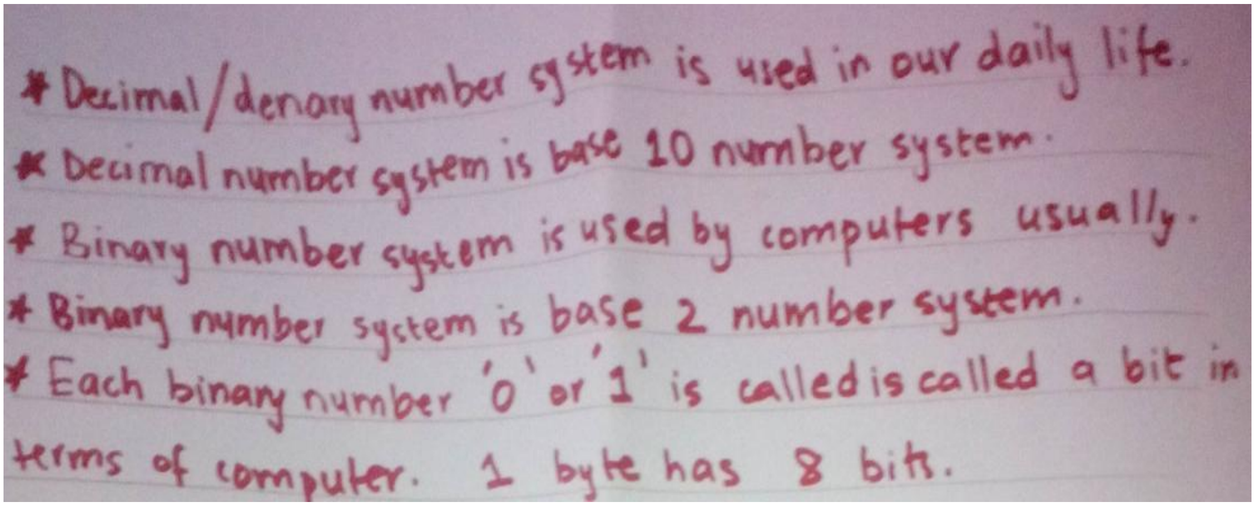
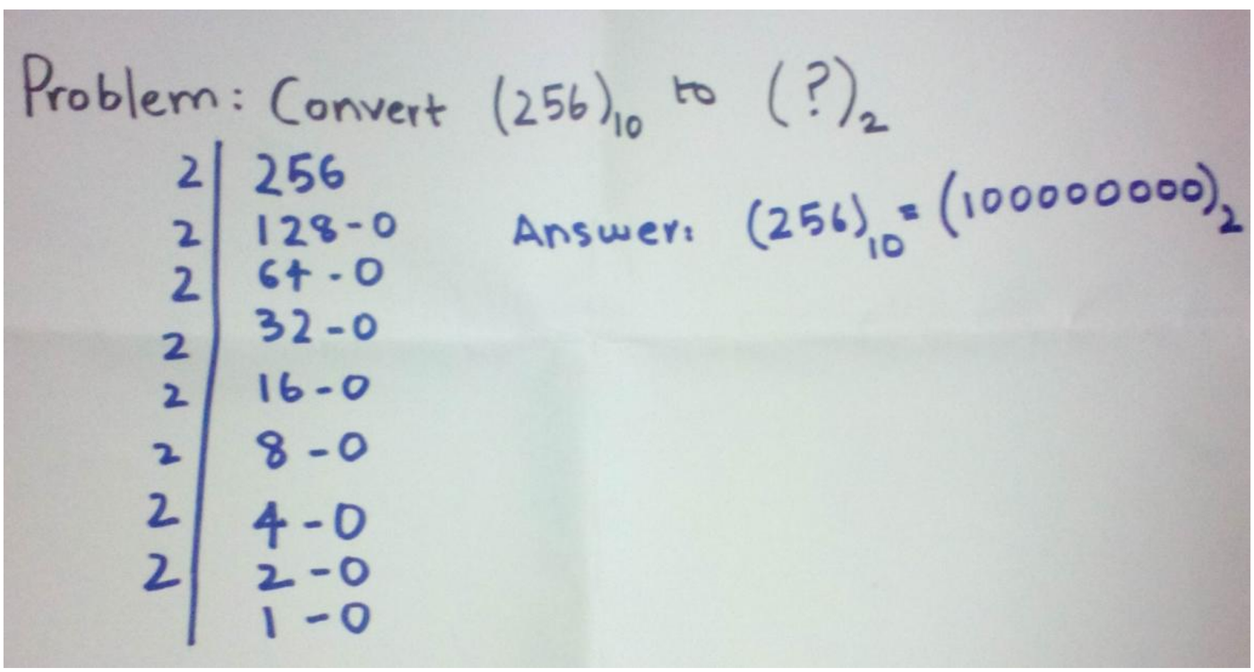
Number System

