

Number Systems

Binary (base2)

Denary (base10)

Hexadecimal (base16)

Memorize the list

128 64 32 16 8 4 2 1

Case-1: Convert denary to binary

65

Place 1 on specific place so the total is 65

128	64	32	16	8	4	2	1
0	1	0	0	0	0	0	1

96

128	64	32	16	8	4	2	1
-----	----	----	----	---	---	---	---

215

374

Exam Style Question:

2 (a) Convert the following denary integer into 8-bit binary.

55

--	--	--	--	--	--	--	--

[1]

Case-2: Convert binary to denary:

01000001

128	64	32	16	8	4	2	1
0	1	0	0	0	0	0	1

Add only the numbers with 1

$$64 + 1 = 65$$

10010101

128	64	32	16	8	4	2	1
-----	----	----	----	---	---	---	---

00110011

Exam Style Question:

2 (a) Convert the following 8-bit binary integer into denary.

01001101

.....[1]

Case-3: Convert binary to hexadecimal

Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

11011001

From right side divide the binary value into groups of four

1101 1001

Write memorize list separately

8	4	2	1		8	4	2	1
1	1	0	1		1	0	0	1

Add only the numbers with 1

$8+4+1 = 13$

$= 9$

$8+1$

So the **D9** is answer

1100011

Exam Style Question:

(b) The current contents of a general purpose register (X) are:

x	1	1	1	1	0	0	1	0
---	---	---	---	---	---	---	---	---

(i) The contents of X represent an unsigned binary integer.

Convert the value in X into hexadecimal

.....[1]

Case-4: Convert denary to hexadecimal

Q-1 Convert 195 to hexadecimal.

First convert denary to binary

128	64	32	16	8	4	2	1
1	1	0	0	0	0	1	1

From right size divide the binary value into groups of four

1100 0011

Write memorize list separately

8	4	2	1	8	4	2	1
1	1	0	0	0	0	1	1

$$8+4 = 12$$

$$2+1 = 3$$

So the **C3** is answer

Q-2 Convert 96 to hexadecimal.

Q-3 Convert 215 to hexadecimal.

Q-4 Convert 174 to hexadecimal.

Case-5: Convert hexadecimal to denary

Q-1 Convert B4 to denary.

Convert to binary

8	4	2	1	8	4	2	1
1	0	1	1	0	1	0	0

Group together

128	64	32	16	8	4	2	1
1	0	1	1	0	1	0	0

$$128+32+16+4 = 180$$

So **180** is answer.

Q-2 Convert FF to denary.

Q-3 Convert 3A2C to denary.

Exam Style Question:

(d) Convert the following hexadecimal number into denary.

4E

.....[1]

Binary Coded Decimal (BCD)

4-bit code for each denary digit

Decimal	Binay (BCD)			
	8	4	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

Any number greater than 9 cannot be represented in BCD 4-bit. For larger numbers each digit is written as 4-bit binary number. For example 46 = 0100 0110

BCD is used in any scenario where a single digit needs to be transmitted / displayed. For example calculator, digital clock, etc.

Case-1: Convert denary to BCD

Q-1 Convert 54 to BCD.

5			
0	1	0	1

4			
0	1	0	0

Answer is 01010100

Exam Style Question:

(b) (i) Convert the following denary integer into Binary Coded Decimal (BCD).

653

.....[1]

Case-2: Convert BCD to denary

Q-1 Convert BCD 01010100 into denary.

From right size divide the binary value into groups of four

0101 0100

Write memorize list separately

8	4	2	1	8	4	2	1
0	1	0	1	0	1	0	0
		4+1 = 5			4		

Answer is 54

Exam Style Question:

(b) Convert the following Binary Coded Decimal (BCD) number into denary.

