



## Data representation – images and sound

GCSE Student Booster

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### Key Information

- 1) Remember this booster is here to **help you**. Please consider your behaviour in the chat.
- 2) If you are in a room with a teacher/group, please login to the meeting. This is so we can mark your attendance. This information goes into a **prize draw**.
- 3) Make sure the name on the meeting is the **SAME** as the name on your Isaac account. We can't mark you present if they don't match.




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### Isaac Computer Science



During this booster you may require access to the [Isaac Computer Science platform](#).

**Accounts are free to create. You will be able to:**

- use the platform to develop your subject knowledge
- use for GCSE for each exam board
- take part in Gameboards
- access self-marking questions




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## Intended Learning Outcomes

By the end of this booster session, you will be able to:

- describe how an image is represented as a series of pixels
- explain the term Metadata
- describe how colour depth and resolution impact image quality and file size.
- explain how sound can be sampled and stored digitally
- discuss the effect of sample rate, duration and bit depth on sound quality and file size




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## Images

Data Representation




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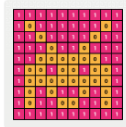
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## Background

- All data on a computer system is represented using **binary**, which are sequences of **1s** and **0s**
- Bitmap images store a grid of coloured squares called **Pixels**, with each colour represented by a unique binary pattern
- The image dimensions and the number of colours used are factors that affect the size of the image file




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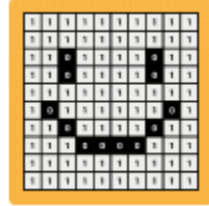
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## Bitmap images – Pixels

- A **pixel**, the **smallest unit** in a bitmap graphic, represents a **single colour**.
- Each colour is designated by a binary code.
- For instance, a monochrome image could use one bit per pixel, with black pixels as 0 and white pixels as 1.




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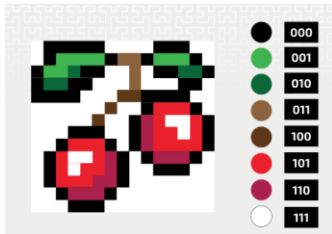
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## Increasing the colours

To have more colours, you need more **bits** per pixel




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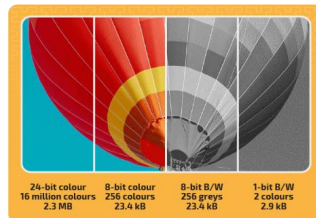
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## Colour depth

The number of bits used per **pixel** is called the **colour depth**.

The greater the colour depth, the more colours are available for an image.



**colour depth** = number of bits per pixel

**more colours in an image** = more bits per pixel

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## Colour depth

1.) How many colours are available with 1 bit per pixel?

✔ **1 bit per pixel =  $2^1 = 2$  colours**

2.) How many colours are available with 2 bit per pixel?

✔ **2 bits per pixel =  $2^2 = 4$  colours**

3.) How many colours are available with 8 bit per pixel?

✔ **8 bits per pixel =  $2^8 = 256$  colours**

4.) How many colours are available with 24 bit per pixel?

✔ **True colour is 24 bits per pixel =  $2^{24}$   
= 16,777,216 colours**




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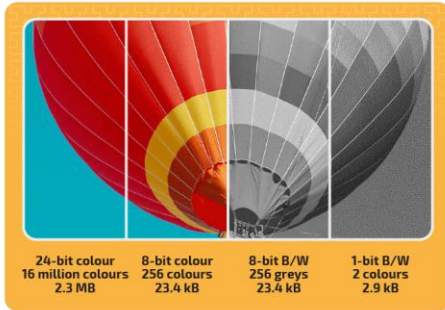
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## Colour depth




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## Resolution

The **image resolution** refers to the level of **detail** in an image.

The resolution is calculated by multiplying the **width** (in pixels) by the **height** (in pixels) of an image.

Resolution is

- **number of pixels** (in an image)
- **height and width** (of an image)

**Higher resolution = better quality image**




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## Effects of colour depth

What is the impact of increased colour depth on the file size?

