Week 3 - Preparing for the Board Experiments

This is ungraded practice work

BBM233 Digital Design Lab - 2024 Fall

AIM

In our first lab session, we will make a brief introduction to BBM233 Logic Design Lab, talk about how board experiments are going to be conducted, and give some important information about how to prepare for the labs and how the grading will work. The aim of this work is to practice implementing digital circuits.

BACKGROUND ON BOOLEAN LOGIC

In digital electronics, Boolean logic refers to the manipulation of binary values in which a 1 represents the concept of *true* and a 0 represents the concept of *false*. In electronic circuits that implement logic, binary values are represented by voltage levels.

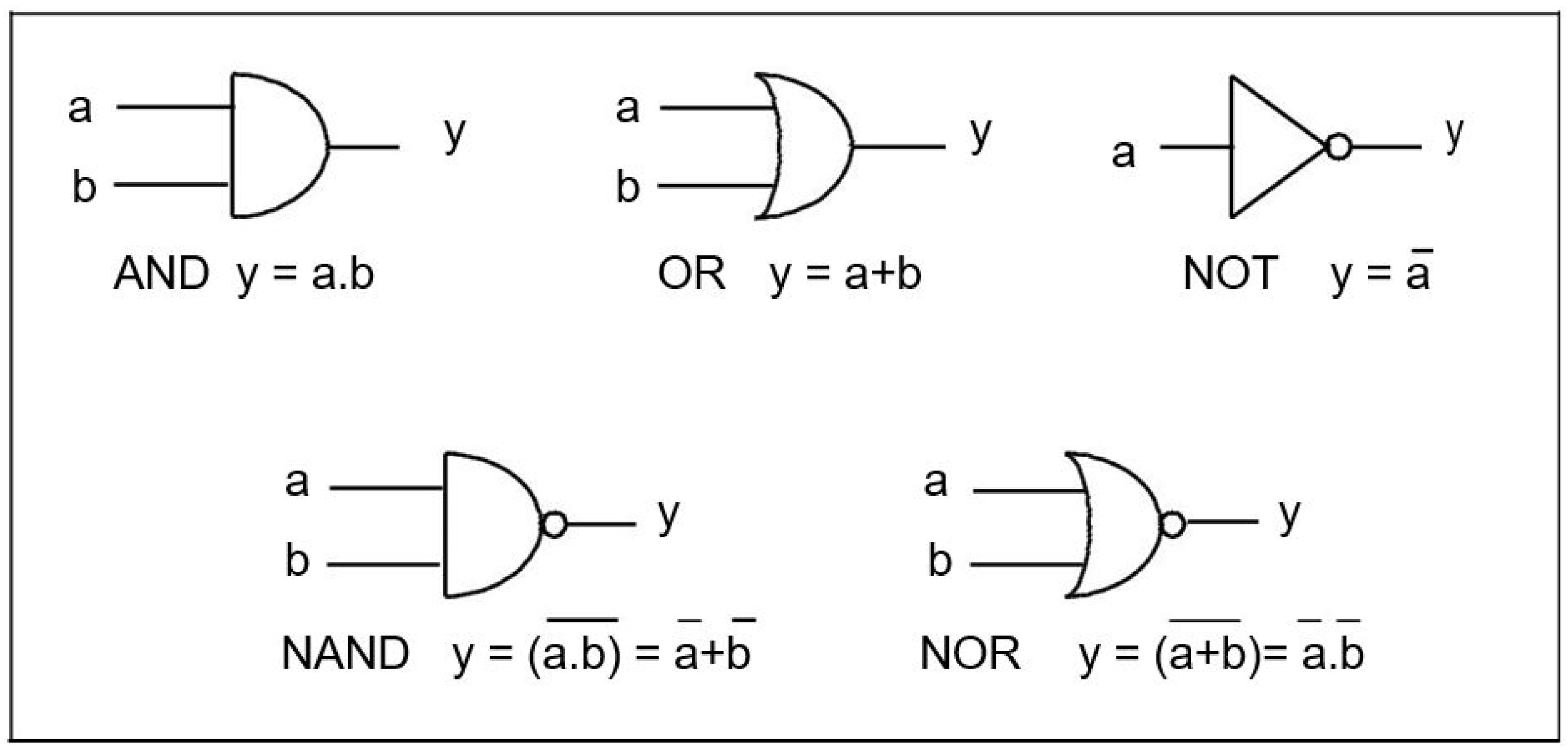
In the framework of digital electronic, logic gates give the possibility to perform Boolean Algebra operations on electrical signals. Within this context:

- A logical 1 on the input or output of a gate corresponds to a relatively high voltage value designated as High, Hi or H.
- A logical 0 on the input or output of a gate corresponds to a relatively low voltage value designated as Low, Lo, L.