10000011

.....[1]

Binary Addition and Subtraction

$$\begin{array}{r}
 0111 \\
 00111 \\
 10101 \\
 \hline
 11100
 \end{array}
 \qquad
 + \qquad
 \begin{array}{r}
 1011 \\
 1110 \\
 \hline
 \end{array}$$

$$\begin{array}{r}
 1001101 \\
 + 0010010 \\
 \hline
 \end{array}$$

$$\begin{array}{r}
 1001001 \\
 + 0011001 \\
 \hline
 \end{array}$$

$$\begin{array}{r}
 1000111 \\
 + 0010110 \\
 \hline
 \end{array}$$

Exam Style Question:

(b) (i) Perform the following binary addition. Show your working.

$$\begin{array}{r}
 10101010 \\
 + 00110111 \\
 \hline
 \end{array}$$

(ii) The amount of green in binary is 00100011. This has the denary number 15 added to it to create a second colour.

Add the denary number 15 to the binary number 00100011 and give your answer in binary.

Perform the addition in binary. Show your working.

Working

.....

.....

.....

.....

Answer (in binary)

[3]

Conversion of Negative Numbers

Q-1 Convert -125 to binary form.

Step-1: Ignore negative sign and convert to binary

128	64	32	16	8	4	2	1
0	1	1	1	1	1	0	1

Step-2: Apply 2's complement

0	1	1	1	1	1	0	1	
1	0	0	0	0	0	1	0	1's complement
							1	Add 1 in 1's complement
1	0	0	0	0	0	1	1	

Note: All 2's complement numbers that start with 1 are negative number.

Exam Style Question:

(iii) Express the following integer in two's complement form.

-17

--	--	--	--	--	--	--	--

[1]

(b) Convert the denary number -194 into 12-bit two's complement.

..... [1]

(c) H is a register. The current contents of H are:

1	1	0	0	0	0	0	1
---	---	---	---	---	---	---	---

The current contents of register H represent an unsigned binary integer.

(i) Convert the value in register H into denary.

.....[1]

(ii) Convert the value in register H into hexadecimal.

.....[1]

(iii) The current contents of register H represent a two's complement binary integer.

Convert the value in register H into denary.

.....[1]

(iv) State why register H does not currently contain a Binary Coded Decimal (BCD).

.....

.....[1]

The first 4-bits would be 12 which is greater than 9 so it is not valid for BCD.

(c) The current contents of a general purpose register (X) are:



(i) The contents of X represent an unsigned binary integer.

Convert the value in X into denary.

.....[1]

(ii) The contents of X represent an unsigned binary integer.

Convert the value in X into hexadecimal.

.....[1]

(iii) The contents of X represent a two's complement binary integer.

Convert the value in X into denary.

.....[1]

(3c) the current contents of a general purpose register (X) are:



(i) The contents of X represent an unsigned binary integer.

Convert the value in X into denary.

..... [1]

(ii) The contents of X represent an unsigned binary integer.

Convert the value in X into hexadecimal.

..... [1]

(iii) The contents of X represent a two's complement binary integer.

Convert the value in X into denary.

..... [1]

Binary Subtraction

$$50 - 20 = 30$$

$$50 + -20 = 30$$

Apply two's complement and then same working as binary addition.

- (iii) Hexadecimal 23 in two's complement representation is 00100011. The denary number 10 needs to be subtracted from this value.

Subtract the denary number 10 from the two's complement representation 00100011.

Give your answer in binary. Show your working.

Working

<p style="color: red; text-align: center;">Converting 10 to -10</p> $\begin{array}{r} 00001010 \rightarrow 10 \\ 1110101 \\ \hline 1110110 \end{array}$		<p style="color: red; text-align: center;">Subtracting</p> $\begin{array}{r} 00100011 \\ + 11110110 \\ \hline 00011001 \end{array}$
<p>Answer (in binary) 00011001</p>		

[3]

$$\begin{array}{r} 10101 \\ 0111 \\ \hline 0110 \end{array}$$

$$\begin{array}{r} 1001110 \\ - 100110 \\ \hline \end{array}$$

$$\begin{array}{r} 1001010 \\ - 101001 \\ \hline \end{array}$$

$$\begin{array}{r} 1101010 \\ - 101101 \\ \hline \end{array}$$

UTF stands for "UCS (Unicode) Transformation Format"

