# Understanding Numbering Systems 

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## WHAT'S COVERED

A numbering system is a way to represent numbers of a certain type, and to have as their root base the same number of digits in the system. The system of numbering we are most familiar with is base10 numbering. This means that there are 10 digits in the numbering system, zero through nine. If we count these digits in numerical order, we stop at nine, and then have to use two digits to express the next number, 10.

The decimal numbering system is not the only numbering system. In fact, computers primarily use the binary numbering system to represent data. As you will learn below, this system uses only two digits - zero and one. Because there are only two digits in this system, representing data in this system can require an incredibly long string of digits. When making computations or processing data, it can be quicker and easier to manage if data is expressed in fewer digits. To make this possible, other numbering systems were developed that contain more digits in their system. This allows the same information to be expressed using fewer digits.

Our discussion will break down as follows:

## 1. Decimal Numbering System

We are most familiar with the decimal number system, which is a base-10 system. This system is natural to us because we have 10 fingers on our hands, and we use our fingers for counting. This system is based in 10 digits, zero to nine. In this system, each digit in the number represents a power of 10 . The far-right digit represents the " 1 s " which can be thought of as $10^{\wedge} 0$. The next digit to the left represents the " 10 s ," which can be thought of as $10^{\wedge} 1$. As we continue to the left, the next digits represent the "hundreds" $\left(10^{\wedge} 2\right)$, the "thousands" (10^3), and so on.
$\rightarrow$ EXAMPLE In the decimal numbering system, the number 1010 contains four digits, and each digit corresponds to a power of 10 . We can break down 1010 into four digits $-1,0,1,0-$ and associate each digit with its corresponding power of $10:(1 \times 1000)+(0 \times 100)+(1 \times 10)+(0 \times 1)$. If we add these numbers, we get the value 1010 .

## - TERM TO KNOW

## Decimal Number System

Base-10 numbering in which each column in the number represents a power of 10; includes the digits

## 2. Binary Numbering System

Computers primarily use the base-two numbering system, also known as thebinary number system. This system is based on two digits: 0 and 1 . In this system, each digit in the number represents a power of two. The far-right digit represents the " 1 s " which can be thought of as $2^{\wedge} 0$. The next digit to the left represents the " 2 s " which can be thought of as $2^{\wedge} 1$. As we continue to the left, the next digits represent the "fours" ( $\left.2^{\wedge} 2\right)$, the "eights" (2^3), and so on.
$\rightarrow$ EXAMPLE In the binary number system, the number 1010 contains four digits, and each digit corresponds to a power of two. We can break down 1010 into the four digits $-1,0,1,0-$ and associate each digit with its corresponding power of two: $(1 \times 8)+(0 \times 4)+(1 \times 2)+(0 \times 1)$. In base-10, this evaluates to 10.

## - TERM TO KNOW

## Binary Number System

Base two numbering system used by computers to work with data; includes the digits 0 and 1.

## 3. Octal Numbering System

The octal number system is based on eight digits (zero through seven). In this system, each digit in the number represents a power of eight. The far-right digit represents the " $1 \mathrm{~s}^{\prime \prime}\left(8^{\wedge} 0\right)$. The next digit to the left represents the "eights" ( $8^{\wedge 1} 1$. As we continue to the left, the next digits represent $8^{\wedge} 2$ (which is 64 ), $8^{\wedge} 3$ (which is 512), and so on.
$\rightarrow$ EXAMPLE In the octal numbering system, the number 1010 contains four digits, and each digit corresponds to a power of eight. We can break down 1010 into the four digits $-1,0,1,0-$ and associate each digit with its corresponding power of eight: $(1 \times 512)+(0 \times 64)+(1 \times 8)+(0 \times 1)$. In base10 , this evaluates to 520 .

## - TERM TO KNOW

## Octal Number System

Numbering system based on eight digits; includes the digits zero through seven.

## 4. Hexadecimal Numbering System

Computers also use a hexadecimal number system for some tasks, such as defining color. Hexadecimal is a numbering system based on 16 digits (hex meaning six, and decimal meaning 10). The first 10 digits are the numbers zero through nine, and because we don't have any single digit numbers to represent 10 through 16, we use the first six letters of the alphabet, $A$ through $F$. In this system, each digit in the number represents a power of 16. The far-right digit represents the "1s" (16^0). The next digit to the left represents the "16s" (16^1). As we continue to the left, the next digits represent $16^{\wedge} 2$ (which is 256 ), $16^{\wedge} 3$, (which is 4096 ), and so on.
$\rightarrow$ EXAMPLE In the hexadecimal numbering system, the number 1010 contains four digits, and each digit corresponds to a power of 16 . We can break down 1010 into the four digits $-1,0,1,0-$ and associate each digit with its corresponding power of 16: $(1 \times 4096)+(0 \times 256)+(1 \times 16)+(0 \times 1)$. In base-10, this evaluates to 4112.

## - TERM TO KNOW

## Hexadecimal Number System

A numbering system based on 16 digits; includes the digits zero through nine and $A$ through $F$.

## v <br> SUMMARY

Numbering systems define how numbers are represented, and they can be used to define how data is processed. Computers represent data primarily using the binary numbering system. However, other number systems can also be used to represent data. Common number systems, such as octal and hexadecimal, can make it easier and quicker to write and manage data by using a smaller number of digits.

Source: Derived from "Information Systems for Business and Beyond" by David T. Bourgeois. Some sections removed for brevity.
https://www.saylor.org/site/textbooks/Information\ Systems\ for\ Business\ and\ Beyond/Text book.html\#_Chapter2:_What

## TERMS TO KNOW

## Binary Number System

Base-two numbering system used by computers to work with data; includes the digits 0 and 1 .

## Decimal Number System

Base-ten numbering in which each column in the number represents a power of ten; includes the digits 0-9.

## Hexadecimal Number System

A numbering system based on sixteen digits; includes the digits 0-9 and A-F.

## Numbering System

Method of representing numbers of a certain type.

## Octal Number System

Numbering system based on eight digits; includes the digits 0-7.

