1.1 DATA REPRESENTATION For IGCSE

PapaCambridge

Chapter 1

1.1 Data representation

S No	Learning Outcome	To Read	Have Read	To Revise	Have Revised	Prepared
	1.1.1: Binary systems					
1	Recognize the use of binary numbers in computer systems					
2	Denary-to-binary and binary-to- denary conversion					
3	Concept of a byte and how the byte is used to measure memory size					
4	Use binary in computer registers for a given application (such as in robotics, digital instruments and counting systems)					
	1.1.2: Hexadecimal					
5	Represent integers as hexadecimal numbers					
6	Reasons for choosing hexadecimal to represent numbers					
7	Convert positive hexadecimal integers to and from denary					
8	Convert positive hexadecimal integers to and from binary					
9	Represent numbers stored in registers and main memory as hexadecimal					
10	Identify current uses of hexadecimal numbers in computing, such as defining colours in Hypertext Markup Language (HTML), Media Access Control (MAC) addresses, assembly languages and machine code, debugging					
	1.1.3: Data storage					
43	File formats sound (music), pictures, video, text and numbers					
44	Identify and describe methods of error detection and correction, such as parity checks, check digits, checksums and Automatic Repeat requests (ARQ)					
45	Concept of (MIDI) files, jpeg files, MP3 and MP4 files					
46	File compression (lossless and lossy compression algorithms) applied to music/video, photos and text files					

Chapter at a glance:

The basic building block in all computers is the binary number system.

A **binary digit** is commonly referred to as a **BIT**; 8 bits are usually referred to as a **BYTE**.

The byte is the **smallest unit of memory** in a computer.

Binary-to-Decimal & Denary-to-Binary Conversion –use binary notation (place values) i.e. 128, 64, 32, 16, 8, 4, 2, 1.

For **Binary-to-Hexadecimal** conversion firstly groups of 4 bits are made from right to left and each group is converted separately using 8, 4, 2, 1 notation.

For **Hexadecimal-to-Binary** conversion each hex digit is separated by other and then each hex digit is converted separately using 8 4 2 1 notation.

For **Denary-to-Hexadecimal** conversion LCM of the denary number is taken.

For Hexadecimal-to-Denary conversion hexadecimal notation (place value) is used e.g. 4096 256 16 1

Memory Dump is display of memory contents and address in hexadecimal on screen or printed on paper. It is powerful fault-tracing tool for expert programmers.

Hexadecimal are used in HTML to represent colour codes (RGB Model). For example: # ff0000 for bright red and #980000 for darker red.

MAC Addresses are unique number of NIC (Wi-Fi, Bluetooth. or wired connection i.e. Ethernet). They are 48 bit long, but converted into 12 hexadecimal digits (in 6 pairs) making them short and easier to understand. For 00-1C-2A-FF-01. 1st 3 pairs represent manufacturer while the other represent serial number of product.

UAA (Universally Administered MAC Address) are most common. These are the MAC addresses set by manufacturer

LAA (Locally Administered MAC Addresses) are changed locally to bypass firewall, or to assign MAC address of specific format.

URL encoding: Web addresses can be written using hexadecimal rather than denary. Hexadecimal codes are preceded by a % sign. For example, the word“**www.ruknuddin.com”** is written as:%72%75%6B%6E%75%64%64%69%6E

Machine code and Assembly code are examples of low-level languages and are used by software developers when producing, for example, computer games. They look difficult but they have many advantages at the development stage of software writing (especially when trying to locate errors in the code). Using hexadecimal makes it much easier, faster and less error prone to write code compared to binary.

Character: Any text, number or symbol.

Compression: The method of reducing file size.

Lossy Compression: The file is reduced in size for transmission and storage; by permanently removing some redundant information from the file

Lossless Compression: The file is reduced in size for transmission and storage; it is then put back together again later producing a file identical to the original

MP3: File compression system for music which does not noticeably affect the quality of the sound.This is done using file compression algorithms which use **PERCEPTUAL MUSIC SHAPING**; this essentially removes sounds that the human ear can't hear properly.

JPEG: File compression format designed to make photo files smaller in size for storage and for transmission.

MIDI: Standard adopted by the electronic music industry for controlling devices such as

synthesisers and sound cards
MP4: MPEG-4 (MP4) format allows the storage of multimedia files rather than just sound. Music, videos, photos and animation can all be stored in the MP4 format. Videos, for example, could be streamed over the internet using the MP4 format.
Algorithm: step-by-step set of instruction to solve a problem.
Register: Immediate access store in the processor. It can store small piece of data.

Computer

The word computer is derived from a word ‘compute’ that means ‘to calculate’.

Computer is an electronic data processing machine, that accepts data and instructions, process the data according to given instructions and output resulting information.

Data is the raw set of facts and figures required to solve a problem.

Process is the work done on data to obtain results.

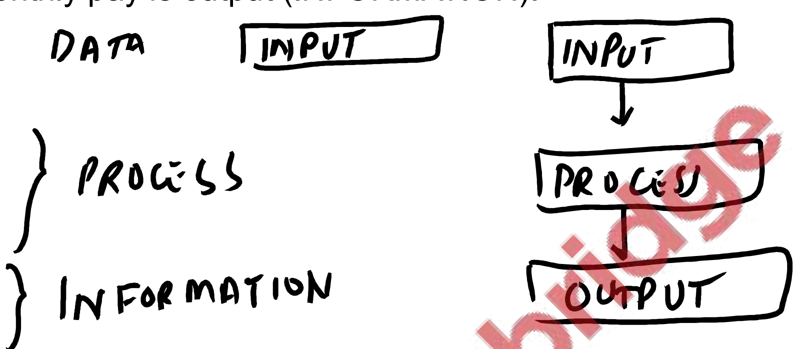
Information is the results of processing.

For example to calculate monthly pay of an employee, daily wages and number of days are required (DATA). To calculate monthly daily wages are multiplied by number of days worked (PROCESS). The monthly pay is output (INFORMATION).

Days = 30
Wages = 500

Pay = Wages * Days
500 * 30

Pay = 15000



1.1 Data Representation

Data is set of raw facts and figures required to solve a problem. Data can be in the form of numbers, text, images, audio and video.

Number System:

"The system of counting and calculating is called number system."

Number system is based on some characters called digits.

The word "digit" is derived from Latin word digitus means "finger" or "toe", and English borrowed from this to mean number.

In fact, the practice of calling numbers digits comes from the digits on your hands as these digits are used in counting.

The number of digits is known as base or radix of the number system. For example binary number system uses two characters 0 and 1 and its base is 2.

Some of the number systems, those are studied in A Level Computer Science are:

i) Denary (Decimal) number system
ii) Binary number system
iii) Hexadecimal number system

Denary (Decimal) Number System:-

"The number system which is based on 10 characters from 0 to 9 is called denary (decimal) system."

It is the most common number system. The digits of decimal system are 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. The value of each digit in a figure depends upon its weight. The weights are based on power of 10.

The weights of digits according to their positions are given below:

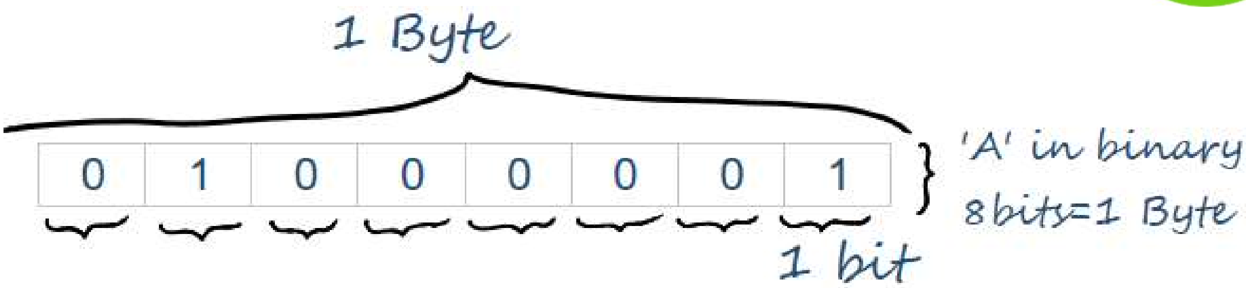
Position	5th	4th	3rd	2nd	1st
	10,000s	1,000s	100s	10s	1s
Weight(Decimal Notation)	$10^4=10000$	$10^3=1000$	$10^2=100$	$10^1=10$	$10^0=1$

For example 76854 can be expressed as:

	TTh	Th	H	T	O
	7	6	8	5	4
Position	4	3	2	1	0
	$10^4=10000$	$10^3=1000$	$10^2=100$	$10^1=10$	$10^0=1$
	10,000s	1,000s	100s	10s	1s
Weight(Decimal Notation)	Ten Thousands	Thousands	Hundreds	Tens	Units

Binary Number System:

In computer data is stored in the form of electric charge ON and OFF, represented by 1s and 0s. These “1’s” and “0’s” are called **bit** (being a contraction of **BI**nary digi**T**), and 8 bits make a byte to represent a single character.



Its value is usually held in memory as an electrical charge stored in a capacitor. Modern memory chips contain millions of these tiny capacitors, each of which is capable of storing exactly one bit of information. A single bit can have one of two values at any given time - *one* or *zero*. As we shall see, in order to represent a number greater than one, we will have to use several bits.

“The number system which is based on 2 characters 0 and 1 is called binary system.”

Using only 0 and 1 makes it easier to design the electronic circuits that the computers will use. This is because, if the computer wants to check a value in any part of the circuit, it only needs to detect whether or not there is any electricity. If there is electricity, the value is 1, if there is no electricity, the value is 0.

Binary numbers are fundamental to the way that all modern computers work. They are used to represent any data stored within a computer system.

The weights of digits according to their positions are given below:

The value of each digit in a figure depends upon its weight. The weights are based on power of 2. The binary notation is a sequence of numbers are based on power of two and arrange from right to left, as given below:

Position	5th	4th	3rd	2nd	1st
Weight	$2^4=16$	$2^3=8$	$2^2=4$	$2^1=2$	$2^0=1$

Position	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary Notation	2048	1024	512	256	128	64	32	16	8	4	2	1

Binary notation is ….512 256 128 64 32 16 8 4 2 1

If a switch is on, it can represent the number 1. If it is off, it represents 0. These states can also be interpreted as TRUE or FALSE. If you have enough switches, you can store all sorts of data. You could ask a question such as 'will you give me some money?' and you can get an answer in binary digits:

0 = NO 1 = YES

This is making use of just 1 bit of data. Add another bit and you can say more:

00 = NO 10 = MAYBE
01 = NEXT WEEK 11 = YES

The more binary digits you have, the more information you can store and process. Most computers store bits of data in memory in groups of eight. Eight bits stored at one location is called a byte. Sometimes it is useful to work on just half a byte. Half a byte is called a nibble.

1	1	1	1	1	1	1	1
Bit	bit	bit	bit	bit	bit	bit	bit
Nibble				Nibble			
Byte							

INTEGERS:

Integers are whole numbers. The range of values that can be stored as an integer depends on whether or not the number is signed (i.e. positive or negative), and how much memory is allocated for it in memory. Programming languages can generally represent integers that are signed or unsigned, and of different sizes.

A single byte can represent unsigned numbers ranging in value from 0 to 255, or signed integers ranging from -128 to +127. If two bytes are used, unsigned numbers from 0 to 65,535 or signed numbers from -32,768 to 32,767 can be stored. Much larger numbers can be represented if more bytes are made available.

For signed numbers, one bit is used to store the sign (+ or -) of the number, so the absolute value of the biggest number that can be stored is only half that for unsigned numbers. The number of bits used to represent an integer value will equal the number of bytes multiplied by eight. An integer represented by *n* bits can represent 2*n* numbers.

The magnitude of a four-byte integer can thus be anything up to $2^{(4×8)}$ or 2^{32} which means it can hold an unsigned value of up to 4,294,967,296 (a tad over two billion). Negative numbers can be represented in several different ways in binary number systems, although the most commonly used method is *two's complement* (the subject of two's complement is dealt with below).

Conversion of Positive Denary Integers into Binary:

Binary notation is used to convert a positive denary integer into binary numbers.

For example 120_{10} can be expressed as:

	120_{10}							
Binary Notation:	128	64	32	16	8	4	2	1

Put the 1 under notations which are required to find sum equals to the number and 0 in remaining places as 64+32+16+8=120

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

To convert a denary number using continuous division method:

	25	
2	12	1
2	6	0
2	3	0
	1	1

Working		
Division by 2	Quotient	Remainder (decimal)
25/2	12	1
12/2	6	0
6/2	3	0
3/2	1	1

Binary-to-Denary Conversion:

Binary notation is used to convert binary number into denary numbers.

For example 100111_2 can be expressed as:

100111_2

$= 1 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$

$= 1 \times 32 + 0 \times 16 + 0 \times 8 + 1 \times 4 + 1 \times 2 + 1 \times 1$

$= 32 + 0 + 0 + 4 + 2 + 1$

$= 39_{10}$

Short-cut method

Binary Value	1	0	0	1	1	1
Binary Notation	32	16	8	4	2	1
Ignore notations under 0 bits	32	0	0	4	2	1
Add the remaining numbers	32+4+2+1					
Equivalent denary number	39					

Binary Value	0	0	1	1	1	0	1	0	0	1	0	0	1	1	1	1
Binary Notation	32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
Ignore notations under 0 bits	0	0	8192	4096	2048	0	512	0	0	64	32	0	8	4	2	1
Add the remaining numbers	8192+4096+2048+512+64+32+8+4+2+1															
Equivalent denary number	14927															

Denary-to-Binary Conversion:

Binary notation is used to convert a denary number into binary numbers.

For example 120_{10} can be expressed as:

120_{10}

Binary Notation:

=128 64 32 16 8 4 2 1

Put the 1 under notations which are required to find sum equals to the number and 0 in remaining places as 64+32+16+8=120

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

Exercise

Convert the following denary numbers into binary

a) 75

b) 63

c) 127

d) 257

e) 79

f) 325

g) 90

h) 100

Answers:
a)1001011. b)111111.
c)1111111. d) 100000001.
e) 1001111. f) 101000101.
g) 1011010 h) 1100100.

Convert the following binary numbers into denary

a) 0 0 1 1 0 0 1 1

b) 0 1 1 1 1 1 1 1

c) 1 0 0 1 1 0 0 1

d) 0 1 1 1 0 1 0 0

e) 1 1 1 1 1 1 1 1

f) 0 0 0 0 1 1 1 1

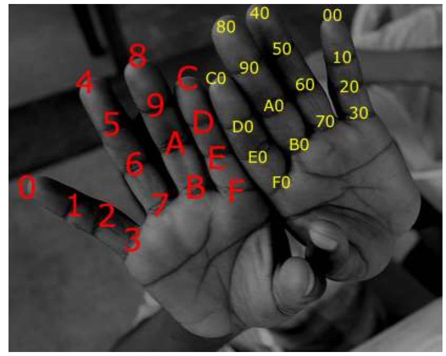
g) 1 0 0 0 1 1 1 1

h) 1 1 1 1 0 0 0 0

Answers:
a)51. b)127.c)153.
d) 116. e) 255. f)15
g) 143. h) 240.

1.1.2 Hexadecimal Number System:-

"The number system which is based on 16 characters from 0 to 9 and A, B, C, D, E & F is called Hexadecimal system."



The reason for the common use of hexadecimal numbers is the relationship between the numbers 2 and 16. Sixteen is a power of 2 (16 = 24). Because of this relationship, four digits in a binary number can be represented with a single hexadecimal digit.

The weights of digits according to their positions are given below:

Position	5th	4th	3rd	2nd	1st
Place Value (Hexadecimal Notation)	$16^4=65536$	$16^3=4096$	$16^2=256$	$16^1=16$	$16^0=1$

	Binary	**Denary**	**Hexadecimal**
Zero	0	0	0
One	1	1	1
Two	10	2	2
Three	11	3	3
Four	100	4	4
Five	101	5	5
Six	110	6	6
Seven	111	7	7
Eight	1000	8	8
Nine	1001	9	9
Ten	1010	10	A
Eleven	1011	11	B
Twelve	1100	12	C
Thirteen	1101	13	D
Fourteen	1110	14	E
Fifteen	1111	15	F
Sixteen	10000	16	10
Seventeen	10001	17	11

<u>Convert a binary number into a hexadecimal number</u>

Divide into groups of 4 bits

Write down binary notation under each group

Ignore the numbers below 0s and add up the numbers below 1s

If sum any 4-bit group is 10 then write A as A represents 10 in hexadecimal. Apply the same in case of 11 (B), 12 (C), 13 (D), 14 (E) and 15 (E)

For Example:

Convert the binary number 10110101 to a hexadecimal number

Conversion of Binary into Hexadecimal		
Groups of 4 bits	1 0 1 1	0 1 0 1
4 bit binary notation	8 4 2 1	~~8~~ 4 ~~2~~ 1
Calculation (Multiply each bit by its place value and add them together.	1x8+0x4+1x2+1x1 =8+0+2+1 =11	0x8+1x4+0x2+1x1 =0+4+0+1 =5
Hex-decimal Number	B	5

$10110101_2 = B5_{16}$

<u>Convert a hexadecimal number into a binary number</u>

Write down binary notation under each hexadecimal digit

Find out the binary notations numbers total of which equals the hexadecimal digit and place 1s below these numbers

Place 0s below remaining binary notation number.

For example: Convert the hex number 3A4F into binary

Conversion of Hexadecimal into Binary				
Hexadecimal Number	3	A	4	F
	3	10	4	15
4 Bit Binary Notation	8 4 2 1	8 4 2 1	8 4 2 1	8 4 2 1
Calculation (Write 1s under binary notation number total of which equals the hexadecimal digit	0 0 1 1 (2+1=3)	10 1 0 (4+3+1=7)	0 1 0 0 (4=4)	1 1 1 1 (8+4+2+1= 15)
Binary Numbers	0011 1010 01001111			

3=2+1 so 1s are written below 2 and 1 and 0s are written below 8 & 4.

7=4+2+1 so 1s are written below 4, 2 and 1 and 0s are written below 8.

4=4 so 1 is written below 4 and 0s are written under 1, 2 & 8.

F=15=8+4+2+1 so 1s are written under all of them.

$374F_{16} = 0011011101001111_2$

Exercise

Convert the following binary numbers into hexadecimal

a) 1 0 1 1 0 0 1 1 0 0 1 1

b) 0 1 1 0 0 0 0 1 0 1 0 1 1 1 1

c) 1 0 0 1 1 0 0 1 0 1 0 1 0 1

d) 0 1 1 1 0 1 11001 1 1 1 0

e) 1 1 1 1 1 1 1 1 01 1 0 1 1 1 0 00

f) 0 0 0 0 1 1 1 1 1 0 0 1 1 1 1

g) 1 0 0 0 1 1 1 1 0 1 1 0 1 1 1 0 0 1 0

h) 1 1 1 1 0 0 0 0 1 1 1 0 0 0 0 1

Answers:
a)B33. b)30AF. c)2655.
d) 3B9E. e) 3FDB8. f) 7CF.
g) 47B72. h) F0E1.

Convert the following hexadecimal numbers into binary

a) 6 B

b) 9 D

c) A B C

d) 1 2 8

e) A5 C3

f) 9 6 F 8

g) 7 8 E

h) 0 0 7

Answers:
a)1101011. b)10011101.
c)101010111100. d) 100101000.
e) 1010010111000011.
f) 1001011011111000
g) 11110001110. h) 111.

<u>Convert a hexadecimal number into a denary number</u>

Method 1: Converting from hex to denary via binary

Separate the hex digits to find each equivalent in binary, and then piece them back together.

Worked example - What is the denary value of hex value 3A4F?

1. Separate the hex digits into 3, A, 4and F and find the equivalent binary numbers.

Hexadecimal Number	3	A	4	F
	3	10	4	15
4 Bit Binary Notation	8 4 2 1	8 4 2 1	8 4 2 1	8 4 2 1
Calculation (Write 1s under binary notation number total of which equals the hexadecimal digit	0 0 1 1 (2+1=3)	10 1 0 (4+3+1=7)	0 1 0 0 (4=4)	1 1 1 1 (8+4+2+1= 15)
Binary Numbers	0011 1010 01001111			

2. Convert binary number into denary

Method 2: Using base 16 place-value columns

Another method is to create base 16 place-value columns, and add the hex value to the appropriate columns. You would then need to work out what the hex digits represent in denary, and multiply this figure with the place-value. Finally, add all the values together.

The base 16 columns would be (16^1=16), (16^2=256), (16^3=4096), etc.

Worked example - What is the denary value of hex value 3A4F?

Place value	16^3=4096	16^2=256	16^1=16	16^0=1
Hex Digit	3	A	4	F
	3	10	4	15
multiply hexdigitwith the place value	3 x 4096 =12288	10 x 256 = 2560	4 x 16 =64	15 x 1 =15
Add all the values together	12288+2560+64+15= 14927			

Convert a denary number into hexadecimal number

Method 1: Converting from denary to hex via binary

1. Convert denary number to binary using binary notation place value:

Denary number: 28345

Place Value: 32768 16384 8192 4096 2048 1024 512 256 128 64 32 16 8 4 2 1

Binary Value: 0 110111010111001

2. Now convert this binary number into hexadecimal

Binary number: 0110111010111001

Place value: 842184218421 8421

Hexadecimal: 6EB 9

Method 2: Converting from denary to hex using LCM method

Conversion steps:

1. Divide the number by 16.
2. Get the integer quotient for the next iteration.
3. Get the remainder for the hex digit.
4. Repeat the steps until the quotient is equal to 0.