- ✓ **More colours per pixel = better quality image** (more colours available) **but increases the size of the file**




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## Effects of resolution

What is the impact of increased resolution on the file size?

- ✓ **Higher resolution = better quality image, but the size of the file will increase**




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## Metadata

Metadata is **data about the data** i.e. it is **data about the image** so it can be **recreated**. Examples of metadata include:

- image dimensions (e.g. width in pixels, height in pixels)
- file format
- date and time of creation
- geographical location of creation
- details about the device used to create the image
- camera settings

This information is needed to recreate the image from a bit stream but makes the file larger than the original




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## Calculating file size

To calculate the size of an image file, you multiply the resolution of the image by the colour depth:

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

- This means that the size of an image file will increase if either the colour depth or the image resolution increases
- When an image has a width of 80 pixels and a height of 80 pixels, with a colour depth of 2 bits, the calculation is:
- Calculate total bits:  $80 \times 80 \times 2 = 12,800$  bits




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## Converting your answer

- Remember the calculation gives you the size of the file in **bits**.
- Questions will often ask you to convert to **bytes**, kilobytes or even megabytes so you need to remember:

1 megabyte = 1000 kilobytes, 1 kilobyte = 1000 bytes, 1 byte = 8 bits

So, to convert 12,800 bits to kilobytes first divide by 8 to get 1,600 bytes

Then divide by 1000 to get 1.6 kilobytes




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## Calculating file size

Calculate the number of bits for an image of height 600px, width of 800px, colour depth = 2 bits

**Bits:**  $600 \times 800 \times 2 = 960,000$  bits

**Bytes:**  $960,000 / 8 = 120,000$  bytes

**Kilobytes:**  $120,000 / 1000 = 120\text{KB}$

**Megabytes:**  $120\text{KB} / 1000 = 0.12\text{MB}$




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## Activity



Handout 1

Complete the questions included in **task 1** on the handout

### Representation of Images and Sound

Handout 1 – Representation of Images and Sound

Task 1 – Representation of Images

Q1: What is a bitmap image made up of?

Q2: What does each pixel in an image contain?

Q3: What does *pixelated* mean?

Q4: What is Metadata and why does it need to be included in the file?




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## Activity review

### Representation of Images and Sound

Handout 1 – Representation of Images and Sound

Task 1 – Representation of Images - **Answers**

Q1: What is a bitmap image made up of?

- Made up of tiny elements, called pixels.

Q2: What does each pixel in an image contain?

- Each pixel stores an individual colour which will be represented by a specific/unique binary value.

Q3: What does *pixelated* mean?

- You can see individual pixels. The image may look 'blurry' to the user.

Q4: What is Metadata and why does it need to be included in the file?




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## Isaac Computer Science

Find out more information about **Data Representation - Images** on the Isaac Computer Science website:

[Click here for Isaac Computer Science website](#)




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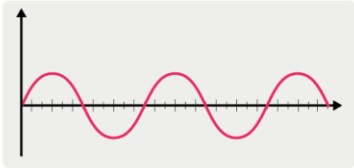


# Sound

## Data Representation

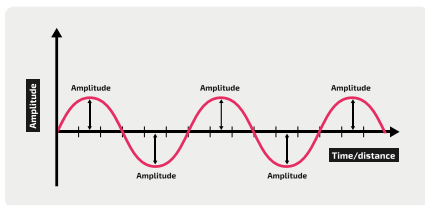
### Background

- Sound is about vibration
- Any sound requires a **source**, such as a human voice or musical instrument, and a **substance** to travel through.



### Background

- The amplitude is the intensity (or **height**) of the sound wave. It relates to the amount of energy the wave carries and it is measured in voltage (V).





