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.

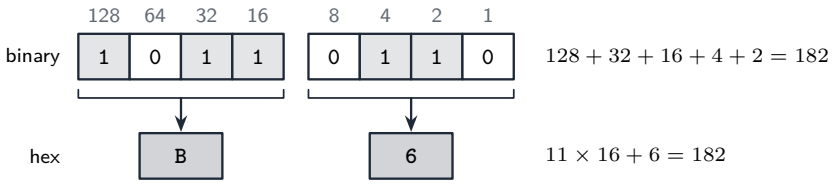
You must be able to:

- 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



$128 + 32 + 16 + 4 + 2 = 182$

$11 \times 16 + 6 = 182$

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` $= 11 =$ 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

$$\text{image size} = \text{width} \times \text{height} \times \text{colour depth}$$

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

$$\text{sound size} = \text{sample rate} \times \text{bit depth} \times \text{channels} \times \text{time}$$

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

- 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 MB = 10^6 bytes). [3]

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