Binary & Decimal Number System:


* Decimal/denary number system is used in our daily life.
* Decimal number system is base 10 number system.
* Binary number system is used by computers usually.
* Binary number system is base 2 number system.
* Each binary number '0' or '1' is called is called a bit in terms of computer. 1 byte has 8 bits.

Conversion from decimal to binary.


Problem: Convert $(256)_{10}$ to $(?)_2$

2 | 256
2 | 128 - 0
2 | 64 - 0
2 | 32 - 0
2 | 16 - 0
2 | 8 - 0
2 | 4 - 0
2 | 2 - 0
  | 1 - 0

Answer: $(256)_{10} = (100000000)_2$

For converting a decimal number or base 10 number into a binary number we take the LCM of number as shown above. 256 is divided by 2 until it is no more divisible.

Note: Remember the answer after the LCM is always written from bottom left to upwards as shown in above figure.

Practice Problems: Convert the following decimal numbers into positive binary numbers.

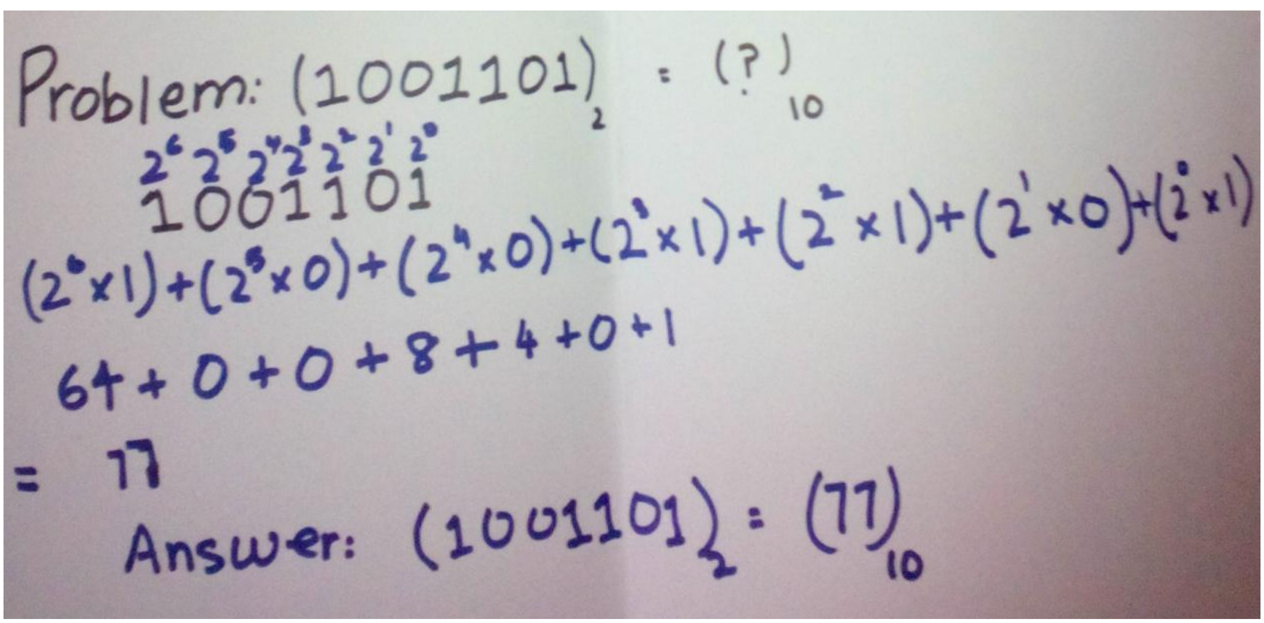
(a) 199

(b) 73

(c) 213

(d) 128

Conversion from binary to decimal



As shown in above problem, to convert a binary number, write 2 with powers starting from 0. Start writing from right hand side always. Multiply the 1s with the 2 having some power.