Example:

Convert denary 28345 to hex:

			Working		
			Division by 16	Quotient	Remainder (decimal)
	28345		28345/16	1771	9
16	1771	9	1771/16	110	11
16	110	B	110/16	6	14
16	6	E	6/16	0	6
16	0	6			

So 28345 = 6EB9

Convert 7562 to hex:

			Division by 16	Quotient	Remainder (decimal)
	7562		7562/16	472	10
16	472	A	472/16	29	8
16	29	8	29/16	1	13
10	1	D	1/16	0	1
	0	1			

So 7562 = 1D8A

Exercise

Convert the following denary numbers into hexadecimal

a) 77

b) 250

c) 151

d) 357

e) 7079

f) 15120

g) 826

h) 10000

Answers:
a)4 D. b)F A. c)9 7.
d) 1 6 5. e) 1 B A 7. f) 3 B 1 0.
g) 3 3 A h) 2 7 1 0.

Convert the following hexadecimal numbers into denary

a) 5 F

b) 3 E D

c) E E

d) B B A

e) 1 2 A E

f) 4 A 2 F

g) 2 D F 5

h) F 9 A 8

Answers:
a)95. b)1005. c)238.
d) 3002. e) 4782. f) 18991
g) 11765. h) 63912.

Uses of Hexadecimal System:

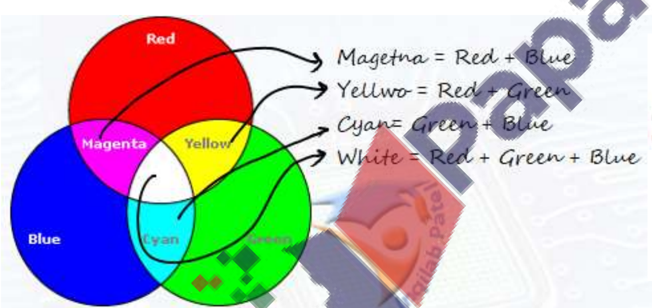
Uses of Hexadecimal in HTML:

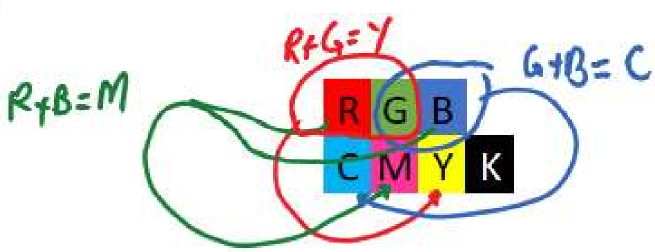
Hyper Text Mark-up Language is used to develop Websites. In HTML a colour is specified according to the intensity of its Red, Green and Blue (RGB) components, each represented by eight bits. Thus, there are 24 bits used to specify a web colour, and 16,777,216 colours that may be so specified. It's easier for the human programmer to represent a 24-bit integer, often used for 32-bit colour values, as #FF0099 instead of 111111110000000010011001

	BINARY (BITS)					HEX	
	1	1	1	1	=	F	RR
	1	1	1	1	=	F	
	0	0	0	0	=	0	GG
	0	0	0	0	=	0	
	1	0	0	1	=	9	BB
	1	0	0	0	=	8	
	111111110000000010011001					FF0099	

HTML TAG Name

RED (RED)
GREEN (GREEN) LIME
BLUE (BLUE)
YELLOW (YELLOW)
MAGENTA (MAGENTA) FUCHSIA
CYAN (CYAN) AQUA





Uses of Hexadecimal in MAC Address:

MAC address is unique identification number of NIC (network interface card). It is 48 bits long, so 281 billion MAC addresses can be assigned computers.

MAC addresses are 48 bit long so they are very difficult to read, write and understand for example 0000 0000 0001 1100 1011 0011 0100 1111 0010 0101. To make them shorter and easy to understand they are shown in 12 hexadecimal digits in 6 groups, like 00 – 1C – B3 – 4F – 25 – FE. First 6 numbers (i.e. 00-1C-B3) are manufacturer identity while last 6 numbers (i.e. 4F-25-FE) are serial number of NIC.

There are two types of MAC address:

UAA (Universally administered MAC address) are the most common MAC address set by manufacturers. These are not changed.

LAA(Locally administered MAC address): These are changed locally, but they must be unique.

There are a few reasons why the MAC address needs to be changed using LAA:

- Certain software used on mainframe systems needs all the MAC addresses of devices to fall into a strict format; because of this, it may be necessary to change the MAC address of some devices to ensure they follow the correct format.
- It may be necessary to bypass a MAC address filter on a router or a firewall; only 24 MAC addresses with a certain format are allowed through, otherwise the devices will be blocked.
- To get past certain types of network restrictions it may be necessary to emulate unrestricted MAC addresses; hence it may require the MAC address to be changed on certain devices connected to the network.

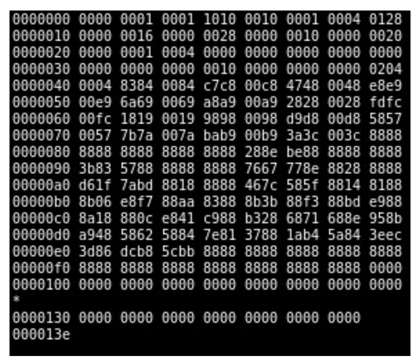
Uses of Hexadecimal in Debugging:

Debugging allows programmers to detect, diagnose, and eliminate errors in a program. The source debugger uses the hexadecimal values of the characters. Hex is often used in error messages. The hex number refers to the memory location of the error. This helps programmers to find and then fix problems.

Memory Dump

Contents of memory are in binary numbers. Binary numbers are long and difficult to understand.

Memory dump is a hexadecimal view (on screen or paper) of computer data, from RAM or from a file or storage device. As memory dump uses hexadecimal number to show memory contents, it become a powerful fault tracing tool but requires expertise in computer architecture.


```
0000000 0000 0001 0001 1010 0010 0001 0004 0128
0000010 0000 0016 0000 0028 0000 0010 0000 0020
0000020 0000 0001 0004 0000 0000 0000 0000 0000
0000030 0000 0000 0000 0010 0000 0000 0000 0204
0000040 0004 8384 0084 c7c8 00c8 4748 0048 e8e9
0000050 00e9 6a69 0069 a8a9 00a9 2828 0028 fdfc
0000060 00fc 1819 0019 9898 0098 d9d8 00d8 5857
0000070 0057 7b7a 007a bab9 00b9 3a3c 003c 8888
0000080 8888 8888 8888 8888 288e be88 8888 8888
0000090 3b83 5788 8888 8888 7667 778e 8828 8888
00000a0 d61f 7abd 8818 8888 467c 585f 8814 8188
00000b0 8b06 e8f7 88aa 8388 8b3b 88f3 88bd e988
00000c0 8a18 880c e841 c988 b328 6871 688e 958b
00000d0 a948 5862 5884 7e81 3788 1ab4 5a84 3eec
00000e0 3d86 dcb8 5cbb 8888 8888 8888 8888 8888
00000f0 8888 8888 8888 8888 8888 8888 8888 0000
0000100 0000 0000 0000 0000 0000 0000 0000 0000
*
0000130 0000 0000 0000 0000 0000 0000 0000
000013e
```

Uses of Hexadecimal in Assembly Language:

Machine codes are written in binary language which is very long and difficult to understand.

Hexadecimal numbers are easier, faster and less error prone to write code.

In assembly language codes are written in hexadecimal. This can have many advantages to program developers or when carrying out troubleshooting.

For example:

LDD A750 (assemble language)

A5E4 FFA4 (machine code using hexadecimal values)

1010 0101 1110 0100 1111 1111 1010 0100 (machine code using binary)

URL encoding:

Web addresses can be written using hexadecimal rather than denary. Hexadecimal codes are preceded by a % sign. For example, the word "**www.ruknuddin.com**" is written as:

	r	u	k	n	u	d	d	i	n
in hex	%72	%75	%6B	%6E	%75	%64	%64	%69	%6E

w	w	w	.	r	u	k	n	u	d	d	i	n	.	c	o	m
%77	%77	%77	%2E	%72	%75	%6B	%6E	%75	%64	%64	%69	%6E	%2E	%63	%6F	%6D

Some characters are not allowed in URL. URL encoding converts characters into a format that can be transmitted over the Internet.

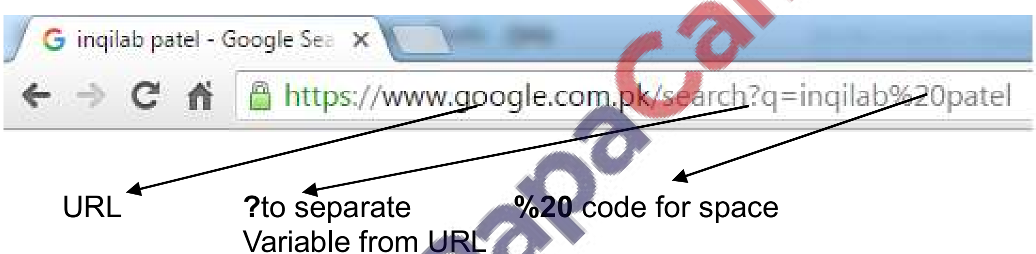
For example

- %20 – is used in URL in place of <space> not allowed in a URL, %20 is the coding for a space (32 in denary)
- ? – separates the URL from all parameters or variables
  e.g. for query to search Inqilabpatel in Google

https://www.google.com.pk/search?q=inqilab%20patel

here**"q"** is variable for query "**?**" separates it from URL
"https://www.google.com.pk/search"

while**"%20"**is used for the space between **"inqilab" and "patel"**



Memory Size Measurement

It should be pointed out here that there is some confusion in the naming of memory sizes.
There are two different methods:

1. **Denary Prefix System** used in SI Units. It is base 10 system. In this system 10^3 = 1000 i.e. Kilo
2. **Binary Prefix System** used in IEC Units (**International Elcrtro-Technical Commission**). It is a base 2 system. In this system 2^{10}=1024 i.e. kibi

SI Units	IEC units
1 kilobyte = 10^3= 1000 byte 1 megabyte = 10^6=1000000 bytes 1 gigabyte = 10^9=1000000000 bytes 1 terabyte = 10^{12}=1000000000000 bytes and so on.	1 kibibyte (1 KiB) = 2^{10}= 1024 bytes 1 mebibyte (1 MiB) = 2^{20}= 1048576 bytes 1 gibibyte (1 GiB) =2^{30}= 1073741824 bytes 1 tebibyte (1 TiB) =2^{40}= 1099511627776 bytes and so on

Example Question: *A company advertises its backup memory device as having 500 GB of storage. A customer wishes to know how many 8 MB files could be stored on the device. The company claimed that up to 62 500 files (assuming each file is 8 MB) could be stored. The customer calculated that 64 000 files could be stored.*
Explain the difference between these two storage values. Show any calculations you use in your explanation. ....
....

–company calculation is based on 1 GByte = 1000 Mbyte – so (500 × 1000)/8 = 62 500 files
– customer calculation based on 1 GByte = 1024 Mbyte – so (500 × 1024)/8 = 64000 files
– giving the difference of 1500 files [3]

1.1.3 Data storage

File formats sound (music), pictures, video, text and numbers					
Identify and describe methods of error detection and correction, such as parity checks, check digits, checksums and Automatic Repeat requests (ARQ)					
Concept of (MIDI) files, jpeg files, MP3 and MP4 files					
File compression (lossless and lossy compression algorithms) applied to music/video, photos and text files					

Following are different types of file formats available to be used in computers for example:
MIDI & MP3 for sound
MP4 for video
Jpeg for pictures
and DOC text and numbers

Representation of Text and Numbers in Computer

Text and numbers can be represented in computer as patterns of binary digits. To represent each character (letter, digit or symbol) a character set is used. Character set is a set of characters can be understood by computer.
ASCII and Unicode are important character sets that are used as standard.

ASCII (American Standard Code for Information Interchange)

The ASCII character set is a 7-bit set of codes that allows 128 different characters. That is enough for every upper-case letter, lower-case letter, digit and punctuation mark on most keyboards. ASCII is only used for the English language.
This table shows some examples of letters represented using the ASCII character set:

Character	Denary Value	Binary Value	HEX	Character	Denary Value	Binary Value	HEX
A	65	1000001	41	N	78	1001110	4E
B	66	1000010	42	O	79	1001111	4F
C	67	1000011	43	P	80	1010000	50
D	68	1000100	44	Q	81	1010001	51
E	69	1000101	45	R	82	1010010	52
F	70	1000110	46	S	83	1010011	53
G	71	1000111	47	T	84	1010100	54
H	72	1001000	48	U	85	1010101	55
I	73	1001001	49	V	86	1010110	56
J	74	1001010	4A	W	87	1010111	57
K	75	1001011	4B	X	88	1011000	58
L	76	1001100	4C	Y	89	1011001	59
M	77	1001101	4D	Z	90	1011010	5A

Extended ASCII

Extended ASCII code is an 8-bit character set that represents 256 different characters, making it possible to use characters such as é or ©. Extended ASCII is useful for European languages.

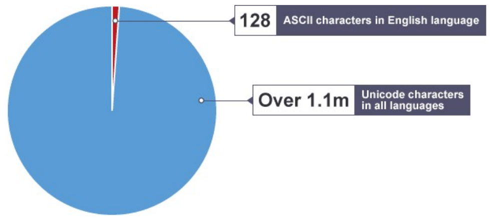
Unicode

Unicode uses between 8 and 32 bits per character, so it can represent any characters from languages from all around the world. It is commonly used across the internet. As it is larger than ASCII, it might take up more storage space when saving documents.
Global companies, like Facebook and Google, would not use the ASCII character set because their

users communicate in many different languages.

How text is encoded in computer

Each character in text has a unique binary code in ASCII, Extended ASCII and Unicode character set. To encode a text each character is replaced with the binary value given in ASCII/Extended/Unicode and stored in sequence.



ASCII Code

DEC	HEX	BIN	Symbol	DEC	HEX	BIN	Symbol	DEC	HEX	BIN	Symbol
0	00	00000000	NUL	43	2B	00101011	+	86	56	01010110	V
1	01	00000001	SOH	44	2C	00101100	,	87	57	01010111	W
2	02	00000010	STX	45	2D	00101101	-	88	58	01011000	X
3	03	00000011	ETX	46	2E	00101110	.	89	59	01011001	Y
4	04	00000100	EOT	47	2F	00101111	/	90	5A	01011010	Z
5	05	00000101	ENQ	48	30	00110000	0	91	5B	01011011	[
6	06	00000110	ACK	49	31	00110001	1	92	5C	01011100	\
7	07	00000111	BEL	50	32	00110010	2	93	5D	01011101	]
8	08	00001000	BS	51	33	00110011	3	94	5E	01011110	^
9	09	00001001	HT	52	34	00110100	4	95	5F	01011111	_
10	0A	00001010	LF	53	35	00110101	5	96	60	01100000	`
11	0B	00001011	VT	54	36	00110110	6	97	61	01100001	a
12	0C	00001100	FF	55	37	00110111	7	98	62	01100010	b
13	0D	00001101	CR	56	38	00111000	8	99	63	01100011	c
14	0E	00001110	SO	57	39	00111001	9	100	64	01100100	d
15	0F	00001111	SI	58	3A	00111010	:	101	65	01100101	e
16	10	00010000	DLE	59	3B	00111011	;	102	66	01100110	f
17	11	00010001	DC1	60	3C	00111100	<	103	67	01100111	g
18	12	00010010	DC2	61	3D	00111101	=	104	68	01101000	h
19	13	00010011	DC3	62	3E	00111110	>	105	69	01101001	i
20	14	00010100	DC4	63	3F	00111111	?	106	6A	01101010	j
21	15	00010101	NAK	64	40	01000000	@	107	6B	01101011	k
22	16	00010110	SYN	65	41	01000001	A	108	6C	01101100	l
23	17	00010111	ETB	66	42	01000010	B	109	6D	01101101	m
24	18	00011000	CAN	67	43	01000011	C	110	6E	01101110	n
25	19	00011001	EM	68	44	01000100	D	111	6F	01101111	o
26	1A	00011010	SUB	69	45	01000101	E	112	70	01110000	p
27	1B	00011011	ESC	70	46	01000110	F	113	71	01110001	q
28	1C	00011100	FS	71	47	01000111	G	114	72	01110010	r
29	1D	00011101	GS	72	48	01001000	H	115	73	01110011	s
30	1E	00011110	RS	73	49	01001001	I	116	74	01110100	t
31	1F	00011111	US	74	4A	01001010	J	117	75	01110101	u
32	20	00100000		75	4B	01001011	K	118	76	01110110	v
33	21	00100001	!	76	4C	01001100	L	119	77	01110111	w
34	22	00100010	"	77	4D	01001101	M	120	78	01111000	x
35	23	00100011	#	78	4E	01001110	N	121	79	01111001	y
36	24	00100100	$	79	4F	01001111	O	122	7A	01111010	z
37	25	00100101	%	80	50	01010000	P	123	7B	01111011	{
38	26	00100110	&	81	51	01010001	Q	124	7C	01111100	|
39	27	00100111	'	82	52	01010010	R	125	7D	01111101	}
40	28	00101000	(	83	53	01010011	S	126	7E	01111110	~
41	29	00101001	)	84	54	01010100	T	127	7F	01111111	
42	2A	00101010	*	85	55	01010101	U				

Memory Size Measurement

It should be pointed out here that there is some confusion in the naming of memory sizes.

The unit was established by the **International Electro-technical Commission (IEC)** in 1998, has been accepted for use by all major standards organizations, and is part of the International System of Quantities. The kibibyte was designed to replace the kilobyte in those computer science contexts in which the term kilobyte is used to mean 1024 bytes. The interpretation of the kilobyte to denote 1024 bytes, conflicting with the SI definition of the prefix kilo (1000), is still common, mostly in informal computer science contexts.

The IEC convention is now adopted by some organisations. Manufacturers of storage devices often use the denary system to measure storage size. For example:

0 or 1 = 1 bit

4 bits = 1 nibble

8 bits = 2 niblles = 1 byte

SI Units	IEC Units
1 kilo byte = 1000 byte	1 kibi byte (1 KiB) = 1,024 bytes
1 mega byte = 1000,000 bytes (1000 * 1000)	1 mebi byte (1 MiB) = 1,048,576 bytes (1,024 * 1,024)
1 giga byte = 1,000,000,000 bytes (1,000,000 * 1000)	1 gibi byte (1 GiB) = 1,073,741,824 bytes (1,048,576 * 1,024)
1 tera byte = 1,000,000,000,000 bytes and so on. (1,000,000,000 *1000)	1 tebi byte (1 TiB) = 1,099,511,627,776 bytes and so on (1,073,741,824 * 1,024)

The IEC convention for computer internal memories (including RAM) becomes:

Example Question: *A company advertises its backup memory device as having 500 GB of storage. A customer wishes to know how many 8 MB files could be stored on the device. The company claimed that up to 62 500 files (assuming each file is 8 MB) could be stored. The customer calculated that 64 000 files could be stored. Explain the difference between these two storage values. Show any calculations you use in your explanation.* ....

....

–company calculation is based on 1 GByte = 1000 Mbyte – so (500 × 1000)/8 = 62 500 files

– customer calculation based on 1 GByte = 1024 Mbyte – so (500 × 1024)/8 = 64000 files

– giving the difference of 1500 files [3]

Representation of Sound Files

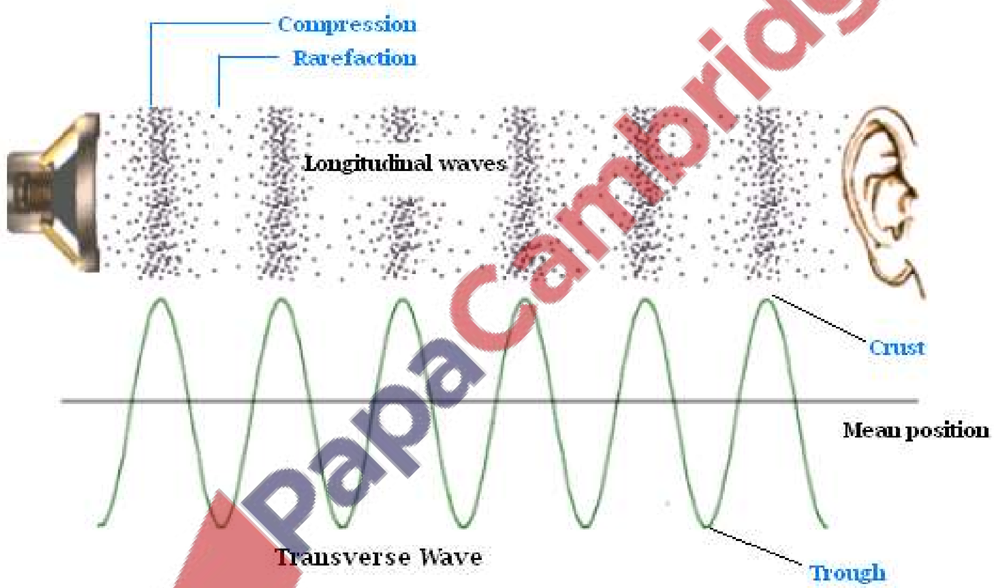
Sampling: A sound wave is broken down into smaller pieces at a regular interval of time. These smaller pieces are known as **Sample** and this process is known as **Sampling.** In sampling amplitude of sound wave is taken at different intervals of time.

Sampling resolution – number of bits used to represent sound amplitude (also known as **bit depth**).

Sampling rate – number of sound samples taken per second.

Sound is a vibration that propagates as an acoustic wave, through a transmission medium such as a gas, liquid or solid.

A sound waves are longitudinal as they consist of alternating compressions and rarefactions, or regions of high pressure and low pressure, moving at a certain speed. The longitudinal sound waves are converted into transverse waves.

