Exercise walk-through

Multimedia ▪ 1.2

eXercise

You must be able to

- describe how a **bitmap 位图** image is encoded, and calculate its file size
- explain how **resolution 分辨率** and **colour depth 颜色深度** affect quality and size
- describe how a **vector graphic 矢量图形** is encoded, and choose bitmap *or* vector for a task
- describe how sound is **sampled 采样**, and how the sampling rate and resolution affect quality and size

Method — Bitmap images and file size

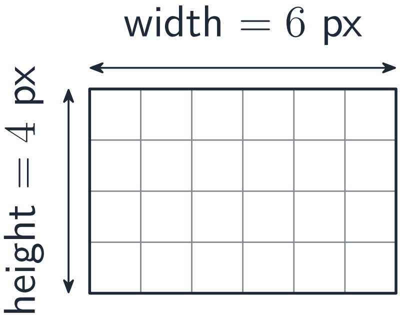
A **bitmap** image stores the colour of every **pixel 像素** in a grid. Two numbers describe it: the **resolution** (width × height in pixels) and the **colour depth** (bits per pixel). Multiply all three to get the size in bits.

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

Then $\div$ 8 for **bytes**, $\div$ 1024 for **KiB**, $\div$ 1024 again for **MiB**.
Example. A 200×150 image at 8 bits per pixel:

$$200 \times 150 \times 8 = 240\,000 \text{ bits} = 30\,000 \text{ bytes} = \frac{30\,000}{1024} \approx 29.3 \text{ KiB}.$$

Method — Bitmap images and file size



pixels $= 6 \times 4 = 24$

size $= 24 \times \mathbf{8} = \mathbf{192}$ bits

($\mathbf{8}$ $=$ colour depth, bits per pixel)

Method — Sound and file size

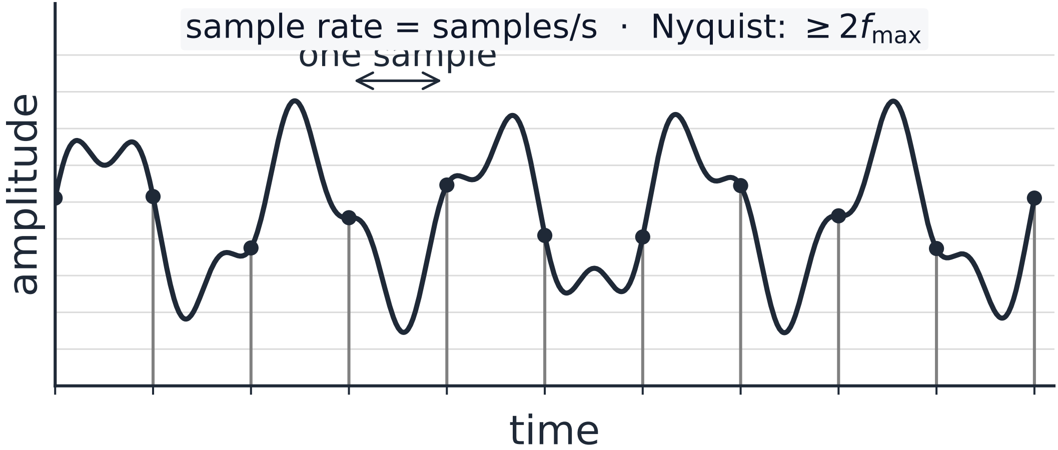
Sound is **sampled**: the wave's height (**amplitude 振幅**) is measured at regular time intervals. The **sampling rate 采样率** is how many samples per second (Hz); the **resolution** is how many bits store each sample.

$$\text{size (bits)} = \text{sampling rate} \times \text{resolution} \times \text{duration} \times \text{channels}$$

Example. A 5-second **mono** (1 channel) clip at 8000 Hz, 16-bit resolution:

$$8000 \times 16 \times 5 \times 1 = 640\,000 \text{ bits} = 80\,000 \text{ bytes} \approx 78.1 \text{ KiB}.$$

Method — Sound and file size



Method — Bitmap or vector?

A **vector graphic** stores the *instructions* to draw the image — geometric shapes (lines, curves, circles, polygons), each with attributes like position, size, colour and line width. The program draws ("renders") them at whatever size is needed, so a vector **scales without losing quality**. It cannot, however, capture the detail of a photograph.

Task	**Better choice**	**Why**
Photograph	**bitmap**	per-pixel detail can't be described as shapes
Logo, icon, road sign	**vector**	sharp at any size; small file
Engineering drawing	**vector**	exact geometry, scales precisely

Practice 2.1 ▪ 2 marks

State what **colour depth** means, and write the formula for a bitmap's file size.

Solution 2.1

Worked steps

Colour depth = the number of **bits used per pixel** B1. Size = width $\times$ height $\times$ colour depth B1.

Practice 2.2 ▪ 3 marks

Calculate the file size of a 1024×768 bitmap at 8 bits per pixel. Give your answer in **KiB**, showing your working.

Solution 2.2

Method: Bitmap images and file size

Worked steps

$1024 \times 768 \times 8 = 6\,291\,456$ bits **M1**; $\div 8 = 786\,432$ bytes, $\div 1024 =$ **768 KiB** **M1** **A1**.