Practice Problems: Convert the following binary numbers into decimal numbers.

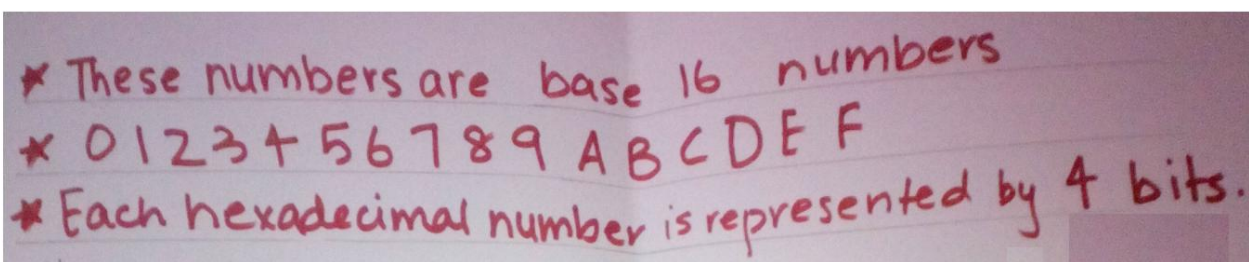
(a) 10101010

(b) 11001100

(c) 11110000

(d) 11111111

Hexadecimal Number System



* These numbers are base 16 numbers
* 0 1 2 3 4 5 6 7 8 9 A B C D E F
* Each hexadecimal number is represented by 4 bits.

To convert a number from Hexadecimal to Binary, we use a table which is shown on next page. It really simple and easy to draw the table. First of all, write all the hexadecimal number in ascending order on left of the table. Then at right side of the table, first write 8 zeros and 8 ones, then 4 zeros and 4 ones alternatively, then 2 zeros and 2 ones alternatively and finaly 1 zero and 1 one alternatively.

HEXADECIMAL	BINARY
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
A	1 0 1 0
B	1 0 1 1
C	1 1 0 0
D	1 1 0 1
E	1 1 1 0
F	1 1 1 1

Converting Hexadecimal number into Binary Number

PROBLEM 1: $(A5)_{16} = (?)_2$

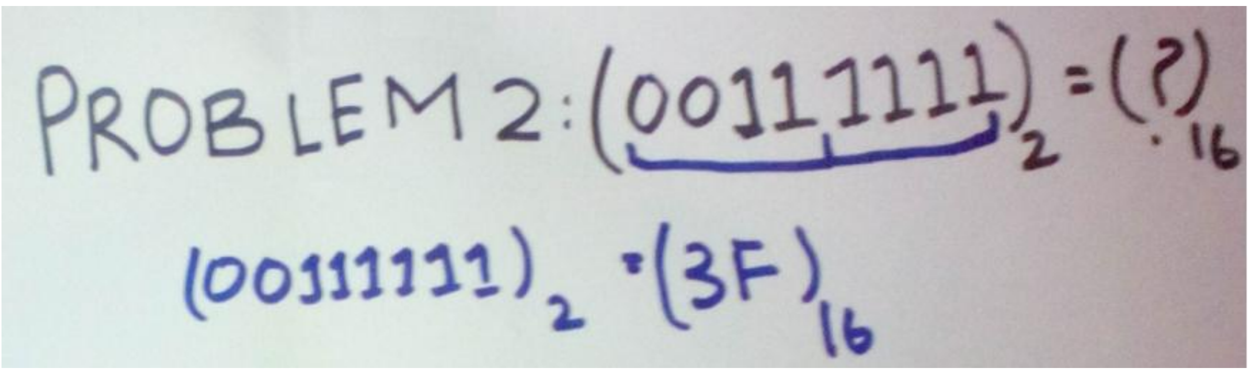
$$(A5)_{16} = (10100101)_2$$

Practice Problems: Convert the following hexadecimal numbers into binary numbers.

