GCSE Computer Science Knowledge Organiser
SLR 1.2.3 Memory and Storage:
Representing Characters

What is a Character set?

A defined list of characters recognised by computer hardware and software. Each character is represented by a single number.

If one device recognises the binary sequence 01000001 as "A", other devices must also recognise this sequence as "A".

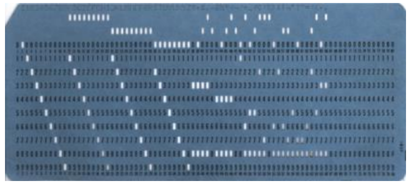
Examples of Character Sets:

- ASCII (7-bit)
- Extended ASCII (8-bit)
- Unicode (16-bit)
- Unicode (24-bit)

TABLE 6
EBCDIC (IBM MAINFRAME) CHARACTER CODES

Each code is shown in decimal, hexadecimal, and character form.

129	81	a	193	C1	A	240	F0	0
130	82	b	194	C2	B	241	F1	1
131	83	c	195	C3	C	242	F2	2
132	84	d	196	C4	D	243	F3	3
133	85	e	197	C5	E	244	F4	4
134	86	f	198	C6	F	245	F5	5
135	87	g	199	C7	G	246	F6	6
136	88	h	200	C8	H	247	F7	7
137	89	i	201	C9	I	248	F8	8
						249	F9	9
145	91	j	209	D1	J			
146	92	k	210	D2	K	64	40	blank
147	93	l	211	D3	L	76	4C	<
148	94	m	212	D4	M	77	4D	(
149	95	n	213	D5	N	78	4E	+
150	96	o	214	D6	O	79	45	|
151	97	p	215	D7	P	80	50	&
152	98	q	216	D8	Q	90	5A	!
153	99	r	217	D9	R	91	5B	$
						92	5C	*
162	A2	s	226	E2	S	93	5D	)
163	A3	t	227	E3	T	94	5E	;
164	A4	u	228	E4	U	96	60	-
165	A5	v	229	E5	V	97	61	/
166	A6	w	230	E6	W	107	6B	,
167	A7	x	231	E7	X	108	6C	%
168	A8	y	232	E8	Y	109	6D	_
169	A9	z	233	E9	Z	110	6E	>
						111	6F	?
122	7A	:	125	7D	'			
123	7B	#	126	7E	=			
124	7C	@	127	7F	"			



Key Terminology	BCS Definition
Character set	"A set of symbols represented by a computer. These symbols, called characters, can include letters, digits, spaces, punctuation marks and control characters."
ASCII	**America Standard Code for Information Interchange:** "A character set devised for early telecommunication systems but proved to be ideal for computer systems. Uses 7 bits, providing 32 control codes and 96 displayable characters. The eighth bit is often used for error checking."
Unicode	"Standard character set that replaces the use of multiple different character sets. Incorporates characters from almost all global languages. A 16-bit extension of ASCII."