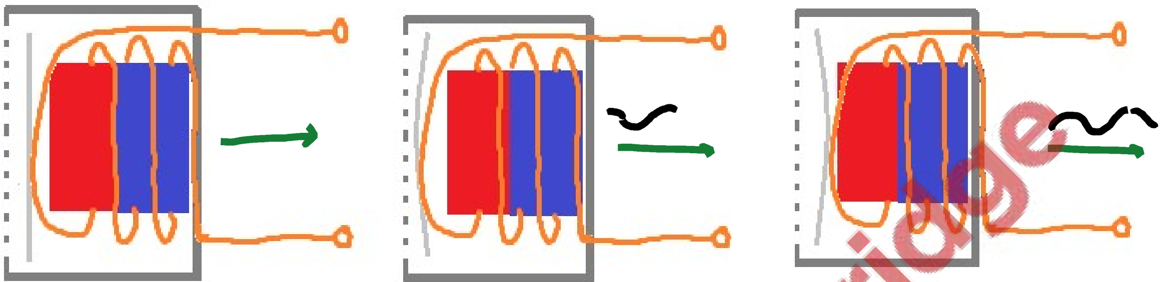


How to capture a sound:

To record a sound microphone is used.

Microphone has a diaphragm. Diaphragm is attached with a moveable coil. Inside this movable coil there is fixed magnet.

When sound waves strike diaphragm, causes vibration in it and the movable coil starts moving to a nd fro around fixed magnet. This movement generates electrical signals. And in this way sound is c aptured.



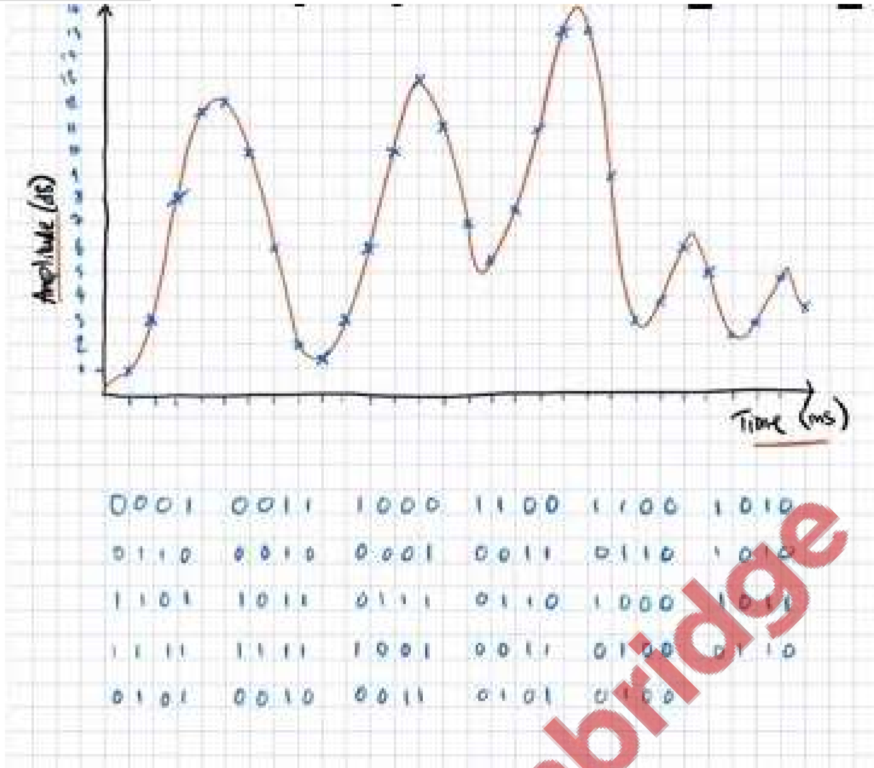
Conversion of Analogue Sound into Digital Format:

Sound waves are analogue values, these analogue values are converted into digital values to manipulate and to store in computer.

ADC (Analogue to Digital Converter) is used to convert analogue sound waves into digital values.

This conversion is done in following steps.

1. Firstly, a filter removes non-audible sound waves. Humans can hear **sounds** in a **frequency range** from about 20 Hz to 20 kHz.
2. Then sound waves are sampled at a given time rate (Sound waves are broken down thousands of smaller parts (samples) per second.)
3. The height/amplitude of each sound wave is determined.
4. Approximation is used when necessary.
5. At last sound wave values are stored in binary digits, depending upon number of bits per sample.



Digital audio quality

Factors that affect the quality of digital audio include:

- **Sample rate** - The **sample rate** is how many samples, or measurements, of the sound are taken each second. The more samples that are taken, the more detail about where the waves rise and fall is recorded and the higher the quality of the audio. Also, the shape of the sound wave is captured more accurately. Each sample represents the amplitude of the digital signal at a specific point in time.
- **Bit depth/Sampling Resolution** Bit depth is the number of bits available for each sample. The higher the bit depth, the higher the quality of the audio. Bit depth is usually 16 bits on a CD and 24 bits on a DVD. A bit depth of 16 has a resolution of 65,536 possible values (ranging from 0 to 65,535), and a bit depth of 24 has over 16 million possible values (ranging from 0 to 16,777, 216).

  Benefits of Higher Bit Depth:

  The higher the bit depth, the higher the quality of the audio.

  Allows for larger dynamic ranges (dynamic range is approximately six times the bit depth).

  More accurate representation/crisper sound quality.

  Increase in bit depth decreases the quantisation error.

Drawback of Higher Bit Depth:

Increasing bit depth also increases files size.

More disc and memory space is required.

Data will be transmitted slowly

Greater processing power will be required.

- **Bit rate -** The bit rate of a file tells us how many bits of data are processed every second. Bit rates are usually measured in **kilobits per second (kbps)**.

A common audio **sample rate** for music is **44,100 samples per second**. The unit for the sample rate is hertz (Hz). 44,100 samples per second is 44,100 hertz or 44.1 kilohertz (kHz).

Telephone networks and VOIP services can use a sample rate as low as 8 kHz. This uses less data to represent the audio. At 8 kHz, the human voice can still be heard clearly - but music at this sample rate would sound low quality.

MIDI

Pronounced *middy*, an acronym for ***m**usical **i**nstrument **d**igital **i**nterface*, a standard adopted by the electronic music industry for controlling devices, such as synthesizers and sound cards, which emit music.

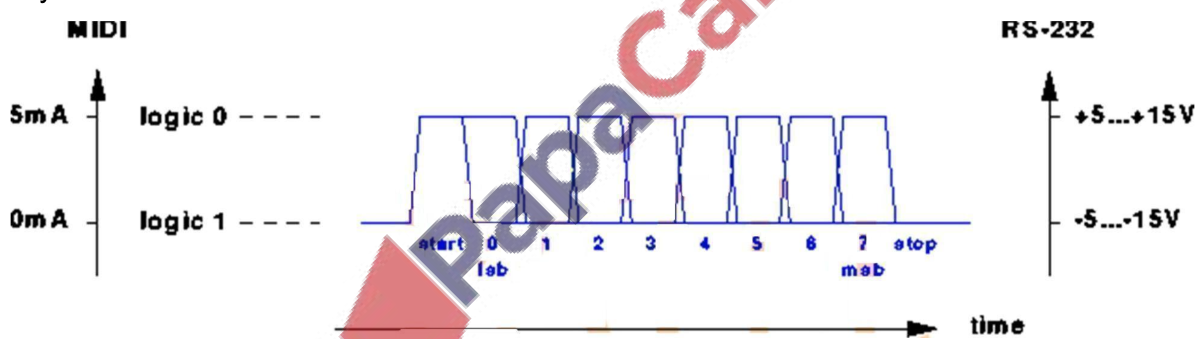
A MIDI file consists of a list of commands that instruct a device like an electronic organ, how to produce a particular sound or musical note.

Examples of MIDI commands include:

- note on/off: this indicates that a key has been pressed/released to produce/stop producing a musical note
- key pressure: this indicates how hard the key has been pressed (this could indicate loudness of the music note or whether any vibrato has been used, and so on).

The whole piece of music will have been stored as a series of commands but no actual musical notes. Their size, compared with an MP3 file, is considerably smaller. MIDI is essentially a communications protocol that allows electronic musical instruments to interact with each other.

The MIDI protocol uses 8-bit serial transmission with one start bit and one stop bit, and is therefore asynchronous.



MIDI is essentially a communications protocol that allows electronic musical instruments to interact with each other.

Two additional bytes are required, a **PITCH BYTE for note t**o play, and a **VELOCITY BYTE for loudness.** However, to play back through an instrument such as a guitar would need the use of **SEQUENCER SOFTWARE.**

MP3 (Moving Pictures Expert Group Audio Layer 3)

This has become the standard for distributing digital music files on the internet. It uses lossy compression to reduce file sizes to about a tenth of the original.

The compression algorithm is intended to remove sounds that are generally beyond the limits of most people's hearing and does not noticeably affect the quality of sound.

When using MP3 format, the size of the music track will be reduced by a factor of 10 (i.e. the size is reduced by 90% and remaining file size is only 10% of original size).This is done using file compression algorithms which use **PERCEPTUAL MUSIC SHAPING**; this essentially removes

> For example, an 50 megabyte music CD can be reduced to 5 megabytes.
> 50 MB x 90/100= 45 MB reduced. 50 MB x 10/100=5 MB new file size.

sounds that the human ear can't hear properly.

The quality of MP3 files depends on the **BIT RATE** – this is the number of bits per second used when creating the file. Bit rates are roughly between 80 and 320 kilobits per second; usually 200 or higher gives a sound quality close to a normal CD.

MPEG-4 (MP4) files are slightly different to MP3 files. This format allows the storage of multimedia files rather than just sound. Music, videos, photos and animation can all be stored in the MP4 format. Videos, for example, could be streamed over the internet using the MP4 format without losing any real discernible quality.

Bitmap Images

Bit-map image – system that uses pixels to make up an image.
Pixel – smallest picture element that makes up an image.
Bit depth – number of bits used to represent the smallest unit in, for example, a sound or image file – the larger the bit depth, the better the quality of the sound or colour image.
Colour depth – number of colours available in a pixel, e.g. 8 bit depth has colour depth of 256 ($2^8 = 256$).
Image resolution – number of pixels that make up an image, for example, an image could contain 4096 × 3192 pixels (12 738 656 pixels in total).

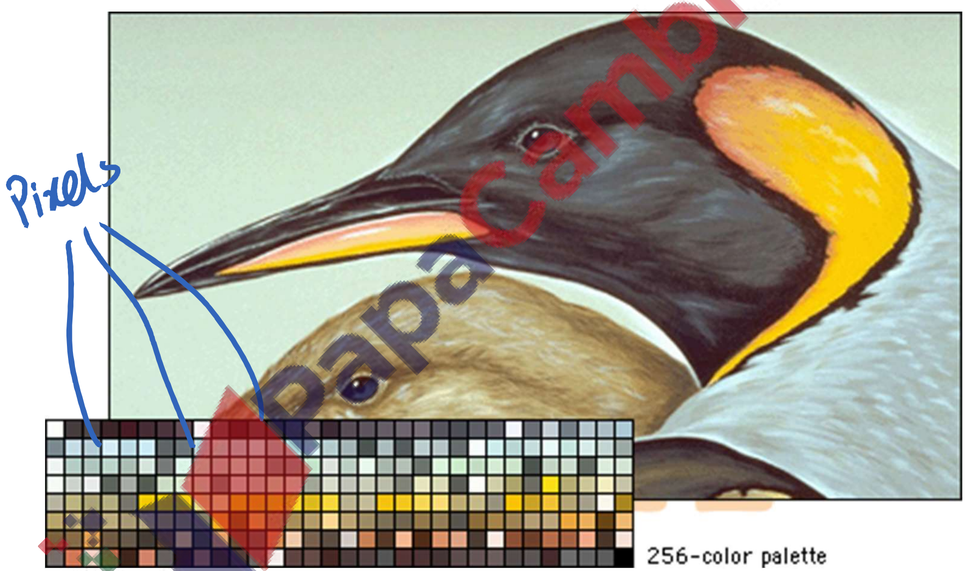
Screen resolution – number of horizontal and vertical pixels that make up a screen display. If the screen resolution is smaller than the image resolution, the whole image cannot be shown on the screen, or the original image will become lower quality.

Resolution – number of pixels per column and per row on a monitor or television screen.

Pixel density – number of pixels per square centimetre.

Vector graphics – images that use 2D points to describe lines and curves and their properties that are grouped to form geometric shapes.

The images that are made up of small picture elements (pixels) are called bitmap image.



How images are stored in computer:

The images are stored in computer as bitmaps

Each image is made up of tiny elements known as **Pixel (Pict**ure **El**ement)

Each pixel is of a single colour. The number of available colours in a pixel is known as **Colour Depth.**

The Colour depth of the image is determined by **Bit Depth** i.e. number of bits per pixel

The image quality is also determined by **Pixel** Density i.e. number of pixels per inch.

The total number of pixels in an image is known as **Image Resolution.**

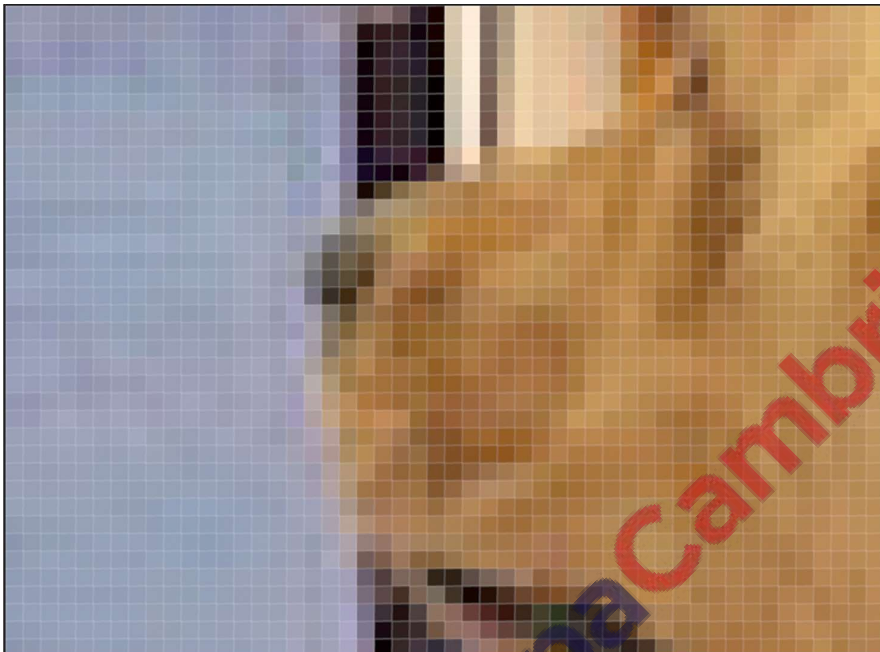
The values of each pixel of the image is stored in binary numbers.

Courtesy :

The Khan Academy team page includes this lovely photo of a dog looking at a computer screen:

At normal resolution, it looks like there are blocks of similar color, like in the dog's fur or the grey in the computer screen. These blocks are picture elements and known as pixels.

Let's zoom in to the pixels:



The Khan Academy team page includes this lovely photo of a dog looking at a computer screen:

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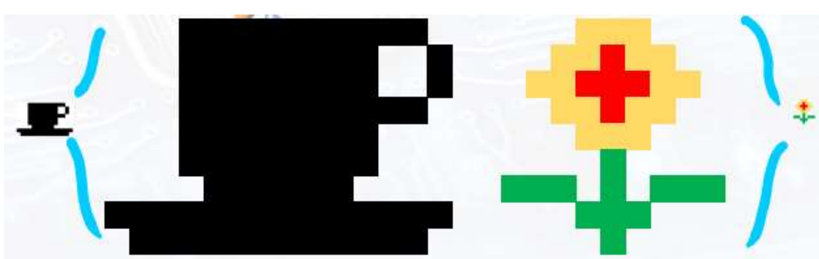
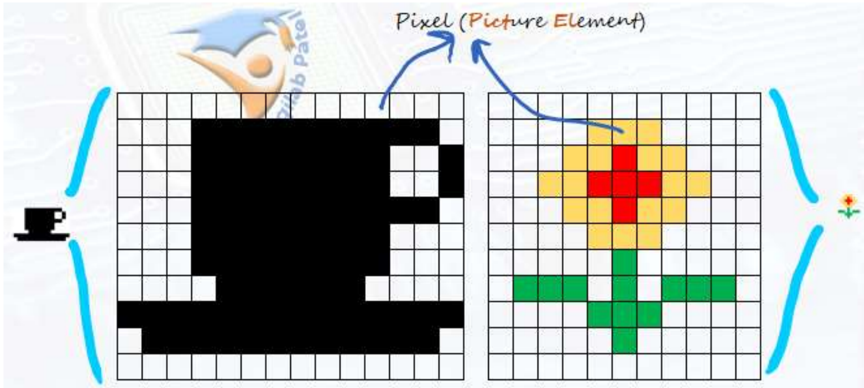
Let's zoom in to the pixels:

Pixels

Consider two a very simple image such as the two below, one has two colours - black and white and other one has 8 colours (CMYK).



This images can be divided up into a grid of smaller elements, as shown below:



Each element in the grid of picture is called a **pixel.** The more pixels used, the finer the details that can be represented.

As we mentioned earlier, computers can only handle and store 1s and 0s. Therefore let a single colour within each pixel be represented by binary 1 (say for white) and let a different colour (black perhaps) be represented by binary 0.

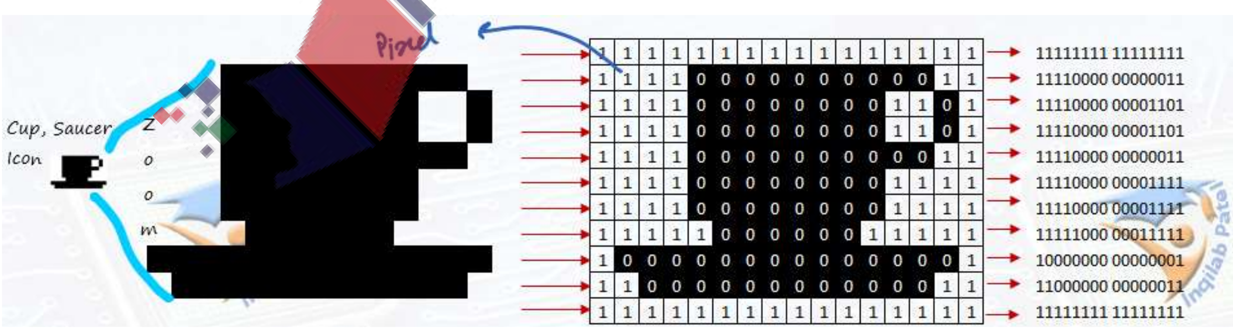
Image display

When a monitor or a printer displays a vector image it is **rasterised** - converted into a grid of pixels. Regardless of the file type, an image will always be outputted onto a screen or printed in pixels.

Colour Depth is the number of colours a bit can store is colour depth while **Bit Depth** is the number of bits per pixel. Colour depth is determined by bit depth (the number of bits per pixel).

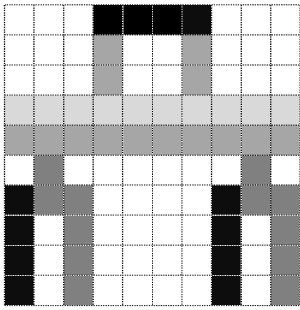
In the black and white image, only two colours are needed. This means it has a colour depth of 1 bit.

In black and white image below shows each 1 bit pixel containing either binary 1 or binary 0.



A 2-bit colour depth would allow four different values: 00, 01, 10, 11. This would allow for a range of colours such as:

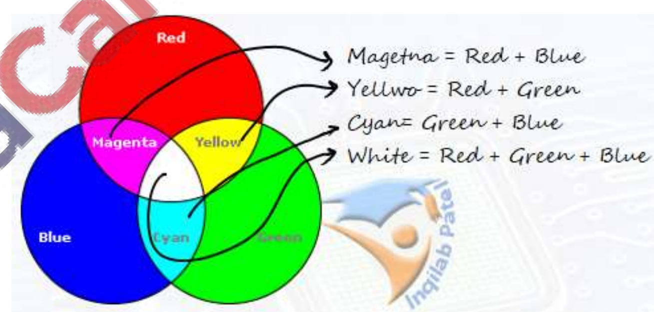
Binary code	Colour
00	Black
01	Dark grey
10	Light grey
11	White

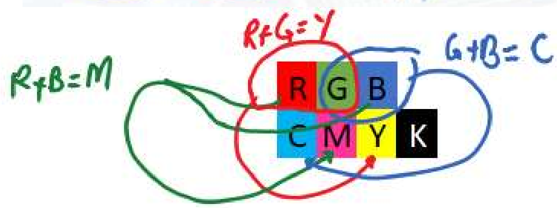


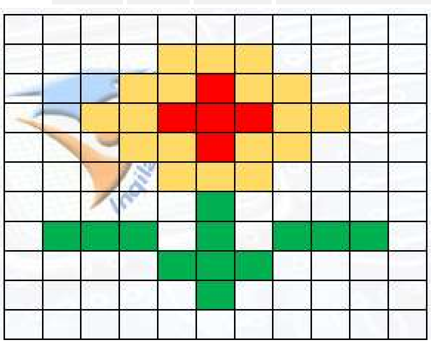
11	11	11	00	00	00	00	11	11	11
11	11	11	10	00	00	10	11	11	11
11	11	11	10	00	00	10	11	11	11
10	10	10	10	10	10	10	10	10	10
01	01	01	01	01	01	01	01	01	01
11	01	11	11	11	11	11	11	01	11
00	01	01	11	11	11	11	00	01	01
00	11	01	11	11	11	11	00	11	01
00	11	01	11	11	11	11	00	11	01
00	11	01	11	11	11	11	00	11	01

A 3-bit colour depth allows 8 colours. The range of colours are:

Binary code			Colour
R	G	B	
0	0	0	Black
0	0	1	Blue
0	1	0	Green
0	1	1	Cyan
1	0	0	Red
1	0	1	Magenta
1	1	0	Yellow
1	1	1	White







111	111	111	111	111	111	111	111	111	111	111
111	111	111	111	110	110	110	111	111	111	111
111	111	111	110	110	100	110	110	111	111	111
111	111	110	110	100	100	100	110	110	111	111
111	111	111	110	110	100	110	110	111	111	111
111	111	111	111	110	110	110	111	111	111	111
111	111	111	111	111	010	111	111	111	111	111
111	010	010	010	111	010	111	010	010	010	111
111	111	111	111	010	010	010	111	111	111	111
111	111	111	111	111	010	111	111	111	111	111
111	111	111	111	111	111	111	111	111	111	111

→ 111 111 111 111 111 111 111 111 111 111 111
→ 111 111 111 111 110 110 110 111 111 111 111
→ 111 111 111 110 110 100 110 110 111 111 111
→ 111 111 110 110 100 100 100 110 110 111 111
→ 111 111 111 110 110 100 110 110 111 111 111
→ 111 111 111 111 110 110 110 111 111 111 111
→ 111 111 111 111 111 010 111 111 111 111 111
→ 111 010 010 010 111 010 111 010 010 010 111
→ 111 111 111 111 010 010 010 111 111 111 111
→ 111 111 111 111 111 010 111 111 111 111 111
→ 111 111 111 111 111 111 111 111 111 111 111

Colour depth

The number of bits used to represent the colour of a single pixel

If bit depth is 8 and then there will be 256 colour ($2^8=256$). While in a true colour image there are 24 bits per pixel generating 16 million colour image (2^{24}= 16,777,216) while only 10 million colours can be recognised by an human eye.

