

1.2 Data representation

Name: _____ Class: _____ Date: _____ **Total: 20 marks**

KEY WORDS binary • hexadecimal • two’s complement • Unicode
• colour depth • sample rate

Objective

Build the skills to answer exam questions on **data representation** – binary, hexadecimal, two’s complement, and the size of text, image and sound files.

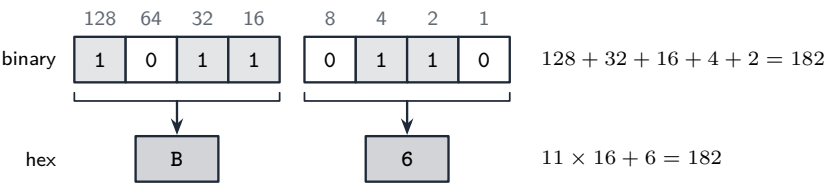
You must be able to:

- convert between denary, **binary** and **hexadecimal**
- write a negative integer in **two’s complement**
- explain how text is stored with ASCII and **Unicode**
- calculate image and sound file sizes from **colour depth**, **sample rate** and bit depth

1 Key knowledge and worked examples

Study these first. Each one shows the method for a question type used later.

■ **Worked example: conversions**



1. Binary to denary: add the place values under each 1: $128 + 32 + 16 + 4 + 2 = 182$.
2. Binary to hex: split into groups of 4: $1011 = 11 = \text{B}$, $0110 = 6$: **B6**.
3. Hex to denary: $11 \times 16 + 6 = 182$.
4. With n bits there are 2^n values: 8 bits give 0 to 255.

■ **Worked example: two’s complement**

Write -42 in 8 bits.

1. $42 = 00101010$.
2. Flip every bit: 11010101 .
3. Add 1: **11010110**.
4. Check with the place value -128 : $-128 + 64 + 16 + 4 + 2 = -42$.

■ **Worked example: file sizes**

image size = width × height × colour depth

$1920 \times 1080 \times 24 = 49\,766\,400 \text{ bits} \div 8 = 6\,220\,800 \text{ bytes}$

sound size = sample rate × bit depth × channels × time

$44\,100 \times 16 \times 2 \times 60 = 84\,672\,000 \text{ bits} \div 8 = 10\,584\,000 \text{ bytes}$

- Divide bits by 8 for bytes; 1 MB = 10^6 bytes, 1 MiB = 2^{20} bytes.
- ASCII: 7 bits, 128 characters. Unicode: up to 32 bits, every writing system.

2 Practice

2.1 Convert to denary: (i) 01101001; (ii) 3C. [2]

2.2 Convert 154 to (i) 8-bit binary; (ii) hexadecimal. [2]

2.3 Write -25 in 8-bit two’s complement. [2]

2.4 State the largest and smallest values in 8-bit two’s complement. [1]

3 Exam-style questions

3.1 How many different values can 10 bits represent? [1]

- ☐ A 10
- ☐ B 100
- ☐ C 512
- ☐ D 1024

3.2 What is 1111 0000 in hexadecimal? [1]

- ☐ A F0
- ☐ B 0F
- ☐ C FF
- ☐ D E0

3.3 Why does a Chinese text app use Unicode rather than ASCII? [1]

- ☐ A Unicode files are always smaller
- ☐ B ASCII has only 128 characters, too few for Chinese
- ☐ C ASCII cannot store numbers
- ☐ D Unicode needs no bits

3.4 A school records a 3-minute stereo announcement and takes a photo for its website.

(a) The recording uses a sample rate of 22 050 Hz and a bit depth of 16. Calculate its size in bytes. [3]

(b) State **two** ways to make the recording file smaller, and the effect of each on quality. [2]

(c) The photo is 1200×800 pixels with a colour depth of 24 bits. Calculate its size in megabytes ($1 \text{ MB} = 10^6 \text{ bytes}$). [3]

(d) Explain how the number of colours available changes if the colour depth is cut from 24 to 8 bits. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- (i) $64 + 32 + 8 + 1 = \mathbf{105}$
- (ii) $3 \times 16 + 12 = \mathbf{60}$

2.2

- (i) $154 = 128 + 16 + 8 + 2$: **10011010**
- (ii) 1001 1010: **9A**

2.3

- $25 = 00011001$, flipped 11100110
- add 1: **11100111**

2.4

- **127** and -128

3.1 D

- $2^{10} = 1024$

3.2 A

- $1111 = \text{F}$, $0000 = 0$

3.3 B

- Chinese needs thousands of characters

3.4

(a)

- $\text{size} = \text{sample rate} \times \text{bit depth} \times \text{channels} \times \text{time}$
- $22\,050 \times 16 \times 2 \times 180 = 127\,008\,000$ bits
- $\div 8 = \mathbf{15\,876\,000}$ bytes

(b)

- lower the sample rate: less accurate sound, high notes lost
- lower the bit depth, or record in mono: less detail or no stereo

(c)

- $\text{size} = \text{width} \times \text{height} \times \text{colour depth}$
- $1200 \times 800 \times 24 = 23\,040\,000$ bits = $2\,880\,000$ bytes
- **2.88 MB**

(d)

- 24 bits give 2^{24} , about 16.7 million colours
- 8 bits give only $2^8 = 256$ colours, so smooth shades look banded