Computer 2210

Number System Workbook by Inqilab Patel

Inqilab Patel (inqilab@ruknuddin.co)
Ruknuddin.com
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1.1 Data representation
Candidates should be able to:
1.1.1 Binary systems
• recognise the use of binary numbers in computer systems
• convert denary numbers into binary and binary numbers into denary
• show understanding of the concept of a byte and how the byte is used to measure memory size
• use binary in computer registers for a given application (such as in robotics, digital instruments and counting systems)
1.1.2 Hexadecimal
• represent integers as hexadecimal numbers
• show understanding of the reasons for choosing hexadecimal to represent numbers
• convert positive hexadecimal integers to and from denary
• convert positive hexadecimal integers to and from binary
• represent numbers stored in registers and main memory as hexadecimal
• 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
• show understanding that sound (music), pictures, video, text and numbers are stored in different formats
• identify and describe methods of error detection and correction, such as parity checks, check digits, checksums and Automatic Repeat reQuests (ARQ)
• show understanding of the concept of Musical Instrument Digital Interface (MIDI) files, jpeg files, MP3 and MP4 files
• show understanding of the principles of data compression (lossless and lossy compression algorithms) applied to music/video, photos and text files

Number System:-

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

Number system is based on some characters called digits. 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.

Computer uses following four numbers:

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	1^{st}
Weight	10^4=10000	10^3=1000	10^2=100	10^1=10	10^0=1

For example 76854 can be expressed as:

$76854 = 7 \times 10^4 + 6 \times 10^3 + 8 \times 10^2 + 5 \times 10^1 + 4 \times 10^0$
$= 7 \times 10000 + 6 \times 1000 + 8 \times 100 + 5 \times 10 + 4 \times 1$
$= 70000 + 6000 + 800 + 50 + 4$
$= 76854$

Binary Number System:-

"The number system which is based on 2 characters 0 and 1 is called binary syst em."

Computer circuitry represents data in a pattern of ON and OFF states of electric current. The state ON is represented by '1' and OFF is represented by '0'. Binary syste m is used for internal working of electronic computers.

The value of each digit in a figure depends upon its weight. The weights are base d on power of 2.

The weights of digits according to their positions are given below:
With the help of above chart we can derive a sequence of number, that sequence is kno wn as Binary Notation. The binary notation is a sequence of numbers are based on pow er 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 No tation	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

Uses of Binary Numbers:

For example 100111_2 can be expressed as:

$100111_2 = 1 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$
$= 1 \times 32 + 0 \times 16 + 0 \times 8 + 1 \times 4 + 1 \times 2 + 1 \times 1$
$= 32 + 0 + 0 + 4 + 2 + 1$
$= 39_{10}$

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 number s 2 and 16. Sixteen is a power of 2 ($16 = 2^4$). Because of this relationship, four digits in a binary number c an be represented with a single hexadecimal digit.

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

Position	5^{th}	4^{th}	3^{rd}	2nd	1^{st}
Weight	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

Uses of Hexadecimal System:

Uses of Hexadecimal in HTML:

Hyper Text Markup Language is used to develop Websites. In HTML a colour is specified according to th e 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

Uses of Hexadecimal in MAC Address:

Media Access Control assigns a unique number to each IP network adapter called the **MAC address**. A MAC address is 48 bits long. The MAC address is commonly written as a sequence of 12 hexadecimal di gits as follows:

48-3F-0A-91-00-BC

Uses of Hexadecimal in Debugging:

Debugging allows programmers to detect, diagnose, and eliminate errors in a program. The source debu gger uses the hexadecimal values of the characters

For example 2134_{16} can be expressed as:

$2134_{16} = 2 \times 16^3 + 1 \times 16^2 + 3 \times 16^1 + 4 \times 16^0$

$= 2 \times 4096 + 1 \times 256 + 3 \times 16 + 4 \times 1$

$= 8192 + 256 + 48 + 4$

$= 8500_{10}$

Conversion:

Convert a denary number into a binary number:

To convert a denary number into a binary number, create a binary notation in column diagram where the l eftmost column heading is greater than the denary number and follow these steps:

1. Start on the left of the diagram.
2. If the column heading is less than the denary number:
   a. Put a 1 in the column.
   b. Subtract the column heading from the denary number.
   c. Move to the next column to the right.
3. d. Go to step 2.
4. If the column heading is greater than the number:
   a. Put a 0 in the column.
   b. Move to the next column to the right.
   c. Go to step 2.

You are normally only expected to be able to do this with numbers up to 255, because that is the biggest number that can be stored in one byte. You may be asked to use more bits for larger numbers.
As an example, we change the denary number 117 into a binary number. First, we set up the column diag ram up to column heading 128 (which is larger than 117).