## Poll



Poll

Which statement about how sound wave is recorded is true:

1. The height (amplitude) of the analogue sound wave is recorded by taking samples at regular intervals which are then converted into binary so the computer can process it.
2. The frequency of the sound wave is recorded and stored as binary
3. The wavelength of the sound wave is sampled and stored as binary




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## Poll – answer



Poll

Which statement about how sound wave is recorded is true:

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3. The wavelength of the sound wave is sampled and stored as binary




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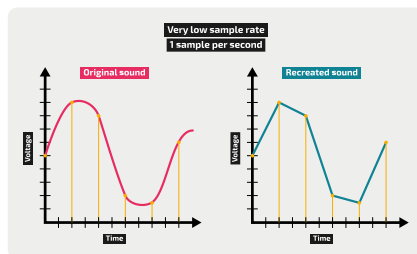
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## Sampling

- **Sampling** is a technique used to convert a sound from analogue to digital form.




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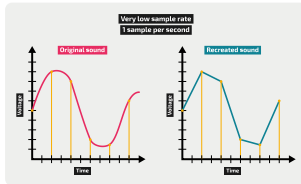
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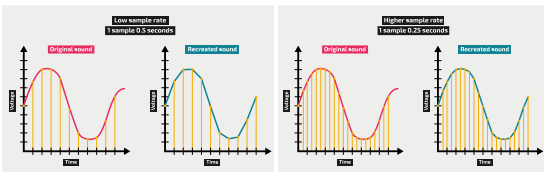
## Sampling

- While sampling a sound, the computer takes measurements of the analogue signal at **regular time intervals**.
- After that, the digitised sound can be stored and processed by a computer as a **sequence of 1's and 0's**.



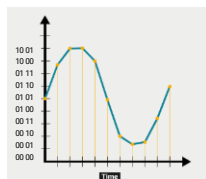
## Sample rate

- Increasing the number of samples **per second** means the recreated sound is more like the original sound wave



## Sample resolution (bit depth)

- The **sample resolution**, also known as **bit depth**, is the number of **bits** used to represent each sample.
- By increasing the sample resolution, more information on the original analogue wave will be taken.





## Sample resolution (bit depth)

How many values can be stored with 8 bits sample resolution/bit depth?

✓ 256 different values

How many values can be stored with 16 bits sample resolution/bit depth?

✓ 65,536 different values




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## Poll



Poll

Which of the following statements are true:

1. Bit depth is how much data is recorded of the original sound wave per sample.
2. Increasing the sample rate and bit depth means better quality sound
3. Sample rate is the number of recordings taken per second
4. All the above




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## Poll – answer



Poll

Which of the following statements are true:

1. Bit depth is how much data is recorded of the original sound wave per sample.
2. Increasing the sample rate and bit depth means better quality sound
3. Sample rate is the number of recordings taken per second
4. All the above




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## Key terms



Sample Rate	Bit Depth / Sample resolution
The number of samples taken per second	The number of bits per sample




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## Calculating file size

Step 1: Calculate the number of samples by multiplying the sampling rate (in hertz) by the length (in seconds) of the sound recording

Step 2: Calculate the number of bits by multiplying the number of samples by the sample resolution (in bits)

The formula to calculate the **file size in bits** is:

**Sampling rate × length of the sound (seconds) × sample resolution**




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## File size example

How big would be the storage requirement (in kilobytes) of a 20 second audio, using 10kHz and 8-bit sampling?

**Sampling rate × length of the sound (seconds) × sample resolution**

$10,000 \times 20 \times 8 = 1,600,000$  **bits**

$1,600,000 / 8 = 200,000$  **bytes**

$200,000 / 1000 = 200$  **kilobytes**




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## Activity



Handout 1

Complete the questions included in **task 2** on the handout.

### Task 2 – Representation of Sound

Q1: Explain how sound is stored digitally.

Q2: Calculate the size of the sound file

Sample rate – 3

Bit depth – 2 bits

Length – 2 mins and 30 seconds

Q3: Calculate the size of the sound file

Sample rate – 44100Hz

Bit depth – 16bits

Length – 2 mins and 30 seconds




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## Activity answers

### Task 2 – Representation of Sound

Q1: Explain how sound is stored digitally.

The height (Amplitude) of the **analogue sound wave** is recorded by taking **samples at regular intervals** which are then converted into **binary** so the computer can process it.

