Exercise walk-through

Text, sound and images ▪ 1.2

eXercise

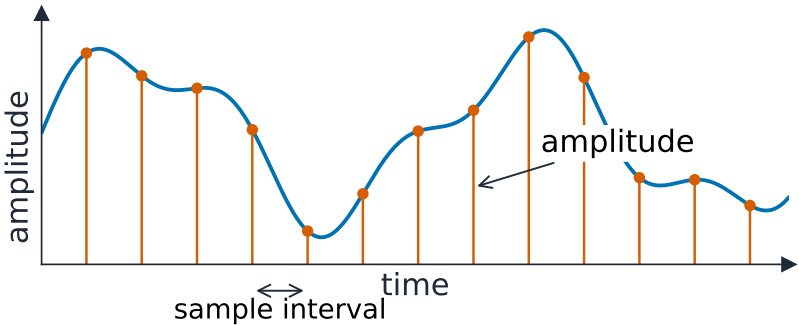
You must be able to

- compare ASCII and Unicode
- define sample rate, sample resolution, resolution and colour depth
- calculate image and sound file sizes

Method — Sampling and pixels

- **image bits** = width × height × colour depth. **sound bits** = sample rate × resolution × seconds.

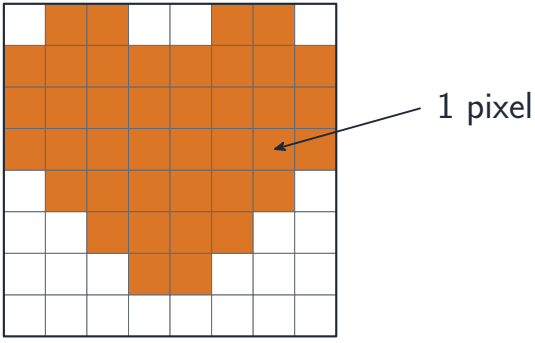
Method — Sampling and pixels



$$\text{sample rate} = \text{samples/s} \cdot \text{Nyquist} \geq 2f_{\max}$$

A sound wave sampled at regular intervals

Method — Sampling and pixels



resolution $= 8 \times 8$ pixels

An 8×8 pixel grid

Method — Text, sound and images: the same three questions

For every kind of data the exam asks the same things: how is it represented, what makes the file bigger, and what is the trade-off?

Text. Each character has a code. **ASCII** uses 7 bits, giving 128 characters, which is enough for English but not for other alphabets. **Unicode 统一码** uses more bits per character (16 or more), so it covers every writing system, emoji included, but the same text takes more storage.

Sound. The wave is **sampled**: its amplitude is measured at regular intervals.

- **Sampling rate 采样率** is the number of samples each second (in Hz or kHz). A higher rate follows the wave more closely, giving better quality and a larger file.
- **Sample resolution 采样分辨率** (bit depth) is the number of bits used per sample. More bits record the amplitude more accurately, again improving quality and increasing the file size.

Method — Text, sound and images: the same three questions

$$\text{file size (bits)} = \text{sampling rate} \times \text{sample resolution} \times \text{seconds} \times \text{channels}$$

Worked example. A 30-second mono recording is sampled at $44\,100$ Hz with a resolution of 16 bits. Size $= 44\,100 \times 16 \times 30 = 21\,168\,000$ bits $= 2\,646\,000$ bytes ≈ 2.6 MB. (Divide bits by 8 for bytes, then by 1024 for kibibytes, then by 1024 again for mebibytes.)

Images. A bitmap is a grid of **pixels** 像素.

- **Resolution** is the number of pixels, for example 1920×1080.
- **Colour depth** 颜色深度 is the number of bits per pixel; n bits give 2^n colours, so 8 bits give 256 colours and 24 bits give over 16 million.

Method — Text, sound and images: the same three questions

$$\text{file size (bits)} = \text{width} \times \text{height} \times \text{colour depth}$$

Worked example. An image of 800×600 pixels with a colour depth of 24 bits: $800 \times 600 \times 24 = 11\,520\,000$ bits $= 1\,440\,000$ bytes ≈ 1.4 MB. Doubling the colour depth doubles the file size; doubling both width and height multiplies it by four.

Practice 2.1 ▪ 2 marks

State the difference between ASCII and Unicode.

Solution 2.1

Method: Text, sound and images: the same three questions

Worked steps

ASCII uses fewer bits (7) and fewer characters **M1**; Unicode uses more bits and can represent many more characters/languages **A1**.

