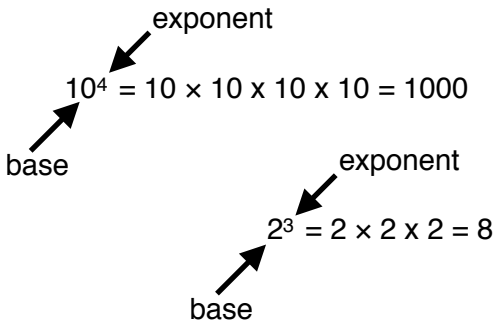
# Binary & Decimal Guide

The **decimal** number system (also called base 10) represents numeric values using ten different symbols (0, 1, 2, 3, 4, 5, 6, 7, 8, 9). It is the system we use!

The **binary** number system (also called base 2) represents numeric values using two different symbols (0 and 1). It is the system used internally by almost all modern computers and computer-based devices. This is because computers have circuits which are either OFF or ON, which gives them two states to work from to make calculations and run processes.

**Bases & Exponents**




**Any number can be expressed in decimal and binary!**

Breaking down a **decimal** number:

| **5** | **4** | **3** | **8** |
|---|---|---|---|
| ⇓ | ⇓ | ⇓ | ⇓ |
| $10^3$ | $10^2$ | $10^1$ | $10^0$ |
| 1000 | 100 | 10 | 1 |

$= \mathbf{5}(10^3) + \mathbf{4}(10^2) + \mathbf{3}(10^1) + \mathbf{8}(10^0)$
$= \mathbf{5}(1000) + \mathbf{4}(100) + \mathbf{3}(10) + \mathbf{8}(1)$
$= \mathbf{5}000 + \mathbf{4}00 + \mathbf{3}0 + \mathbf{8}$
$= \mathbf{5438}$

Converting **binary** to **decimal** number:

| **1** | **0** | **1** | **1** | **0** |
|---|---|---|---|---|
| ⇓ | ⇓ | ⇓ | ⇓ | ⇓ |
| $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| 16 | 8 | 4 | 2 | 1 |

$= \mathbf{1}(2^4) + \mathbf{0}(2^3) + \mathbf{1}(2^2) + \mathbf{1}(2^1) + \mathbf{0}(2^0)$
$= \mathbf{1}(16) + \mathbf{0}(8) + \mathbf{1}(4) + \mathbf{1}(2) + \mathbf{0}(1)$
$= 16 + 0 + 4 + 2 + 0$
$= 22$

Converting **decimal** to **binary** number:

Decimal number (to convert): 22

What is largest $2^x$ that fits in 22?

$2^0 = 1$
$2^1 = 2$
$2^2 = 4$
$2^3 = 8$
☛ $2^4 = 16$ ☚
$2^5 = 32$

Place a 1 in that spot

| **1** | **0** | **0** | **0** | **0** |
|---|---|---|---|---|
| $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| 16 | 8 | 4 | 2 | 1 |

Subtract: 22 – 16 = 6

We have 6 left over

What is largest $2^x$ that fits in 6?

$2^0 = 1$
$2^1 = 2$
☛ $2^2 = 4$ ☚
$2^3 = 8$
$2^4 = 16$
$2^5 = 32$

Place a 1 in that spot

| **1** | **0** | **1** | **0** | **0** |
|---|---|---|---|---|
| $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| 16 | 8 | 4 | 2 | 1 |

Subtact: 6 – 4 = 2

We have 2 left over

What is largest $2^x$ that fits in 2?

$2^0 = 1$
☛ $2^1 = 2$ ☚
$2^2 = 4$
$2^3 = 8$
$2^4 = 16$
$2^5 = 32$

Place a 1 in that spot

| **1** | **0** | **1** | **1** | **0** |
|---|---|---|---|---|
| $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| 16 | 8 | 4 | 2 | 1 |

Subtract: 2 – 2 = 0
We're done!

# Decoding Binary Music

*Decode the secret messages in the music!*

**Part 1: Fill in the table**

| Decimal Number | Binary Number | | | | |
|---|---|---|---|---|---|
| | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| | 16 | 8 | 4 | 2 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | 0 | 1 | 0 | 0 | 0 |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |
| 17 | | | | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |
| 21 | | | | | |
| 22 | 1 | 0 | 1 | 1 | 0 |
| 23 | | | | | |
| 24 | | | | | |
| 25 | | | | | |
| 26 | | | | | |

**Part 2: Decode the messages**

1) Go to the following website:

   https://estemestemsquad.weebly.com/computer-science.html

2) Click song (example: "Song 1") to decode

3) Transcribe song in chunks of 5 notes

   High note ⇒ 1

   Low note ⇒ 0

   Example: high-low-high-high-low ⇒ 10110

4) Convert binary numbers to decimal numbers using your table (on the left)

   Example: 10110 ⇒ 22

5) Decode decimal number using key (below)

   Example: 22 ⇒ V

6) Write down the secret messages!

**Decoding Key**

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| space | A | B | C | D | E | F | G | H |
| | | | | | | | | |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| I | J | K | L | M | N | O | P | Q |
| | | | | | | | | |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| R | S | T | U | V | W | X | Y | Z |

*Binary joke: There are 10 kinds of people in the world: those who understand binary and those who don't.*