

Objective:

- Show understanding of how data for a **bitmapped image** are encoded.
- Use and understand terms: pixel, file header, image resolution, screen resolution, colour depth, bit depth.
- Perform calculations to estimate file size for a bitmap image.
- Show understanding of effects of changing elements of a bitmap image on image quality and file size. Use the terms: image resolution, colour depth
- Show understanding of how data for a **vector graphic** are encoded. Use terms: drawing object, property, drawing list.
- Justify use of a bitmap image or a vector graphic for a given task.
- Show understanding of how sound is represented and encoded. Use terms: sampling, sampling rate, sampling resolution, analogue and digital data
- Show understanding of impact of changing sampling rate and resolution. Impact on file size and accuracy.

Graphics

Images can be stored in a computer in two common formats:

- Bit-map image
- Vector graphic.

Bit-Map Images

Bit-map images are made up of **pixels** (picture elements). Image is stored in a two dimensional **matrix** of pixels. Each pixel can be small rectangle, a small circle or a dot.

Picture element (pixel) are smallest identifiable component of a bitmap image, defined by just two properties: its position in the bitmap matrix and its colour.

Bitmaps are also known as **pixelmaps** or **raster graphics**.

Use: Bitmap images are widely used on digital cameras, smartphones and online.

Simplest scheme used to represent the colour option is to use one bit to represent the colour, so that the pixel is either black or white.

Storage of the colour in **four bits** allows simple **greyscale** colouring.



Greyscale

- At least 8 bits (per pixel are needed to code coloured image, this will gives 256 possible colours by **varying** the **intensity** of the blue, green and red elements.

True colour requires 3 bytes per pixel (24 bits), which gives more than one million colours.

Colour Depth:

Number of bits used to represent one pixel is known as **colour depth**. Colour depth of 8 bits per pixel provides 256 different colours. When **colour depth increases**, number of possible colours which can be represented also increases.

Bit Depth:

Bit depth is number of bits used to store each of red, green and blue primary colours in RGB colour.

When **bit depth increases**, number of possible colours which can be represented also increases. A bit depth of 8 bits (2^8) per primary colour (Red , Green , Blue) provides $256 \times 256 \times 256 = 16\,777\,216$ different colours.

If a **lower bit depth** is used, image will show **bands** of colour.

Note: Colour depth and bit depth term can be used interchangeably.

Image resolution:

It is number of pixels in bitmap file defined as product of width and height values.

Screen Resolution:

Product of width and height values for number of pixels that the screen can display.

If **screen resolution** is smaller than **image resolution** then whole image cannot be shown on screen or the original image will now be a **lower quality**.



Pixel Density:

Number of pixels per square inch is known as pixel density.

ESQ: Why bitmap image quality become poor during zooming?

Bitmap images are organized as a **grid** of coloured squares called pixels. Image is therefore **scalable** but when image is **scaled** the number of pixels in it does not change. When zooming in or enlarging a bitmap image, pixels are stretched and made into larger blocks. This is why bitmap images appear as **poor quality** when enlarged too much. Enlarging a bitmap image causes it to **look blocky** and "**pixelated**."

File Size:

Large file occupies **more** memory space and takes longer to display or to be transmitted across a network.

Calculating size of a Bitmap Graphic:

Consider that a bitmap graphic is needed to fill a laptop screen where resolution is 1366 by 768. If **colour depth** is 24 then **number of bits** we need is:

$$1366 \times 768 \times 24 = 25\,178\,112 \text{ bits}$$

$$\begin{aligned}25\ 178\ 112 \div 8 &= 3\ 147\ 264 \text{ bytes} \\3147\ 264 \div 1024 &= 3073.5 \text{ kibibytes (3073.5 KiB)} \\&= 3073.5 \div 1024 = \text{approximately } 3 \text{ MiB}\end{aligned}$$

Note in above calculation, colour depth was given. If information given was that **bit depth** was 8, then calculation would use $8 + 8 + 8$ for **number of bits per pixel**.

Example:

Calculate minimum size of bitmap file. Bitmap is to use a bit depth of 8 and bitmap is to be printed with 72 dpi (dots per inch) and to have dimensions 5 inches by 3 inches.

Solution:

To find **number of bits per pixel** in image we need to know value of colour depth or bit depth. In this case we know value of bit depth. i.e 8 bit which means 8 bits for each of RGB components, so **24 bits** are needed for **one pixel**.

72 dpi means 72 pixels per inch so,

Number of **pixels per row** is $5 \times 72 = 360$

And number of **pixels per column** is $3 \times 72 = 216$

Total number of pixels is $360 \times 216 = 77\ 760$

For total number of bits, multiply total number of pixel by 24 bit or 3 Byte.

