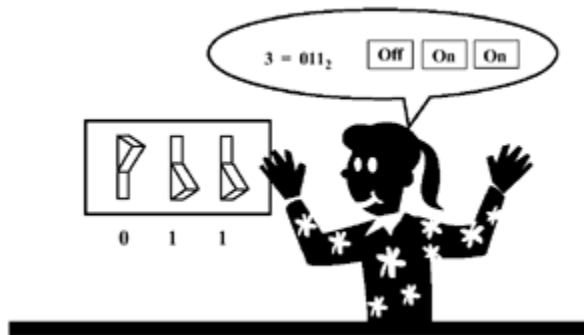


## The Journey Inside<sup>SM</sup>: Digital Information Student Handout: Binary Numbers

### Binary Numbers

You learned how to count when you were very young. The number system that you used is called the decimal system. The word decimal means ten. The decimal number system has 10 symbols. The 10 symbols are: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.

With just these 10 symbols, you can count forever. You know that once you have used the digits from 0 to 9, you next create numbers with two digits, such as 10, 11, 12, 13, and so on. Next you use a combination of three digits to get 100, 101, 102, 103, and so on.



The word binary means two. The binary number system has two symbols, 0 and 1. With just these two symbols, you can also count forever.

1=1 <sub>2</sub>	2=10 <sub>2</sub>	3=11 <sub>2</sub>	4=100 <sub>2</sub>	5=101 <sub>2</sub>
6=110 <sub>2</sub>	7=111 <sub>2</sub>	8=1000 <sub>2</sub>	9=1001 <sub>2</sub>	10=1010 <sub>2</sub>

When we write binary numbers we use a "2" for a subscript to represent the binary system. The above table shows the binary numbers that are equivalent to decimal numbers from 0 to 10. (These numbers are read "Zero base 2," "One base 2," "One-zero base 2," and so forth.)

You can easily see that it takes many more number value placeholders to represent even small numbers using the binary system than it does using the decimal system. In the decimal system you use 14 to represent 1 tens unit and 4 ones units. This is equivalent to: 1(10) + 4(1). In the binary system this same number is 1110<sub>2</sub> to represent 1 eights unit, 1 fours unit, 1 twos unit and 0 ones unit. This is equivalent to: 1(8) + 1(4) + 1(2) + 0(1). It is easier to say, "I am 14 years old," than to say, "I am one-one-one-zero base 2 (1110<sub>2</sub>) years old."

Computers are built to work with the binary symbols 0 and 1. People are taught to work with the decimal symbols 0, 1, ..., 9. People can learn to convert from decimal to binary, and back again. Computers can be programmed to convert from decimal to binary, and back again. In this way, computers and people can each work with the symbol set that is most comfortable and best suits their abilities.

## Activities

- Binary numbers and decimal numbers are two different ways to represent a quantity. Complete the following table.

Decimal	8s	4s	2s	1s	Binary
0	0	0	0	0	$0_2$
1	0	0	0	1	$1_2$
2	0	0	1	0	$10_2$
3	0	0	1	1	$11_2$
4	0	1	0	0	
5	0	1	0	1	
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

- You already know how to do addition in base 10. So you can easily do the problem:

$$\begin{array}{r} 394 \\ + 825 \\ \hline 1219 \end{array}$$

- The same ideas can be used to add binary numbers. Try the following addition problems. Use this addition table to help you.

$$\begin{array}{r} 1011_2 \\ + 110_2 \end{array} \quad \begin{array}{r} 101_2 \\ + 10110_2 \end{array} \quad \begin{array}{r} 10110_2 \\ + 10110_2 \end{array} \quad \begin{array}{r} 1011011_2 \\ + 1110011_2 \end{array}$$

- Write an explanation of how to add two binary numbers. Give an explanation that will enable someone who has never done this exercise to succeed in adding the two numbers.