ASCII (7 bit) Table

Dec	Bin	Hex	Char	Dec	Bin	Hex	Char	Dec	Bin	Hex	Char	Dec	Bin	Hex	Char
0	0000 0000	00	[NUL]	32	0010 0000	20	space	64	0100 0000	40	@	96	0110 0000	60	`
1	0000 0001	01	[SOH]	33	0010 0001	21	!	65	0100 0001	41	A	97	0110 0001	61	a
2	0000 0010	02	[STX]	34	0010 0010	22	"	66	0100 0010	42	B	98	0110 0010	62	b
3	0000 0011	03	[ETX]	35	0010 0011	23	#	67	0100 0011	43	C	99	0110 0011	63	c
4	0000 0100	04	[EOT]	36	0010 0100	24	$	68	0100 0100	44	D	100	0110 0100	64	d
5	0000 0101	05	[ENQ]	37	0010 0101	25	%	69	0100 0101	45	E	101	0110 0101	65	e
6	0000 0110	06	[ACK]	38	0010 0110	26	&	70	0100 0110	46	F	102	0110 0110	66	f
7	0000 0111	07	[BEL]	39	0010 0111	27	'	71	0100 0111	47	G	103	0110 0111	67	g
8	0000 1000	08	[BS]	40	0010 1000	28	(	72	0100 1000	48	H	104	0110 1000	68	h
9	0000 1001	09	[TAB]	41	0010 1001	29	)	73	0100 1001	49	I	105	0110 1001	69	i
10	0000 1010	0A	[LF]	42	0010 1010	2A	*	74	0100 1010	4A	J	106	0110 1010	6A	j
11	0000 1011	0B	[VT]	43	0010 1011	2B	+	75	0100 1011	4B	K	107	0110 1011	6B	k
12	0000 1100	0C	[FF]	44	0010 1100	2C	,	76	0100 1100	4C	L	108	0110 1100	6C	l
13	0000 1101	0D	[CR]	45	0010 1101	2D	-	77	0100 1101	4D	M	109	0110 1101	6D	m
14	0000 1110	0E	[SO]	46	0010 1110	2E	.	78	0100 1110	4E	N	110	0110 1110	6E	n
15	0000 1111	0F	[SI]	47	0010 1111	2F	/	79	0100 1111	4F	O	111	0110 1111	6F	o
16	0001 0000	10	[DLE]	48	0011 0000	30	0	80	0101 0000	50	P	112	0111 0000	70	p
17	0001 0001	11	[DC1]	49	0011 0001	31	1	81	0101 0001	51	Q	113	0111 0001	71	q
18	0001 0010	12	[DC2]	50	0011 0010	32	2	82	0101 0010	52	R	114	0111 0010	72	r
19	0001 0011	13	[DC3]	51	0011 0011	33	3	83	0101 0011	53	S	115	0111 0011	73	s
20	0001 0100	14	[DC4]	52	0011 0100	34	4	84	0101 0100	54	T	116	0111 0100	74	t
21	0001 0101	15	[NAK]	53	0011 0101	35	5	85	0101 0101	55	U	117	0111 0101	75	u
22	0001 0110	16	[SYN]	54	0011 0110	36	6	86	0101 0110	56	V	118	0111 0110	76	v
23	0001 0111	17	[ETB]	55	0011 0111	37	7	87	0101 0111	57	W	119	0111 0111	77	w
24	0001 1000	18	[CAN]	56	0011 1000	38	8	88	0101 1000	58	X	120	0111 1000	78	x
25	0001 1001	19	[EM]	57	0011 1001	39	9	89	0101 1001	59	Y	121	0111 1001	79	y
26	0001 1010	1A	[SUB]	58	0011 1010	3A	:	90	0101 1010	5A	Z	122	0111 1010	7A	z
27	0001 1011	1B	[ESC]	59	0011 1011	3B	;	91	0101 1011	5B	[	123	0111 1011	7B	{
28	0001 1100	1C	[FS]	60	0011 1100	3C	<	92	0101 1100	5C	\	124	0111 1100	7C	|
29	0001 1101	1D	[GS]	61	0011 1101	3D	=	93	0101 1101	5D	]	125	0111 1101	7D	}
30	0001 1110	1E	[RS]	62	0011 1110	3E	>	94	0101 1110	5E	^	126	0111 1110	7E	~
31	0001 1111	1F	[US]	63	0011 1111	3F	?	95	0101 1111	5F		127	0111 1111	7F	[DEL]

There are two versions of ASCII

- ASCII (7-bit) 2^7 combinations = 128
- Extended ASCII (8-bit) 2^8 combinations = 256

- ASCII is nowadays only suitable to contain the characters used in the English alphabet and a few other characters from some other European languages.

As Computers began being used all over the world the need for character sets to be able to represent other languages were required. Character Sets like Unicode became popular because of this.