(a) AD **(b) F8**

(c) C5 **(d) B9**

Converting a Binary Number into Hexadecimal Number.



Practice Problems: Convert the following binary numbers into hexadecimal numbers.

(a) 10101010 **(b) 11001100**

(c) 11110000 **(d) 11111111**

Problem: Convert Hexadecimal Number A9 into a Decimal Number.
Solution:
First of all convert the hexadecimal number into binary number and then finally convert that binary number into decimal by using the binary to decimal conversion method.

A9 = 1010 1001 (hexadecimal to binary conversion)
1010 1001 = 169 (Binary to decimal conversion)

Finally, we calculated that **A9** in hexadecimal is equal to **169** of decimal.

Practice Problems: Convert the following hexadecimal numbers into decimal numbers.

(a) A6 **(b) B0**

(c) F1 **(d) E4**

Problem: Convert 179 of decimal into hexadecimal number.
Solution:
First of all convert the decimal number into binary number and then finally look for the hexadecimal values for these binary numbers by using the table.

179 = 10110011 (decimal to binary conversion)
1011 0011 = B3 (binary to hexadecimal conversion)

The decimal of 179 is equal to B3 of hexadecimal.

In above binary to hexadecimal conversion, always make group of four binary digits starting from right side. Sometimes you may not be able to find exact group of four binary digits for example

101011 is given and you are supposed to convert it into hexadecimal so make the groups of four from right side 10 1011 , as you can see we have one group of 4 bits and 1 group of 2 bits. To make all the group of 4 bits add zeros on left side. So **0010 1011 = 2B**

Practice Problems: Convert the following decimal numbers into hexadecimal numbers.

(a) 256

(b) 200

(c) 81

(d) 173

USES/APPLICATIONS OF BINARY NUMBERS:

* Binary numbers are also called as bits.
* Computer works on bits/binary numbers.
* Data is stored in the form of 1s & 0s in memory.
* Binary numbers are used in digital data transmission.
* Storage capacity is represented with the help of binary digits.

USES/APPLICATIONS OF HEXADECIMAL NUMBERS:

* Used to represent memory & MAC addresses.
* Used as colour codes on HTML.

Practice Problems (Number System & Bit Pattern)

Question 1: (Specimen 2015)

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 than binary, when debugging his program that reads the key presses.

....

....

....

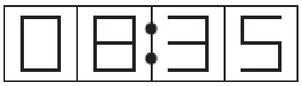
.... [2]

Question 2: (Specimen 2015)

A digital alarm clock is controlled by a microprocessor. It uses the 24-hour clock system (i.e. 6 pm is 18:00).

Each digit in a typical display is represented by a 4-digit binary code.

For example:



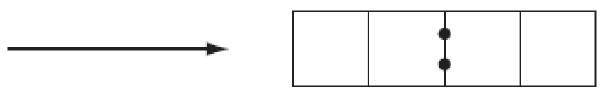
(clock display)

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)

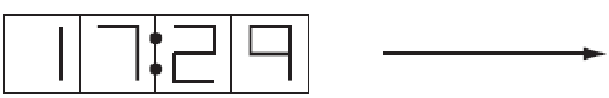
(a) What time is shown on the clock display if the 4-digit binary codes are:

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



(clock display)

(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

(c) The clock alarm has been set at 08:00.

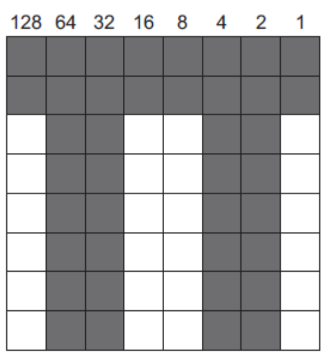
Describe the actions of the microprocessor which enable the alarm to sound at 08:00.