$77\ 760 \times 3 = 233\ 280$ bytes.

$233\ 280 / 1024 = 227.8$ KiB

Bitmap File Header:

A **set of bytes** at beginning of a bitmap file which identifies the **file type** and contains **information** about the coding used. File header define **colour depth** or **bit depth** and **image resolution** of image. It also contain information about **type of compression** used and **dimension** of image e.g ($100 * 100$ Pixel).



ESQ: Why bitmap file size is larger than the size of the graphic alone?

A bitmap file store **pixel data** that defines the graphic and also have a **file header** that contains information on how the graphic has been **constructed**.

ESQ: What Are File Headers?

File header is a 'signature' placed at the beginning of a file, so operating system and other software know what to do with the following contents.

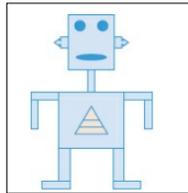
Many applications (computer programs) use the file header as a means to verify file types.

Drawback of using high resolution images:

High resolution will **increase file size**. As number of pixels used to represent image is increased, size of file will also increase. This impacts on how many images can be stored on a hard drive. It also impacts on time to download an image from internet or time to transfer images from device to device.

Vector Graphics

A vector image uses **scalable** shapes such as straight lines and curves, using coordinates and geometry to precisely define the parts of the image.



Vector graphics can be designed using computer aided design (CAD) software or using an application which uses a drawing canvas on the screen.

A vector graphic will contain a **drawing list** (included in file header) that is made up of

- ▣ The **command** used for each object that makes up the graphic image.
- ▣ The **attributes** that define the properties that make up each object
- ▣ The **relative** position of each object will also need to be included.
- ▣ The **dimensions** of each object are not defined, but the relative positions of objects to each other in the final graphic need to be defined; this means that **scaling up** the vector graphic image will result in no loss of quality.



A vector graphic file will have a smaller size than a corresponding bitmap file.

Comparison between Vector Graphics and Bit-map images

Vector graphic images	Bit-map images
Made up of geometric shapes which require definition/attributes	Made up of tiny pixels of different colours
to alter/edit the design, it is necessary to change each of the geometric shapes	possible to alter/edit each of the pixels to change the design of the image
they do not require large file size since it is made up of simple geometric shapes	because of the use of pixels (which give very accurate designs), the file size is very large
because the number of geometric shapes is limited, vector graphics are not usually very realistic	since images are built up pixel by pixel, the final image is usually very realistic
file formats are usually .svg, .cgm, .odg	file formats are usually .jpeg, .bmp, .png



Does the image need to be drawn to **scale**? Vector graphic is the best option.

Vector graphic file can only be displayed directly on a **graph plotter**, which is an expensive specialised piece of hardware. For the image to appear correctly on other types of display, vector graphic file often has to be converted to a **bitmap**.

What happen when vector graphic is displayed ?



Whenever image is to be displayed, file is read, appropriate calculations are made and objects are drawn to a suitable scale. If the user then requests that the image is redrawn at a larger scale the file is read again and another set of calculations are made before the image is displayed. This avoids image **distortion**, such as the image appearing **squashed** or **stretched**.

When designing a logo for a company or composing an 'exploded diagram' of a car engine, vector graphics are the best choice



A digital camera automatically produces a bitmap. A bitmap file is the choice for insertion of an image into a document, publication or web page.



Vector graphic is chosen if a diagram is needed to be constructed for part of architectural, engineering or manufacturing design. • If a vector graphic file has been created but there is a need to print a copy using a laser or inkjet printer, file has first to be converted to a bitmap.

Sound

Sound cannot travel in a vacuum. It requires a medium to travel. It is transmitted by causing oscillations of particles within medium. Human ear picks up these oscillations (changes in air pressure) and interprets them as sound.

Each sound wave has **frequency** and **wavelength**; amplitude specifies loudness of sound. **Amplitude** of sound varies in a continuous but irregular pattern.

How Sound is transmitted electronically or stored in computer?

Original analogue sound signal has to be converted to a **binary code**. Measured sound values are input to a **sound encoder** which has two components.

First Component is a **band-limiting filter** which is used to remove **high** frequency components. A human ear cannot detect these very high frequencies and they could cause problems for coding if not removed. Other component in encoder is an **analogue-to-digital converter** (ADC) which converts analogue data to digital data.

Does the image need to be **resized**? If so, a vector graphic could be the best option.