Overflow

Overflow occurs when there are more bits to store but less space.

$$\begin{array}{r} 10001101 \\ + 10011001 \\ \hline 100100110 \end{array}$$

↑ Ninth digit (overflow)

ASCII Table

Dec	Hex	Oct	Char	Dec	Hex	Oct	Char	Dec	Hex	Oct	Char	Dec	Hex	Oct	Char
0	0	0		32	20	40	[space]	64	40	100	@	96	60	140	`
1	1	1		33	21	41	!	65	41	101	A	97	61	141	a
2	2	2		34	22	42	*	66	42	102	B	98	62	142	b
3	3	3		35	23	43	#	67	43	103	C	99	63	143	c
4	4	4		36	24	44	\$	68	44	104	D	100	64	144	d
5	5	5		37	25	45	%	69	45	105	E	101	65	145	e
6	6	6		38	26	46	&	70	46	106	F	102	66	146	f
7	7	7		39	27	47	'	71	47	107	G	103	67	147	g
8	8	10		40	28	50	(	72	48	110	H	104	68	150	h
9	9	11		41	29	51	)	73	49	111	I	105	69	151	i
10	A	12		42	2A	52	*	74	4A	112	J	106	6A	152	j
11	B	13		43	2B	53	+	75	4B	113	K	107	6B	153	k
12	C	14		44	2C	54	,	76	4C	114	L	108	6C	154	l
13	D	15		45	2D	55	-	77	4D	115	M	109	6D	155	m
14	E	16		46	2E	56	.	78	4E	116	N	110	6E	156	n
15	F	17		47	2F	57	/	79	4F	117	O	111	6F	157	o
16	10	20		48	30	60	0	80	50	120	P	112	70	160	p
17	11	21		49	31	61	1	81	51	121	Q	113	71	161	q
18	12	22		50	32	62	2	82	52	122	R	114	72	162	r
19	13	23		51	33	63	3	83	53	123	S	115	73	163	s
20	14	24		52	34	64	4	84	54	124	T	116	74	164	t
21	15	25		53	35	65	5	85	55	125	U	117	75	165	u
22	16	26		54	36	66	6	86	56	126	V	118	76	166	v
23	17	27		55	37	67	7	87	57	127	W	119	77	167	w
24	18	30		56	38	70	8	88	58	130	X	120	78	170	x
25	19	31		57	39	71	9	89	59	131	Y	121	79	171	y
26	1A	32		58	3A	72	:	90	5A	132	Z	122	7A	172	z
27	1B	33		59	3B	73	;	91	5B	133	[	123	7B	173	{
28	1C	34		60	3C	74	<	92	5C	134	\	124	7C	174	|
29	1D	35		61	3D	75	=	93	5D	135	]	125	7D	175	}
30	1E	36		62	3E	76	>	94	5E	136	^	126	7E	176	~
31	1F	37		63	3F	77	?	95	5F	137	_	127	7F	177	

ASCII

- ASCII stands for American Standard Code for Information Interchange
- It is 7-bit code, 128 characters can be represented.

Extended ASCII

- It is 8-bit code, 256 characters can be represented.

Unicode

- It is designed so that most characters in other languages can be represented.
- It uses 16, 24, 32 bits
- It is superset of ASCII

Exam Style Question

- (a) State the number of unique binary values that can be represented in 16 bits.

..... [1]

Exam Style Question

6 A computer uses the ASCII character set.

- (a) State the number of characters that can be represented by the ASCII character set and the extended ASCII character set.

ASCII 128

Extended ASCII 256

[2]

- (b) Explain how a word such as 'HOUSE' is represented by the ASCII character set.

• Each character has its own unique code
• Each character in the word is replaced by its code
• The codes are stored in the order in the word.

[2]

- (c) Unicode is a different character set.

The Unicode value for the character '1' is denary value 49.

- (i) Write the hexadecimal value for the Unicode character '1'.

