SN EDUCATOR GUIDE

September 28, 2019

Computer Chip Milestone Reached

Activity Guide for Students: Digital Circuit Design

Directions:

Image 1 shows basic logic gates used in computer chips and Image 2 shows how these logic gates can be connected to form a simple program. After reviewing the general information about the symbols and tables below with your teacher, answer the questions that follow. The questions will help you understand the general aspects of the gates below. When needed, use an additional resource to find background information.

Image 1: Symbols and truth tables for logic gates

AND gate

$Input_A$	0	0	1	1
$Input_B$	0	1	0	1
Output	0	0	0	1

OR gate

$Input_A$	0	0	1	1
$Input_B$	0	1	0	1
Output	0	1	1	1

XOR gate

$Input_A$	0	0	1	1
$Input_B$	0	1	0	1
Output	0	1	1	0

NOT gate

Input	0	1
Output	1	0

NAND gate

$Input_A$	0	0	1	1
$Input_B$	0	1	0	1
Output	1	1	1	0

NOR gate

$Input_A$	0	0	1	1
$Input_B$	0	1	0	1
Output	1	0	0	0

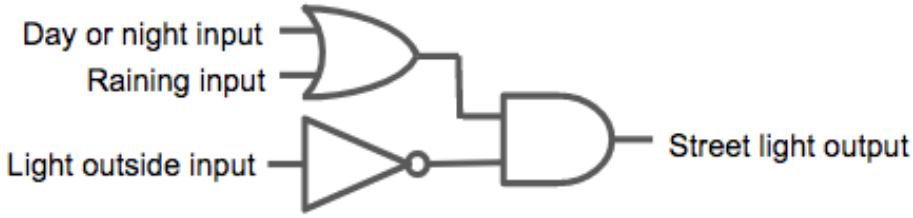
XNOR gate

$Input_A$	0	0	1	1
$Input_B$	0	1	0	1
Output	1	0	0	1

Buffer gate

Input	0	1
Output	0	1

Image 2: Street lights turn on computer chip



Background questions

1. The symbols for both the AND and the NOT gates start with two lines on the left but end with one line on the right. What does this tell you about the inputs and outputs?

2. The symbol for the NOT gate has only one line on the left and one line on the right. What does this tell you about the gate?

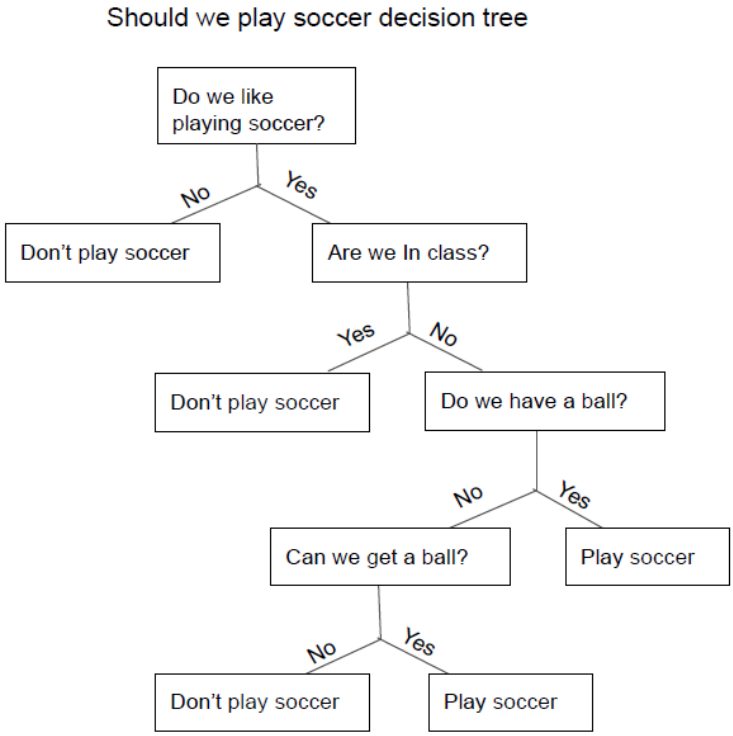
3. What kind of data are used in the gates?

4. How can the data used in gates be transmitted by transistors in circuits?

5. The table accompanying each gate in Image 1 is called a "truth table." What does a truth table tell you?

6. Which gates are a combination of two other gates? How did you determine this?

7. Decision trees are a model of possible decisions and their outcomes. An example of a decision tree is below. How are circuits that use logic gates similar to decision trees? How are they different?



Circuit design

In this activity, you will use logic gates to design a simple computer program. The computer program should start a quiet alarm if a vehicle's lights are on or a door is open when the key is left in the ignition. Table 1 shows the binary values for the different types of inputs and outputs. To begin designing the program, first think about how you would separate the program into separate steps and then think about the circuits for those steps. Note that for the alarm to be turned on, the binary output of the final gate must be 1.

Table 1: Binary values for car actions

Inputs and outputs		Binary value
Key	Left in ignition	1
	Removed from ignition	0
Running lights	On	1
	Off	0
Interior lights	On	1
	Off	0
Door	Closed	1
	Open (not closed)	0
Quiet alarm	On	1
	Off	0

8. Which data will be the inputs for the car circuit you will design?

9. Which data will be the outputs of the circuit you will design?

10. For a circuit that determines if the running lights were on when the key was left in the ignition, what would the inputs be? What would their binary values have to be to turn the alarm on?

11. Complete the truth table that shows these input and output values, and draw its logic gate.

$Input_A$	Key	0			
$Input_B$	Running lights	0			
Output	Quiet alarm	0			

12. For a circuit that determines if either the running lights or the interior lights were on, what would the inputs be? What would their binary values be to make the alarm go on?

13. Complete the truth table that shows these input and output values, and draw its logic gate.

$Input_A$	Interior lights	0			
$Input_B$	Running lights	0			
Output	Quiet alarm	0			

14. For a circuit that determines if the door was open when a key was left in the ignition, what would the inputs be? What would their binary values be to make the alarm go on?

15. If you wanted to use an AND gate to combine these inputs to turn the alarm on (1), what other gate would you have to use first? Why?

16. Create the truth tables for your two gates that show the input and output values, and draw their logic gates.

17. Now think about how to combine these functions into a single program that could be built on one computer chip. Combine the three types of circuits you just drew to create a single computer chip that will turn on the quiet alarm if the key is in the ignition while the door is open or any of the lights are on.

18. Brainstorm with a partner another way to design a circuit to create the same alarm under the same circumstances. (Hint: Doing this could require rearranging the gates, using more or fewer gates or using different gates.) Draw the logic gates you would use in your new design and how they connect to each other.