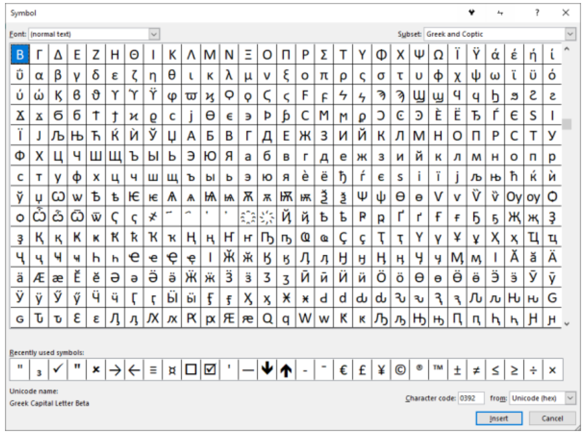
Unicode (24-bit)

2^{24} characters = over 16 million!

Writing in 24 bits is slower and prone to error, so hexadecimal is often used instead.

6 digits in hexadecimal = 24 bits in binary.

Remember, 1 nibble = 1 hex digit.



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SLR 1.2.3 Memory and Storage:
Representing Images

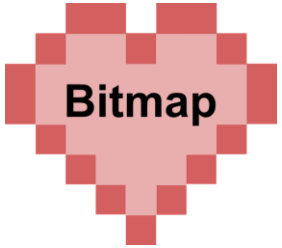
Bitmaps Vs Vectors

Bitmaps

- A bitmap image is made up of different-coloured squares.
- Each square has a binary value.

Use:

- Detailed images (e.g., photographs, digital art)

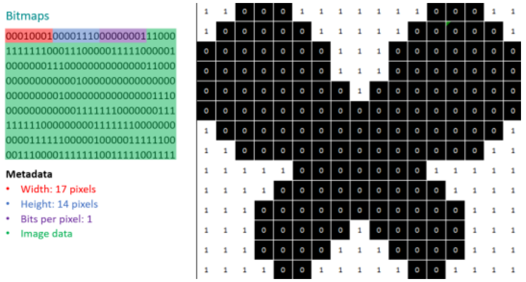


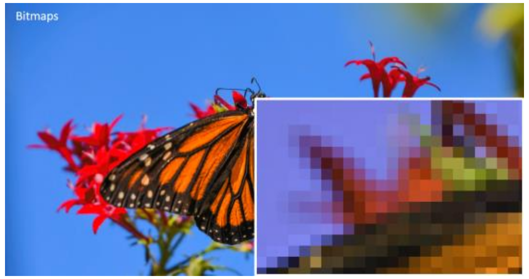
Vector

- A vector image stores the mathematics required to draw a shape. For example, a circle can be drawn just by storing its:
- XY coordinates from the middle
- Radius
- Width
- Colour

Use:

- Simple shapes (e.g., logos, clipart)





Key Terminology	BCS Definition
Pixels	"The smallest unit of a digital image or graphic that can be displayed on a digital device. A pixel is represented by a dot or square on a computer display."
Metadata	"A collection of data that describes and provides information about other data."
Colour depth	"Also known as bit depth. Either the number of bits used to indicate a) the colour of a single pixel in a bitmap image or video frame buffer or b) each colour component of a single pixel."
Resolution	"The number of pixels (individual points of colour) in a display, expressed in terms of the number of pixels on the horizontal and vertical axes."
Image quality	"The overall detail of an image, affected by colour depth and resolution."
Image file size	"The total size of an image file in storage. Size in bits = Width in pixels * Height in pixels * Colour depth in bits."

Calculating Image File Size

Formula:

Image width x Image height x Colour depth

Size of a bitmap file		
Image height	14	Height measured in pixels
Image width	17	Width measured in pixels
Colour depth	3	Number of bits needed to store each pixel
14 x 17 x 3	=	714 bits = 90 bytes

Colour Key using 3 bits per colour:

000	100
001	101
010	110
011	111

111	111	001	001	001	111	111	111	111	111	111	111	001	001	001	111	111
111	001	001	001	100	001	111	111	111	111	111	001	100	001	001	001	111
001	001	100	011	011	100	100	111	111	111	100	100	011	011	100	001	001
001	001	011	110	110	011	100	111	111	111	100	011	110	110	011	001	001
001	100	011	110	110	011	100	000	111	000	100	011	110	110	011	100	001
001	001	100	011	011	001	100	100	000	100	100	001	011	011	100	001	001
111	001	001	100	100	100	001	100	000	100	001	100	100	100	001	001	111
111	111	001	001	100	100	100	001	000	001	100	100	100	001	001	111	111
111	111	111	111	111	010	010	010	000	010	010	010	111	111	111	111	111
111	111	111	111	101	101	001	010	000	010	001	101	101	111	111	111	111
111	111	111	101	101	001	101	010	000	010	101	001	101	101	111	111	111
111	111	111	101	001	101	101	010	111	010	101	101	001	101	111	111	111
111	111	111	001	101	101	010	111	111	111	010	101	101	001	111	111	111
111	111	111	111	001	001	111	111	111	111	111	001	001	111	111	111	111

Images can be stored in binary as bitmaps or vectors:

- Bitmap images are constructed from coloured squares called pixels.
- Vector images store the mathematics required to draw shapes.

Each pixel of a bitmap is stored in binary. The number of bits required for each pixel depends on the number of colours:

- 1 bit has 2 possible values; 0 and 1. Therefore, 1 bit can store 2 colours; black or white.
- 2 bits have 4 possible values; 00, 01, 10 and 11. That means 2 bits can store 4 colours.

The number of colours can be calculated as 2^n, where n is the number of bits required for each pixel.

The number of bits required for each pixel is known as the image's colour depth. The greater the colour depth and resolution, the larger the file size of the image.

Photographs typically use 24-bit colour, meaning each pixel is made up of 24 bits.

2^{24} = over 16 million colours, believed to be the maximum number of different colours visible to the human eye.

Metadata is additional data stored with the image to define its width, height, colour depth and colour palette.

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SLR 1.2.3 Memory and Storage:
Representing Sound

Key Terminology	BCS Definition
Sample rate	"The number of samples taken per second, measured in hertz (Hz)."
Sample duration	"How many seconds of audio a sound file contains."
Sample bit depth	"The number of bits available to store each sample (e.g., 16-bit)."
Playback quality	"The finished quality of the digital sound file – this is affected by the sample rate and bit depth. The higher the number, the better the quality and the larger the file size. CD quality is 44,100 samples per second."
Sound file size	"The total size of a sound file in storage. Size in bits = Sampling rate * Sample resolution * Number of seconds."

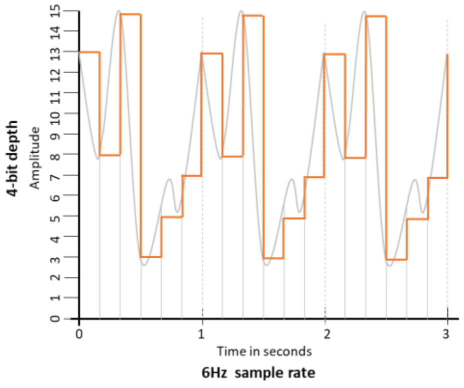
- Sound file size: The total number of bits in a sound file. Calculated as: (Number of samples per second) x (Number of bits per sample) x (Length of sample in seconds).
- Bit depth: The number of bits stored per sample. The higher the bit depth, the greater the quality of the sound and the larger the file size.
- Sample rate: The number of samples stored per second. The higher the sample rate, the higher the quality of the sound, and the larger the file size.

Calculating Image File Size

Formula:

Sound file size = (Number of samples per second) x (Number of bits per sample) x (Length of sample in seconds)

Size of a sound file		
Sample rate	**6**	Number of samples per second
Duration	**3**	Length of sample in seconds
Bit depth	**4**	Number of bits needed to store each sample
6 x 3 x 4	**=**	**72 bits =** 9 bytes

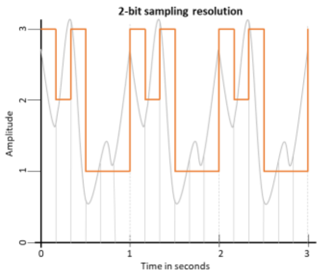


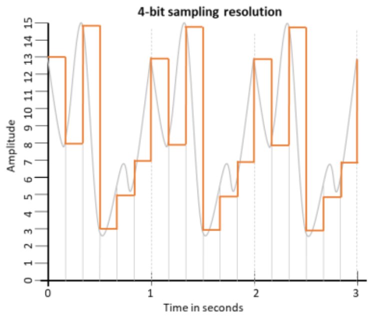
Bit Depth

How many different gradations of amplitude can be represented in a digital waveform.

