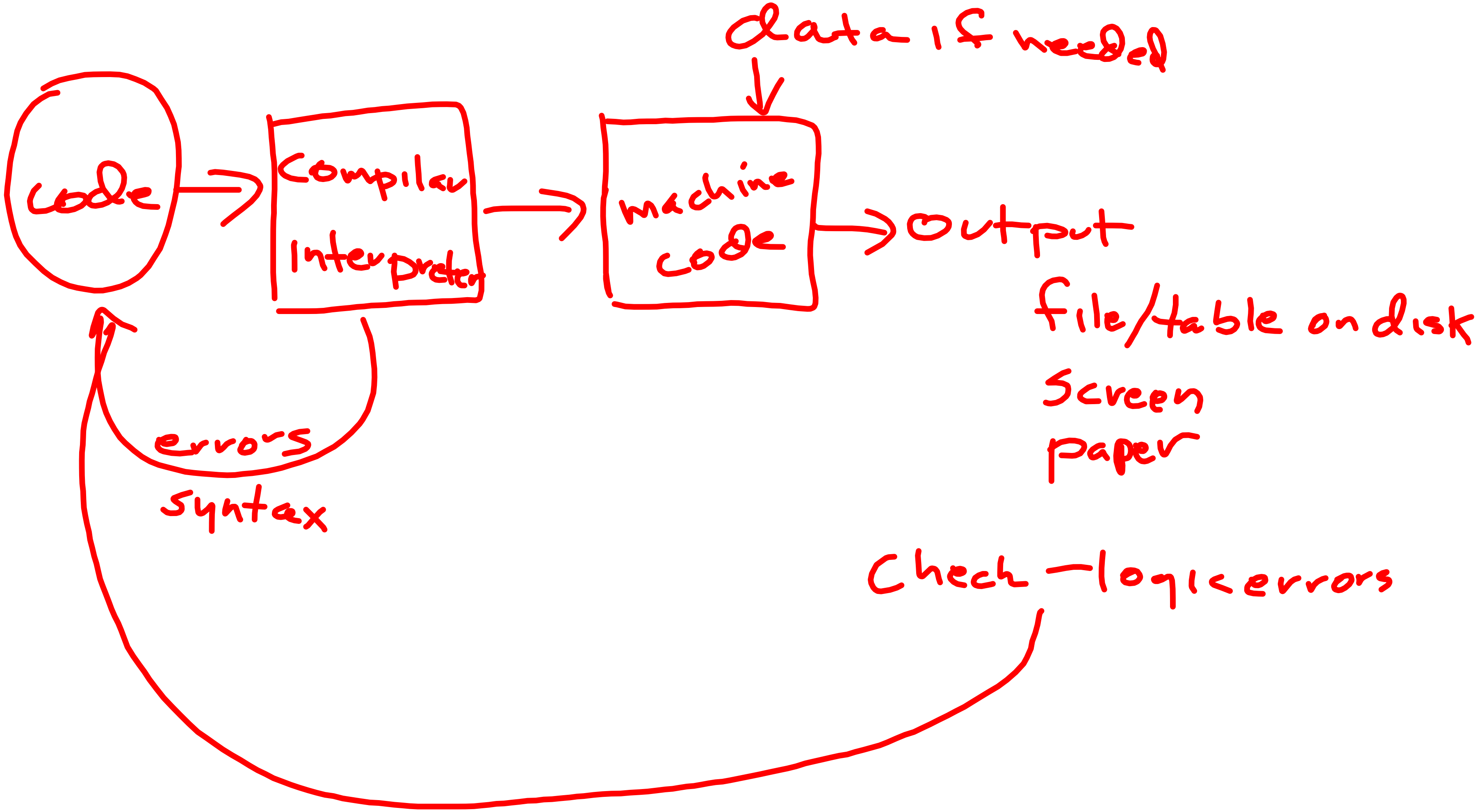
data if needed
code
compiler
interpreter
machine code
output
file/table on disk
screen
paper
errors
syntax
check - logic errors

Numbering Systems and Computer ×

www.pgrocer.net/Cis17/notes/numbers.html

Numbering Systems and Computer Codes
Prepared by The Computer Information Systems Department

