Bitmap images

2.2.2 · Data · revision notes

How bitmap images are stored in binary as a grid of pixels, and how resolution and colour depth affect image quality and file size. Expect definitions, questions on reading or writing pixel codes, 'explain the effect' questions and file size expressions.

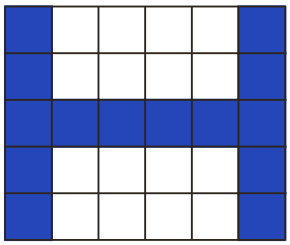
Key facts

- Pixel = the smallest single-coloured element of a bitmap image
- Resolution = number of pixels (width × height)
- Image size in bits = width × height × colour depth
- More pixels or more bits per pixel: better quality, bigger file
- Colour depth = number of bits per pixel
- Number of colours = $2^{\text{colour depth}}$
- bits ÷ 8 = bytes; bytes ÷ 1024 = KiB; KiB ÷ 1024 = MiB

Notes

Pixels and binary

- A **bitmap image** is a grid of tiny dots called **pixels** (picture elements). Each pixel is a single colour.
- The colour of each pixel is stored as a binary code, and the codes are stored in order, row by row.
- In a black-and-white image, 1 bit per pixel is enough, e.g. 1 = black and 0 = white.



1 bit per pixel

100001
100001
111111
100001
100001
stored row by row

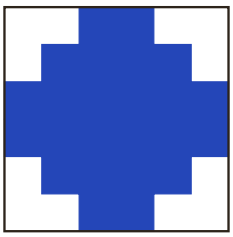
A two-colour bitmap needs 1 bit per pixel: here 1 = coloured, 0 = blank.
A black-and-white image works the same way

Colour depth

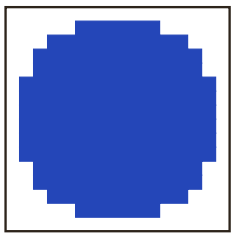
- **Colour depth** is the number of bits used to store the colour of each pixel.
- n bits give 2^n colours: 1 bit gives 2, 2 bits give 4, 4 bits give 16, 8 bits give 256 and 24 bits give 16,777,216.
- A greater colour depth gives more colours, so the image looks more realistic, but the file is larger.
- If every code is already used, adding one more colour needs 1 extra bit per pixel, which doubles the number of colours available. Grade 6+ only

Resolution

- **Resolution** is the number of pixels in an image, usually given as width × height, e.g. 800 × 600 pixels.
- A higher resolution means more pixels, so more detail and a sharper image, but a larger file.
- A low-resolution image looks blocky (pixelated) when it is enlarged.



6 × 6 = 36 pixels



16 × 16 = 256 pixels

Higher resolution: more pixels, more detail, but a bigger file

File size

- File size in bits = width × height × colour depth.
- Divide by 8 for bytes, then by 1024 for KiB and by 1024 again for MiB.
- Example: 256 × 128 pixels with a colour depth of 8 bits: 256 × 128 × 8 = 262,144 bits = 32,768 bytes = 32 KiB.
- Work out the pixel data only, unless the question tells you otherwise.

How to answer each type of question

Define the key terms 1 mark each **Grade 4**

1. Pixel: the smallest element of the image, a single colour.
2. Colour depth: use the words 'number of bits' and 'each pixel'.
3. Resolution: the number of pixels, width × height.

Example. (a) Define the term 'colour depth'.
(b) State the number of different colours that can be represented with a colour depth of 5 bits.

Model answer.

(a) The number of bits used to store the colour of each pixel (1)

(b) 32 (2^5) (1)

Encode a small image

2 marks | Grade 5

1. Use the colour codes given in the question.
2. Work along each row from left to right.
3. Number of bits = number of pixels × colour depth.

Example. A bitmap image is 4 pixels wide and 2 pixels high. It has a colour depth of 2 bits and uses these codes:

Colour	Code
white	00
green	01
blue	10
black	11

The colours of the pixels are:

	Pixel 1	Pixel 2	Pixel 3	Pixel 4
Row 1	white	green	green	black
Row 2	blue	blue	white	white

(a) Give the binary code for row 1.
(b) State the number of bits needed to store the whole image.

Model answer.

(a) 00 01 01 11 (1)
(b) 8 pixels × 2 bits = 16 bits (1)

Explain the effect of changing resolution or colour depth

2 marks | Grade 6

1. Say what happens to the image quality, and why.
2. Say what happens to the file size, and by how much if you can.
3. Use numbers from the question.

Example. A photographer reduces the resolution of a photo from 4000 × 3000 pixels to 2000 × 1500 pixels. The colour depth is unchanged.
Explain the effect of this change on the photo and on its file size.

Model answer. There are fewer pixels, so less detail can be shown and the photo may look pixelated when it is enlarged (1). Only a quarter as many pixels are stored (3,000,000 instead of 12,000,000), so the file size is a quarter of the original (1).

Construct an expression for the file size of an image

2 to 3 marks | Grade 7

1. Multiply width × height to get the number of pixels.
2. Multiply by the colour depth to get bits.
3. Divide by 8 for bytes, then by 1024 for each step up (KiB, MiB).
4. You do not have to work it out unless the question asks you to.

Example. A bitmap image is 1200 pixels wide and 900 pixels high, with a colour depth of 24 bits. Construct an expression to calculate the file size of the image in mebibytes (MiB). You do not need to do the calculation.

Model answer. 1200 × 900 × 24 (1) ÷ 8 (1) ÷ 1024 ÷ 1024 (1)

Don't lose marks

- Defining colour depth as 'the number of colours'. It is the number of bits per pixel.
- Forgetting to divide by 8 to change bits into bytes.
- Dividing by 1000 instead of 1024 when converting to KiB or MiB.
- Saying a higher resolution means 'bigger pixels'. It means more pixels.
- Giving only one effect when the question asks about quality and file size.

More tips

Memory tricks

- Colour depth to colours: 2 to the power of the bits. Colours to colour depth: the smallest power of 2 that is enough.
- Double the colour depth and the file size doubles. Double both the width and the height and there are four times as many pixels, so the file is four times as big.
- Divide early to keep numbers small: 24 bits = 3 bytes per pixel, so the size in bytes is width × height × 3.
- Remember the chain: bits (÷ 8) bytes (÷ 1024) KiB (÷ 1024) MiB.

Exam technique

- 'Construct an expression' only needs the expression: marks are given for each stage (bits, bytes, then the final unit).
- When explaining a change, cover both sides: what happens to the quality and what happens to the file size.
- Quote numbers from the context (e.g. 256 colours instead of 16) to make an explanation precise.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Define pixel**
The smallest single-coloured element (dot) of a bitmap image.

Grade 4 — **Define resolution and colour depth**

Resolution is the number of pixels (width × height); colour depth is the number of bits per pixel.

Grade 5

Find the number of colours

A colour depth of n bits gives 2^n colours, e.g. 8 bits give 256.

Grade 5

Encode and decode a simple bitmap

Use the given code for each colour to turn the pixels into binary, row by row.

Grade 6

Explain effects of changing resolution or colour depth

More pixels or more bits per pixel improve quality but increase the file size.

Grade 7

Construct a file size expression for an image

width × height × colour depth gives bits; ÷ 8 for bytes, then ÷ 1024 for KiB.

Grade 8

Work backwards to find colour depth

Colour depth = total bits ÷ number of pixels, after converting the size into bits.

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