Bit Depth	Colour Depth Available colours	Available Colours
1-bit	$2^1 = 2$	Monochrome (Black & White)
2-bit	$2^2 = 4$	Grey Scale
3-bit	$2^3 = 8$	RGB 8 Colours
7-bit	$2^7 = 128$	128 Colours
8-bit= 1 byte	$2^8 = 256$	256 Colour
24-bit= 3 byte	2^{24} = 16,777,216	True colours 16,777,216 Colours

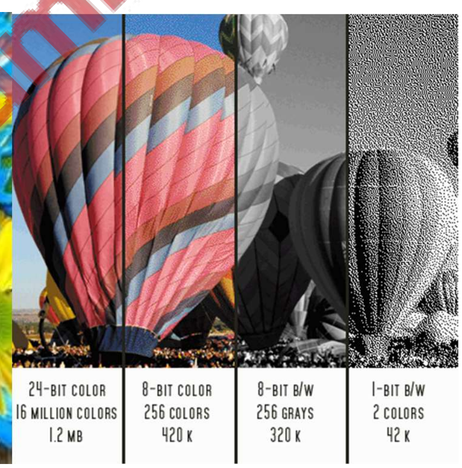
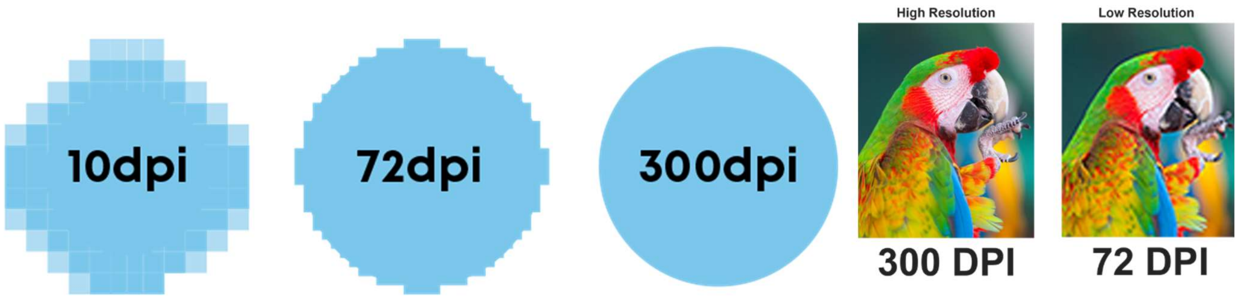


Image Resolution refers to the number of pixels that make up an image; for example, an image could contain 4096 × 3192 pixels (12 738 656 pixels in total) i.e. 12 Mega Pixel (mp) image.

Pixel density, usually measured in **dots per inch (dpi)**. Images on websites usually have a pixel density of 72 dpi. This means that a 1-inch square contains a grid of pixels that is 72 pixels wide by 72 pixels high. 72 x 72 = 5184 pixels per square inch.

Pixel density determines the image quality, more the pixel density, better the image quality.



Effects of changing elements of a bitmap image on the image quality and file size

The image quality is determined by image resolution and pixel density. When magnifying an image, the number of pixels that makes up the image remains the same but the area they cover is now increased. This means some of the sharpness could be lost. For example, look at following image:

A B C D E F

Image A is the original. By the time it has been scaled up to make image F it has become pixelated ('fuzzy'). This is because images A and F have different pixel densities.

The main drawback of using high resolution images is the increase in file size. As the number of pixels used to represent the image is increased, the size of the file will also increase. This impacts on how many images can be stored on, for example, a hard drive. It also impacts on the time to download an image from the internet or the time to transfer images from device to device.

Screen resolution refers to the number of horizontal pixels and the number of vertical pixels that make up a screen display (for example, if the screen resolution is smaller than the image resolution then the whole image cannot be shown on the screen or the original image will now.

<u>JPG or JPEG (Joint Photographic Experts Group)</u>

PEG is the file compression format designed to make photo files smaller in size for storage and for transmission. It uses lossy compression and compresses a file between factor of 5 to 15.

Image File Size Calculation

To calculate image file size, firstly number of pixels found out then these are multiplied to find total number of pixels in an image that gives, image resolution.

For example 2000 pixels wide and 2000 pixels high image will have 2000 × 2000= 4,000,000 pixels. This is often referred to as a 4-megapixel image.

Uncompressed raw image

Then Image resolution is multiplied by bit depth.

Black & White image	Grey Scale	8-Colour	True Colour
Bit Depth=1	Bit Depth=2	Bit Depth= 3	Bit Depth=24
Image Size = 4,000,000 x 1 bit = 4,000,000 bit = 4,000,000 / 8 Byte = 500,000 Bytes = 500 KB	Image Size = 4,000,000 x 2 bit = 8,000,000 bit = 8,000,000 / 8 Byte = 1,000,000 Bytes = 1 MB	Image Size = 4,000,000 x 3 bit = 12,000,000 bit = 12,000,000 / 8 Byte = 1,500,000 Bytes = 1.5 MB	Image Size = 4,000,000 x 24 bit = 4,000,000 x 3 Byte = 12,000,000 Byte = 12 MB
Image Size = 500 KB	Image Size = 1 MB	Image Size = 1.5 MB	Image Size = 12MB

File Compression

Compression is a useful tool for reducing file sizes. When images, sounds or videos are compressed, data is removed to reduce the file size.

Advantage of File Compression

- Compressed file occupies lesser storage space
- Compressed file occupies lesser space in memory
- File can be uploaded and download quickly
- Lesser internet data is used in transmission of compressed file.

This is very helpful when streaming and downloading files.

Streamed music and downloadable files, such as MP3s, are usually between 128 kbps and 320 kbps - much lower than the 1,411 kbps of an uncompressed file.

Videos are also compressed when they are streamed over a network. Streaming HD video requires a high-speed internet connection. Without it, the user would experience buffering and regular drops in quality. HD video is usually around 3 mbps. SD is around 1,500 kbps.

Lossy and lossless compression

Compression can be lossy or lossless.

Lossless compression means that as the file size is compressed but data is restored back to its original state on uncompressing. Run Length Encoding is a method of lossless file compression. Lossless compression is mostly used for documents and software, sometime images and audio are also compressed using lossless compression.

Lossless compression can compress up-to 50%

Lossy compression permanently removes data. For example, an image file compressed to **jpeg** using factor of 5 to 15 while an audio WAV file compressed to an **MP3** (90% reduction in file size). Lossy file compression is mostly used for images, audio and video files.

Text file compression

Text and numbers are usually stored in an ASCII format.

Text files are also compressed. Lossless compression method is used for text and numbers.

Algorithm 1:

These use complex algorithms that work on redundancy or repeated sections of words (e.g. OU in

THIS SECTION SHOWS YOU HOW THIS WOULD WORK'

Repeated words, such as 'THIS' could be put into a data dictionary and be replaced by '1'. Repeated word sections, such as 'HOW' and 'OU' could be replaced by the numbers '2' and '3'. Our phrase then becomes

1 SECTION S2S Y3 2 1 W3LD WORK

yOUr, cOUntry or mOUntain).

THIS	1
HOW	2
OU	3

Text compression typically works by finding similar strings within a **text file**, and replacing those strings with a temporary binary representation to make the overall **file** size smaller. Computers can compress text by finding repeated sequences and replacing them with shorter representations, a character that isn't part of the original text.

For example a quote having 84 characters "Think left and think right and think low and think high. Oh, the thinks you can think up if only you try!"

The computer also needs to store the table of replacements that it made, so that it can reconstruct the original.

replacement	original
$	think
&	and
#	you

The repeated words replaced with the character and the compressed file has 50 characters. The compressed file is "$ left & $ right & $ low & $ high. Oh, the $s # can $ up if only # try!"

Text is compressed using Run Length Encoding method also.

Algorithm 2: Run length encoding (RLE) on text data

One of the simplest examples of compression is **RLE**.

RLE is a basic form of data compression that converts consecutive identical values into a code consisting of the character and the number marking the length of the run.

The more similar values there are, the more values can be compressed.

The sequence of data is stored as count and a single value.

For example to compress a text string “aaaabbbbcccccccddddd” as “4a4b7c5d”

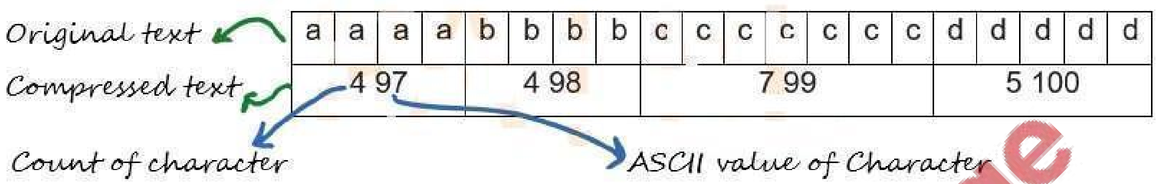


Image File Compression

Images are all around us, from application icons to animated GIFs to photos. Image files can take up a lot of space, so computers employ a range of algorithms to compress image files.

Lossy File Compression for Images

For lossy file compression of image file following steps are taken:

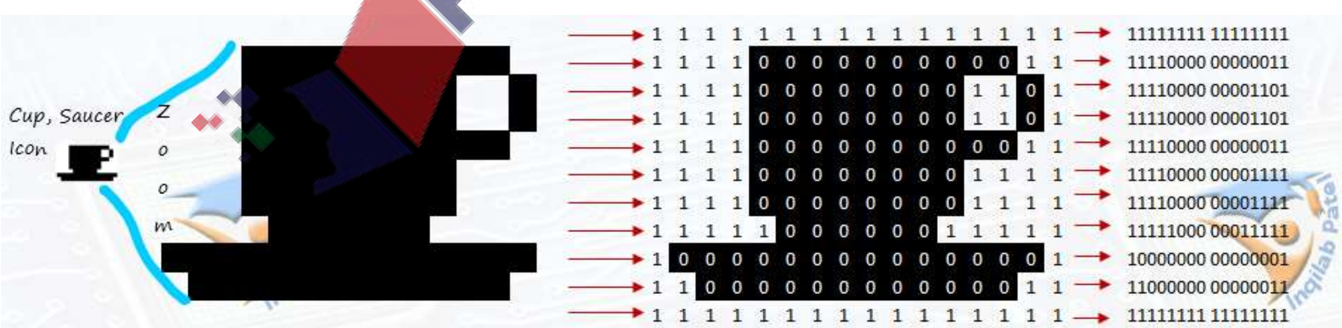
- A lossy file compression algorithm is used
- **Bit Depth** (bits per pixel) is reduced resulting in reduction in colour depth (number of available colour) as well as file size (lesser number of bits lesser file size)
- **Pixel density** (pixel per inch) is decreased resulting decrease in image resolution it too reduce file size (lesser pixel lesser bits means lesser file size).
- Reducing bit depth and pixel density reduces the file size but the removed data cannot be put back so original image cannot be recreated.

Lossless File Compression of Images

One of the simplest examples of lossless compression is **RLE**. To perform lossless compression of image following steps are taken:

- A lossless file compression algorithm RLE is used
- Consecutive pattern on images are identified.
- Consecutive identical pattern values converted into a code consisting of the image pattern and the number marking the length of the run.
- The more similar values there are, the more values can be compressed.
- The sequence of data is stored as a single value and count.

For example a Here's a simple image, a 16x11 black cup saucer icon with white background.

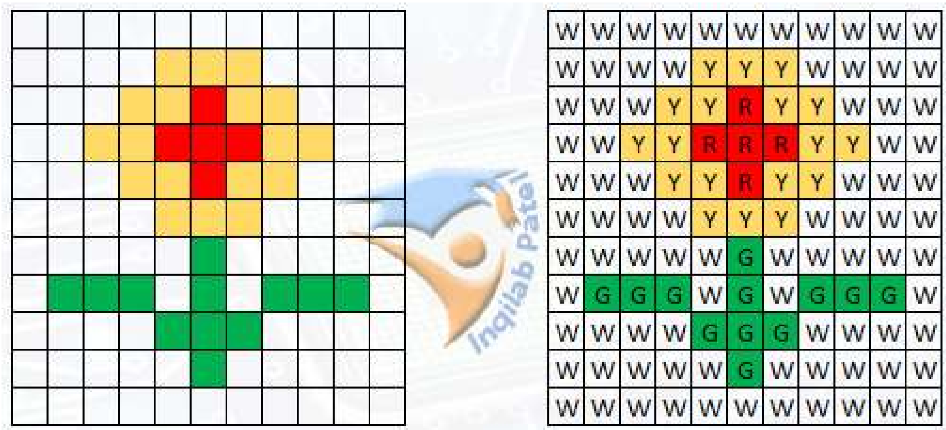


In run-length encoding, the computer replaces each row with numbers that say how many consecutive pixels are the same color, For example, 4 white pixels, 10 black pixels, and then 2 white pixels:

1111 0000 0000 0011 or WWWW BBBB BBBB BBWW

This would be represented after Run Length Encoding as follows:4 1 10 0 2 1 or **4W 10B 2W**

Here is another image



WWWWWWWWWWWWWWWYYYWWWWWWWYYRYYWWWWWYYRRRYYWWWWWYYRYYWW
WWWWWYYYWWWWWWWWWGWWWWWWGGGWGWGGGWWWWWGGGWWWWWWWWWG
WWWWWWWWWWWWWWWW
(121 Characters are there before compression)

This image is compressed in

15W3Y7W2Y1R2Y5W2Y3R2Y5W2Y1R2Y7W3Y9W1G6W3G1W1G1W3G5W3G9W1G16W

(60 characters in the compressed file)

Image file size calculation

PNG is a **lossy** compression type. It is often used where the graphic might be changed by another person or where the image contains layers of graphics that need to be kept separate from each other. It is **high quality**.

JPEG is the lossy file compression format designed to make photo files smaller in size for storage and for transmission. It uses lossy compression and compresses a file between factor of 5 to 15.

For example 2000 pixels wide and 2000 pixels high image will have 2000 × 2000= 4,000,000 pixels. This is often referred to as a 4-megapixel image. A raw bitmap can often be referred to as a **TIFF** or **BMP** image (file extension **.TIF** or **.BMP**). The file size of this image is determined by the number of pixels. In the previous example, a 4-megapixel image would be 4 megapixels × 3 colours (RGB) =12 megabytes.

This image will be compressed at factor of 5 (12/5=2.5 mb) to factor of 15 (12/15= 0.8mb).

Audio File Compression

Lossy File Compression of Audio using MP3:

This has become the standard for distributing digital music files on the internet. To perform lossy file compression on audio file following steps are take:

- Lossy file compression algorithm is used
- **Perceptual Music Shaping algorithm** is the lossy file compression for audio file
- It removes the background noise.
- It removes sounds that are generally beyond the limits of most people's hearing and does not noticeably affect the quality of sound.
- When using MP3 format, the size of the music track will be reduced by a factor of 10 (i.e. the size is reduced by 90% and remaining file size is only 10% of original size).
- The quality of MP3 files depends on the **BIT RATE** – this is the number of bits per second used when creating the file. Bit rates are roughly between 80 and 320 kilobits per second; usually 200 or higher gives a sound quality close to a normal CD.

For example, an 50 megabyte music CD can be reduced to 5 megabytes.
50 MB x 90/100= 45 MB reduced. 50 MB x 10/100=5 MB new file size.

Lossless File Compression of Audio File

For lossless file compression of audio file following steps are taken:

- A lossless file compression algorithm RLE is used
- Consecutive sound patterns are identified.
- Consecutive identical sound pattern values are converted into a code consisting of the sound pattern and the number marking the length of the run.
- The more similar values there are, the more values can be compressed.
- The sequence of data is stored as a single value and count.

Video File Compression

- A compression algorithm is used
- Redundant data is removed
- Reduce colour depth
- Reduce image resolution
- Reduce sample rate
- Reduce sample resolution
- Reduce frame rate
- Use perceptual music shaping
- Data is **permanently** removed

Quick Revision Questions

1 Convert the following number [6 marks]

a. denary 156 into binary

…………………………………………………………………………………………………

…………………………………………………………………………………………………

b. denary 756 into hexadecimal

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

c. binary 101101100 into denary

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

d. binary 100101001110000 into hexadecimal

…………………………………………………………………………………………………

…………………………………………………………………………………………………

e. hexadecimal C9F into denary

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

f. hexadecimal C9F into 12 bit binary

…………………………………………………………………………………………………

…………………………………………………………………………………………………

2 A 32-second sound clip will be recorded. The sound will be sampled 16000 times a second.

Each sample will be stored using 8 bits.

Calculate the file size. **You must show all of your working.** *(March 2018 P12 (India) Q 9)*

File Size ....B [3]

Write your answer in KB and MB

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

Comments on Question

Many candidates provided a correct answer for this question. It would be helpful if candidates clea rly showed all the stages of their working in the work space. Some candidates scattered their worki ng around, outside of the provided answer space into other answer spaces, which has the risk of b eing unseen by the examiner.

3 In the ASCII character set, the denary (base 10) character codes for the 'A' is 65 and 'B' is 66 wh ile for 'a' is 97 and 'b' is 98.

(i) Write these denary numbers of 'A' and 'a' in 8 bit binary numbers.

65:……...

....

97: ………………...

.... [2]

(ii) Predict the denary values for 'I' and 'i'.

'I':……...

....

'i': ………………...

.... [2]

(iii) Write these denary numbers in 8 bit binary numbers.

'I':……...

....

'i': ………………...

.... [2]

(iv) using the denary values of upper and lower case in part i and ii, suggest an easy way to find th e ASCII binary code of any small case letter if its upper case binary code is known, (e.g. 'P')

....

....

....

.... [2]

(v) Write in Register X the binary number you would use with OR gates to convert the ASCII value of upper case letter ‘A’ to its lower case letter ‘a’ binary value. [1]

								‘A’

								Register X

OR logic operation

								‘a’

Test the Register X to apply with the letter ‘I’ to convert it into ‘i’

								‘I’

								Register X

								‘i’

4 A process is devised for encoding letters using 16 bits. The process starts by giving each letter of the alphabet a value: A = 1, B = 2, C = 3, ..., Z = 26.

(a) The value for each letter is represented using 16 bits. For the letter ‘V’ write its 16-bit binary value

(b) All the bits in the register are shifted **one** place to the **left** to convert a upper case letter into small case letter

i. write down contents of 16-bit binary register after the bits have been moved to left to convert ‘V’ into ‘v’.

ii. convert this binary value for ‘V’ and ‘v’ in denary

‘V’ ……………………………………………………………………………………………………...

…………………………………………………………………………………………………….

‘v’ ……………………………………………………………………………………………………...

……………………………………………………………………………………………………. [2]

iii. State the effect the shift to the left had on the original denary number from **part (bii)**.

………

…..………………………………………………………………………………………………...………………

………. [1]

iv. Predict what will be happened to a denary value when its binary values are moved 1 place to right.

………

…..………………………………………………………………………………………………...………………

………. [1]

v. Predict the denary values for the following letters

'i' ……...

…….

'p' ………...

………. [2]

Examiner Report

In parts **(a))** most candidates could provide a correct conversion from denary to binary.
In part **(bii)** many candidates could identify the effect that the shift had on the number. Some candidates were too vague in their response stating the number had merely decreased.
In part **(biii)** most candidates could not accurately explain the effect of the shift. They were not able to express that the right most bit would be lost from the register, making the number inaccurate.