Decimal Numbering Systems:
The decimal numbering system is a base 10 numbering system (this means there are 10 digits we can use - these digits are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9). When we talk about a number, we understand what the number is because of its face value and its positional value. Thus, the digit 5 has a different meaning when it is in the tens position than when it is in the ones position (i.e. when it is in the tens position, we express it as 50 and when it is in the ones position, we express it as 5). In this case, the face value of the digit is 5 and the positional value of a number is based on the position it occupies. In decimal, the positional value of a number is based on the powers of 10 (remember, we are in base 10):

5	7	2	4	Face value
10^3	10^2	10^1	10^0	Positional Value (powers of 10)
1000	100	10	1	Resolved positional value

To figure out the value of 5724, we do the following:

$5 \times 10^3 = 5 \times 1000 = 5000$
$7 \times 10^2 = 7 \times 100 = 700$
$2 \times 10^1 = 2 \times 10 = 20$
$4 \times 10^0 = 4 \times 1 = 4$
5724

Binary Numbering systems:
The binary numbering system works much the same way as the decimal numbering system except that now we are in base 2 so we only have 2 digits (0, 1). The value of the number is still determined by the face value times the positional value, but since we are in base 2, the positional values are the powers of 2. Since the face values can only be 0 or 1, this means that the 0 or 1 is multiplied by the positional place in which it is found.
Example: binary number 1011011

1	0	1	1	0	1	1	Face value
2^6	2^5	2^4	2^3	2^2	2^1	2^0	Positional value
64	32	16	8	4	2	1	Resolved positional value

The positional values are first shown in the powers of 2 and then as the resolved number - in other words, 2 to the 6th is equal to 64.

Converting binary to decimal:
In the previous example to find the decimal equivalent for the number 1011011, we do the following:

?isk

12:43 PM
10/23/2018

Title: Oct 23-12:43 PM (2 of 20)

Numbering Systems and Compute

www.pgrocer.net/Cis17/notes/numbers.html

Binary Numbering systems:
The binary numbering system works much the same way as the decimal numbering system except that now we are in base 2 so we only have 2 digits (0, 1). The value of the number is still determined by the face value times the positional value, but since we are in base 2, the positional values are the powers of 2. Since the face values can only be 0 or 1, this means that the 0 or 1 is multiplied by the positional place in which it is found.
Example: binary number 1011011

1	0	1	1	0	1	1	Face value
2^6	2^5	2^4	2^3	2^2	2^1	2^0	Positional value
64	32	16	8	4	2	1	Resolved positional value

1011011

The positional values are first shown in the powers of 2 and then as the resolved number - in other words, 2 to the 6th is equal to 64.

Converting binary to decimal:
In the previous example to find the decimal equivalent for the number 1011011, we do the following:

$1 \times 2^6 = 1 \times 64 =$	64
$0 \times 2^5 = 0 \times 32 =$	0
$1 \times 2^4 = 1 \times 16 =$	16
$1 \times 2^3 = 1 \times 8 =$	8
$0 \times 2^2 = 0 \times 4 =$	0
$1 \times 2^1 = 1 \times 2 =$	2
$1 \times 2^0 = 1 \times 1 =$	1
	91

Converting decimal to binary:
Before doing this it is important that we review the decimal equivalent for the frequently used powers of 2:

$2^0 = 1$	$2^1 = 2$	$2^2 = 4$	$2^3 = 8$	$2^4 = 16$	$2^5 = 32$
$2^6 = 64$	$2^7 = 128$	$2^8 = 256$	$2^9 = 512$	$2^{10} = 1024$	etc.

To convert 91 from decimal to binary, you can follow the following steps:

1. Look at 91 and see what power of 2 can be taken from it. The highest power that can be subtracted is 2 to the 6th which is 64. Therefore we put a 1 in the 2 to the 6th position. Then we subtract: 91 - 64 = 27

12:48 PM 10/23/2018

Numbering Systems and Compute
www.pgrocer.net/Cis17/notes/numbers.html
SMART Ink

Binary Numbering systems:
The binary numbering system works much the same way as the decimal numbering system except that now we are in base 2 so we only have 2 digits (0, 1). The value of the number is still determined by the face value times the positional value, but since we are in base 2, the positional values are the powers of 2. Since the face values can only be 0 or 1, this means that the 0 or 1 is multiplied by the positional place in which it is found.
Example: binary number 1011011

1	0	1	1	0	1	1	Face value
2^6	2^5	2^4	2^3	2^2	2^1	2^0	Positional value
64	32	16	8	4	2	1	Resolved positional value

The positional values are first shown in the powers of 2 and then as the resolved number - in other words, 2 to the 6th is equal to 64.

