

## Binary-Decimal Conversions

When making use of binary numbers (as you'll learn over the next few classes), it becomes necessary to convert base-10 (decimal) numbers into binary, and vice versa. Today you'll learn how to perform these conversions.

### I. Binary-to-Decimal Conversion

Let's do these together:

$$\begin{array}{r} 526 \\ \underline{10} \quad \underline{10} \quad \underline{1} \\ 100 \quad 10 \quad 1 \end{array} \quad \{0, 1, 2, \dots, 9\}$$

- Example #1: Convert  $1010_2$  to base-10.

$$\begin{array}{r} 1 \\ \underline{2} \\ 2 \end{array} \quad \begin{array}{r} 0 \\ \underline{2} \\ 4 \end{array} \quad \begin{array}{r} 1 \\ \underline{2} \\ 2 \end{array} \quad \begin{array}{r} 0 \\ \underline{2} \\ 1 \end{array} = 10$$

- Example #2:  $1001_2 = \underline{\quad}_{10}$

$$\begin{array}{r} 1 \\ \underline{8} \\ 8 \end{array} \quad \begin{array}{r} 0 \\ \underline{4} \\ 4 \end{array} \quad \begin{array}{r} 0 \\ \underline{2} \\ 2 \end{array} \quad \begin{array}{r} 1 \\ \underline{1} \\ 1 \end{array} = 9$$

- Example #3: Convert  $1001\ 0011_2$  to an equivalent decimal number.

$$\begin{array}{r} 1 \\ \underline{128} \\ 128 \end{array} \quad \begin{array}{r} 0 \\ \underline{64} \\ 64 \end{array} \quad \begin{array}{r} 0 \\ \underline{32} \\ 32 \end{array} \quad \begin{array}{r} 1 \\ \underline{16} \\ 16 \end{array} \quad \begin{array}{r} 0 \\ \underline{8} \\ 8 \end{array} \quad \begin{array}{r} 0 \\ \underline{4} \\ 4 \end{array} \quad \begin{array}{r} 1 \\ \underline{2} \\ 2 \end{array} \quad \begin{array}{r} 1 \\ \underline{1} \\ 1 \end{array} = 147$$

Exercises: Convert the following binary numbers into equivalent decimal numbers.

1.  $0\ 0\ 0\ 0 = 0$

2.  $0\ 0\ 0\ 1 = 1$

3.  $\begin{array}{r} 1 \\ 8 \end{array} \begin{array}{r} 0 \\ 4 \end{array} \begin{array}{r} 1 \\ 2 \end{array} \begin{array}{r} 1 \\ 1 \end{array} = 11$

4.  $\begin{array}{r} 1 \\ 8 \end{array} \begin{array}{r} 1 \\ 4 \end{array} \begin{array}{r} 1 \\ 2 \end{array} \begin{array}{r} 1 \\ 1 \end{array} = 15$

5.  $\begin{array}{r} 0 \\ 128 \end{array} \begin{array}{r} 1 \\ 64 \end{array} \begin{array}{r} 0 \\ 32 \end{array} \begin{array}{r} 0 \\ 16 \end{array} \quad \begin{array}{r} 0 \\ 8 \end{array} \begin{array}{r} 1 \\ 4 \end{array} \begin{array}{r} 1 \\ 2 \end{array} \begin{array}{r} 1 \\ 1 \end{array} = 71$

6.  $\begin{array}{r} 1 \\ 128 \end{array} \begin{array}{r} 0 \\ 64 \end{array} \begin{array}{r} 0 \\ 32 \end{array} \begin{array}{r} 1 \\ 16 \end{array} \quad \begin{array}{r} 0 \\ 8 \end{array} \begin{array}{r} 0 \\ 4 \end{array} \begin{array}{r} 1 \\ 2 \end{array} \begin{array}{r} 0 \\ 1 \end{array} = 146$

7.  $\begin{array}{r} 1 \\ 128 \end{array} \begin{array}{r} 1 \\ 64 \end{array} \begin{array}{r} 1 \\ 32 \end{array} \begin{array}{r} 1 \\ 16 \end{array} \quad \begin{array}{r} 0 \\ 8 \end{array} \begin{array}{r} 0 \\ 4 \end{array} \begin{array}{r} 0 \\ 2 \end{array} \begin{array}{r} 0 \\ 1 \end{array} = 240$

8.  $\begin{array}{r} 1 \\ 128 \end{array} \begin{array}{r} 1 \\ 64 \end{array} \begin{array}{r} 1 \\ 32 \end{array} \begin{array}{r} 1 \\ 16 \end{array} \quad \begin{array}{r} 0 \\ 8 \end{array} \begin{array}{r} 0 \\ 4 \end{array} \begin{array}{r} 0 \\ 2 \end{array} \begin{array}{r} 1 \\ 1 \end{array} = 241$

## II. Decimal-to-Binary Conversion

$11_{10}$  eleven       $11_2$  binary for 3

Let's do these together:

- Example #1: Convert 5 to binary.

"consumption" method

$$\begin{array}{r} -4 \\ 1 \\ -1 \\ \hline 0 \end{array} \checkmark \quad \frac{0}{8} \quad \frac{1}{4} \quad \frac{0}{2} \quad \frac{1}{1}$$

- Example #2: Convert 15 to base-2.

$$\begin{array}{r} -8 \\ 7 \\ -4 \\ 3 \\ -2 \\ 1 \end{array} \quad \frac{0}{16} \quad \frac{1}{8} \quad \frac{1}{4} \quad \frac{1}{2} \quad \frac{1}{1}$$

- Example #3:  $26_{10}$  to binary.

$$\frac{0}{32} \quad \frac{1}{16} \quad \frac{1}{8} \quad \frac{0}{4} \quad \frac{1}{2} \quad \frac{0}{1}$$

- Example #4:  $108_{10} = \underline{1101100}_2$

$$\begin{array}{r} -64 \\ 44 \\ -32 \\ 12 \end{array} \quad \frac{0}{128} \quad \frac{1}{64} \quad \frac{1}{32} \quad \frac{0}{16} \quad \frac{1}{8} \quad \frac{1}{4} \quad \frac{0}{2} \quad \frac{0}{1}$$

Exercises: Convert the given decimal numbers into binary.

(1)  $6 = \underline{\quad} \underline{\quad} \underline{\quad} \underline{\quad}$

(2)  $9$

(3)  $16$

(4)  $26$

(5)  $31$

(6)  $32$

(7)  $59$

(8)  $65$   
 $2^5 = 32$  (0 → 31)       $2^7 = 128$   
 $2^6 = 64$  (0 → 63)       $2^8 = 256$  (0 → 255)

→ (9)  $253$        $\underline{1} \underline{1} \underline{1} \underline{1} \quad \underline{1} \underline{1} \underline{0} \underline{1}$   
 $\quad \quad \quad \quad \quad \quad \quad \quad \frac{1}{8} \quad \frac{1}{4} \quad \frac{0}{2} \quad \frac{1}{1}$

(10)  $257$        $1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1$

(11)  $513$

(12)  $982$