128	64	32	16	8	4	2	1

Then we follow the algorithm. 128 is greater than 117 so put a 0 in the 128s column and move to the 64s column

128	64	32	16	8	4	2	1
0							

64 is less than 117 so put a 1 in the 64s column, subtract 64 from 117 (117-64= 53) and move to the 32s column.

128	64	32	16	8	4	2	1
0	1						

32 is less than 53, so put a 1 in the 32s column, subtract 32 from 53 (53-32= 21) and move to the 16s col umn.

128	64	32	16	8	4	2	1
0	1	1					

If you continue this until you reach 1 or 0 in the denary number, the result is:

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

So 117 (in denary) = 01110101 (in binary).

Convert a binary number into a denary number:

To turn a binary number into denary, simply put the binary notation below the binary number and add up all the binary notation numbers of each column with a 1 in it.
As an example, we change the binary number 10110110 into a denary number.

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

128 + 32 + 16 + 4 + 2 = 182
So 10110110 = 128 (in denary).

Convert a binary number into a hexadecimal number

Divide into groups for 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

1 0 1 1	0 1 0 1
8 4 2 1	~~8~~ 4 ~~2~~ 1
11	5
B	5

$10110101_2 = B5_{16}$

Convert a hexadecimal number into a binary number

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 the se numbers
Place 0s below remaining binary notation number.
For example: Convert the hex number 374F into binary

3	7	4	F
3	7	4	15
8 4 2 1	8 4 2 1	8 4 2 1	8 4 2 1
0 0 1 1	0 1 1 1	0 1 0 0	1 1 1 1

3=2+1 so 1s are below 2 and 1 are written below written nd 0s a 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.

$374F_{16} = 0011011101001111_2$

ASCII (American Standard Code for Information Interchange)

Decimal - Binary - Octal - Hex – ASCII
Conversion Chart

Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII
0	00000000	000	00	NUL	32	00100000	040	20	SP	64	01000000	100	40	@	96	01100000	140	60	`
1	00000001	001	01	SOH	33	00100001	041	21	!	65	01000001	101	41	A	97	01100001	141	61	a
2	00000010	002	02	STX	34	00100010	042	22	"	66	01000010	102	42	B	98	01100010	142	62	b
3	00000011	003	03	ETX	35	00100011	043	23	#	67	01000011	103	43	C	99	01100011	143	63	c
4	00000100	004	04	EOT	36	00100100	044	24	$	68	01000100	104	44	D	100	01100100	144	64	d
5	00000101	005	05	ENQ	37	00100101	045	25	%	69	01000101	105	45	E	101	01100101	145	65	e
6	00000110	006	06	ACK	38	00100110	046	26	&	70	01000110	106	46	F	102	01100110	146	66	f
7	00000111	007	07	BEL	39	00100111	047	27	'	71	01000111	107	47	G	103	01100111	147	67	g
8	00001000	010	08	BS	40	00101000	050	28	(	72	01001000	110	48	H	104	01101000	150	68	h
9	00001001	011	09	HT	41	00101001	051	29	)	73	01001001	111	49	I	105	01101001	151	69	i
10	00001010	012	0A	LF	42	00101010	052	2A	*	74	01001010	112	4A	J	106	01101010	152	6A	j
11	00001011	013	0B	VT	43	00101011	053	2B	+	75	01001011	113	4B	K	107	01101011	153	6B	k
12	00001100	014	0C	FF	44	00101100	054	2C	,	76	01001100	114	4C	L	108	01101100	154	6C	l
13	00001101	015	0D	CR	45	00101101	055	2D	-	77	01001101	115	4D	M	109	01101101	155	6D	m
14	00001110	016	0E	SO	46	00101110	056	2E	.	78	01001110	116	4E	N	110	01101110	156	6E	n
15	00001111	017	0F	SI	47	00101111	057	2F	/	79	01001111	117	4F	O	111	01101111	157	6F	o
16	00010000	020	10	DLE	48	00110000	060	30	0	80	01010000	120	50	P	112	01110000	160	70	p
17	00010001	021	11	DC1	49	00110001	061	31	1	81	01010001	121	51	Q	113	01110001	161	71	q
18	00010010	022	12	DC2	50	00110010	062	32	2	82	01010010	122	52	R	114	01110010	162	72	r
19	00010011	023	13	DC3	51	00110011	063	33	3	83	01010011	123	53	S	115	01110011	163	73	s
20	00010100	024	14	DC4	52	00110100	064	34	4	84	01010100	124	54	T	116	01110100	164	74	t
21	00010101	025	15	NAK	53	00110101	065	35	5	85	01010101	125	55	U	117	01110101	165	75	u
22	00010110	026	16	SYN	54	00110110	066	36	6	86	01010110	126	56	V	118	01110110	166	76	v
23	00010111	027	17	ETB	55	00110111	067	37	7	87	01010111	127	57	W	119	01110111	167	77	w
24	00011000	030	18	CAN	56	00111000	070	38	8	88	01011000	130	58	X	120	01111000	170	78	x
25	00011001	031	19	EM	57	00111001	071	39	9	89	01011001	131	59	Y	121	01111001	171	79	y
26	00011010	032	1A	SUB	58	00111010	072	3A	:	90	01011010	132	5A	Z	122	01111010	172	7A	z
27	00011011	033	1B	ESC	59	00111011	073	3B	;	91	01011011	133	5B	[	123	01111011	173	7B	{
28	00011100	034	1C	FS	60	00111100	074	3C	<	92	01011100	134	5C	\	124	01111100	174	7C	|
29	00011101	035	1D	GS	61	00111101	075	3D	=	93	01011101	135	5D	]	125	01111101	175	7D	}
30	00011110	036	1E	RS	62	00111110	076	3E	>	94	01011110	136	5E	^	126	01111110	176	7E	~
31	00011111	037	1F	US	63	00111111	077	3F	?	95	01011111	137	5F	_	127	01111111	177	7F	DEL

