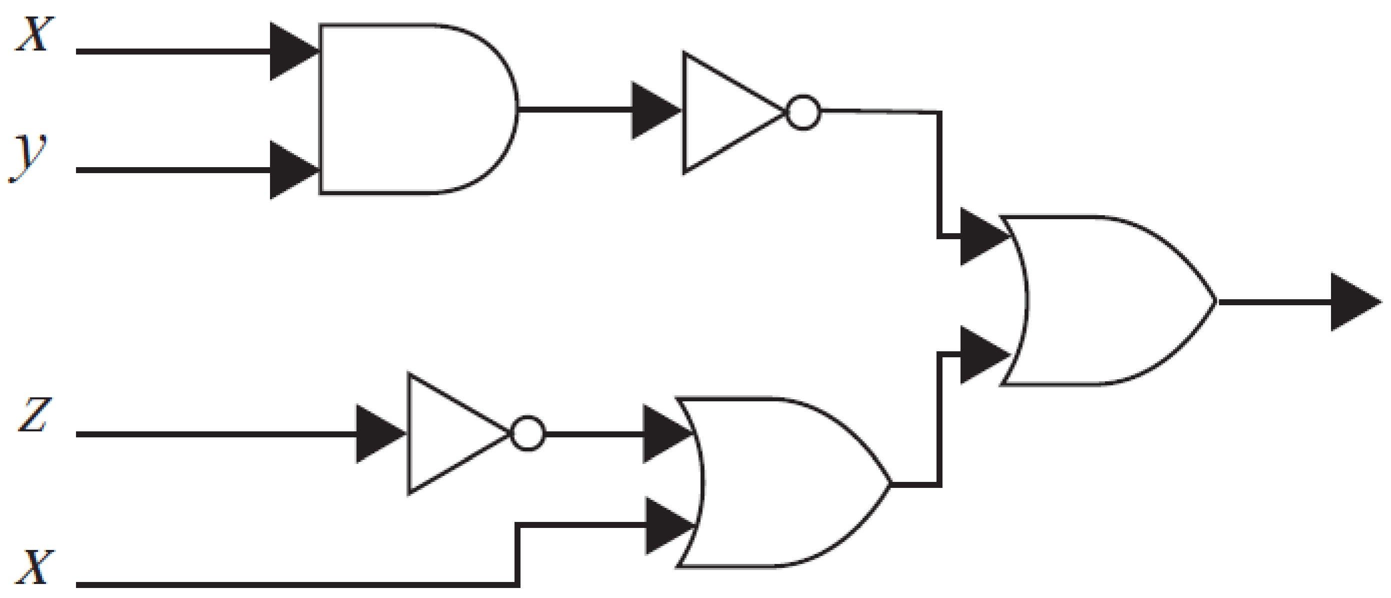
1. Find the outputs from the following logic circuits.

   i.