5 Explain why and how hexadecimal notation is used rather than in binary. [6]

(i) MAC Address ……………………………...……………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………………

Reason …….………………………………………………………………………………………

……………………………………………………………………………………………………..……

……………………………………………………………………………………………………

(ii) Memory Dump ….……………………………...………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………………

Reason …….……………………………………………………………………………………

……………………………………………………………………………………………………..……

……………………………………………………………………………………………………

(iii) HTML ………………..………………………………...……………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………………

Reason …….………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

9 Draw a line to connect each question to the correct answer. *(2210/0478 summer 2015 P11 Q 9)* [8]

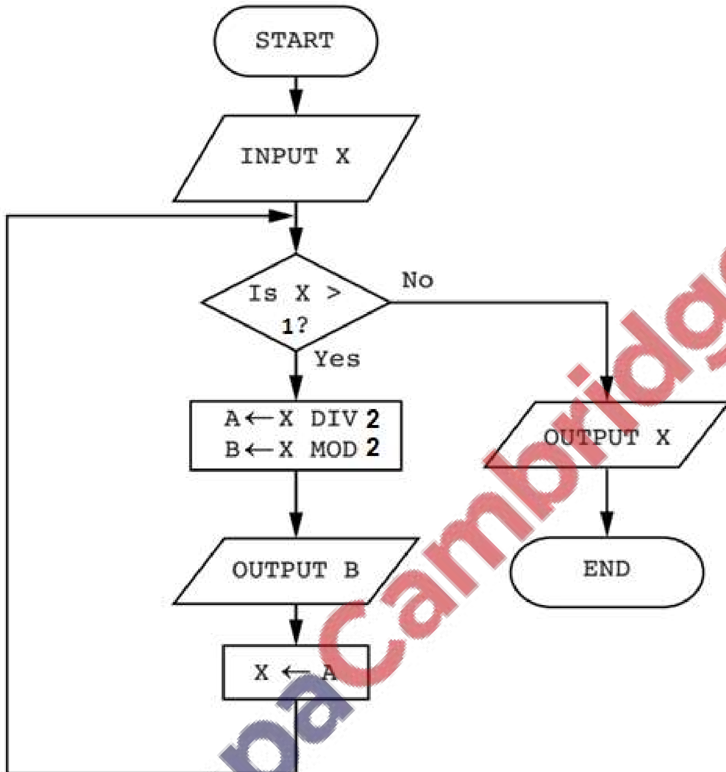
Question	**Answer**
What is the denary (base 10) equivalent to the hexadecimal digit **E**?	**8**
If 1 GB = 2^x then what is the value of X?	**6**
How many bits are there in one byte?	**14**
If the broadband data download rate is 40 megabits per second, how many seconds will it take to download a 60 MB file?	**19**
What is the denary (base 10) value of the binary number 0 0 1 0 0 1 0 0 ?	**2**
What hexadecimal value is obtained when the two hexadecimal digits **C** and **D** are added together?	**36**
The following binary pattern 1010011000111101 is stored in X bytes. What is the value of X?	**30**
An array, Number[1:4], contains; **6** **8** **10** **12** x ← Number [1]What is x?	**12**

Examiner's Comments on Question 9

The full range of marks was awarded for this question. Many candidates gained full marks. The most common errors were miscalculations for 30, 19 and 12.

10 Following flowchart is used to convert a denary number into binary (base 2)

The flowchart below inputs an integer. The predefined function DIV gives the value of the division, for example Z ←11 DIV 3 gives the value Z = 3. The predefined function MOD gives the value of the remainder, for example Z ←11 MOD 3 gives the value Z = 2. (Winter 2016 P22 Q 3)



Complete a trace table for each of the two input values **33** and **75**. [4]

Trace table for input value **33**

X	A	B	OUTPUT

Trace table for input value **75**

X	A	B	OUTPUT

11 (a) This pseudo code inputs an integer. The predefined function DIV gives the value of the division, e.g. Y 10 DIV 3 gives the value Y = 3. The predefined function MOD gives the value of the remainder, e.g. Y 10 MOD 3 gives the value Y = 1.gives the value Y = 1. (Winter 2015 P23 Q 3)

```
INPUT X
WHILE X > 15
  DO
  T1 ← X DIV 16
  T2 ← X MOD 16
  CASE T2 OF
    10:OUTPUT A
    11:OUTPUT B
    12:OUTPUT C
    13:OUTPUT D
    14:OUTPUT E
    15:OUTPUT F
    OTHERWISE OUTPUT T2
  ENDCASE
  X ← T1
ENDWHILE
CASE X OF
  10:OUTPUT A
  11:OUTPUT B
  12:OUTPUT C
  13:OUTPUT D
  14:OUTPUT E
  15:OUTPUT F
  OTHERWISE OUTPUT X
ENDCASE
```

Complete a trace table for each of the **two** input values 37 and 191.

Trace table for input value 37

X	T1	T2	OUTPUT

Trace table for input value 191

X	T1	T2	OUTPUT

(b) State the purpose of the pseudo code in **part (a)**.

....

....[2]

14 Abdullah wants to convert a denary number into hexadecimal. Write down the series of steps for Abdullah.

....

....

....

....

....

....

....

....

....

....

....

....

....

.... [4]

15 Abdullah also wants to convert a denary number into binary. Write down the series of steps for Abdullah clearly so he can perform this conversion.

....

....

....

....

....

....

....

....

....

....

....

....

....

.... [4]

16a Integers can be represented in Binary Coded Decimal (BCD). In BCD each denary digit is converted into 4 bit BCD separately, for example Denary 6 can be represented in BCD

		8	4	2	1
6	**=**	**0**	**1**	**1**	**0**

(i) State BCD equivalent of 4 and 7.

		8	4	2	1
4	**=**				

		8	4	2	1
7	**=**				

(ii) State what denary number is represented by this 2-byte BCD number.

1	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**1**	**1**	**1**

Denary ………………………………………….. [1]

(ii) A second BCD 2-byte number has been copied incorrectly.

1	**1**	**0**	**1**	**0**	**0**	**1**	**1**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**

Without converting the whole pattern, how can you identify that this cannot be a valid BCD representation?

………

………[1]

(b) Binary Coded Decimal (BCD) is another way of representing numbers.

(i) Write the number 359 in BCD form.

………[1]

(ii) Describe a use of BCD number representation.

………

………[2]

Memory Size Measurement

It should be pointed out here that there is some confusion in the naming of memory sizes.
The unit was established by the **International Electrotechnical Commission (IEC)** in 1998, has been accepted for use by all major standards organizations, and is part of the International System of Quantities. The kibibyte was designed to replace the kilobyte in those computer science contexts in which the term kilobyte is used to mean 1024 bytes. The interpretation of the kilobyte to denote 1024 bytes, conflicting with the SI definition of the prefix kilo (1000), is still common, mostly in informal computer science contexts.

The IEC convention is now adopted by some organisations. Manufacturers of storage devices often use the denary system to measure storage size. For example:

0 or 1 = 1 bit

4 bits = 1 Nibble

8 bits = 2 Nibbles = 1 byte

1 kilobyte = 1000 byte

1 megabyte = 1000000 bytes

1 gigabyte = 1000000000 bytes

1 terabyte = 1000000000000 bytes and so on.

The IEC convention for computer internal memories (including RAM) becomes:
1 kibibyte (1 KiB) = 1024 bytes
1 mebibyte (1 MiB) = 1048576 bytes
1 gibibyte (1 GiB) = 1073741824 bytes
1 tebibyte (1 TiB) = 1099511627776 bytes and so on

Example Question: *A company advertises its backup memory device as having 500 GB of storage. A customer wishes to know how many 8 MB files could be stored on the device. The company claimed that up to 62 500 files (assuming each file is 8 MB) could be stored. The customer calculated that 64 000 files could be stored.*

Explain the difference between these two storage values. Show any calculations you use in your explanation. ....

..

–company calculation is based on 1 GByte = 1000 Mbyte – so (500 × 1000)/8 = 62 500 files
– customer calculation based on 1 GByte = 1024 Mbyte – so (500 × 1024)/8 = 64000 files
– giving the difference of 1500 files *[3]*

Candidate Example response

Example candidate response – high

10 Letters from the alphabet are represented in a computer by the following denary (base 10) values:

A = 97
G = 103
I = 105
L = 108
N = 110

The word **"A L I G N"** is stored as: 97 108 105 103 110

(a) Convert each of the five values to binary. The first one has been done for you.

Letter	Denary value 128	64	32	16	8	4	2	1
A (97):	0	1	1	0	0	0	0	1
L (108):	0	1	1	0	1	1	0	0
I (105):	0	1	1	0	1	0	0	1
G (103):	0	1	1	0	0	1	1	1
N (110):	0	1	1	0	1	1	1	0

[2]

(b) An encryption system works by shifting the binary value for a letter one place to the left. "A" then becomes:

1	1	0	0	0	0	1	0

This binary value is then converted to hexadecimal; the hexadecimal value for "A" will be:

C 2

For the two letters "L" and "G", shift the binary values one place to the left and convert these values into hexadecimal:

	8	4	2	1	8	4	2	1	hexadecimal
L:	1	1	0	1	1	0	0	0	D8
G:	1	1	0	0	1	1	1	0	CE

[4]

Examiner comment – high

In part **(a)** this candidate converted all four letters correctly

In part **(b)** this candidate managed to perform the bit shift correctly and converted the binary to hexadecimal successfully.

Marks awarded for **(a)** = 2 out of 2

Marks awarded for **(b)** = 4 out of 4

Total mark awarded = 6 out of 6

Example candidate response – middle

10 Letters from the alphabet are represented in a computer by the following denary (base 10) values:

A = 97
G = 103
I = 105
L = 108
N = 110

The word "**A L I G N**" is stored as: 97 108 105 103 110

(a) Convert each of the five values to binary. The first one has been done for you.

Letter	Denary value							
A (97):	0	1	1	0	0	0	0	1
L (108):	0	0	0	1	1	0	1	1
I (105):	0	1	0	0	1	0	1	1
G (103):	0	1	1	1	0	0	1	1
N (110):	0	0	1	1	1	0	1	1

[2]

(b) An encryption system works by shifting the binary value for a letter one place to the left. "A" then becomes:

1	1	0	0	0	0	1	0

This binary value is then converted to hexadecimal; the hexadecimal value for "A" will be:

C 2

For the two letters "L" and "G", shift the binary values one place to the left and convert these values into hexadecimal:

									hexadecimal
L:	0	0	1	1	0	1	1	0	3 6
G:	1	1	1	0	0	1	1	0	E 6

[4]

Examiner comment – middle

In part **(a)** this candidate was not able to correctly convert any of the letters into binary.

In part **(b)** this candidate did manage to perform the bit shift correctly and converted the binary to hexadecimal successfully. This was done on an initial incorrect binary value from part **(a)**, but as they could demonstrate the skill of a bit shift and convert those values in correct hexadecimal values, they were awarded all four marks.

Marks awarded for **(a)** = 0 out of 2

Marks awarded for **(b)** = 4 out of 4

Total mark awarded = 4 out of 6

Example candidate response – low

10 Letters from the alphabet are represented in a computer by the following denary (base 10) values:

A = 97
G = 103
I = 105
L = 108
N = 110

The word "**A L I G N**" is stored as: 97 108 105 103 110

(a) Convert each of the five values to binary. The first one has been done for you.

Letter	Denary value							
A (97):	0	1	1	0	0	0	0	1
L (108):	0	1	1	0	1	1	0	0
I (105):	0	1	1	0	1	0	0	1
G (103):	0	1	1	0	0	0	1	1
N (110):	0	1	1	0	1	1	1	0

[2]

(b) An encryption system works by shifting the binary value for a letter one place to the left. "A" then becomes:

1	1	0	0	0	0	1	0

This binary value is then converted to hexadecimal; the hexadecimal value for "A" will be:

C 2

For the two letters "L" and "G", shift the binary values one place to the left and convert these values into hexadecimal:

									hexadecimal
L:	0	1	1	0	1	1	0	0	12_{16}
G:	1	1	1	0	0	0	1	0	E 2

[4]

Examiner comment – low

In part **(a)** the candidate was able to convert two of the letters correctly for a mark.

In part **(b)** they did not manage to perform the bit shift correctly on either binary number, but they coulddemonstrate enough skill for one mark in converting one of their binary values to the correct hex value.

Marks awarded for **(a)** = 1 out of 2

Marks awarded for **(b)** = 1 out of 4

Total mark awarded = 2 out of 6

Topical Past Paper Questions

Q 1) Summer 2015 P11

8 An alarm clock is controlled by a microprocessor. It uses the 24 hour clock. The hour is represented by an 8-bit register, **A**, and the number of minutes is represented by another 8-bit register, **B**.

(a) Identify what time is represented by the following two 8-bit registers.

A

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

:

B

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

Hours .... Minutes .... [2]

(b) An alarm has been set for 07:30. Two 8-bit registers, **C** and **D**, are used to represent the hours and minutes of the alarm time.

Show how 07:30 would be represented by these two registers:

C

:

D

Hours Minutes [2]

(c) Describe how the microprocessor can determine when to sound the clock alarm.

....

....

....

....

....

....[3]

9 Draw a line to connect each question to the correct answer. [5]

Question	Answer
What is the denary (base 10) equivalent to the hexadecimal digit **E**?	**8**
If 1 GB = 2^X then what is the value of X?	**12**
How many bits are there in one byte?	**14**
If the broadband data download rate is 40 megabits per second, how many seconds will it take to download a 60 MB file?	**19**
What is the denary (base 10) value of the binary number 0 0 1 0 0 1 0 0 ?	**30**
What hexadecimal value is obtained when the two hexadecimal digits **C** and **D** are added together?	**36**

Examiner's Comments on Question 9

The full range of marks was awarded for this question. Many candidates gained full marks. The most common errors were miscalculations for 30, 19 and 12.

Q 2) Summer 2015 P12

10 Letters from the alphabet are represented in a computer by the following denary (base 10) values:

A = 97
G = 103
I = 105
L = 108
N = 110

The word “**A L I G N**” is stored as: 97 108 105 103 110

(a) Convert each of the five values to binary. The first one has been done for you. [2]

Letter	Binary value							
A (97):	0	1	1	0	0	0	0	1
L(108):								
I (105):								
G (103):								
N (110):								

(b) An encryption system works by shifting the binary value for a letter one place to the left. “A” then becomes:

1	**1**	**0**	**0**	**0**	**0**	**1**	**0**

This binary value is then converted to hexadecimal; the hexadecimal value for “A” will be:

C 2

For the two letters “L” and “G”, shift the binary values one place to the left and convert these values into hexadecimal: [4]

									hexadecimal
L:									....
G:									....

Examiner's comments onQuestions 10(a) and 10(b)

Many candidates showed some knowledge of binary conversion in part (a) and could correctly convert the values. Some candidates showed little knowledge and gave a random and incorrect response as a result.

In part (b) many candidates were able to correctly carry out the bit shift then covert the value to hex. Some candidates gained marks for a correct bit shift but were unable to demonstrate the knowledge to convert the values to hex so gained two marks. Candidates were awarded follow through marks if they had calculated the values incorrectly in part (a) for both their bit shift and the hex conversion.

Q 3) Winter 2015 P12

2 Seven computer terms and seven descriptions are shown below.

Draw a line to link each computer term to its most appropriate description.

Computer term	Description
Interface	Reduction of file size by permanently removing some redundant information from the file
JPEG	File compression system for music which does not noticeably affect the quality of the sound
Lossless compression	Hardware component that allows the user to communicate with a computer or operating system
Lossy compression	The file is reduced in size for transmission and storage; it is then put back together again later producing a file identical to the original
MIDI	File compression format designed to make photo files smaller in size for storage and for transmission
MP3 format	Standard adopted by the electronic music industry for controlling devices such as synthesisers and sound cards

Examiners' Comments Question 2

Many candidates gained high marks for this question. Some candidates confused common areas such as lossy and lossless compression.

4 (a) (i) Convert the following **two** hexadecimal numbers into binary:

F A 7
D 3 E

F A 7												
D 3 E												

[4]

(ii) Now perform the AND (logic) operation on each corresponding pair of binary bits in the two numbers from **part (i)**.

[2]

(iii) Convert your answer in **part (ii)** into hexadecimal.

.... [2]

(b) (i) The following code shows HTML ‘tag’ pairs on either side of the text stating the colour that each creates.

 RED
 GREEN
 BLUE
 YELLOW
 MAGENTA
 CYAN

Yellow is a combination of red and green, magenta a combination of red and blue and cyan a combination of green and blue.

State what 6-digit hexadecimal values should replace X, Y and Z in the above code.

X ....

Y ....

Z ....[3]

(ii) Describe how other colours, such as a darker shade of blue, are created.

....

....

....[2]

(c) 1A – 16 – C5 – 22 – FF – FF is an example of a MAC address.

(i) Identify what the first six and last six hexadecimal digits represent.

First six digits ....

....

Last six digits ....

....

.... [2]

(ii) State why MAC addresses are used.

....

.... [1]

Examiners´Comments Question 4(a) (b) and (c)

In part (a) most candidates were able to demonstrate a high level on knowledge in data representation and logic. Some candidates made small errors but still gained later marks with follow through on their answers.

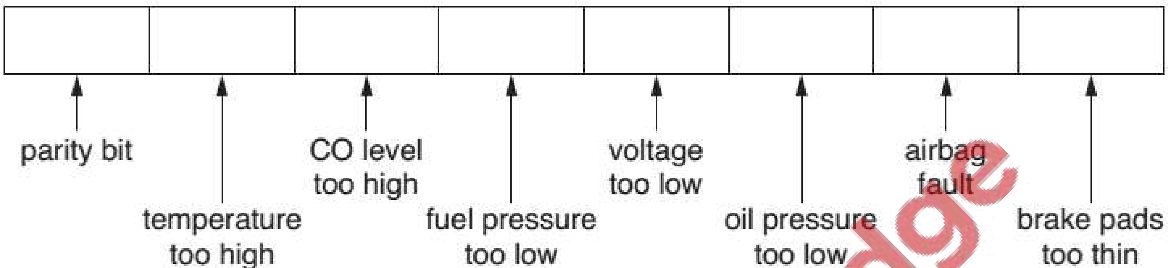
In part (b) some candidates were able to provide a correct response. Some candidates made an error in putting the two codes for the two different colours, rather than combining the codes to create the colour requested.

In part (b)(ii) many candidates gave a vague response and did not describe that HTML codes are combined to create different colours. Many candidates provided a minimum level answer, such as adding the colour black to blue. They did not add the Computer Science aspect, that different HTML codes are combined to do this. Candidates need to make sure they are thinking about the computer science aspect of the question in *questions such as this one.*

In part (c) many candidates did not recognise what information they needed to give. They provided conversions of the hex values to denary or binary, rather than stating what the code actually represents.
Some candidates were too vague in stating what it represented, candidates need to be specific in their responses. In part (c)(ii) some candidates were able to state that MAC addresses are a unique identifier for a device on a network. Many candidates were not specific enough, stating that MAC addresses identified a device on a network, but not stating that the identification is unique.

Q 4) Winter 2015 P13

2 (b) The information from seven sensors is sent to an engine management system in the car. The status of each sensor is stored in an 8-bit register; a value of 1 indicates a fault condition



For example, a register showing **0 1 0 1 1 0 0 0** indicates:

- temperature too high
- fuel pressure too low
- voltage too low

(i) Identify the fault condition(s) that the following register indicates:

0	**0**	**1**	**0**	**0**	**1**	**0**	**1**

....
....
....[2]

(ii) The system uses **odd** parity.
Write the correct parity bit in each register.

	1	**1**	**1**	**0**	**0**	**1**	**0**

	0	**0**	**0**	**1**	**1**	**1**	**0**

[2]

(iii) A car has a faulty airbag and the CO level is too high.
Write what should be contained in the 8-bit register.

[2]

(iv) Give the hexadecimal value of the binary number shown in **part (iii)**.

....
....[1]

Examiners' Comments Question 2 (a) and (b)

In part (a) most candidates were able to gain some marks for a description of how sensors and the microprocessor would be used. Some candidates missed naming the type of sensor that could be used. This would have gained further marks. Some candidates were not specific in their answer, merely talking about comparing values, but specifically which values. Candidates need to make sure they are specific to the question in their answer.

In part (b) many candidates were able to correctly identify the fault condition provided. Most were able to provide the correct parity bit, and many were able to provide the correct vales in the register and convert this to hexadecimal. Candidates need to make sure their answer is clear when providing hexadecimal and that it can be distinguished from any working.

9 MP3 file compression reduces the size of a music file by 90%.

(a) A music track is 80 MB in size.

Calculate the file size after compression.

....

How many MP3 files of the size calculated above could be stored on an 800 MB CD?

....[2]

(b) (i) Explain how MP3 files retain most of the original music quality.

....

....

....

....

.... [2]

(ii) State the type of file compression used in MP3 files.

.... [1]

(iii) Name another file compression format.

.... [1]

Examiners´Comments Question 9 (a) and (b)

In part (a) most candidates were able to carry out a correct calculation for this question.

In part (b)(i) some candidates could provide a good level of detail about MP3 file compression. Many candidates gave a vague description of compression itself and could not gain any marks for this. In part (b)(ii) many candidates could provide the correct type of compression, but in part (b)(iii) many candidates provided the opposing compression method, for example lossless and did not provide a file format.

Q 5) Winter 2015 P11

2 (a) Convert the hexadecimal number **B5** into binary:

....

Convert the binary number **1 1 1 1 0 1 1 0** into hexadecimal:

....[2]

(b) Give **two** examples where hexadecimal numbers are used in computer science.

1: ....

2: ....

....[2]

(c) State **two** benefits of using hexadecimal numbers in computer science.

1: ....

....

2:...

....[2]

7 (a) Describe what is meant by lossy and lossless compression when applied to files.

Lossy: ....

....

....

Lossless: ....

....

....[2]

(b) Name and describe **one** type of file that uses lossy compression.

Name: ....

Description: ....

....

....[2]

(c) A company advertises its backup memory device as having 500 GB of storage.
A customer wishes to know how many 8 MB files could be stored on the device.
The company claimed that up to 62 500 files (assuming each file is 8 MB) could be stored.
The customer calculated that 64 000 files could be stored.
Explain the difference between these two storage values. Show any calculations you use in your explanation.