Q1) When texts are transferred large amounts of data are transmitted.
The characters are sent as ASCII characters. Explain what is meant by an ASCII character. [2]

Q2) State **three** functions of the arithmetic logic unit. [3]

Q3) Specimen 2015 P1 (Q13)

When a key is pressed on the keyboard, the computer stores the ASCII representation of the character typed into main memory. The ASCII representation for A is 65 (denary), for B is 66 (denary), etc.
There are two letters stored in the following memory locations:

Location 1	A
Location 2	C

(a) (i) Show the contents of Location 1 and Location 2 as binary.
Location 1, Location 2 [2]
(ii) Show the contents of Location 1 and Location 2 as hexadecimal.
Location 1, Location 2 [2]
(b) The following machine code instruction is stored in a location of main memory:

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

Convert this binary pattern into hexadecimal. [4]
(c) Explain why a programmer would prefer to see the contents of the locations displayed as hexadecimal rather th

an binary, when debugging his program that reads the key presses. [2]

Q4) Here are the contents of three memory locations with addresses shown in denary.

Address	Memory contents
150	0100 0111
151	1100 1101
152	1001 1100

(a) (i) What is the binary value for address 150? [1]
(ii) What is the hexadecimal value for the contents of address 152? [1]
(b) The numbers in location 151 and 152 are the height and width (in pixels) of a bitmap graphic currentl y in main memory. What are the dimensions of the bitmap in denary?
Height: __________________ pixels
Width: __________________ pixels [2]
(c) A bitmap graphic can be saved in a number of different image resolutions.
(i) How many bits are required to store each pixel for a black and white bitmap? [1]
(ii) For a 256-colour bitmap, each pixel requires a byte of memory.
Explain this statement. [2]
(iii) In addition to the pixel data values and its dimensions, what other information is stored in the bitma p file? [2]

Q 5) (9691_w13_p13)
(a) (i) A positive integer is represented in binary as 10101101 .
What is the denary value? [1]
(ii) How would the denary value 73 be represented as a positive binary integer? [1]

Marking_Scheme:
Q1) • (A member of the) character set that a computer recognises
• character on a standard keyboard
• standard to many machines
• stored in binary as . . .
• 7, 8 or 9 bits per character [2]
Q2) • The arithmetic logic unit carries out arithmetic.
• The arithmetic logic unit enables the processor to make logical decisions.
• The arithmetic logic unit carries out communication with peripheral devices.

Q4) (a) (i) 1001 0110 [1] (ii) 9C [1]
(b) height: 205 pixels [1] width: 156 pixels [1]
(c) (i) 1 bit [1] (ii) Each colour is represented by a number. [1]
1 byte makes possible 256 different numbers/colours. [1]
(iii) the header [1]

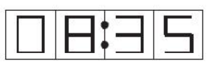
the resolution [1]
Q5) 2 (a) (i) 173 [1]
(ii) (0) 1 0 0 1 0 0 1 [1]
(b) - symbols recognised/used by a computer
- often equates to symbols on a keyboard [2]
(c) - represented by a set of bits
- each set of bits is unique for each character
- ASCII/UNICODE is a common set used
- example of set of bits [2]

Bit Pattern:

Specimen 2015 P1 (Q4)

A digital alarm clock is controlled by a microprocessor. It uses the 24-hour clock system (i.e. 6 pm is 18:00). Each di git in a typical display is represented by a 4-digit binary code.