Q2: Calculate the size of the sound file

Sample rate – 3

Bit depth – 2 bits

Length – 2 mins and 30 seconds

$3 \times 2 \times 150$  (2mins and 30seconds in seconds) = 900 bits

$900/8 = 112.5$  bytes




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## Isaac Computer Science

Find out more information about **Data Representation - Sound** on the Isaac Computer Science website:

[Click here for Isaac Computer Science website](#)




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## Isaac Computer Science

Find out more information about **Data Representation - Images** on the Isaac Computer Science website:

[Click here for Isaac Computer Science website](#)




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## Compression

Data Representation




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## Compression

- Digitising audio and images can create very large file sizes. This is especially true for video, which is a combination of both.
- Compression reduces file sizes, which makes these large files more efficient to store and share.




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## Compression

• **Lossy Compression** - This is where we remove parts of the original file in order to significantly reduce the size of the file. Once we do this we CAN'T recreate the original file.

• **Lossless Compression** - Is where we use repetition techniques. It makes the file smaller but not as much as Lossy compression. You can recreate the original file once compression has taken place.

Question: What type of compression would you use on text file?




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## Compressing images

- A bitmapped photograph (.bmp) taken with a 12-megapixel camera using 24-bit colour could create a 36MB file for a single photograph.
- To save space on storage and be able to transmit these quicker, they could be compressed using run-length encoding (RLE) or JPEG compression (.jpg).




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## Activity



Handout 1

Complete the questions included in **task3** on the handout.

### Task 3 - Compression

Q1. What are the two types of compression?

Q2. If you wanted to reduce the size of a book, what type of compression would you use and why?

Q3. If you were sending a large video file across the internet, what type of compression might you use? Justify your reasons.

Q4. Groups are discussing with a friend the benefits of compression. One of them thinks compression is better than lossy compression. Discuss with an image the which type of compression you think is better and why. (5)






















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## Image file formats

Common file formats of bitmapped graphics are:

### PNG

- Portable Network Graphic (.png)
- Supports transparency

### Bitmap

- file extension is .bmp
- Uncompressed and supports a range of colours

### JPEG

- Joint Photographic Experts Group
- file extension is .jpg or .jpeg

### GIF

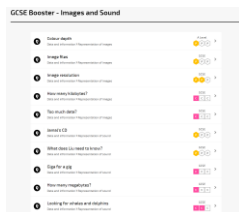
- Graphics Interchange Format (.gif)
- Generally used for logos / graphics

## Compressing sound

- Sound files can be very large. Compressing the files can make them more efficient to transmit and use less storage.
- Compressing of sound is often **lossy** (so data is permanently lost that the algorithm assumes will not be noticed by humans).
- An example of a compressed audio file is .mp3

## Isaac Gameboard practice

- If you want more sound and images practice, then try this gameboard.
- You will need to sign in to **Isaac Computer Science** or register for a free account if not done already.



[nccse.io/isc-soundimages](https://nccse.io/isc-soundimages)



## Check for more ISAAC boosters

The screenshot shows the ISAAC website interface. At the top, there's a navigation bar with links like 'HOME', 'ABOUT', 'CONTACT', 'SUPPORT', and 'LOGIN'. Below this, a 'Welcome' section is visible, featuring a 'For your students' area with links to 'GCSE resources', 'A Level resources', and 'Events'. A 'For you' section lists 'Key stage 3 courses', 'Key stage 4 courses', and 'A level courses'. A callout box on the right says 'Keep an eye out for more student booster events' with an arrow pointing to a 'Snooze' button. The bottom of the page has a yellow and blue decorative border.

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## Intended Learning Outcomes

By the end of this booster session, you will be able to:

- describe how an image is represented as a series of pixels
- explain the term Metadata
- describe how colour depth and resolution impact image quality and file size.
- explain how sound can be sampled and stored digitally
- discuss the effect of sample rate, duration and bit depth on sound quality and file size

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**"The more that you read, the more things you will know, the more that you learn, the more places you'll go."**

Dr Seuss

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# Thank you



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