Analogue data is data obtained by measurement of a physical property which can have any value from a continuous range of values. **Digital data** is data that has been stored as a binary value which can have one of a discrete range of values

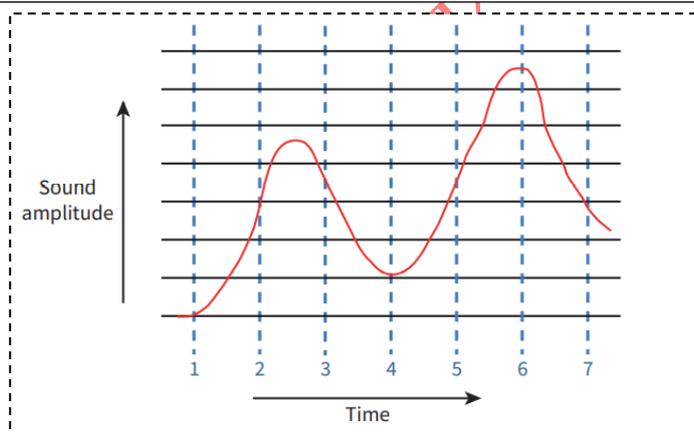
Sampling is taking measurements at regular intervals and storing the value.

Sampling Resolution is number of **bits** used to store **each sample**. Larger sampling resolution will mean there are **more values** available to store each sample. Larger sampling resolution will improve **accuracy** of **digitised** sound and decrease **distortion** of sound. **Increased sampling** resolution means a smaller **quantization** error.

Sampling Rate is **number of samples** taken **per second**. Increasing sampling rate will increase **accuracy / precision** of digitised sound. Increasing sampling rate will result in smaller **quantisation** errors.



Sampling rate should be in accordance with **Nyquist's** theorem which states that sampling must be done at a frequency at least **twice** highest frequency of the sound in sample.



Higher **sampling rate** and/or **sampling resolution**, greater the file size and will result in a more faithful representation of original sound source. 16-bit sampling resolution is used when recording CDs to give better sound quality.

📊 Pros and cons of using a larger sampling resolution

Pros	Cons
larger dynamic range	produces larger file size
better sound quality	takes longer to transmit/download sound files
less sound distortion	requires greater processing power

Features of sound Editor Software:

- edit the start/stop times and duration of a sample
- extract and save (or delete) part of a sample
- alter the frequency and amplitude of a sample
- fade in and fade out
- mix and/or merge multiple sound tracks or sources
- combine various sound sources together and alter their properties
- remove 'noise' to enhance one sound wave in a multiple of waves
- Convert between different audio formats.

Exam Style Question

ESQ:1 Photographs has a bit depth of 8 bytes and image resolution of 1500 pixels wide and 3000 pixels high. Calculate file size of photograph in megabytes. Jun 23 P11

Ans: Total Pixel = $1500 \times 3000 = 4500000$
image Size = $(4500000 \times 8) / 1000 / 1000 = 36 \text{ MB}$

ESQ:2 Describe how sound is represented in computer. Jun 23 P13

Ans: Amplitude is recorded a set number of times a second. Each amplitude is given a corresponding binary number. Binary number of amplitude is saved in sequence.

ESQ# 3: Camera detector has an array of 1920 by 1536 pixels. Colour depth of 16bits is used. Calculate size of photograph, giving your answer in MiB.

Ans: $1920 \times 1536 = 2\,949\,120$ pixels
colour depth = 16

$16 \times 2\,949\,120 = 47\,185\,920$ bits
bits ($\div 8$) $\rightarrow 5\,898\,240$ bytes $\rightarrow (\div (1024 \times 1024)) \rightarrow 5.625 \text{ MiB}$

ESQ #4 Photographs have been taken by a smartphone which uses a detector with a 1024×1536 pixel array. Software uses a colour depth of 24bits. How many photographs could be stored on 16GiB memory card?

ANS: $1024 \times 1536 = 1\,572\,864$ pixels
colour depth = 24 $\rightarrow 24 \times 1\,572\,864 = 37\,748\,736$ bits
bits ($\div 8$) $\rightarrow 4\,718\,592$ bytes $\rightarrow 16 \text{ GiB} = 17\,179\,869$ bytes
number of photos = $(17\,179\,869) / (4\,718\,592) = 3640$ photos

ESQ#4: Audio is being sampled at the rate of 44.1 kHz using 8 bits. Two channels (Stereo) are being used. Calculate: the size of a 30-second audio recording in MiB.

ANS: file size = $44\,100 \times 8 \times 30 \times 2$ (two tracks) = $21\,168\,000$ bits
 $21\,168\,000$ bits ($\div 8$) $\rightarrow 2\,646\,000$ bytes $\rightarrow 2646000 / (1024 \times 1024) = 2.5 \text{ MiB}$