....

....

....

....

.... [3]

Examiners' Comments Question 7(a) (b) and (c)

In part (a) some candidates were able to give an accurate description of lossy and lossless compression, but many candidates were vague in their response and could not obtain marks as a result. Candidates need to make sure they are clear and accurate when providing a description or definition. It must be clear they have a firm understanding of the term or process.

In part (b) many candidates were able to accurately name a file type that uses lossy compression.

In part (c) some candidates were able to gain a mark by stating that measure of bytes used is different 1000/1024. They were vague in their description of this though and did not clearly state what the company and the customer used and why the difference occurred.

10 Characters can be represented in a computer by a numerical code.
The following list shows 16 characters with their numerical codes in denary:

a = 97	d = 100	h = 104	m = 109	t = 116
b = 98	e = 101	i = 105	o = 111	u = 117
c = 99	g = 103	k = 107	r = 114	w = 119

. = 46 (code for the full stop)

Web addresses can be written using hexadecimal rather than denary. Hexadecimal codes are preceded by a % sign. For example, the word "**c a g e**" is written as:

either	99	97	103	101	(in denary)
or	%63	%61	%67	%65	(in hexadecimal)

(a) Complete the conversion of the following web address into hexadecimal: [3]

w	w	W	.	c	i	e	.	o	r	g	.	u	K
%77	%77	%77											

b) Complete the web address from the given hexadecimal codes: [3]

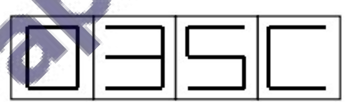
%77	%77	%77	%2E	%72	%6F	%63	%6B	%69	%63	%74	%2E	%63	%6F	%6D
w	w	W												

Examiners´Comments Question 10(a) and (b)

Some candidates were able to carry out the conversions with great accuracy. Some candidates had clearly not read the question in full and were missing detail in their answer as a result, for example the code for a full stop (.). Candidates need to make sure they read the whole of a question before writing their response, to make sure they do not miss any important details.

Q 6) Summer 2016 P11 & P13

7 Each seat on a flight is uniquely identified on an LCD above the seat. For example, seat 035C is shown as:



The first three characters are digits that represent the row.
The fourth character is the seat position in that row. This is a single letter, A to F, that is stored as a hexadecimal value.
Each of the four display characters can be stored in a 4-bit register. For example, 0 and C would be represented as:

	8	4	2	1
0:	0	0	0	0
C:	1	1	0	0

(a) Show how the 4-bit registers would store the remaining two characters, 3 and 5. [2]

3				

5				

(b) Identify which seat is stored in the following 4-bit registers.

0	0	0	1	→ ....
1	0	0	1	→ ....
0	1	0	0	→ ....
1	1	1	0	→ ....

Examiner Report Question 7 (a) and (b)

In part (a) most candidates were able to provide the correct binary values.

In part (b) most candidates could correctly convert the first three binary digits to 194. Some candidates could convert the final binary value to E, but many candidates provided 14 as an answer to this, and did not fully convert this to the correct hexadecimal value of E.

12 (a) Name the following type of barcode:

....[1]

(b) The barcode in **part (a)** contains the denary value 2 6 4 0

Convert this value to hexadecimal.

....

....

Write the value as a 12-bit binary number. [4]

Q 7) Summer 2016 P12

3 (a) Convert the following hexadecimal number into 12-bit binary: [3]

4 A F

(b) The 2016 Olympic Games will be held in Rio de Janeiro. A timer that counts down to the opening of the Games is shown on a microprocessor-controlled display.

The number of hours, minutes and seconds until the Games open are held in three 8-bitregisters.

The present register values are:

0	1	1	0	1	0	0	1	105 Hours
0	0	1	0	0	0	0	0	32 Minutes
0	0	0	1	0	1	0	0	20 Seconds

The timer will count down in seconds.

(i) Show the values in each 8-bit register 30 seconds after the time shown above: [3]

								hours
								minutes
								seconds

(ii) Write the hexadecimal value of the minutes register from part (b)(i).

.... [1]

Examiner Report Question 3(a), (b)(i) and (ii)

In part (a) most candidates made a correct conversion to binary.

In part (b)(i) some candidates were able to provide the correct three binary registers. A number of candidates did not fully understand the question and added on the time, rather than deducting it. This gave them the wrong value for the minute's register.

In part (b)(ii) most candidates were able to provide a correct hexadecimal conversion, either from the correct binary register, or as a follow through answer.

4 Nigel wants to send a large text file electronically to Mashuda.

(a) Describe how the size of the text file can be reduced.

....

....

....

....

....

....[3]

(b) This file will be transmitted to Mashuda as an email attachment. Mashuda then stores it on her computer.

Explain how checksums can be used to verify that the file has not been corrupted during transmission or data storage.

....

....

....

....

....

....

....

....

....

....

....[4]

Examiner Report Question 4(a) and (b)

In part (a) many candidates gained a mark for stating that compression could be used. Some candidates gained further marks by stating the compression method used would be lossless, and describing how this would work. A number of candidates began to describe the two compression methods, both lossy and lossless. They could not be awarded marks for this as the question required candidates to describe one suitable method and the only suitable method was lossless.
In part (b) some candidates gained marks for an accurate description of how a checksum is used. A number of candidates incorrectly referred to Nigel and Mashuda carry out the calculations and the processes. Candidates need to clearly recognise it is the computer and not the person that carries these things out. A number of candidates incorrectly described a detailed process of how to calculate a checksum. The question did not require this, it required candidates to show how it was used in error detection, so this could not be awarded marks.

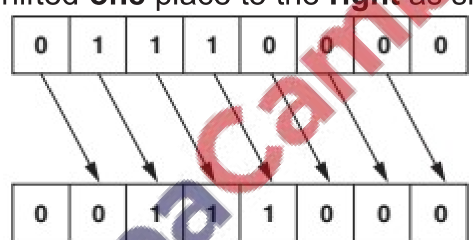
Q 8) Winter 2016 P12

5 A computer uses an 8-bit register.
The 8-bit register contains binary integers.
(a) Write the denary (base 10) value represented by:

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

.... [1]

(b) All the bits in the register are shifted **one** place to the **right** as shown below.



Write the denary number that is represented after this shift.
.... [1]
(c) State the effect the shift to the right had on the original denary number from **part (a)**.
.... [1]
(d) The original number in **part (a)** is shifted **three** places to the **right**.
(i) Show the new binary number: [1]

(ii) Write the equivalent denary number.
.... [1]
(e) Describe the problems that could be caused if the original binary number in **part (a)** is shifted **five** places to the **right**.
....
....
....
....
.... [2]

11 A security system is installed in a house. A hexadecimal number is entered to activate or deactivate the alarm.
(a) The alarm code is set to hexadecimal number **2 A F**
Show how this number would be stored in a 12-bit binary register.[3]

Q 9) Winter 2016 P11& 13

10 (a) A manufacturer of aeroplane engines assigns a denary identification number (ID) to each engine.
One engine has the ID: 0431
(i) Convert this denary number to a 12-bit binary format. [2]

(ii) Show how this number would be represented in hexadecimal.
....
.... [3]
(b) The current status of the engine is sent to a computer in the aeroplane.
Each piece of data collected is 8 bytes in size. Data collection occurs every 30 seconds.
Calculate the number of kilobytes that would be needed to store the data collected during a 10-hour flight. Show your working..
....
....

.... kilobytes [3]

(c) At the end of the flight, all of the data are sent to the aeroplane engine manufacturer using the Internet. The computer in the aeroplane has a MAC address and an IP address.
State what is meant by these two terms.
MAC address ....
....
IP address ....
....
.... [2]

Q 10) March 2017 India

7 A high definition video and a large text file are to be sent as email attachments. Both files are compressed before sending. Each file is compressed using a different type of data compression algorithm.
Explain, with reasons, which type of data compression algorithm should be chosen for each file.
....
....
....
....
....
....
.... [4]

Examiner Report
Most candidates correctly stated the appropriate type of file compression for each of the given files. Some candidates then incorrectly went on to describe the type of compression used rather than explaining why that method was chosen.

8 A register in a computer contains binary digits.

0	0	1	1	0	1	1	1

(a) The contents of the register could represent a binary integer.
Convert the binary integer to denary and hexadecimal.
Denary ....
Hexadecimal .... [2]

(b) The contents of the register could represent the ASCII value for the single denary digit ‘7’.
Write down the ASCII value for ‘9’ in binary, denary and hexadecimal.
Binary ....
Denary ....
Hexadecimal .... [3]

(c) Write in Register X the binary number you would use with AND gates to convert the ASCII value of ‘7’ to its binary integer value. [1]

0	**0**	**1**	**1**	**0**	**1**	**1**	**1**	**ASCII**
								Register X

Examiner Report
(a) This was generally well answered.
(b) Some candidates gave the contents of the register correctly in all three number systems. Common errors included incorrectly stating the binary for the integer value of 9 rather than the binary value of the ASCII value for 9.
(c) Better candidates correctly identified the binary number required. A common error was not to mask out the two ones for the ASCII code.

12 (a) Identify **three** uses for hexadecimal and for each one give an example of hexadecimal that matches the use.
Use 1 ....
....
Example ....
Use 2 ....
....
Example ....
Use 3 ....
....
Example .... [6]

(b) Explain why hexadecimal is used to represent binary numbers.
....
....
....
....

....

.... [2]

Examiner Report

(a) Many candidates were unsure about uses for hexadecimal. Correct uses identified included MAC addresses and colours in HTML.

(b) Most candidates correctly stated that programs displayed using hexadecimal were easier to understand and debug. A common error was stating incorrectly that hexadecimal took up less storage space.

Q 11) Summer 2017 P11

1 The memory of a computer contains data and instructions in binary.
The following instruction is stored in a location of the memory.

0	0	1	0	1	0	0	1	1	1	1	1	1	1	0	0

(a) Convert the instruction into hexadecimal.

....

....

.... [2]

(b) Explain why a programmer might prefer to read the instruction in hexadecimal rather than in binary.

....

....

....

.... [2]

(c) Give **two** other uses of hexadecimal.

Use 1 ....

....

Use 2 ....

.... [2]

Examiner's Comments Question 1(a)

Many candidates correctly identified all four hexadecimal characters. Some candidates wrote 15 and 12 in place of F and C. Candidates are reminded that they must fully convert binary to hexadecimal values to be awarded the marks.

1(b)

Many candidates provided accurate reasons for why hexadecimal is used. The most common answers given being that it is easier to read and easier to identify errors. Some candidates made the error of stating that it is used as it will take up less space in memory. Candidates must recognise this is incorrect as it will be stored as binary.

1(c)

Some candidates correctly identified at least one additional use of hexadecimal. The most common correct answer given was a MAC address. Some candidates accurately stated it is used for colour codes in HTML, other candidates gave a vague reference to this, e.g. colour in websites. Candidates must be accurate in their description and make sure they fully describe the additional use.

3 Steffi has a number of files of different sizes that contain her work. [4]

Tick to show whether each statement is **true** or **false**.

Statement	**True**	**False**
47KB is larger than 10MB.		
250bytes is smaller than 0.5MB.		
50GB is larger than 100MB.		
1TB is smaller than 4GB.		

Examiner Comment on Q 3

Most candidates correctly identified which statement was true or false. The most common incorrect answergiven was 'true' given for 47 KB is larger than 10 MB. It was apparent that some candidates understood a KBto be larger than a MB. Candidates are reminded to follow the instruction given and tick (✓) the appropriatebox. Some candidates used crosses (✗) instead or a mixture of both.

13 (a) Gurdeep wants to send a large file to Jennifer over the Internet.

State **two** benefits of compressing the file to send it.

Benefit 1 ....

....

....

Benefit 2 ....

....

.... [2]

(b) Two types of compression are lossy and lossless.

Choose the most suitable type of compression for the following and explain your choice.

(i) Downloading the code for a computer program:

Type of compression ....

Explanation ....

....

....

.... [3]

(ii) Streaming a video file:

Type of compression ....

Explanation ....

....

....

.... [3]

Examiner Comment on Q 13(a)

Many candidates gained marks for stating the file would be smaller and that it would be quicker to send. Some candidates provided an answer regarding the fact that it would take up less storage space. Candidates are reminded to read the question and answer according to the context. In the case, the qu estionasked about the transmission of the data and not the storage of it. Some candidates demonstrated amisunderstanding that just because it was a s maller file, there was less chance of it being corrupted. This isspeculative and not an accurate statement.

Examiner Comment on Q 13(b)(i)

Many candidates provided the correct compression method of lossless. Many candidates did not answer thequestion beyond this. Many candidates desc ribed the operation of lossless compression, rather than statingwhy it would be suitable, as required by the question.

Examiner Comment on Q 13(b)(ii)

Many candidates provided the correct compression method of lossy. Many candidates did not answer thequestion beyond this. Many candidates describ ed the operation of lossy compression, rather than statingwhy it would be suitable, as required by the question.

Q 12) Summer 2017 P12

5 (a) The denary number 57 is to be stored in two different computer registers.
Convert 57 from denary to binary and show your working.

....

....

....

.... [2]

(b) Show the binary number from **part (a)** as it would be stored in the following registers. [2]

Register 1

Register 2

(c) A binary number stored in a register can have many different uses, for example an address in main memory.
Give **two** other uses for a binary number stored in a register.

Use 1 ....

Use 2 .... [2]

(d) A register in a computer contains binary digits.

0	**0**	**1**	**1**	**1**	**0**	**1**	**0**

The contents of the register represent a binary integer.
Convert the binary integer to hexadecimal.

....

.... [1]

Examiner Comment on Q 5(a)
Many candidates provided a correct binary value and demonstrated their working.
Examiner Comment on Q 5(b)
Many candidates correctly represented the value in the two different registers.
Examiner Comment on Q 5(c)
Some candidates identified two correct examples, but some candidates misunderstood the question.Candidates were required to provide two further examples of what could be stored as a binary value in aregister.
Examiner Comment on Q 5(d)
Most candidates provided a correct conversion to hexadecimal.

Q 13) Winter 2017 P12

1 A robot arm in a factory is programmed to move products.
The binary instructions to operate the robot arm are:

Operation	Binary Instruction			
UP	1	1	1	1
Down	0	0	0	1
Left	1	0	0	1
Right	0	1	1	0
Open	1	1	0	0
Close	0	0	1	1

Convert the values and write down the operation (e.g. RIGHT) carried out by the robot arm.

9 ....

1 ....

C ....

3 ....

F .... [5]

3 (a) Explain the differences between the binary number system and the denary number system.

....

....

....

....

....

....

....

....

.... [4]

(b) Explain the process of converting the binary number 1010 into a denary number.

....

....

....

....

....

....

....

....

.... [5

Q 14) Winter 2017 P13

1 A washing machine has a small display screen built into it.

One use of the display screen is to show an error code when a problem has occurred with a washing cycle.

(a) State whether the display screen is an input, output or storage device.

.... [1]

(b) The display screen shows a hexadecimal error code:

E04

This error code means that the water will not empty out of the washing machine.

Convert this error code to binary.

[3]

(c) State why hexadecimal is used to display the error code.

....

....

....

....[1]

(d) Identify three sensors that could be used in the washing machine.

State what each sensor could be used for.

Sensor 1..

Use ....

....

Sensor 2 ....

Use ....

....

Sensor 3 ....

Use ....

.... [6]

2 Data files are stored in different file formats.

Complete the table by providing a suitable file format for each file type. The first one has been done for you. [3]

File type	File format
Pictures	.JPEG
Text	
Sound	
Video	

Q 15) March 2018 P12 (India)

5 The IP address of a computer is stored as a set of four 8-bit binary numbers.
The network administrator converts each binary number into hexadecimal.
(a) Complete the table to show the hexadecimal equivalent of the binary IP address.
The first number has already been converted.

Binary IP address [3]

11000100	00010000	11111110	00001001

Hexadecimal

C4			

(b) Explain why the network administrator uses hexadecimal.

....

....

....

....[2]

Comments on Question 5

(a) *Many candidates answered this question well. Two common errors were not providing the full regi ster values for the last register. Some candidates only gave 9 as the value, but the values for the whol e register should have been provided, for example 09. It would be helpful if candidates understood th at even if they are asked to convert the whole register, any 0 value should also be given.*
Some candidates converted the value again for the first register. They should have provided the resp

onse 10, but treated this as a denary value and further converted it giving an answer of A. It would be helpful if candidates understood that the initial values from the conversion were hexadecimal values a nd not a denary value of 10.

(b)*Many candidates provided a good response for this question. The most common responses were t hat it would make it easier to read and that fewer errors may be made.*

11 Miriam needs to use a large high-resolution photo as a thumbnail image on a website.

She will use lossy compression to reduce the file size of the photo to create the thumbnail image.

(a) State why a smaller file size is appropriate for this situation.

....

....[1]

(b) Explain how lossy compression reduces the file size.

....

....

....

....

....

....

....

.....................................[4]

Comments on Question 11

(a) Many candidates answered this question well. Some candidates referred to making the downloading process easier. It would be helpful for candidates to understand that the downloading process would not change, it would be the download time that would be reduced.

Some candidates also referred to the download speed being reduced. It would be advisable for candidates to understand the difference between the speed of a download and the time it takes to download something. In this situation, the speed of the download would not be reduced, it would stay the same depending on the user's bandwidth.

(b) Some candidates provided a good level of knowledge of the compression process for an image.

Some candidates described the compression process for sound. It would be helpful if candidates provided a response that described the context they are given in the question and not a generalised response about the compression of data.

Q 16) Summer 2018 P11

1 Jane answers an examination question about computers and data correctly.

Six different words or numbers have been removed from her answer.

Complete the sentences in Jane's answer, using the list given. Not all items in the list need to be used.

- 2
- 10
- 16
- analogue
- binary
- denary
- digital
- hexadecimal

As humans, we process …………………………………… data, but a computer cannot process this type of data. For a computer to be able to process data it needs to be converted to …………………………………… data.

As humans, we mostly use a …………………………………… number system; this is a base …………………………………… number system.

Computers use a …………………………………… number system; this is a base …………………………………… number system. [6]

2 Dheeraj identifies **three** hexadecimal numbers.

Write the **denary** number for each of the three hexadecimal numbers:

2A ....

101 ....

21E .... [3]

Working Space

....

....

....

....

....

....

4 Michele wants to email a file to Elsa. The file is too large so it must be compressed.

(a) Name **two** types of compression that Michele could use.

Compression type 1 ....

Compression type 2 .... [2]

(b) The file Michele is sending contains the source code for a large computer program.

Identify which type of compression would be most suitable for Michele to use.

Explain your choice.

Compression type...

Explanation ....

....

....

....

....

.... [4]

Q 17) Summer 2018 P12

1 Different units of data can be used to represent the size of a file, as it changes in size.

Fill in the missing units of data, using the list given: [4]

- byte
- gigabyte (GB)
- megabyte (MB)
- nibble

Smallest — bit

....

....

Kilobyte (KB)

....

....

Largest — Terabyte (TB)

2 (a) Nancy has captured images of her holiday with her camera. The captured images are stored as digital photo files on her camera. Explain how the captured images are converted to digital photo files.

....

....

....

....

....

....[4]

(b) Nancy wants to email the photos to Nadia.

Many of the photos are very large files, so Nancy needs to reduce their file size as much as possible.

Identify which type of compression would be most suitable for Nancy to use. Explain your choice.

Compression type ....

Explanation ....

....

....

....

....

....[4]

3 A stopwatch uses six digits to display hours, minutes and seconds.

The stopwatch is stopped at:

0 2	:	3 1	:	5 8
Hours		**Minutes**		**Seconds**

An 8-bit register is used to store each pair of digits.

(a) Write the 8-bit binary numbers that are currently stored for the **Hours**, **Minutes** and **Seconds**.

[3]

Hours								
Minutes								
Seconds								

(b) The stopwatch is started again and then stopped.

Hours	0	0	0	0	0	1	0	1
Minutes	0	0	0	1	1	0	1	0
Seconds	0	0	1	1	0	1	1	1

Write the denary values that will now be shown on the stopwatch. [3]

Hours	:	Minutes	:	Seconds
	:		:	

4 Jafar is using the Internet when he gets the message:

"D03, page is not available"

Jafar remembers that hexadecimal is often used to represent binary values in error codes.

Convert the hexadecimal number in the error message into 12-bit binary. [3]

5 The three binary numbers in the registers X, Y and Z have been transmitted from one computer to another.

								Parity bit
Register X	1	0	0	1	0	0	1	0
Register Y	1	1	1	0	0	1	1	1
Register Z	1	1	1	0	1	0	0	1

Only **one** binary number has been transmitted correctly. This is identified through the use of a parity bit. Identify which register contains the binary number that has been transmitted **correctly**. Explain the reason for your choice.

The binary number that has been transmitted correctly is in **Register** ....

Explanation ....

....

....

....[4]

Q 18) Winter 2018 P12

1 Computers use a character set to convert text into binary.

One character set that can be used is ASCII.

Each letter in ASCII can also be represented as a denary value.

(a) The word BUS has the denary values:

B	U	S
66	85	83

Convert the denary values into 8-bit binary. [3]

66								
85								
83								

(b) Each letter in ASCII can also be represented as a hexadecimal value.

The word KEY has the 8-bit binary values:

K	E	Y
01001011	01000101	01011001

(i) Convert the three 8-bit binary values into hexadecimal.

01001011 ....

01000101 ....

01011001 .... [3]

(ii) Give **three** other uses of hexadecimal notation in computer science.

1 ....

2 ....

3 .... [3]

(iii) State **two** benefits of using hexadecimal notation to represent binary values.

Benefit 1 ....