The amount of information stored with each sample, measured in bits.

Typically, CDs are 16-bit, meaning each sample takes up 2 bytes and can store one of 65,536 amplitudes.



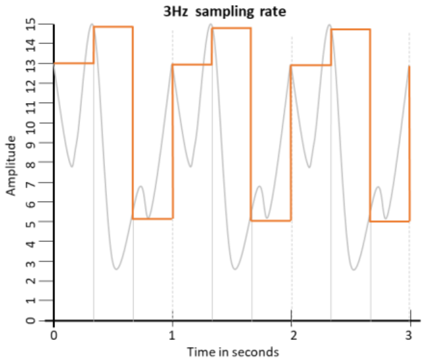


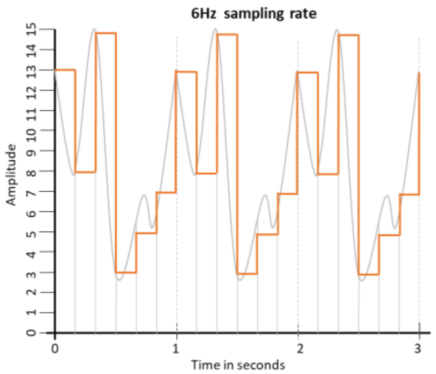
Sample Rate

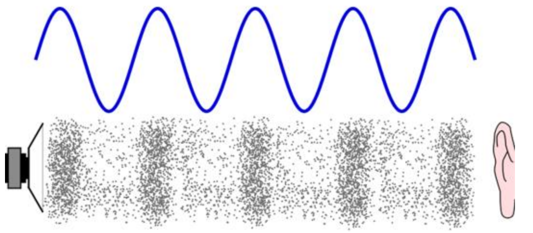
How often (frequency) the amplitude of a sound wave is recorded. The more often a sample is recorded, the smoother the playback will sound.

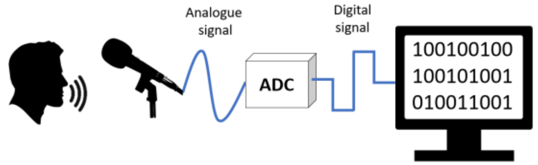
The number of samples per second, measured in hertz (Hz).

A typical audio file is recorded at 44,100Hz – i.e., 44,100 samples per second.