Question 3: (Past Paper, Q 11, May/June 2013)

Letters from the Greek alphabet are to be transferred to a computer system. Each letter can be represented on an 8 by 8 grid. Each column has a value from 1 to 128.

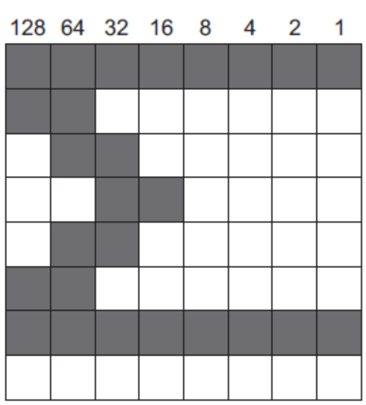
The value of each row is stored in a table. The values in the column headings are used to work out the value for each row (e.g. in our example, row 8 has the value 64 + 32 + 4 + 2 = 102).

Thus, in the example below, the letter (π) is stored as:



row	value
1	255
2	255
3	102
4	102
5	102
6	102
7	102
8	102

What values would be stored in the table for the Greek character (Σ)?



row	value
1	
2	
3	
4	
5	
6	
7	
8	

(b) Draw the character formed from the following value table:

row	value
1	146
2	146
3	84
4	84
5	56
6	16
7	16
8	16

→

128	64	32	16	8	4	2	1

Question 4: (Q 14, May/June 2013 P12)

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	white
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

sequence of colours ....

....

....

timing ....

....

(b) What will the two registers contain if the coloured light sequence is ***red***, ***green*** and ***black*** and the timing is 5 seconds?

R1

R2

(c) What is the problem with trying to display ***green***, ***blue***, ***red*** in that order?

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Question 5: (May/June 2014, Q12)

A digital light meter has a 3-digit LCD. The value of each digit on the instrument display is stored as a 4-bit binary number in a register.

For example:

X	Y	Z
7	4	5

is represented by:

8	4	2	1	
0	**1**	**1**	**1**	**X**
0	**1**	**0**	**0**	**Y**
0	**1**	**0**	**1**	**Z**

(a) What value is shown on the display if the 4-bit binary registers contain:

	8	4	2	1
X	**0**	**0**	**1**	**0**
Y	**1**	**0**	**0**	**1**
Z	**0**	**0**	**0**	**1**

→

X	Y	Z

(b) What would be stored in the 4-bit binary registers if the display shows:

X	Y	Z
3	8	0

→

8	4	2	1	
				X
				Y
				Z

(c) If any of the 4-bit binary registers X, Y or Z contain the value **1 1 1 1** this indicates an error.

(i) How could this error be shown on the instrument display?

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(ii) What could cause an error to occur?

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Question 06: (May/June 2014, P12, Q 16)

An encryption system gives each letter of the alphabet a value:

A = 1, B = 2, C = 3, ……… , Y = 25, Z = 26.

Each letter is stored in a 12-bit binary register. The letter "**S**" (19th letter) is stored as:

2048	1024	512	256	128	64	32	16	8	4	2	1
0	0	0	0	0	0	0	**1**	**0**	**0**	**1**	**1**

A 4-bit register is used to store the encryption key. This register shows how many places the bits are shifted to the left in the 12-bit register when it is encrypted. So,

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

means each bit in the 12-bit register is shifted 5 places to the left and the register now becomes:

2048	1024	512	256	128	64	32	16	8	4	2	1
0	0	**1**	**0**	**0**	**1**	**1**	0	0	0	0	0

Therefore, the letter **"S"** would be transmitted with the 4-bit register and the 12-bit register as follows:

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

(a) **"W"** is the 23rd letter of the alphabet.

(i) Show how this letter would be stored in the 12-bit register before encryption:

(ii) The 4-bit register contains the following value:

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

Show how the letter **"W"** is now stored in the 12-bit register in encrypted form:

(b) Find which letter of the alphabet has been encrypted here. (Show all your working.)

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

....

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....

(c) **(i)** What is the largest encryption key that can be stored in the 4-bit register?

8	4	2	1

(ii) Convert this into denary (base 10).

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(iii) If this encryption key were used, what problem would it cause?

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