31

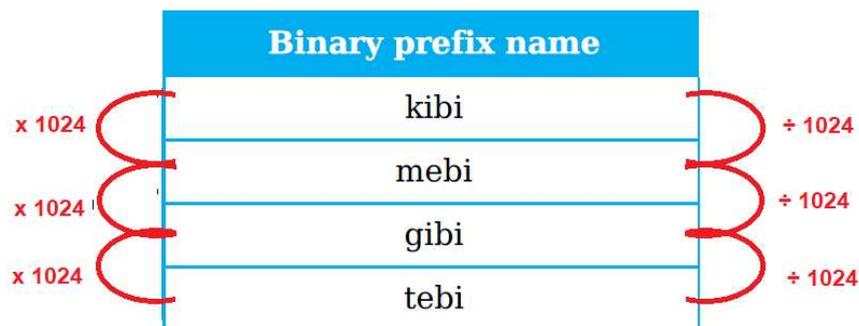
[1]

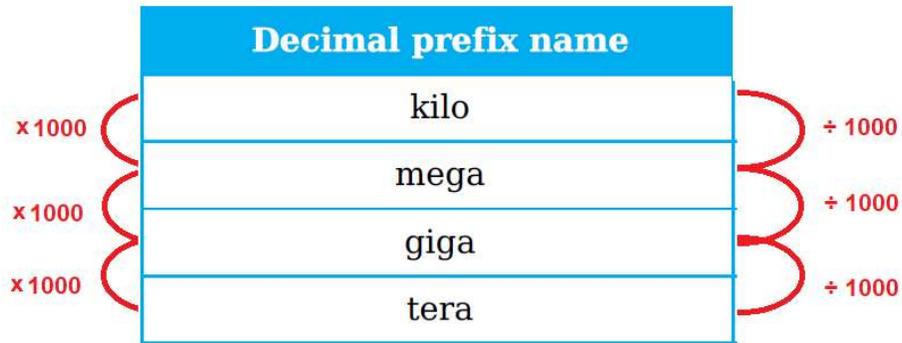
- (ii) Write the denary value for the Unicode character '5'.

53

[1]