Practice 2.3 ▪ 3 marks

A 30-second **mono** sound clip is sampled at 16 kHz (16 000 Hz) with 8-bit resolution. Calculate its file size in **KiB**.

Solution 2.3

Method: Sound and file size

Worked steps

$16\,000 \times 8 \times 30 \times 1 = 3\,840\,000$ bits M1; $\div 8 = 480\,000$ bytes, $\div 1024 = \mathbf{468.75}$ **KiB** M1 A1.

Practice 2.4 ▪ 1 mark

Give one reason a **vector** graphic is a good choice for a company logo.

Solution 2.4

Method: Bitmap or vector?

Worked steps

e.g. it stays **sharp at any size** (a logo is used large and small) / the file is small **B1**.

Exam-style 3.1 ▪ 3 marks

A photo is 1920×1080 pixels with a colour depth of 24 bits.

(a) Calculate the file size in **MiB**. Show your working.

(b) State **one** change to the image that would reduce its file size, and explain its effect on quality.

Solution 3.1

Method: Bitmap images and file size

Worked steps

(a) $1920 \times 1080 \times 24 = 49\,766\,400$ bits **M1**; $\div 8 \div 1024 \div 1024 \approx \mathbf{5.93}$ **MiB** **M1** **A1**.

(b) e.g. **lower the colour depth** (or resolution) $\rightarrow$ smaller file, but fewer colours / less detail **B1** **B1** *change, effect*.

Exam-style 3.2 ▪ 3 marks

A 3-minute song is recorded in **stereo** (2 channels), sampled at 44.1 kHz with 16-bit resolution.

(a) Calculate the file size in **MiB**. Show your working.

(b) Explain the effect on the recording of **halving** the sampling rate.

Solution 3.2

Method: Sound and file size

Worked steps

(a) $44\,100 \times 16 \times 180 \times 2 = 254\,016\,000$ bits M1; $\div 8 \div 1024 \div 1024 \approx$ **30.28 MiB** M1 A1.

(b) Fewer samples per second M1: the file is roughly **half the size**, but high-pitched sounds are lost / quality drops A1.

Exam-style 3.3 ▪ 2 marks

(a) State **two** pieces of data a vector graphic would store to describe a single circle.
(b) A museum scans old paintings to put online. Justify whether a bitmap or a vector format is the better choice.

Solution 3.3

Method: Bitmap or vector?

Worked steps

(a) Any two of: centre position (x, y); radius; line/fill colour; line width **B1** **B1**.
(b) **Bitmap** **B1** — a painting has continuous, per-pixel tonal detail that cannot be described as a few shapes **B1**.

Exam-style 3.4 ▪ 2 marks

Explain why a bitmap logo looks blocky when it is enlarged, but a vector logo stays sharp.

Solution 3.4

Method: Bitmap or vector?

Worked steps

A bitmap has a fixed number of pixels; enlarging it makes each pixel bigger, so the squares show **B1**. A vector stores shapes and is **re-drawn** at the new size, so edges stay smooth **B1**.

Exam-style 3.6 ▪ 4 marks

A school records a 45-second announcement and also stores a scanned photograph of the school badge.

(a) The sound is sampled at 44.1 kHz with a sample resolution of 16 bits, in **stereo** (two channels). **Estimate** the file size in **mebibytes**, showing your working.

(b) The recording is re-sampled at 22.05 kHz with an 8-bit resolution. **Describe** the effect on the file size and on the **accuracy** of the recording.

(c) The badge is stored as a bitmap 600 pixels wide and 400 pixels high, using a colour depth of 24 bits. **Estimate** the file size in **kibibytes**.

(d) **Explain** why the actual file on disk is **larger** than your answer to (c).

(e) The badge uses only 6 distinct colours in large flat areas. **Explain** how **run-length encoding** would compress it, and **state** why it works far better on this image than on a photograph.

Solution 3.6

Method: Bitmap images and file size

Worked steps

(a) Bits $= 44\,100 \times 16 \times 2 \times 45$ M1 M1 $= 6.35 \times 10^7$ bits; bytes $= \dfrac{6.35 \times 10^7}{8} = 7.94 \times 10^6$ M1; mebibytes $= \dfrac{7.94 \times 10^6}{1\,048\,576} = 7.6$ MiB A1.
(b) Halving both the sampling rate and the resolution divides the size by **four**, to about 1.9 MiB B1. The lower rate captures fewer samples per second, so high frequencies are lost B1; the smaller resolution records each sample more coarsely, so the waveform is a poorer match to the original and quantisation noise increases B1.
(c) Bits $= 600 \times 400 \times 24$ M1 $= 5\,760\,000$; bytes $= 720\,000$ M1; kibibytes

Solution 3.6

$$= \frac{720\,000}{1024} = 703 \text{ KiB}$$ A1.

(d) The file also stores **metadata** in a header — the dimensions, the colour depth, the file format B1 — and may include a colour palette or padding, none of which the pixel calculation counts B1.

(e) Run-length encoding replaces each run of identical pixels with **one colour value and a count** B1. Large flat areas of one colour become very short records, so the file shrinks a great deal B1. In a photograph adjacent pixels almost always differ slightly B1, so runs are one pixel long and the encoding stores a count beside every pixel, which can make the file **bigger** than the original B1.