Images

Computer systems (Paper 1) · revision notes

How a bitmap image is stored as a grid of pixels, with each pixel's colour held in binary, plus metadata. You need to explain how colour depth and resolution affect image quality and file size, and calculate file sizes. Expect definitions, questions on turning a small image into binary, and non-calculator file size calculations.

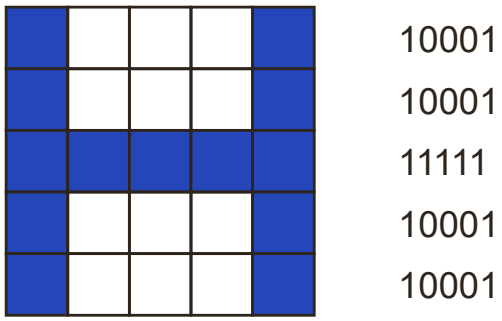
Key facts

- Pixel: a single dot of colour in a bitmap image
- Number of colours = $2^{\text{colour depth}}$ (1 bit = 2, 4 bits = 16, 8 bits = 256)
- File size (bits) = colour depth × width × height
- More pixels or more bits per pixel → better quality but a larger file
- Colour depth: number of bits per pixel
- Resolution: number of pixels in the image (width × height)
- Metadata: data about the image, e.g. width, height, colour depth

Notes

Pixels and colour depth

- A bitmap image is made up of a grid of **pixels** (picture elements). Each pixel is a single colour.
- The colour of each pixel is stored as a binary code. With 1 bit per pixel only 2 colours are possible, e.g. 0 = white and 1 = black.



Each pixel's colour is a binary code; this 5 × 5 image needs 25 bits of pixel data

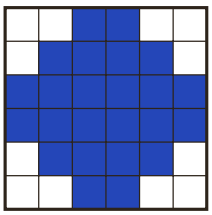
- **Colour depth** is the number of bits used to store the colour of each pixel. n bits give 2^n colours: 1 bit → 2, 2 bits → 4, 8 bits → 256, 24 bits → about 16.7 million.
- **Resolution** is the number of pixels in the image, often given as width × height, e.g. 1920 × 1080.

Metadata

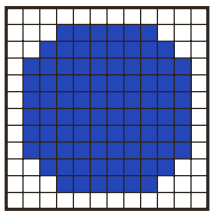
- **Metadata** is data about the image, stored in the file along with the pixel data.
- It includes the width and height (in pixels) and the colour depth, so the computer knows how many pixels are in each row and how many bits to read for each pixel.
- It can also include the date and time the image was created, the location, the camera settings and the file format.

Quality and file size

- Higher **resolution**: more pixels, so more detail and a sharper image that looks less blocky (pixelated) when enlarged, but a larger file.



6 × 6 = 36 pixels
blocky, smaller file



12 × 12 = 144 pixels
more detail, bigger file

Higher resolution: more pixels, so more detail but a larger file

- Higher **colour depth**: more possible colours, so more realistic colours and smoother shading, but every pixel uses more bits, so a larger file.
- File size (bits) = colour depth × width × height. E.g. an image 200 × 100 pixels at 8 bits: 200 × 100 × 8 = 160,000 bits; ÷ 8 = 20,000 bytes = 20 KB.
- The actual file is slightly larger than this because it also stores metadata.
- Changes multiply: doubling both the width and the height gives 4 times as many pixels; doubling the colour depth as well gives 8 times the file size. Grade 8+ only

How to answer each type of question

Define the key terms and explain metadata 1 to 2 marks each **Grade 4**

1. Give precise definitions: colour depth is bits per pixel, not 'the number of colours'.
2. For metadata, say what it is (data about the image), give examples, and say why it is needed.

Example. (a) State what is meant by colour depth. [1]
(b) Explain why metadata is stored in an image file. [2]

Model answer.

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

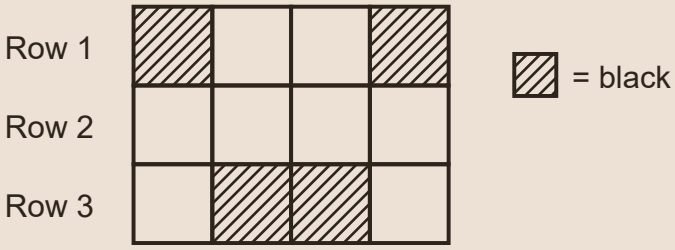
(b) Metadata stores information such as the width, height and colour depth of the image (1), so the computer knows how to display the image correctly, e.g. how many pixels are in each row and how many bits to read for each pixel (1).