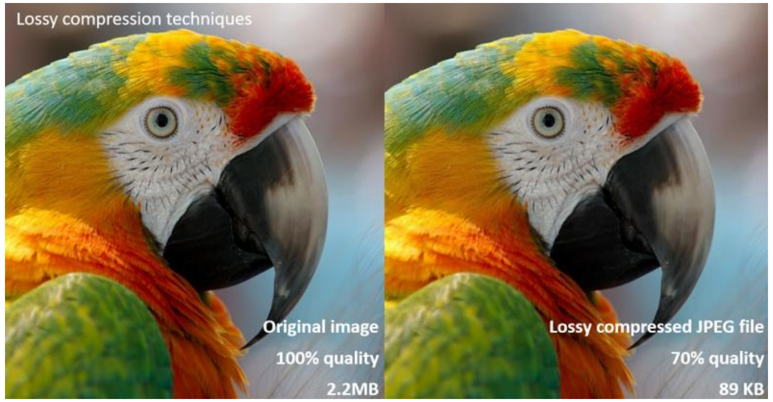






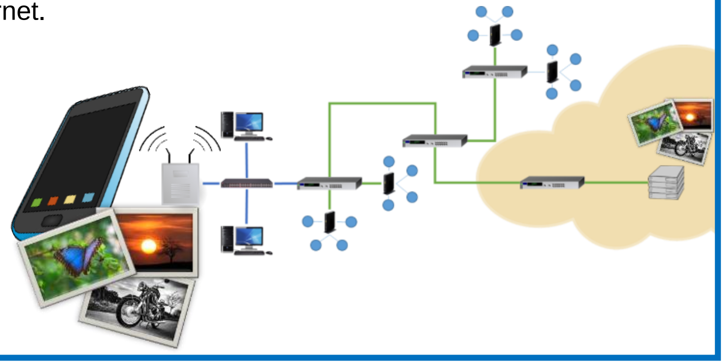
GCSE Computer Science Knowledge Organiser
SLR 1.2.3 Memory and Storage:
Compression

Key Terminology	BCS Definition
Compression	"The process of reducing the size of a file."
Lossy compression	"A compression method that generally involves a loss of quality where experience tells us that it will be least noticed."
Lossless compression	"A compression method that allows a file to be recreated in its original quality."



Why we use compression

- Compression reduces the size of a file so it takes up less space, helping to maximise the amount of data we can store on our devices.
- Smaller files are also quicker to transfer or stream over the internet.

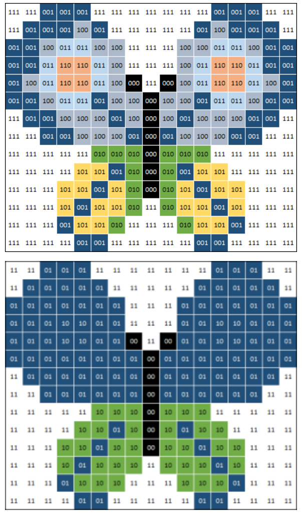


Lossy Compression

With an image, the number of colours increases the file size – this is because we need more bits per pixel to store a greater range of possible colours.

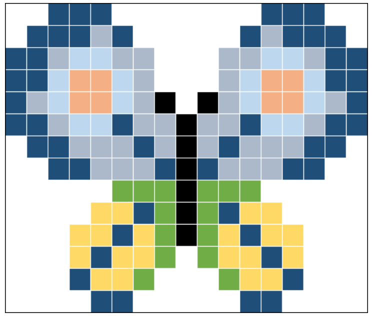
One way to make a file smaller would be to store a lower number of colours – alternatively, we can store larger areas of pixels as one colour.

Both of these techniques will reduce the quality of the image, known as **lossy** compression.



Lossless Compression

Smaller files are also quicker to transfer or As the name suggests, lossless compression does not cause any data to be lost during the process.
 over the internet.
In this image, there are large areas of white pixels. Instead of storing every pixel with the same binary pattern, we could store the binary for white followed by the number of contiguous white pixels in a row.

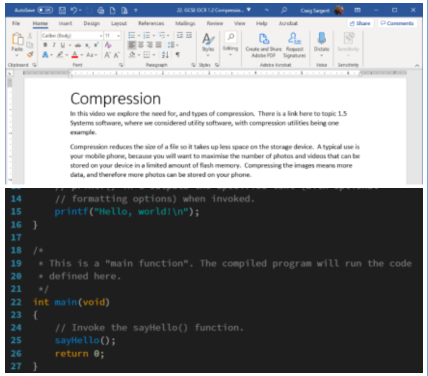


Suitability of lossy and lossless compression

Some types of files are not suitable for lossy compression.

Text documents and executable code must be compressed in their entirety to avoid losing essential data.

For these file types, we must use lossless compression so we can revert the file back to its original state.



Compression is used to reduce the number of bits in a file, making it smaller in size and increasing its speed of transfer.

Lossy compression:

- Some data is lost and cannot be recovered.
- Greatly reduces file size.
- Reduces the quality of images/sound.
- Suitable for images, sound and video.
- Cannot be used with text or executable files.

Lossless compression:

- No data is lost, just encoded differently.
- Files are recovered to their original state.
- Can be used with all types of data.
- Less effective at reducing file size.
- Most suitable for text documents and executable files.