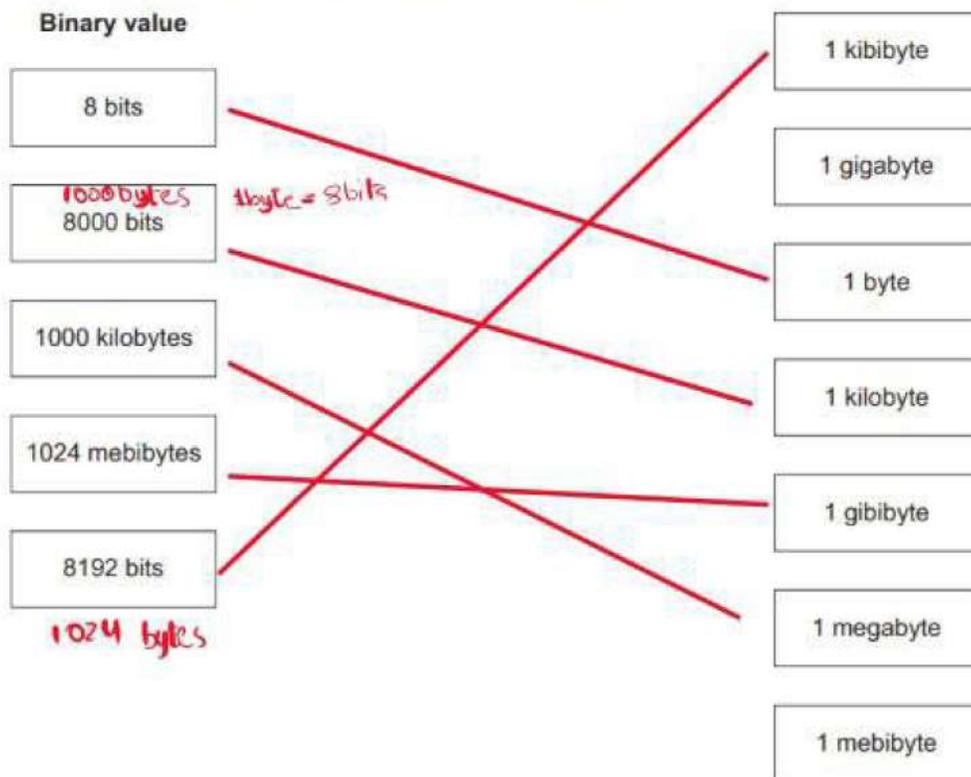
Binary and denary prefixes





- The smallest unit is bit.
- 1 byte contains 8-bits
- 4-bits are known as “nibble”
- 1 kilobyte = 1000 bytes
- 1 kibibyte = 1024 bytes

1 (a) Draw **one** line from each binary value to its equivalent (same) value on the right.



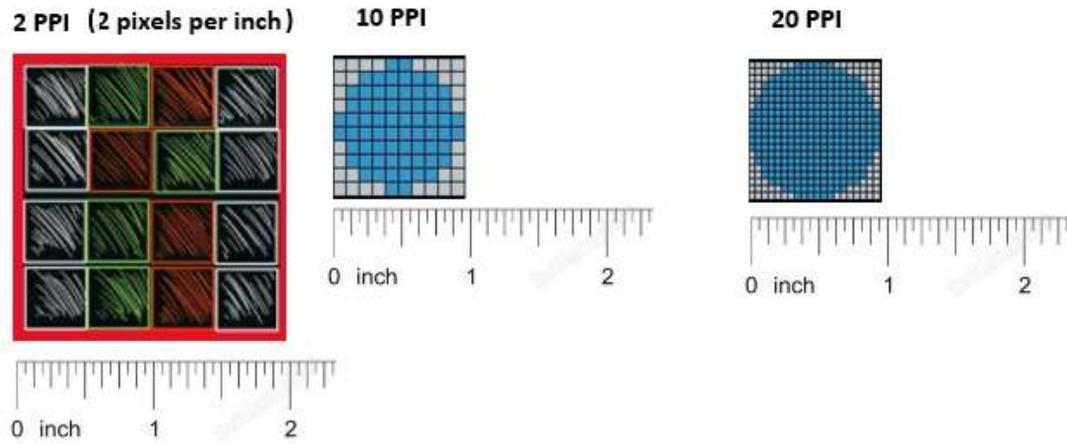
[5]

BITMAP

Pixel: Smallest picture element

Image Resolution:

Image resolution is measured in pixels per inch, this value determines the amount of detail an image has. Higher resolution means there are more pixels per inch.



Screen Resolution:

Number of pixels which can be views horizontally and vertically on the screen.

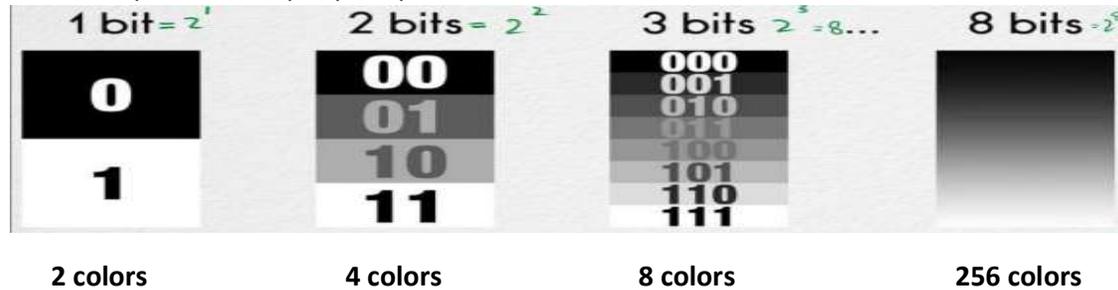


Screen Resolution is $1920 \times 1080 = 2,073,600$

Color Depth

The number of bits used to represent one pixel.

A color depth of 8 bits per pixel provides 256 different colors.



File size calculation

Size = (Width pixels) x (Height Pixels) x (Color Depth)

Color Depth unit is bit

4) A digital camera takes a bitmap image. The image is 2000 pixels wide by 1000 pixels high with a colour depth of 24-bits.