For example:



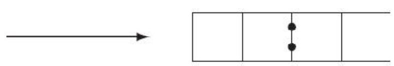
(clock display)

is represented by:

0	0	0	0	1st digit (0)
1	0	0	0	2nd digit (8)
0	0	1	1	3rd digit (3)
0	1	0	1	4th digit (5)

(a) What time is shown on the clock display if the 4-digit binary codes are:

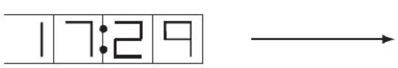
0	0	0	1
0	1	1	0
0	1	0	0
1	0	0	1



(clock display)

[2]

(b) What would be stored in the 4-digit binary codes if the clock display time was:



				1st digit
				2nd digit
				3rd digit
				4th digit

[4]

(c) The clock alarm has been set at 08:00.
Describe the actions of the microprocessor which enable the alarm to sound at 08:00. [2]

Summer 2013 P13 (Question 14)

14 Some decorative lights are made up from a cluster of red, blue, green, yellow and white LEDs.

Each colour is represented by a binary code:

32	16	8	4	2	1	
1	0	0	0	0	0	red
0	1	0	0	0	0	blue
0	0	1	0	0	0	green
0	0	0	1	0	0	yellow
0	0	0	0	1	0	while
0	0	0	0	0	1	black (all lights off)

A 6-bit register, R1, stores the 1-values to represent a sequence of colours.

Thus, if R1 contains:

0	1	0	1	0	1

this means the blue, yellow and black colour sequence is stored and displayed in that order.

The length of time each light is on is set by a binary value in another register, R2: Thus

0	1	0

means each colour is on for 2 seconds.

(a) The two registers contain the following values. What is the sequence of coloured lights and the timing for each colour?

R1

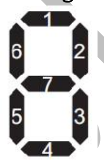
0	1	1	0	1	0

R2

1	1	1

Summer 2007 P1 (Question 9)

A 7-segment display is used to indicate which floor a lift is on. Each segment is numbered as shown:



A byte is used to hold the data needed to light the correct segments. Bit 0 is always zero.
For example, 3 is represented by

and by

1	0	0	1	1	1	1	0
7	6	5	4	3	2	1	0

Bit Number

(a) If the lift is to stop at more than one floor, the data is held in successive bytes. For example:

FIRST BYTE:	0	0	0	0	1	1	1	0
SECOND BYTE:	1	1	0	1	1	0	1	0

Which floor numbers are stored in each byte?
First byte floor number
Second byte floor number [2]

(b) What bit pattern is used to indicate Floor 2?

(c) The lift is travelling down to stop at Floors 5, 3 and 1. When it stops at Floor 5, a passenger gets in and presses t he button for Floor 2.
How does the system ensure that the lift stops at Floors 3, 2 and 1 in that order? [3]

Summer 2005 (Question 8)

A microprocessor controls the washing cycle of an automatic washing machine and gives output to the following d evices:

• water valve • heater • wash motor • pump

Control bits are sent to turn parts of the system on or off, i.e. 1 is on and 0 is off.

8	7	6	5	4	3	2	1
0	1	1	0	0	0	0	0
water valve	heater	wash motor	pump	.... not in use			

(a) State what is happening when the above bit pattern is set.
....[1]

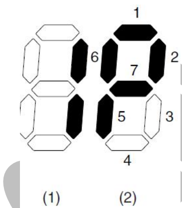
(b) Write down the bit pattern that would be set if the water has reached the correct level, the temperature is the required temperature, the clothes have been washed and the pump is now pumping the water out of the machine.

8	7	6	5	4	3	2	1

(c) State **one** other process that the microprocessor could control.
....[1]

Winter 2003 (Question 12)

Two 7 segment displays are used on a car dashboard to give information to the driver. Each segment is numbered as shown.



For example, the information **1P** shown above is represented by:

	7	6	5	4	3	2	1	0
(1)	0	0	0	0	1	1	0	0

and by:

	7	6	5	4	3	2	1	0
(2)	1	1	1	0	0	1	1	0

Bit 0 is always zero

(a) What is being displayed to the driver if bytes (1) and (2) are showing?

(1)	1	1	0	0	1	1	0	0

(2)	1	1	1	0	0	0	1	0

(b) What bit patterns must be used to show the information **0L**?

(0)							

(L)							

(c) Most of the other information on the dashboard is in analogue form.

(i) State **one** advantage of displaying information in analogue form.

....

....1]

(ii) State **one** disadvantage of displaying information in analogue form.

....

....1]