....

Benefit 2 ....

.... [2]

Q 19) Winter 2018 P13

4 The MAC address of a device is represented using hexadecimal. A section of a MAC address is shown. Each pair of hexadecimal digits is stored using 8-bit binary.

(a) Complete the table to show the 8-bit binary equivalents for the section of MAC address. The first number has already been converted. 6A FF 08 93 01101010 [3]

6A	FF	08	93
01101010			

(b) Explain why data is stored as binary in computers.

…………..

....

....

....

……………………………………….. [2]

7 David is writing a program using a high-level language. The program will be published and sold for profit.

(c) David needs to send a large section of the programming code as an email attachment. He uses lossless compression to reduce the file size. Explain how the file size is reduced.

....

....

....

....

....

....

……………………………………….. [3]

12 Explain the difference between a Musical Instrument Digital Interface (MIDI) file and a MP3 file.

....

....

....

....

....

....

……………………………………….. [4]

Q 20) March 2019 P12

1 (a) Elle has a file stored on her computer that is 20 MB in size. Jordan has a file that is 10GB in size.
Tick (✓) to show which is the **larger** file. [1]

File size	**Tick (✓)**
20MB	
10GB	

(b) Bob has a file stored on his computer that is 3500kB in size. Gerty has a file that is 3MB in size.
Tick (✓) to show which is the **larger** file. [1]

File size	**Tick (✓)**
3500kB	
3MB	

3 (a) A long distance running race uses an electronic counter that counts each competitor who finishes the race.
The count is stored as binary in a **12-bit** register.
A denary value of the count is displayed on a screen above the finish line.
(i) The screen currently displays:
State the binary value that is currently stored to display the count shown.

0 0 3 9

....

.... [2]

(ii) More competitors cross the finish line and the screen now displays:

State the binary value that is currently stored to display the count shown.

0 3 5 0

....

.... [2]

(iii) At the end of the race the binary value stored is:

011011000111

Give the denary value that would be displayed on the screen at the end of the race. [2]
Show your working.

....

....

....

....

Screen display:

Q 21) Summer 2019 P11

1 Hexadecimal is used for MAC addresses.

Part of a MAC address is given:

97 – 5C – E1

Each pair of digits is stored as binary in an 8-bit register.

(a) Show what the binary register stores for each pair of the given digits. [6]

97								
5C								
E1								

(b) Explain what is meant by a MAC address.

....

....

....

....

....

....

....

.... [4]

(c) Give **two** other examples where hexadecimal can be used.

Example 1 ....

....

Example 2 ....

.... [2]

5 The following text is stored as a text file:

She sells sea shells on the seashore. The shells that she sells are sea shells I am sure.

Explain how lossless compression would compress this file.

....

....

....

....

....

....

....

....

....

.... [5]

7 Annie writes a paragraph of text as an answer to an examination question about programming languages. Using the list given, complete Annie's answer by inserting the correct **six** missing terms. Not all terms will be used.

- Assembly
- Converter
- Denary
- Hexadecimal
- High-level language
- Low-level language
- Machine Code
- Source Code
- Syntax
- Translator

The structure of language statements in a computer program is called the .... A programming language that uses natural language statements is called a ………………… . When programs are written in this type of language they need a .... to convert them into .... A programming language that is written using mnemonic codes is called .... language. this is an example of a .... [6]

Q 21) Winter 2019 P13

1 (c) The library has a website that customers can use to search for a book.

(i) The website has a background colour with the hexadecimal colour code #F92A10The colour code is stored in two 12-bit binary registers. [6]

Show how the colour code would be stored in the registers.

F92												
A10												

(ii) Videos on the library website show customers which books the library will soon have in stock.

The library wants the file size of a video to be as small as possible.

Identify **and** describe a method the library could use to reduce the file size of a video as much as pos sible.

....

....

....

....

....

....

.... [4]

Q 22) Winter 2019 P12

1 Computer memory size is measured in multiples of bytes.

Four statements about computer memory sizes are given in the table.

Tick (✓) to show if the statement is **True** or **False**. [4]

Statement	**True (✓)**	**False (✓)**
25kB is larger than 100MB		
999MB is larger than 50GB		
3500kB is smaller than 2GB		
2350bytes is smaller than 2kB		

3 The data from a sensor must be converted from analogue to digital to be processed by a computer.

(a) State what is meant by analogue data.

....

.... [1]

(b) State what is meant by digital data.

....

.... [1]

4 An 8-bit binary register contains the value:

0	0	1	1	0	1	0	0

(a) Convert the binary value to denary.

....

.... [1]

(b) The contents of the register shifted one place to the right would give the result:

0	0	0	1	1	0	1	0

The contents of the register shown at the start of question 4 are shifted two places to the left.

Show the contents of the register after this shift has taken place. [1]

(c) State the effect this shift has on the denary value in **part (a)**.

....

.... [1]

5 Audrey wants to send a sound file to Nico using email.

The file is too large to attach to an email so Audrey decides to compress the file.

She uses lossy compression to reduce the size of the sound file.

(a) Describe how lossy compression reduces the size of the sound file.

....

....

....

....

....

....

....

.... [4]

(b) Nico asks Audrey why she used lossy compression rather than lossless.

(i) State **one** advantage Audrey could give of using lossy rather than lossless to compress the sound file.

....

.... [1]

(ii) State **one** disadvantage Nico could give of using lossy rather than lossless to compress the sound file.

....

.... [1]

(c) Audrey sometimes records MIDI files.

(i) Explain what is meant by a MIDI file.

....

....

....

....

....

....

....

.... [4]

(ii) MIDI uses serial data transmission.

Explain **two** advantages of using serial transmission rather than parallel transmission.

Advantage 1 ....

....

....

....

Advantage 2 ....

....

....

.... [4]

Q 23) March 20 P12

3 (d) Priya shares her sound files with other students. Before sharing the sound files, she compresses the files using lossless compression.

Describe how lossless compression reduces the size of a sound file.

....

....

....

.... [2]

(e) Priya currently uses MIDI files to store her music. Priya's friends have asked her if they can have an MP3 version of the file.

(i) Give **two** features of a MIDI file.

1 ....

....

2 ....

.... [2]

(ii) Give **two** features of an MP3 file.

1 ....

....

2 ....

.... [2]

5 Programmers can use denary and hexadecimal values. These values are stored in a computer system using binary.

(a) Explain why binary is used to store data in a computer system.

....

....

....

.... [2]

(b) Complete the table to show how the denary value would be stored as binary in an 8-bit register. [2]

Denary value	8-bit register
129	
56	

Working space

....

....

....

....

(c) Complete the table to show how the hexadecimal value **3A9** would be stored as binary in a 12-bit register.

[3]

(d) Identify **two** uses of hexadecimal values in computer science.

1 ....

2 .... [2]

Q 24) Summer 20 P12

7 (a) Give the **denary** value of each of the three 12-bit binary values.

(i) 000000001100

.... [1]

(ii) 000011000110

.... [1]

(iii) 010011000001

.... [1]

Working space

....

....

....

....

....

....

....

(b) 12-bit binary values can also be represented as hexadecimal values.

Give the **hexadecimal** value of the 12-bit binary value.

000011101001

.... [3]

Q 25) Summer 20 P11

1 (c) All smartphones have a MAC address.

(i) State what is meant by the term MAC address.

....

.... [1]

(ii) Describe the structure of a MAC address.

....

....

....

....

....

.... [3]

9 (d) A low-level language needs to be converted to binary before it can be processed by a computer.

(i) Give the **8-bit binary** value of the two denary values:

180 ....

201 .... [2]

Working space

....

....

....

....

(ii) Give the **12-bit binary** value of the denary value **250**.

.... [1]

Working space

....

....

....

....

(iii) Binary can be represented as hexadecimal to make it easier to read.

Give the **hexadecimal** values of the 8-bit binary values:

10010011 ....

00011101 .... [2]

Q 26) Winter 20 P12

1 Tina is creating a website for charity events. She uses HTML to create the website.

(a) State what is meant by HTML.

....

.... [1]

(b) She uses the hexadecimal colour code #43B7F0 as the background colour for her website.

(i) State whether background colour is an example of **structure** or **presentation**, in the website.

.... [1]

(ii) The hexadecimal colour code #**43B7F0** is stored in three **8-bit** registers.

Give the **8-bit binary** values for each part of the hexadecimal code. [6]

43								
B7								
F0								

(c) Tina uses a microphone to record a welcome message for her website.

(i) State whether the microphone is an **input** or **output** device.

.... [1]

(ii) She wants to compress the recording to make sure that the file is as small as possible for the website.

Identify which type of compression she should use and describe how this would compress the file for the website.

Type of compression ....

Description ....

....

....

....

....

....

....

.... [4]

(iii) Give **two** benefits of compressing the file for the website.

Benefit 1 ....

....

Benefit 2 ....

.... [2]

Q 27) Winter 20 P13

3 (a) Four denary to 8-bit binary conversions are given.
Tick (✓) to show if each denary to 8-bit binary conversion is **Correct** or **Incorrect**. [4]

Denary	Binary Conversion	Correct (✓)	Incorrect (✓)
145	10010001		
179	10110101		
11	00010011		
100	01100010		

(b) Convert the **12-bit** binary number into hexadecimal.

1	1	0	0	0	1	0	0	0	0	0	0

.... [3]

Q 28) March 21 P12

1 A hockey club records the number of people that watch each match. An 8-bit binary register is used to store this value.
(a) 46 people watch the first match and 171 people watch the second match.
Show how the registers would store these denary values as 8-bit binary. [2]

Denary value	8-bit binary							
46								
171								

Working space
....
....
....
....

(b) Give the largest denary value that can be stored in the 8-bit binary register.
.... [1]

(c) The hockey club wants to increase the number of people that can watch each match to 2000.
The 8-bit binary register may no longer be able to store the value.
Give the smallest number of bits that can be used to store the denary value 2000.
.... [1]

Working space
....
....
....
....

2 Gurdeep takes high definition photographs using a digital camera. She has set up a website where users can view thumbnails of her photographs. A thumbnail is a small version of the high definition photograph.

(a) Gurdeep compresses the high definition photographs to create the thumbnails. She uses lossy compression. Describe how lossy compression creates the thumbnails.

....

....

....

....

....

.... [3]

Marking Scheme

8 **(a)** hours: **18**

minutes: **53** [2]

(b)

hours (**"C"**)								:	minutes (**"D"**)							
0	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**:**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**0**

(c) Any **three** from:

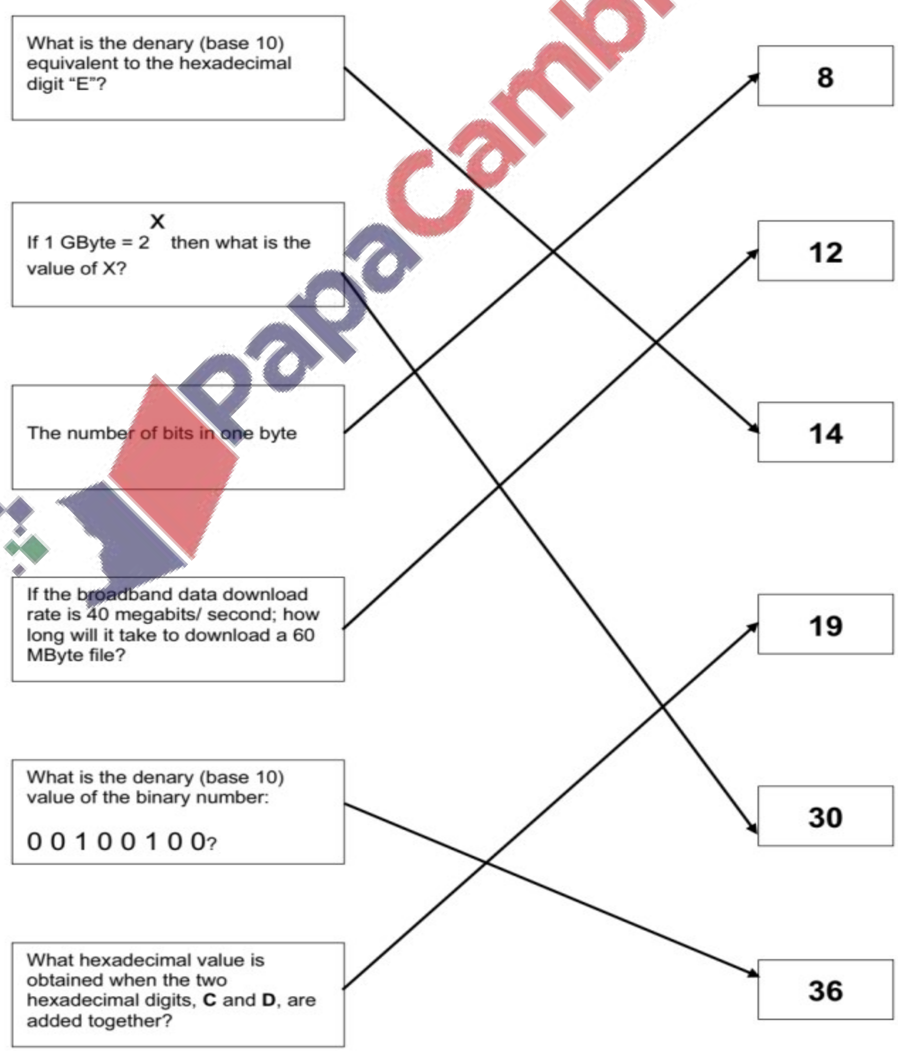
– reads values in registers "C" and "D"

– and checks the values against those stored in registers "A" and "B"
(**NOTE**: the first two statements can be interchanged, i.e. "A" and "B" read first)

– If values in corresponding registers are the same

– the microprocessor sends a signal to sound alarm/ring [3]

9



Q 2) Summer 2015 P12

Page 11	Mark Scheme	Syllabus	Paper
	Cambridge O Level – May/June 2015	2210	12

10 (a) 1 mark for two correct lines, 2 marks for four correct lines

L (108):	0	1	1	0	1	1	0	0
I (105):	0	1	1	0	1	0	0	1
G (103):	0	1	1	0	0	1	1	1
N (110):	0	1	1	0	1	1	1	0

[2]

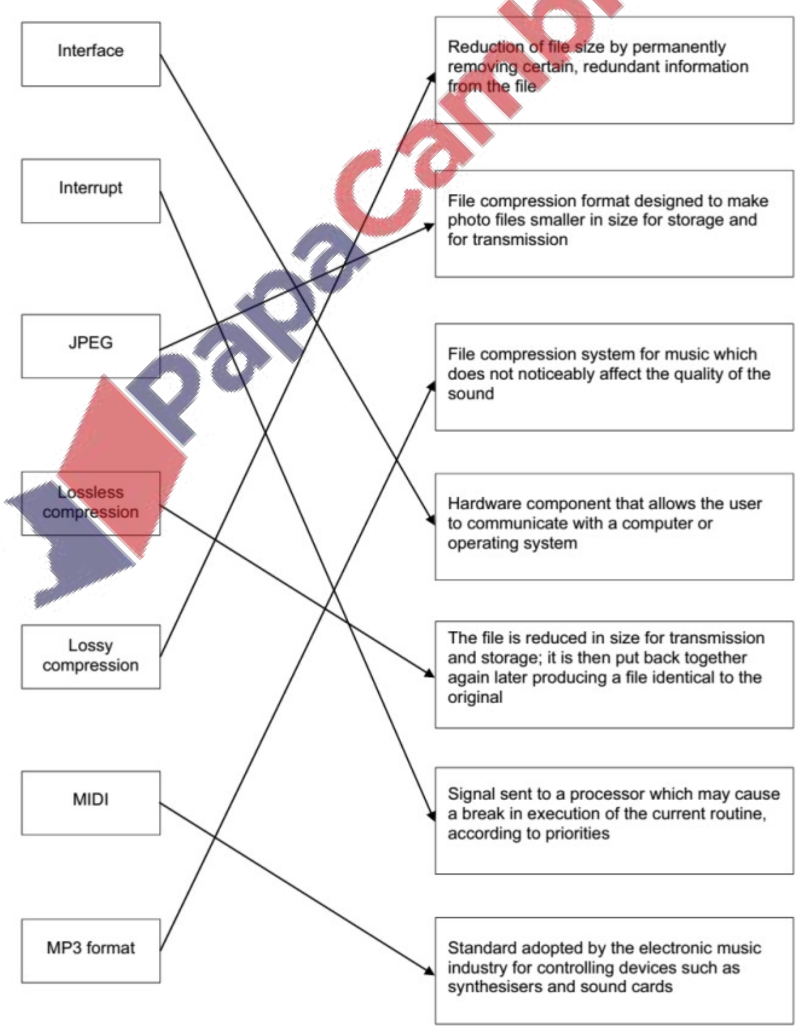
(b) 1 mark for each correct binary value
1 mark for each correct hexadecimal value

									hexidecimal
L:	1	1	0	1	1	0	0	0	D8
G:	1	1	0	0	1	1	1	0	CE

[4]

Q 3) Winter 2015 P12

2



4 **(a)** **(i)** For each hex number, 2 marks if all correct, 1 mark for 2 correct conversions

F A 7:	1	1	1	1		1	0	1	0		0	1	1	1
D 3 E:	1	1	0	1		0	0	1	1		1	1	1	0

[4]

(ii) 2 marks if all correct, 1 mark for 2 correct conversions – Follow through

1	1	0	1		0	0	1	0		0	1	1	0

[2]

(iii) 2 marks if all correct, 1 mark for 2 correct conversions – Follow through
D 2 6 [2]

(b) **(i)** (X) FF FF 00

(Y) FF 00 FF

(Z) 00 FF FF [3]

(ii)
– hex values between 0 to F are combined together to create a hex code
– different combinations in hex codes will create different shades/tones/colours [2]

(c) **(i)** First six digits: manufacturer code/manufacturer ID

Last six digits: serial number/serial ID of device/product [2]

(ii) Allows all devices to be uniquely identified [1]

Q 4) Winter 2015 P13

(b) **(i)** **2 marks for all correct conditions, 1 mark for 2 correct conditions**

CO (carbon monoxide) level too high
oil pressure too low
brake pads too thin [2]

(ii) 1 mark for each correct parity bit in position 1

1	1	1	1	0	0	1	0
0	0	0	0	1	1	1	0

[2]

(iii) 1 mark for correct parity bit + 1 mark for remainder of binary value

1	0	1	0	0	0	1	0

[2]

(iv) A 2 (allow follow through from part (iii)) [1]

3 (a) (i)

MAR	1	0	0	0	0	0	0	1
MDR	0	1	0	1	0	0	0	1

9 (a) 8 MB
100

(b) (i) Any **two** from:
– removes sounds human ear can't hear very well
– if two sounds played at same time, softer sound removed
– uses perceptual music shaping

(ii) Lossy

(iii) **One** from, for example:
– jpeg
– MP4
– zip
– gif

Q 5) Winter 2015 P11

2 (a) 1 0 1 1 0 1 0 1

F 6

(b) Any **two** from:
– HTML
– MAC address
– used in assembly language/machine code
– debugging (displays bytes in hex when using memory dumps)

(c) – Can represent 16 bit words as only 4 hexadecimal digits
– It is easy to convert hex digits back to binary if necessary

7 **(a)** Lossy

– when decompressed, some detail is lost and file is not exactly like the original (but difference is usually not noticeable)

Lossless

– when decompressed the original file is restored with no loss of data

(b) 1 mark for type of file + 1 mark for description
e.g:

– JPG
– Used to store images/pictures

– MP3
– Used to store audio/sound files

(c) Any **three** from:

– company calculation is based on 1 GByte = 1000 MByte

– so (500 × 1000)/8 = 62 500 files

– customer calculation based on 1 GByte = 1024 MByte

– so (500 × 1024)/8 = 64 000 files

– giving the difference of 1500 files

10 **(a)**

w	w	w	.	c	i	e	.	o	r	g	.	u	k
%77	%77	%77	**%2E**	**%63**	**%69**	**%65**	**%2E**	**%6F**	**%72**	**%67**	**%2E**	**%75**	**%6B**

1 mark 1 mark 1 mark

[3]

(b)

%77	%77	%77	%2E	%72	%6F	%63	%6B	%69	%63	%74	%2E	%63	%6F	%6D
W	W	W	**.**	**r**	**o**	**c**	**k**	**i**	**c**	**t**	**.**	**c**	**o**	**m**

1 mark 1 mark 1 mark

[3]

Q 6) Summer 2016 P11 & P13

7 (a) **1** mark for each correct binary value

3	**0**	**0**	**1**	**1**
5	**0**	**1**	**0**	**1**

(b)

0	**0**	**0**	**1**	→ **1**	1 mark
1	**0**	**0**	**1**	→ **9**	
0	**1**	**0**	**0**	→ **4**	
1	**1**	**1**	**0**	→ **E**	1 mark

Page 10	Mark Scheme	Syllabus	Paper
	Cambridge O Level – May/June 2016	2210	11

12 (a) **QR (quick response) Code** [1]

(b) – **A 5 0** (1 mark)

1	0	1	0

1 mark

0	1	0	1

1 mark

0	0	0	0

1 mark

[4]

(c) Any **three** from:

- visitor scans the QR code with (the camera on) the mobile device
- App is used to read/interpret the QR code
- links to a website/opens a document …
- … to access local tourist information
- can store the QR code to refer to again for the information [3]

Q 7) Summer 2016 P12

3 **(a)** **1** mark for each nibble

0100 1010 1111 [3]

(b) **(i)**

0 1 1 0 1 0 0 1	105 hours	1 mark
0 0 0 1 1 1 1 1	31 minutes	1 mark
0 0 1 1 0 0 1 0	50 seconds	1 mark

[3]

(ii) 1F [1]

