Binary, Quaternary, Octary, Denary and Hexadecimal number systems

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There are some methods of handling various number system not described in the textbook.

(1) Binary → Denary

Rule : Start for the right-most digit, multiply by 2 and add to adjacent digit on its left. Continue to do this until the left-most digit.

e.g. Change **101101**$_{(2)}$ to denary system.

(1) $1 \times 2 + 0 = 2$

(2) $2 \times 2 + 1 = 5$

(3) $5 \times 2 + 1 = 11$

(4) $11 \times 2 + 0 = 22$

(5) $22 \times 2 + 1 = 45$ $\quad\therefore\quad 101101_{(2)} = 45_{(10)}$

(2) Quaternary → Denary

Rule : Start for the right-most digit, multiply by 4 and add to adjacent digit on its left. Continue to do this until the left-most digit.

e.g. Change **13201**$_{(4)}$ to denary system.

(1) $1 \times 4 + 3 = 7$

(2) $7 \times 4 + 2 = 30$

(3) $30 \times 4 + 0 = 120$

(4) $120 \times 4 + 1 = 481$ $\quad\therefore\quad 13201_{(4)} = 481_{(10)}$

(3) Octary → Denary

Rule : Start for the right-most digit, multiply by 8 and add to adjacent digit on its left. Continue to do this until the left-most digit.

e.g. Change **13746**$_{(8)}$ to denary system.

(1) $1 \times 8 + 3 = 11$

(2) $11 \times 8 + 7 = 95$

(3) $95 \times 8 + 4 = 764$

(4) $764 \times 8 + 6 = 6118$ $\quad\therefore\quad 13746_{(8)} = 6118_{(10)}$

(4) Hexadecimal → Denary

Rule : Start for the right-most digit, multiply by 16 and add to adjacent digit on its left. Continue to do this until the left-most digit.

e.g. Change **A2D7**$_{(16)}$ to denary system.

(1) **10** × 16 + **2** = 162 (Note : $A_{(16)} = 10_{(10)}$)

(2) 162 × 16 + **13** = 2605 (Note : $D_{(16)} = 13_{(10)}$)

(3) 2605 × 16 + **7** = 41687 ∴ $A2D7_{(16)} = 41687_{(10)}$

(5) Binary → Quaternary

Rule : Starting from the left-most, divide the binary number into groups of **two** digits.
Change binary number in each group to a **denary** number.

e.g. Change **1001101**$_{(2)}$ to quaternary system.

1|00|11|01$_{(2)}$

= **1| 0 | 3 | 1**$_{(4)}$

(6) Binary → Octary

Rule : Starting from the left-most, divide the binary number into groups of **three** digits.
Change binary number in each group to a **denary** number.

e.g. Change **1001101**$_{(2)}$ to octary system.

1|001|101$_{(2)}$

= **1| 1| 5**$_{(8)}$

(7) Binary → Hexadecimal

Rule : Starting from the left-most, divide the binary number into groups of **four** digits.
Change binary number in each group to a **denary** number (but express in hexadecimal)

e.g. Change **1001101**$_{(2)}$ to hexadecimal system.

100|1101$_{(2)}$

= **4| D**$_{(16)}$

Note that you may use **(1)** above to help you to calculate.

Also note that $1101_{(2)} = 13_{(10)} = D_{(16)}$.

(8) Quaternary → Binary , Octary → Binary , Hexadecimal →Binary

You can do the reverse way of **(4), (5), (6)** .

e.g. **(a)** 3 | 2| 1| $0_{(4)}$ **(b)** 5| 2| $1_{(8)}$ **(c)** B| 4| $7_{(16)}$

= 11 | 10 | 01 | 00 $_{(2)}$ = 101|010|001$_{(2)}$ = 1011|0100|0111$_{(2)}$

(9) Quaternary → Hexadecimal

Of course you can use the scheme " **Quaternary → Denary → Hexadecimal**" or
" **Quaternary → Binary → Hexadecimal**"

But you can also use:

Rule : Starting from the left-most, divide the quaternary number into groups of **two** digits.

Change quaternary number in each group to a **denary** number. (but express in hexadecimal)

e.g. $3\,2|\,1\,0_{(4)}$

$= E|\ \ 4_{(16)}$ Note : $32_{(4)} = 14_{(10)} = E_{(16)}$.

(10) Hexadecimal→ Quaternary

Do in the reverse direction of **(8)** :

e.g. $A|\ \ B|\ C|\ \ 1_{(16)}$

$= 22|\ 23|\ 30|\ 01_{(4)}$ Note : $A_{(16)} = 10_{(10)} = 22_{(4)}$.

(11) Octary ↔Hexadecimal, Octary ↔ Quaternary

Use either : **(a) Octary ↔Binary↔Hexadecimal, Octary ↔Binary ↔ Quaternary**

(b) Octary ↔Denary↔Hexadecimal, Octary ↔ Denary↔Quaternary

Sometimes method **(a)** is better!

e.g 1. Change $1765_{(8)}$ to Hexadecimal number.

$1765_{(8)} = 1|111|110|101_{(2)} = 11|1111|0101_{(2)} = 3|F|5_{(12)}$

e.g. 2. Change $123123_{(4)}$ to Octary number.

$123123_{(4)} = 1|10|11|01|10|11_{(2)} = 11|011|011|011_{(2)} = 3333_{(8)}$

(12) Binary → Denary

If the binary number is too long, try to do via **Quaternary** , **Octary** or even **Hexadecimal** may sometimes be faster. Compare :

$1110110110001_{(2)} = 2^{12} + 2^{11} + 2^{10} + 2^8 + 2^7 + 2^5 + 2^4 + 2^0$

$= 4096 + 2048 + 1024 + 256 + 128 + 32 + 16 + 1$, or use **(1)**

$= 7601_{(10)}$

$1|11|01|10|11|00|01_{(2)} = 1312301_{(4)}$, by **(5)**

$= 1 \times 4^6 + 3\times4^5 + 1 \times4^4 + 2\times4^3 + 3\times4^2 + 1$, or use **(2)**

$= 4096 + 3072 + 256 + 128 + 48 + 1 = 7601_{(10)}$

$1|11|01|10|11|00|01_{(2)} = 1|31|23|01_{(4)}$

$= 1|\ D|\ B|\ 1_{(16)}$

$= 1 \times 16^3 + 13 \times 16^2 + 11 \times 16 + 1$,or use **(4)**

$= 4096 + 3328 + 176 + 1$

$= 7601_{(10)}$

$1|110|110|110|001_{(2)} = 16661_{(8)}$, by **(6)**

$= 1 \times 8^4 + 6 \times8^3 + 6 \times 8^2 + 6 \times 8 + 1$,or use **(3)**

$= 4096 + 3072 + 384 + 48 + 1$

$= 7601_{(10)}$