The basic logic gates are:

- Inverter (NOT gate),
- AND gate, and
- OR gate.

As their names indicate, these gates represent a basic operation in Boolean Algebra. The AND and the OR gates can each have any number of inputs but only one output. An inverter has only one input and one output.



A NAND gate is equivalent to the combination of an AND gate and an inverter (NOT gate). Therefore the word NAND is a contraction of the words NOT and AND. There is also NOR (NOT-OR) gate which is the concatenation of OR and NOT gates. Because the fabrication of NAND and NOR gates is much easier than the AND and OR's, these two combination gates represent the most popular off-the-shelf packages.

BOARD PRACTICE EXERCISES

To get introduced to a breadboard and how to implement circuits on breadboards, watch the following instruction videos:

1. Introduction to Breadboard (Protoboard) Part 1
2. Introduction to Breadboard (Protoboard) Part 2
3. How our board experiments will look like (recorded during pandemics).

For the practice exercises you will use a digital circuit simulator. However, in the lab you will deal with the real digital components and implement your circuits on a breadboard. Please register an account at CircuitVerse (you may use your **CS e-mail address** <bstudentID>@cs.hacettepe.edu.tr, but it is not mandatory).

Exercise 1 - Basic Logic Gates

Exercises to be performed in the simulator:

1. Verify the truth table for a 2-input AND gate.
2. Verify the truth table for a 2-input OR gate.
3. Verify the truth table for a 2-input NAND gate.
4. Verify the truth table for a 2-input NOR gate
5. Verify the truth table for a 2-input XOR gate.
6. Verify the truth table for a NOT gate.

Exercise 2 - Practice Problem

Mr. Salazar works at a supermarket along with his colleague Mr. Six. One of their duties is to control the lighting system of the premises, so that the customers can see around and inside the shop.

- Mr. Salazar is responsible for turning the lights **OFF**, when it's **SUNNY**, and when it's **DAYTIME**.
- Mr. Six is responsible for turning the lights **ON** if the weather is **RAINY** or if it's **NIGHTTIME**.

Mr. White, the owner of the supermarket, thinks that this task can be automated using two sensors that would detect if the weather is **SUNNY** or **RAINY**, and a clock that would report if it is **DAYTIME** or **NIGHTTIME**.

Can you help Mr. White design a logic circuit that would automate this tedious task?

Hacettepe University Computer Engineering Department

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Exercise 2 - Step 1

Construct a truth table using two variables SUNNY and DAYTIME. (Note that RAINY ≡ ¬ SUNNY and NIGHTTIME ≡ ¬ DAYTIME)

Answer:

SUNNY	DAYTIME	LIGHTS
F	F	ON
F	T	ON
T	F	ON
T	T	OFF

Exercise 2 - Step 2

Write the Boolean expression that would control the LIGHT.

1. Using an AND operator and a NOT operator.
2. Using an OR operator and two NOT operators.

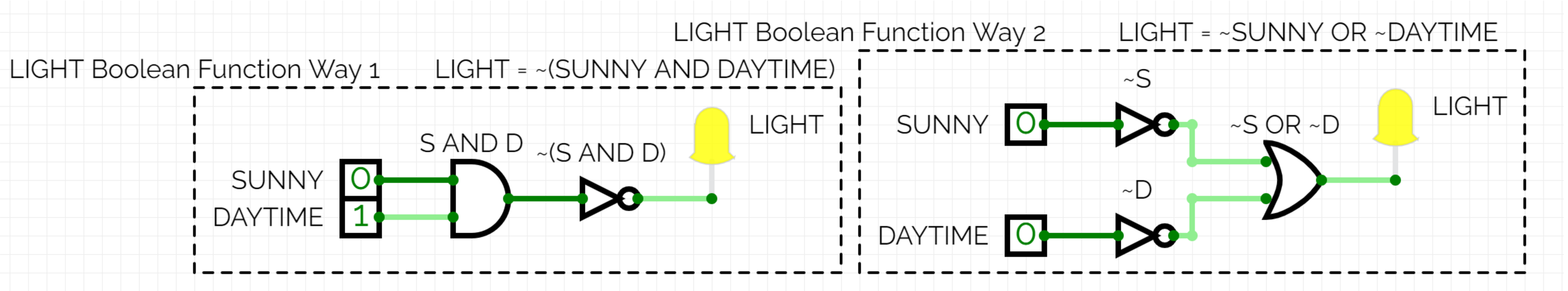
Answer:

1. LIGHT ≡ ¬(SUNNY ∧ DAYTIME)
2. LIGHT ≡ ¬SUNNY ∨ ¬DAYTIME

Exercise 2 - Step 3

Implement both Boolean expressions using basic logic gates on CircuitVerse.

