1 Information representation – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	**中文**	**Write it 3 times** (English)		
bit	位			
byte	字节			
binary	二进制			
denary	十进制			
number system	数制			
place value	位值			
hexadecimal	十六进制			
nibble	半字节			
remainders	余数			
two's complement	补码			
sign bit	符号位			
overflow	溢出			
BCD	二进码十进数			
character set	字符集			

Recall

You already started this at IGCSE. Bring it with you:

- A **bit** 位 is a single 0 or 1. Eight bits make one **byte** 字节.
- You used **binary** 二进制 (base 2) and **denary** 十进制 (base 10, the everyday numbers), and converted between them.
- At AS we add three new ideas: **hexadecimal**, **negative** numbers in binary, and **BCD**.

Nothing here is harder than IGCSE — it builds straight on the binary you already know.

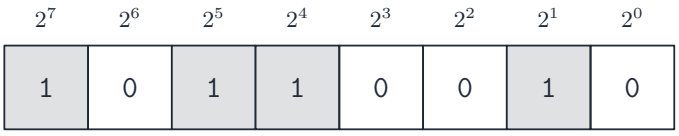
New ideas

Read these first. Each idea has a worked example. Then do the Practice below.

■ 1 Number bases and the general method

A **number system** 数制 uses a fixed set of digits, and a digit's value depends on its **place value** 位值 (which column it is in). Binary is base 2, denary base 10, and **hexadecimal** 十六进制 base 16. Four bits make a **nibble** 半字节. The two methods below work for **any** base — learn these, not a binary-only trick.

Any base → denary. Multiply each digit by the base raised to its position (count positions from 0 at the right), then add.

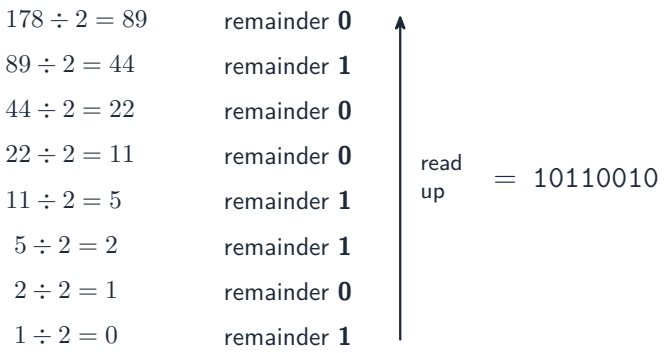


$$(1\times2^7)+(1\times2^5)+(1\times2^4)+(1\times2^1)$$
$$= 128+32+16+2 = \mathbf{178}$$

$$10110010_2 = (1\times2^7)+(1\times2^5)+(1\times2^4)+(1\times2^1) = 128+32+16+2 = 178.$$

For hexadecimal you use powers of 16 instead — exactly the same method.

Denary → any base. Divide by the base again and again; the **remainders** 余数, read from bottom to top, are the digits.



To get hexadecimal instead, divide by 16 the same way.

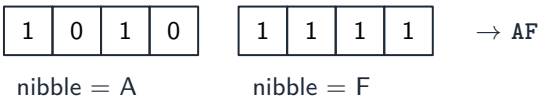
■ 2 Working with hexadecimal

Hexadecimal digits are 0–9, then A, B, C, D, E, F for 10 to 15. It is a short way to write binary, so programmers use it for memory addresses and colour codes.

Hex → denary is the same powers method, with base 16:

$$0\text{xB2} = (11\times16^1) + (2\times16^0) = 176 + 2 = 178.$$

Shortcut (binary ↔ hex): group the bits into nibbles of four from the right, and convert each nibble on its own.




```
1011 0010   ->   B   2      so 10110010 = 0xB2
```

■ 3 Negative numbers: two's complement

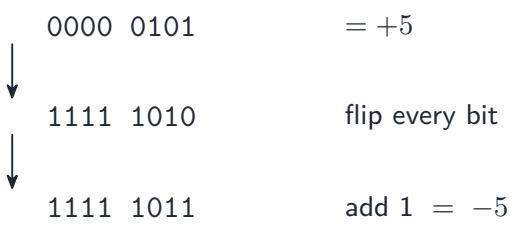
To store a negative whole number we use **two's complement** 补码. The left-most bit becomes the **sign bit** 符号位: 0 means positive, 1 means negative.

To write a negative number (8 bits): write the positive value, flip every bit, then add 1.

Worked example — store −5:

step	bits
+5	0000 0101
flip every bit	1111 1010
add 1	1111 1011

So −5 is 11111011. If a sum needs more bits than the register has, you get **overflow** 溢出 and the answer is wrong.



Watch out: flip the bits *then add 1* — just once. Flipping a second time only takes you back to where you started.

4 Binary Coded Decimal (BCD)

In **BCD** 二进码十进数 each denary digit is written as its own 4-bit nibble. It keeps the digits separate (useful for clocks and calculators).

Worked example: 59 in BCD is 0101 1001 — that is 5 then 9, **not** the pure binary 00111011.

5 Text is data too

Letters are stored with a **character set** 字符集 — a table giving each symbol a number (for example, ASCII stores `A` as 65). The computer still stores only bits; the character set says what they mean.

Practice

Try these in order. The methods are all above. Show your working.

2.1 Convert the denary number 45 to an 8-bit binary number. [2]

2.2 Convert the binary number 00110100 to denary. [1]

2.3 Convert the binary number 11101010 to hexadecimal. [2]

2.4 Convert the hexadecimal number 2F to denary. [1]

2.5 Using 8-bit two's complement, write the number −12. Show each step. [3]

2.6 Write the denary number 72 in BCD. [2]

2.7 Give one reason programmers use hexadecimal instead of long binary numbers. [1]

2.8 In 8-bit two's complement, explain *why* the left-most bit alone tells you whether the number is negative. [2]