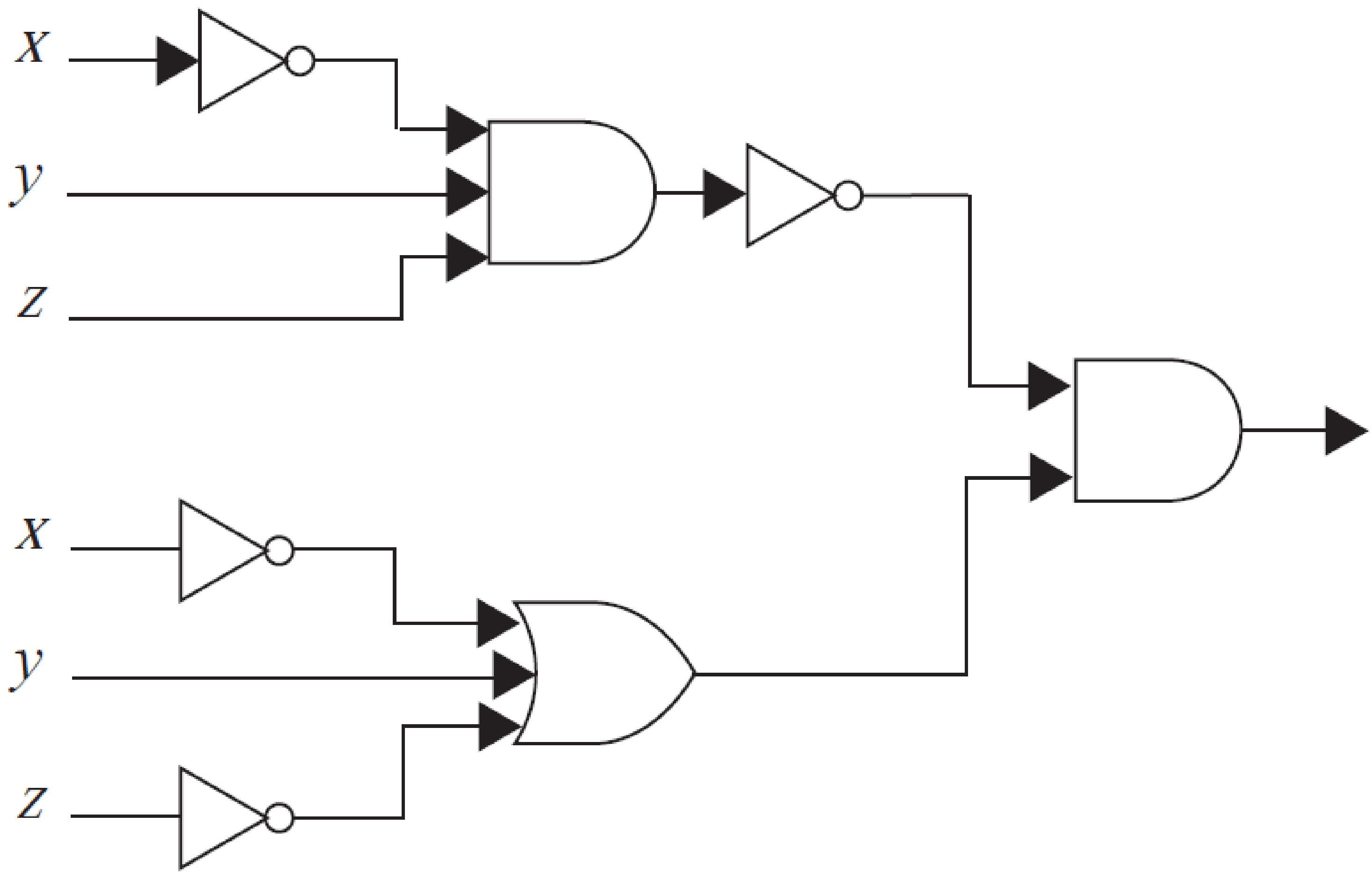
Exercises (cont'd.)

ii.



Exercises (cont'd.)

iii.



Exercises (cont'd.)

2. Construct circuits from inverters, AND gates, and OR gates to produce these outputs.
   i. $\overline{A} + B$
   ii. $\overline{(A + B)A}$
   iii. $ABC + \overline{A}\,\overline{B}\,\overline{C}$
   iv. $\overline{(\overline{x} + z)(y + \overline{z})}$
   v. $\overline{W}\,\overline{X}\,\overline{Y}\,\overline{Z} + \overline{W}X\overline{Y}\,\overline{Z} + WX\overline{Y}\,\overline{Z} + W\overline{X}\,\overline{Y}\,\overline{Z}$
3. Design a circuit for a light fixture controlled by three switches, where flipping one of the switches turns the light on when it is off and turns it off when it is on.

[redacted]

Summary

- Students should be able to,
  - Get an understanding about the need and usage of logic gates.
  - Understand basic logic gates and the connection with boolean operators.
  - The functions obtained by the logic gates.
  - Draw truth tables for the logic gates.
  - Draw circuit diagrams for the logic gates using the standard symbols.
  - Drawing circuit diagrams from boolean expressions and vice versa.

End of Lecture 2