Answer:



Exercise 2 - Can we do better?

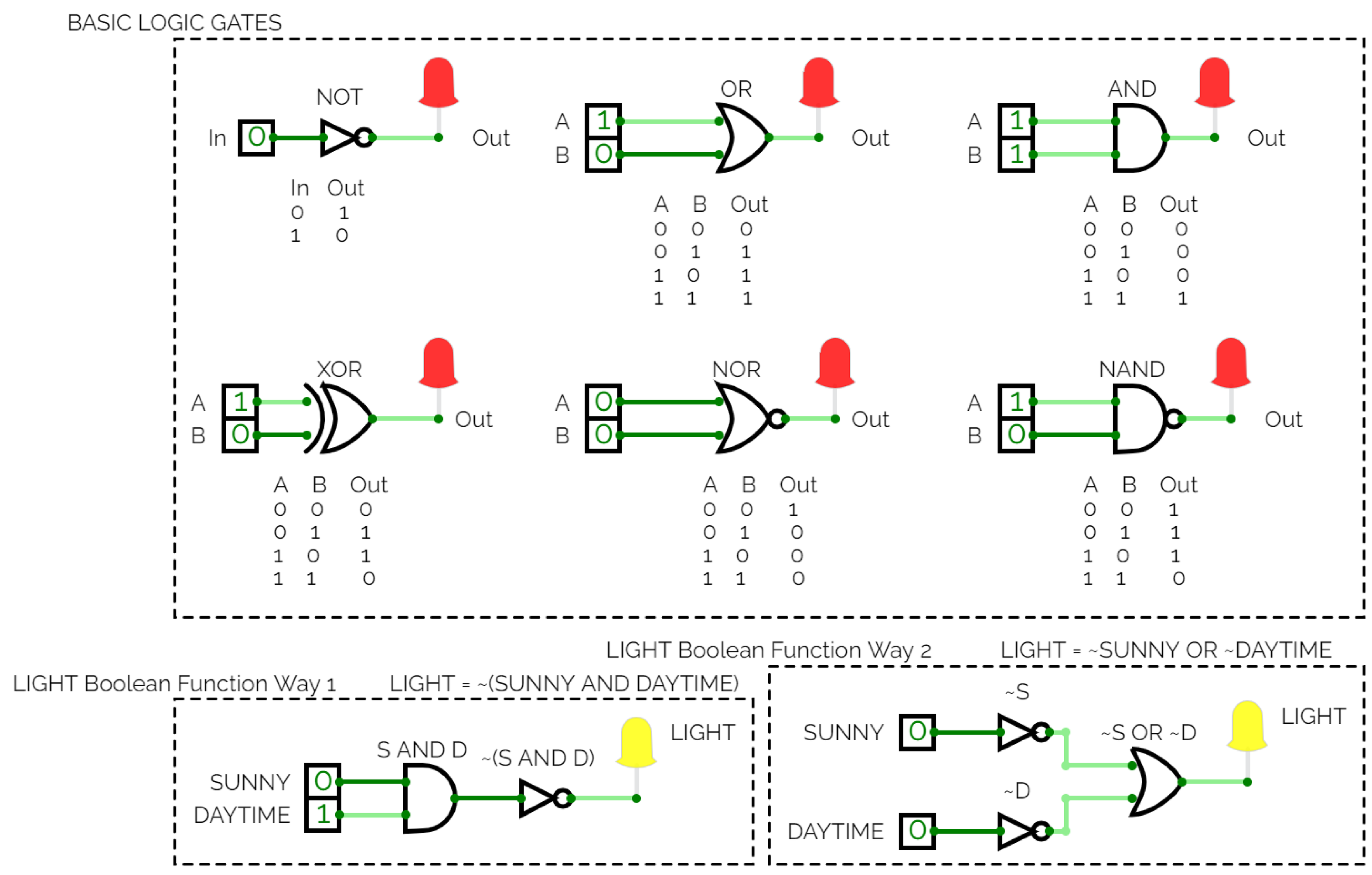
A question for you to consider: 

Can we implement the Boolean function LIGHT using only one logic gate, which would give us a much more efficient design? If yes, which one?

Expected Outcomes

Log in to CircuitVerse and **launch the simulator**.

Do the practice exercises, test your implementation with all possible input combinations, and save your project by clicking on **Project/Save Online** in the simulator menu. Your implementation should look something like this:



This is an ungraded experiment

These practice exercises will not be graded or checked. The first graded experiment will be done in Week 4. However, you are highly encouraged to do the practice exercises before the graded experiment instructions are shared in Week 3.