Practice 2.2 ▪ 1 mark

Define sample rate.

Solution 2.2

Worked steps

the number of samples taken each second B1.

Practice 2.3 ▪ 2 marks

Give one advantage and one disadvantage of Unicode compared with ASCII.

Solution 2.3

Method: Text, sound and images: the same three questions

Worked steps

Advantage: Unicode represents the characters of every writing system, not just English B1. Disadvantage: it uses more bits per character, so the same text takes more storage B1.

Practice 2.4 ▪ 3 marks

Calculate the file size, in bytes, of a 10-second mono sound recording sampled at 8000 Hz with a resolution of 8 bits.

Solution 2.4

Method: Text, sound and images: the same three questions

Worked steps

$8000 \times 8 \times 10 = 640\,000$ bits (M1)(M1); $640\,000 \div 8 = 80\,000$ bytes (A1).

Practice 2.5 ▪ 1 mark

State what happens to the file size of an image if its colour depth is increased from 8 bits to 16 bits.

Solution 2.5

Method: Text, sound and images: the same three questions

Worked steps

It doubles B1.

Exam-style 3.1 ▪ 1 mark

Increasing the colour depth of an image will:

A reduce the file size

B increase the file size and quality

C have no effect

D reduce the resolution

Solution 3.1

Method: Text, sound and images: the same three questions

A reduce the file size

B increase the file size and quality ✓

C have no effect

D reduce the resolution

Worked steps

B. A greater colour depth increases the file size (and quality).

Exam-style 3.2 ▪ 2 marks

An image is 200 × 100 pixels with a colour depth of 8 bits.
(a) Calculate the file size in bits.
(b) Convert your answer to bytes.

Solution 3.2

Method: Text, sound and images: the same three questions

Worked steps

(a) $200 \times 100 \times 8 = 160\,000$ bits **M1** **A1**.
(b) $160\,000 \div 8 = 20\,000$ bytes **B1**.

Exam-style 3.3 ▪ 2 marks

A sound is recorded for 20 seconds at a sample rate of 10 000 Hz with a sample resolution of 8 bits. Calculate the file size in bits.

Solution 3.3

Method: Text, sound and images: the same three questions

Worked steps

(a) The sampling rate is the number of samples taken each second B1; the sample resolution is the number of bits used to store each sample B1.
(b) $22\,050 \times 16 \times 60 = 21\,168\,000$ bits M1 M1; $\div 8 = 2\,646\,000$ bytes M1; $\div 1024 \div 1024 = 2.52$ MiB A1.
(c) The file size halves B1; the quality falls, because the samples follow the shape of the original wave less closely B1.
(d) $1200 \times 900 \times 24 = 25\,920\,000$ bits M1; $\div 8 = 3\,240\,000$ bytes M1; $\div 1024 \div 1024 = 3.09$ MiB A1.

Solution 3.3

(e) Each pixel has 24 bits, and each bit has two possible values B1; the number of combinations is $2^{24} = 16\,777\,216$ B1.
(f) ASCII has only 128 codes, which cover the English alphabet, digits and punctuation but no Chinese characters B1; Unicode uses more bits per character, so it has enough codes for every writing system, including Chinese B1.

Exam-style 3.3 ▪ 2 marks

A student records a podcast and takes a photograph for its cover.
(a) Explain what is meant by sampling rate and by sample resolution.
(b) The recording lasts 60 seconds, is mono, is sampled at $22\,050$ Hz and uses a resolution of 16 bits. Calculate the file size in mebibytes.
(c) The student halves the sampling rate. State the effect on the file size and on the sound quality.
(d) The cover photograph is 1200×900 pixels with a colour depth of 24 bits. Calculate its file size in mebibytes.
(e) Explain why a colour depth of 24 bits allows over 16 million different colours.
(f) The student's text file of show notes contains Chinese characters. Explain why it must use Unicode rather than ASCII.

Solution 3.3

Method: Text, sound and images: the same three questions

Worked steps

(a) The sampling rate is the number of samples taken each second B1; the sample resolution is the number of bits used to store each sample B1.
(b) $22\,050 \times 16 \times 60 = 21\,168\,000$ bits M1 M1; $\div 8 = 2\,646\,000$ bytes M1; $\div 1024 \div 1024 = 2.52$ MiB A1.
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