(a) Calculate an estimate of the file size for the image. Give your answer in megabytes. Show your working.

Working

Size = width x height x color depth

2000 x 1000 x 24 = 48 000 000 bits

Convert to bytes by dividing with 8

$\frac{48000000}{8} = \frac{6000000 \text{ bytes}}{1000 \times 1000} = 6 \text{ MB}$

Answer..... **6** MB [3]

4(a)	<p>1 mark per bullet point</p> <ul style="list-style-type: none"> • $2000 * 1000 * 24 = 48\,000\,000$ bits • $48\,000\,000 / 8 / 1024 / 1024$ • = 6 MB or 5.7 MB
------	--

- (ii) The image is scanned with an image resolution of 1024×512 pixels, and a colour depth of 8 bits per pixel.

Calculate an estimate for the file size, giving your answer in mebibytes. Show your working.

Working

.....

.....

.....

Answer mebibytes

[3]

1 mark per bullet point for working, **1 mark** for answer

Working:

- $1024 \times 512 = 524\,288$ pixels/bytes
- $524288 / 1024 / 1024$

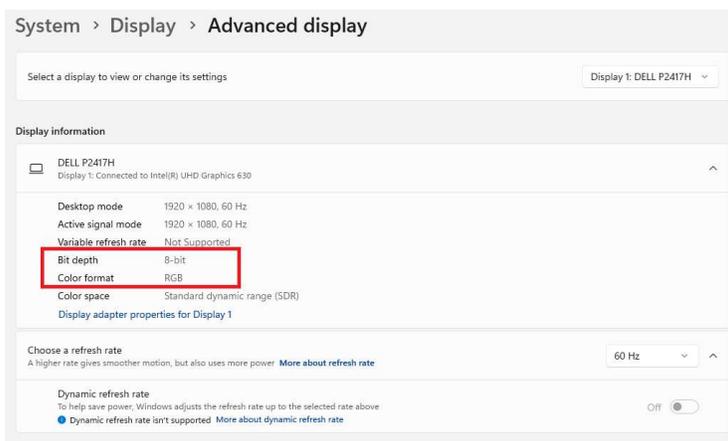
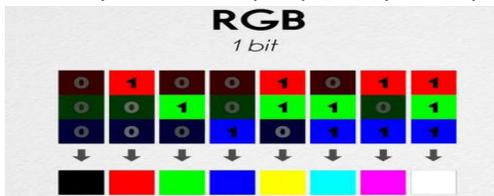
Answer:

0.50 mebibytes

Bit Depth

The number of bits used to represent each of the red, green and blue color.

A bit depth of 8 bits per primary color provides $256 \times 256 \times 256 = 16\,777\,216$ different colors.



WORKED EXAMPLE 1.04

You have been asked to calculate a value for the minimum size of a bitmap file. The bitmap is to use a bit depth of 8 and the bitmap is to be printed with 72 dpi (dots per inch) and to have dimensions 5 inches by 3 inches.

We use the information provided about the colour depth or the bit depth to give the number of bits per pixel. In this case the bit depth is 8, which means 8 bits for each of the RGB components, so 24 bits are needed for one pixel.

Let's state that 72 dpi means 72 pixels per inch.

So, the number of pixels per row is $5 \times 72 = 360$

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

Therefore, the total number of pixels is $360 \times 216 = 77\,760$

The total number of bits is this value multiplied by 24. However, we want the size in bytes not bits, so we multiply by 3 because there are 8 bits in a byte. So, we get:

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

We can quote this in kibibytes by dividing by 1024:

$233\,280 / 1024 = 227.8$ KiB

Metadata

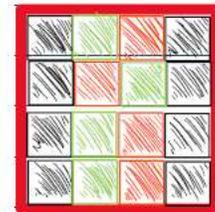
Data about data for example filename, file format, color depth

File Header

It contains information regarding the image such as image size, number of pixels, type of compression, color depth, bit depth or file location. Because of this, the bitmap file size is larger than the size of graphic alone.