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0478	12

4 **(a)** Any **three** from:
- The file can be compressed
- The compression that is used is lossless (not lossy)
- use of a compression algorithm
- repeated words can be indexed
- repeated word sections (e.g. "OU") can be replaced by a numerical value
- reference to zip files
- save file as a pdf/convert to pdf [3]

(b) Any **four** from:
- the checksum for the bytes is calculated
- this value is then transmitted with the block of data
- at the receiving end, the checksum is re-calculated from the block of data received
- the calculated value is then compared to the checksum transmitted
- if they are the same value, then the data was transmitted without any error
- if the values are different, then an error has been found
- if the values are different, then a request is sent for the data to be re-transmitted [4]

Q 8) Winter 2016 P12

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2016	0478	12

5 **(a)** 112 [1]

(b) 56 [1]

(c) divided by 2 // value 112 was halved // multiplied by 0.5 [1]

(d) **(i)**

0	**0**	**0**	**0**	**1**	**1**	**1**	**0**

[1]

(ii) 14 [1]

(e) Any **two** from:

- run out of places to the right of register / at the end of register
- right-most 1 would be lost
- number would become 3 instead of 3.5
- loss of precision

[2]

Q 9) Winter 2016 P11& 13

10 (a) (i) 2 marks for 3 correct binary conversions, 1 mark for 2 correct binary conversions [2]

0	**0**	**0**	**1**	**1**	**0**	**1**	**0**	**1**	**1**	**1**	**1**

(ii) 1 mark for each correct hex value converted

1 A F [3]

(b) 2 marks for working + 1 mark for correct answer

Working
– $1200 \times 8 = 9600$ (bytes)
– 9600/1024 or 9600/1000

Answer
– 9.4 or 9.6 kilobytes [3]

(c) Any **one** from:

MAC address

– Media Access Control (address)
– unique number that identifies a device (connected to the Internet)
– address is made up of manufacturer id + serial number of device
– address is allocated by the manufacturer

Any **one** from:

IP address

– Internet Protocol (address)
– location/address of a device on the Internet
– address is unique for given Internet session
– address is supplied when a device connects to the Internet
– address is allocated by the network [2]

Q 10) March 2017 India

Question	Answer	Marks
7	High definition video – lossy (algorithm) – images may contain less detail without noticeable degradation in quality Text – lossless (algorithm) – so that the original and the decompressed text will be exactly the same	4

Question	Answer	Marks
8(a)	Denary – 55 Hexadecimal – 37	2
8(b)	Binary – (00)111001 Denary – 57 Hexadecimal – 39	3
8(c)	0/1 | 0/1 | 0 | 0 | 0/1 | 1 | 1 | 1	1

Question	Answer	Marks
12(a)	1 mark for appropriate use and 1 mark for suitable example for up to three uses e.g. ∞ HTML colours ∞ e.g. blue `0000FF` ∞ Display machine code/programs/memory dump ∞ e.g. `5F 3A 09 F1` ∞ Display (MAC) addresses ∞ e.g. `01-23-45-67-89-AB-CD` ∞ Display ASCII/Unicode values ∞ e.g. `%41` for A ∞ Display error codes ∞ e.g. error #404 page not found	6
12(b)	Any **two** from: ∞ easier for programmers to read and understand ∞ easier to find errors ∞ conversion to binary easier than denary to binary ∞ more can be displayed on a screen for addresses etc. // smaller display screens can be used ∞ faster than binary for entering numbers	2

Q 11) Summer 2017 P11

Question	Answer	Marks
1(a)	1 mark for **any** two correct values, 2 marks for all 4 correct values. 29FC	2
1(b)	**Two** from: ∞ Easier/quicker to understand/read ∞ Easier to debug/identify errors ∞ Fewer digits are used / shorter // takes up less space on screen // more can be shown on screen / page	2
1(c)	**Two** from: ∞ Notations for colour in HTML // HTML colour (codes) ∞ Error messages ∞ MAC address // IP address ∞ Locations in memory ∞ Memory dump	2

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>3</td><td>1 mark per correct tick
<table>
<tr><th>Statement</th><th>true (✓)</th><th>false (✓)</th></tr>
<tr><td>47KB is larger than 10MB.</td><td></td><td>✓</td></tr>
<tr><td>250bytes is smaller than 0.5MB.</td><td>✓</td><td></td></tr>
<tr><td>50GB is larger than 100MB.</td><td>✓</td><td></td></tr>
<tr><td>1TB is smaller than 4GB.</td><td></td><td>✓</td></tr>
</table></td><td>4</td></tr>
</table>

Question	Answer	Marks
13(a)	**Two** from: • Smaller file to transmit • The file is transmitted quicker • Uses / requires less bandwidth	2
13(b)(i)	• Lossless (compression) … • … It is important the code must be (exactly) the same as the original file • … If it does not match the original file it will not work	3
13(b)(ii)	• Lossy (compression) … • … It would make the file smaller than lossless compression / the file would stream faster than lossless compression • … The quality of the video can be reduced but it can still be viewed	3

Q 12) Summer 2017 P12

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>5(a)</td><td>1 mark for correct method, 1 mark for correct answer

32 + 16 + 8 + 1
(00)111001</td><td>2</td></tr>
<tr><td>5(b)</td><td>registers must have leading zeros, allow follow through from 5(a) for an incorrect value
1 mark for each correct register.
<table><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td></tr></table>
<table><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td></tr></table></td><td>2</td></tr>
<tr><td>5(c)</td><td>Two from:

• data
• ASCII value / Unicode value / character
• number
• part of image / small image
• a sound / sound sample / small sound track
• instruction</td><td>2</td></tr>
<tr><td>5(d)</td><td>3A</td><td>1</td></tr>
</table>

Q 13) Winter 2017 P12

1	1 mark per correct instruction: 9 – LEFT 1 – DOWN C – OPEN 3 – CLOSE F – UP	5

3(a)	Any **four** from (**Max 2** per number system) : - A binary number system is a base-2 system - A denary number system is a base-10 system - A binary number system uses 0 and 1 values - A denary number system uses 0 to 9 values - A binary number system has units/ placeholders/column headings that increase by the power of 2 - A denary number system has units/ placeholders/column headings that increase by the power of 10 - Binary has more digit <u>for the same value</u>// Denary has less digits <u>for the same value</u>	4

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Question	Answer	Marks
3(b)	**Five** from: - Correct column headings / place holders by example - Correctly place a 1 or a 0 for each column - Identify the columns to be added - Add together the (denary) values identified … - … this will give a total which is the denary number/answer - Answer is 10	5

Q 14) Winter 2017 P13

Question	Answer	Marks
1(a)	Output	1
1(b)	1 mark for each correct conversion	3

E				0				4			
1	1	1	0	0	0	0	0	0	1	0	0

Question	Answer	Marks
1(c)	Any **one** from: – Hexadecimal codes can fit in a smaller display rather than a full text based message – Smaller amount of memory needed to store the hex error messages than text based	1
1(d)	1 mark for correct sensor, 1 mark for corresponding use Possible examples could include: – Temperature (sensor) – To monitor the temperature of the water – Pressure (sensor) – To monitor the level of water in the washing machine – Motion (sensor) – To monitor whether the drum is still in motion – pH (sensor) – To monitor the level of water hardness/detergent present in the water	6

Question	Answer	Marks
2	1 mark for each correct file format e.g.	3

File type	File format
Pictures	.JPEG
Text	.doc, .txt, .rtf, .docx, .odt .pdf
Sound	.mp3, .wav, .aif, .flac, .mid
Video	.mp4, .flv, .wmv

Q 15) March 2018 P12 (India)

Question	Answer	Marks
5(a)	One mark for each correct Hexadecimal value C4 | 10 | FE | 09	3
5(b)	Any **two** from: Easier / simpler to remember / write down // quicker to transcribe Less likely to make error Less digits to use	2

Question	Answer	Marks
11(a)	Smaller file size reduces download / display time // reduces upload time	1
11(b)	Any **four** from: A compression algorithm is used Permanently deleting some data // file cannot be restored to original Colour depth / palette can be reduced Resolution can be reduced // number of pixels can be reduced Less bits will be required for each pixel / colour	4

Q 16) Summer 2018 P11

Question	Answer	Marks
1	1 mark for each correct answer, in the given order: – analogue – digital – denary – 10 – binary – 2	6

Question	Answer	Marks
2	1 mark for each correct conversion: – 42 – 257 – 542	3

Question	Answer	Marks
4(a)	1 mark for each correct answer: Lossy (compression) Lossless (compression)	2
4(b)	1 mark for correct compression, 3 marks for description: – Lossless (compression) Any **three** from: – The file can be restored/decompressed to the exact same state it was before compression/ to original – (It is a computer program so) no data can be lost // Lossy would remove data – Will not run correctly (with any other compression) – (Lossless) will give repeating words/sections of word a value// RLE is used // Other valid examples of methods of lossless compression – Value is recorded in an index	4

Q 17) Summer 2018 P12

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Question	Answer	Marks
1	1 mark for each unit, in the given order: – nibble – byte – megabyte (MB) – gigabyte (GB)	4

2(a)	Any **four** from: – Image is converted from analogue to digital (using ADC) – Image is turned into pixels – Each pixel is given a binary value – Pixels form a grid (to create the image) – Each pixel has a colour – Pixels are stored in sequence (in a file) – Meta data is stored (to describe the dimensions/resolution of the image) // It stores the dimensions/colour depth .etc. – An example of a suitable photo file format e.g. JPEG	**4**
2(b)	1 mark for correct compression, 3 marks for explanation: – Lossy Any **three** from: – Lossy would reduce the file size **more** (than lossless) – The **redundant** data can be removed from the files // by example (must be about redundant data) – Images can still be a similar quality – There is no requirement for the files to be exactly the same as original file – Photos can be sent quick**er** // fast**er** to upload // fast**er** to download	**4**

3(a) 1 mark for each correct register — **3**

Hours	0	0	0	0	0	0	1	0
Minutes	0	0	0	1	1	1	1	1
Seconds	0	0	1	1	1	0	1	0

3(b) 1 mark for each correct section: — **3**

Hours		:	Minutes		:	Seconds	
0	5	:	2	6	:	5	5

4 1 mark for each correct section: — **3**

1	1	0	1	0	0	0	0	0	0	1	1
← 1 mark →				← 1 mark →				← 1 mark →			

Q 18) Winter 2018 P12

Question	Answer	Marks
1(a)	1 mark for each correct 8-bit binary number 66: 0 1 0 0 0 0 1 0 85: 0 1 0 1 0 1 0 1 83: 0 1 0 1 0 0 1 1	3
1(b)(i)	1 mark for each correct hexadecimal number 4B 45 59	3
1(b)(ii)	**Three** from: ∞ (HTML) colour codes ∞ Error messages ∞ MAC addresses ∞ IP addresses ∞ Assembly language ∞ Memory dump ∞ Locations in memory	3
1(b)(iii)	**Two** from: ∞ Easier to read/write/understand (for humans) ∞ Easier to remember (for humans) ∞ Short way to represent binary // Uses less **screen/display** space ∞ Fewer errors made (in data transcription) ∞ Easier to debug (for humans)	2

Q 19) Winter 2018 P13

Question	Answer	Marks
4(a)	1 mark for each correct conversion *01101010* | **11111111** | **00001000** | **10010011**	3
4(b)	∝ Computers use switches / logic gates ∞ Only uses 2 states / On or Off / 1 or 0	2
7(c)	**Three** from: ∞ Uses compression algorithm / by example e.g. RLE ∞ Repeating words / phrases / patterns identified… ∞ … replaced with value ∞ File / dictionary / index of phrases created ∞ Index will store word/phrase with value	3

Question	Answer	Marks
12	**Four from (**Max three from each): **MP3** ∞ Digital recording of sound ∞ Produced by recording software / microphone ∞ Used when distributing sound files ∞ Compressed file format **MIDI** ∞ Instructions of how to make sound ∞ Non-audio recording ∞ File created using **digital** musical instruments ∞ Produced by synthesizer ∞ Used when composing music ∞ Individual notes/instruments can be changed	4

Q 20) March 2019 P12

1(a)	**File size** | **Tick (✓)** 20 MB | 10 GB | ✓	1
1(b)	**File size** | **Tick (✓)** 3500 kB | ✓ 3 MB |	1

3(a)(i)	– 000000100111 1 mark 1 mark	2
3(a)(ii)	– 000101011110 1 mark 1 mark	2
3(a)(iii)	1 mark for working, 1 mark for correct answer – 1024 + 512 + 128 + 64 + 4 + 2 + 1 – 1735	2

Q 21) Summer 2019 P11

1(a) — Marks: **6**

97

1	0	0	1	0	1	1	1

1 mark (first 4 bits) — 1 mark (last 4 bits)

5C

0	1	0	1	1	1	0	0

1 mark (first 4 bits) — 1 mark (last 4 bits)

E1

1	1	1	0	0	0	0	1

1 mark (first 4 bits) — 1 mark (last 4 bits)

1(b) — Marks: **4**

Four from:
- Media Access Control (address)
- Used to identify a device
- It is a **unique** (address)
- It is a static address // It does not change
- It is set by the manufacturer
- The first part is the manufacturer ID/number/identifies the manufacturer
- The second part is the serial number/ID

5 — Marks: **5**

Five from:
- A (compression) algorithm is used
- No data is removed in the process // original file can be restored
- **Repeated** words (are identified) // **Patterns** in the data (are identified)
- … and are indexed/put into a table // by example
- … and are replaced with their index // by example
- … and their positions are stored (in the table) // by example
- … and the number of times the word/pattern appears is stored (in the table) // by example

NOTE: Other valid methods of lossless compression can be awarded marks

Q 21) Winter 2019 P13

1(c)(i) — Marks: **6**

1	1	1	1	1	0	0	1	0	0	1	0

1 mark — 1 mark — 1 mark

1	0	1	0	0	0	0	1	0	0	0	0

1 mark — 1 mark — 1 mark

Question	Answer	Marks
1(c)(ii)	**One** mark for identification: • Compression **Three** from e.g.: • Best compression would be lossy • Use compression algorithm • This would remove all the unnecessary data from the file // removes detail/sound that the human eye/ear may not see/hear • Reduce colour palette … • … so each pixel requires fewer bits • Reduce resolution • Only store what changes between frames // temporal redundancy	**4**

Q 22) Winter 2019 P12

Question	Answer	Marks
1	**One** mark for each correct tick	**4**

Statement	True (✓)	False (✓)
25 kB is larger than 100 MB		✓
999 MB is larger than 50 GB		✓
3500 kB is smaller than 2 GB	✓	
2350 bytes is smaller than 2 kB		✓

Question	Answer	Marks
3(a)	**One** from: • Continuous data // by description • Non-discrete data // by description • By example, e.g. data such as a sound wave	**1**
3(b)	**One** from: • <u>Discrete</u> data that has only two values • By example, e.g. binary data / 1's and 0's	**1**

Question	Answer	Marks
4(a)	• 52	**1**
4(b)	1 | 1 | 0 | 1 | 0 | 0 | 0 | 0	**1**
4(c)	• It is multiplied by 4	**1**

Question	Answer	Marks
5(a)	**Four** from: ∞ A compression algorithm is used ∞ Discards any unnecessary sounds … ∞ … using perceptual musical shaping ∞ … such as removing background noise / sounds humans can't hear // or other suitable example ∞ Reduces sample size / resolution // by example ∞ Reduces sample rate // by example ∞ Sound is clipped ∞ The data is permanently removed	4
5(b)(i)	**One** from: ∞ The file size will be smaller than lossless ∞ Requires less storage space ∞ Requires less time to transmit	1
5(b)(ii)	**One** from: ∞ The quality of the sound will be reduced ∞ The original file cannot be restored	1

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Question	Answer	Marks
5(c)(i)	**Four** from: ∞ Musical Instrument Digital Interface file ∞ Stores a set of commands / instructions for how the sound should be played ∞ Does not store the actual sounds ∞ Data in the file has been recorded using digital instruments ∞ Specifies pitch of the note // specifies the note to be played ∞ Specifies when each note plays and stops playing // Specifies key on/off ∞ Specifies duration of the note ∞ Specifies volume of the note ∞ Specifies the tempo ∞ Specifies the type of instrument	4
5(c)(ii)	**Four** from: ∞ It uses a single wire … ∞ … therefore, it is cheaper to manufacture / buy / install ∞ … therefore, less likely to have interference // no crosstalk ∞ … therefore, can be used over longer distances ∞ Data is sent a bit at a time … ∞ … therefore, less chance of data being skewed // data is received in order ∞ Transmission can be synchronised … ∞ … can reduce rate of errors	4

Q 23) March 20 P12

0478/12 Cambridge IGCSE – Mark Scheme March 2020
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Question	Answer	Mark
3(d)	Any **two** from: • Uses a compression algorithm • Does not **permanently** remove any data • Repeated patterns of notes are identified … • … and are grouped, with an index NOTE: Other possible methods of lossless compression of sound can be credited	2
3(e)(i)	Any **two** from: • Stores the notes played and not the sound • Contains instructions/commands for digital instruments // Is recorded / played on a digital instrument e.g. synthesiser • Stores data about notes e.g. pitch byte (Note: Two examples can be awarded) • Can be a compressed format • Can edit **individual notes**	2
3(e)(ii)	Any **two** from: • Contains actual **sound** • Contains samples of the sound wave • Contains metadata // by example • Uses lossy compression • Recorded using microphone // Is recorded/played on an MP3 recorder/player	2

Question	Answer	Mark
5(a)	Any **two** from: • Computer consist of transistors / logic circuits • … that can **only store/process** data in two states / as high-low / on-off / 1 and 0	**2**
5(b)	1 mark per each correct 8-bit binary value: **Denary Value** – **8-bit binary register** 129 – **10000001** 56 – **00111000**	**2**

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Question	Answer	Mark
5(c)	1 mark per each correct conversion: 0 0 1 1 | 1 0 1 0 | 1 0 0 1 1 mark | 1 mark | 1 mark	**3**
5(d)	Any **two** from: • Represent colours in HTML // HTML colour **codes** • MAC address • Assembly Language • Error messages • IP address • ASCII values • URL • Memory dump • Memory locations	**2**

Q 24) Summer 20 P12

2210/12 Cambridge O Level – Mark Scheme PUBLISHED May/June 2020

Question	Answer	Marks
7(a)(i)	– 12 (ignore leading zeros)	**1**
7(a)(ii)	– 198 (ignore leading zeros)	**1**
7(a)(iii)	– 1217	**1**
7(b)	**One** mark per each correct hex value in correct order – 0E9	**3**

Q 25) Summer 20 P11

1(c)(i)	Any **one** from: – Media access control – Unique address given to each device	**1**
1(c)(ii)	Any **three** from: – Uses hexadecimal values – Normally 48/64 bits in length (accept any other reasonable value) – First half is manufacturer number/code/ID – Second half is serial number	**3**

9(d)(i)	– 10110100 – 11001001	**2**
9(d)(ii)	– 000011111010 (must have leading zeros)	**1**
9(d)(iii)	– 93 – 1D	**2**

Q 26) Winter 20 P12

<table>
<tr><td>1(a)</td><td>Any one from:
– Hypertext Mark-up Language
– Web authoring language // language used to write/create websites/web pages</td><td>1</td></tr>
<tr><td>1(b)(i)</td><td>– Presentation</td><td>1</td></tr>
<tr><td>1(b)(ii)</td><td>One mark per each nibble:
<table>
<tr><td>43</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>B7</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>F0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table></td><td>6</td></tr>
<tr><td>1(c)(i)</td><td>– Input</td><td>1</td></tr>
</table>

<table>
<tr><td>1(c)(ii)</td><td>One from:
– Lossy (compression)

Any three from:
– A (compression) algorithm is used
– Removes redundant/unnecessary data from the file
– Removes sounds that cannot be heard by the human ear/background noise
– Reduces sample rate
– Reduces sample resolution
– Data is permanently removed // original file cannot be re-instated
– Perceptual music shaping is used

NOTE: If lossless given, marks can be awarded for a correct description of lossless as follow through.

Any three from (lossless):
– A (compression) algorithm is used
– Repeating patterns are identified
– … are replaced with a value
– … and indexed
– No data is permanently removed // original file can be re-instated
– Suitable example of a lossless algorithm</td><td>4</td></tr>
<tr><td>1(c)(iii)</td><td>Any two from:
– Quicker for her to upload
– Quicker for users to download
– Won't slow website down as much when loading
– Takes up less storage space</td><td>2</td></tr>
</table>

Q 27) Winter 20 P13

<table>
<tr><td>3(a)</td><td>One mark per each correct row:
<table>
<tr><th>Denary</th><th>Binary Conversion</th><th>Correct (✓)</th><th>Incorrect (✓)</th></tr>
<tr><td>145</td><td>10010001</td><td>✓</td><td></td></tr>
<tr><td>179</td><td>10110101</td><td></td><td>✓</td></tr>
<tr><td>11</td><td>00010011</td><td></td><td>✓</td></tr>
<tr><td>100</td><td>01100010</td><td></td><td>✓</td></tr>
</table></td><td>4</td></tr>
<tr><td>3(b)</td><td>One mark for each correct conversion in the correct order:
– C
– 4
– 0</td><td>3</td></tr>
</table>

Q 28) March 21 P12

1(a)	1 mark each **Denary Value** / **8-bit binary** 46: **0 0 1 0 1 1 1 0** 171: **1 0 1 0 1 0 1 1**	**2**
1(b)	– 255	**1**
1(c)	– 11	**1**

2(a)	Any **three** from: – A compression algorithm is used – Data will be lost/deleted **permanently** // original file cannot be recreated – Reduce the range of colours used / colour depth / bits per pixel – Reduce the number of pixels / image resolution removes data that will not be noticed by the user // removes unnecessary data	**3**