Represent an image in binary and choose a colour depth

2 to 5 marks | **Grade 5**

1. Use the key given: write one code per pixel, row by row.
2. For a number of colours, find the smallest power of 2 that is big enough.
3. Explain using 2^n.

Example. A 4 × 3 pixel image uses 1 bit per pixel, where 1 = black and 0 = white. Row 1 is black, white, white, black. Row 2 is all white. Row 3 is white, black, black, white.



(a) Write the binary for each row of the image. [3]
(b) The artist now wants to use 5 different colours. State the minimum colour depth needed and explain why. [2]

Model answer.

(a) Row 1: 1001 (1), Row 2: 0000 (1), Row 3: 0110 (1)

(b) 3 bits (1). 2 bits give only $2^2 = 4$ colours, but 3 bits give $2^3 = 8$ colours, which is enough (1).

Explain the effect of changing resolution or colour depth

2 to 4 marks | **Grade 6**

1. Say what changes: the number of pixels, or the number of bits per pixel.
2. Explain the effect on quality: detail and sharpness, or accuracy of colours.
3. Explain the effect on file size, using the numbers if they are given.

Example. A photographer reduces the colour depth of a photo from 24 bits to 8 bits. The resolution stays the same. Explain the effect on the image and on its file size. [4]

Model answer. Fewer colours are available: 256 instead of about 16.7 million (1), so the colours are less accurate and smooth shading may show visible bands (1). Each pixel is stored using 8 bits instead of 24 bits (1), so the file size becomes a third of the original (1).

Calculate the file size of an image

2 to 3 marks | Grade 7

1. Write the formula: colour depth × width × height.
2. Multiply to get bits, doing the easiest multiplication first.
3. Divide by 8 for bytes, then by 1000 for KB if asked.
4. Write the unit at each step.

Example. An image is 400 pixels wide and 250 pixels high, with a colour depth of 8 bits. Calculate the file size in kilobytes. Use 1 KB = 1000 bytes. Show your working. [3]

Model answer.

400 × 250 × 8 = 800,000 bits (1)

800,000 ÷ 8 = 100,000 bytes (1)

100,000 ÷ 1000 = 100 KB (1)

Don't lose marks

- Saying colour depth is 'the number of colours'. It is the number of bits per pixel.
- Saying resolution is 'the quality of the image'. It is the number of pixels.
- Forgetting to divide by 8 to change bits into bytes.
- Rounding the number of bits down: 5 colours need 3 bits, not 2.
- Mixing up the two effects: resolution changes the amount of detail; colour depth changes how many colours can be shown.

More tips

Memory tricks

- With a colour depth of 8 bits, the number of bytes equals the number of pixels (8 bits = 1 byte per pixel).
- Colours from bits: keep doubling from 2: 1 bit → 2, 2 bits → 4, 3 bits → 8, 4 bits → 16.
- Bits from colours: find the smallest power of 2 that is at least the number of colours: 5 colours → 8 → 3 bits.
- Ratios save time: half the width and half the height gives a quarter of the file size.

Exam technique

- Link cause and both effects: more pixels, so more detail AND a larger file.
- Write the formula before substituting the numbers: it earns method marks.
- Multiply in an easy order without a calculator: 400 × 250 = 100,000 first, then × 8.

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, colour depth and resolution**

A pixel is a single dot of colour; colour depth is the number of bits per pixel; resolution is the number of pixels.

Grade 4

Represent a simple image in binary

With 1 bit per pixel, e.g. 1 = black and 0 = white, each row of pixels becomes a row of bits.

Grade 5

Explain what metadata is and why it's needed

Data about the image, such as width, height and colour depth, so the computer can display it correctly.

Grade 5

Work out colours from colour depth

n bits per pixel give 2^n colours, e.g. 3 bits give 8 colours.

Grade 6

Explain effects of resolution and colour depth

Increasing either improves the quality of the image but increases the file size.

Grade 7

Calculate an image's file size

Colour depth × width × height gives the size in bits; divide by 8 for bytes.

Grade 8

Compare file sizes after changes

Use ratios, e.g. halving the width and height leaves a quarter of the pixels and a quarter of the file size.

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