Features of graphic editing software:

Some features are re-size, crop, blur, red eye reduction (Reduces red light reflected from human eye)



Q-1 How images are encoded into digital format?

- The images are stored as bitmap images.
- Each image is made up pixels.
- Each pixels is of single color.
- Each color has a unique binary number.
- Sequence of each binary number is stored of each image.

•	11	11	00	01	11
•	00	11	01	00	11
•	01	11	00	01	11
		11	00	01	11

Q-2 What is difference between bitmap and vector?

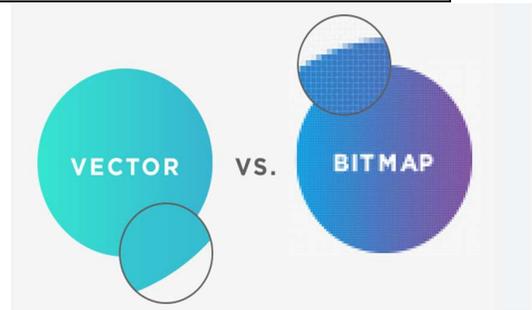
Bitmap	Vector
Bitmap are made up of pixels.	Vector graphics store a set of instructions about how to draw the image.
When bitmap is enlarged, the pixels get bigger and pixelates.	When vector is enlarged, it is recalculated and does not pixelate.
Bitmap files are usually bigger than vector graphics files because of the need to store data about each pixel.	Vector graphics have smaller file size because they contain just the instructions to create the shape.
Bitmap images can be compressed with significant reduction in file size	Vector graphic images do not compress well because of little redundant data.

Vector Graphic Terms

Property: Data about the shape.

Drawing List: The list of shapes involved in an image.

Drawing Objects: The object made with different shapes.



Maximum number of colours

68

256

127

2

249

Minimum number of bits

2 1 2¹

4 2 2²

8 3 2³

128 7 2⁷

256 8 2⁸

512 9 2⁹

256 = 8 [3]

Compression

Q-1 Why do we need to compress a file?

- The data files are very long.
- It would take a long time to send the non-compressed file.
- Compressed files will download fast.
- A higher bandwidth would be needed to transmit the uncompressed file.

Types of compression.

Lossless File Compression:

In this technique the data is not lost and the file can be decompressed as the original. This compression method is used where accuracy of data is important.

Lossy File Compression:

In this technique, the data is lost and the decompressed file is not same as the original. This compression method is used where accuracy of data is important.

Q-2 A person wants to compress source code, which compression method is suitable?

- Lossless technique will use.
- Data will not lost. Any lost data means program will not work.

Q-3 Photograph is to be emailed to a friend, which compression method is suitable?

Lossy

- All the data is not required.
- The number of colors can be reduced without the user noticing.
- Email requires a significantly smaller file size.
- Takes a shorter time to transmit.

Or Lossless

- A high quality image may be needed.
- All of the data is needed and cannot afford to lose any data.

Sound

Digital Data:

Data that has been stored as binary value which can be either 0 or 1.

Analogue Data:

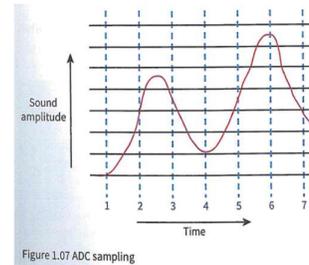
Data obtained by measurement of physical property which can have any value from a continuous range of values.

Sampling:

Taking measurement of sound at regular time interval.

Sampling Rate:

The number of samples taken per second.



Sampling Resolution:

The number of bits used to store each sample.

An increase sampling rate and increased sampling resolution will both cause an increase in file size.

Q-1 How sampling is used to store the sound clip.

The amplitude of the sound wave is determined at set time interval to get an approximation of the sound wave. Then encoded as sequence of binary numbers. Increasing the sampling rate will improve the accuracy of the recording.

Quantization Error:

It is the difference between the analog signal and the closest digital value at each sampling instant.