Converting binary to decimal:
In the previous example to find the decimal equivalent for the number 1011011, we do the following:

$1 \times 2^6 = 1 \times 64 =$	64
$0 \times 2^5 = 0 \times 32 =$	0
$1 \times 2^4 = 1 \times 16 =$	16
$1 \times 2^3 = 1 \times 8 =$	8
$0 \times 2^2 = 0 \times 4 =$	0
$1 \times 2^1 = 1 \times 2 =$	2
$1 \times 2^0 = 1 \times 1 =$	1
	91

101101_2
32 16 8 4 2 1

32
8
4
1
45_{10}

Converting decimal to binary:
Before doing this it is important that we review the decimal equivalent for the frequently used powers of 2:

$2^0 = 1$	$2^1 = 2$	$2^2 = 4$	$2^3 = 8$	$2^4 = 16$	$2^5 = 32$
$2^6 = 64$	$2^7 = 128$	$2^8 = 256$	$2^9 = 512$	$2^{10} = 1024$	etc.

To convert 91 from decimal to binary, you can follow the following steps:

1. Look at 91 and see what power of 2 can be taken from it. The highest power that can be subtracted is 2 to the 6th which is 64. Therefore we put a 1 in the 2 to the 6th position. Then we subtract: 91 - 64 = 27

12:49 PM
10/23/2018

Numbering Systems and Compute

www.pgrocer.net/Cis17/notes/numbers.html

Binary Numbering systems:
The binary numbering system works much the same way as the decimal numbering system except that now we are in base 2 so we only have 2 digits (0, 1). The value of the number is still determined by the face value times the positional value, but since we are in base 2, the positional values are the powers of 2. Since the face values can only be 0 or 1, this means that the 0 or 1 is multiplied by the positional place in which it is found.
Example: binary number 1011011

1	0	1	1	0	1	1	Face value
2^6	2^5	2^4	2^3	2^2	2^1	2^0	Positional value
64	32	16	8	4	2	1	Resolved positional value

1 1 1 1 0 0 1

64 32 16 8 4 2 1

The positional values are first shown in the powers of 2 and then as the resolved number - in other words, 2 to the 6th is equal to 64.

Converting binary to decimal:
In the previous example to find the decimal equivalent for the number 1011011, we do the following:

$1111001_2 = 121_{10}$

$1 \times 2^6 = 1 \times 64 =$	64
$0 \times 2^5 = 0 \times 32 =$	0
$1 \times 2^4 = 1 \times 16 =$	16
$1 \times 2^3 = 1 \times 8 =$	8
$0 \times 2^2 = 0 \times 4 =$	0
$1 \times 2^1 = 1 \times 2 =$	2
$1 \times 2^0 = 1 \times 1 =$	1
	91

64
32
16
8
1
121

Converting decimal to binary:
Before doing this it is important that we review the decimal equivalent for the frequently used powers of 2:

$2^0 = 1$	$2^1 = 2$	$2^2 = 4$	$2^3 = 8$	$2^4 = 16$	$2^5 = 32$
$2^6 = 64$	$2^7 = 128$	$2^8 = 256$	$2^9 = 512$	$2^{10} = 1024$	etc.

To convert 91 from decimal to binary, you can follow the following steps:

1. Look at 91 and see what power of 2 can be taken from it. The highest power that can be subtracted is 2 to the 6th which is 64. Therefore we put a 1 in the 2 to the 6th position. Then we subtract: 91 - 64 = 27

12:52 PM 10/23/2018

Numbering Systems and Computer

www.pgrocer.net/Cis17/notes/numbers.html

Binary Numbering systems:
The binary numbering system works much the same way as the decimal numbering system except that now we are in base 2 so we only have 2 digits (0, 1). The value of the number is still determined by the face value times the positional value, but since we are in base 2, the positional values are the powers of 2. Since the face values can only be 0 or 1, this means that the 0 or 1 is multiplied by the positional place in which it is found.
Example: binary number 1011011

1	0	1	1	0	1	1	Face value
2^6	2^5	2^4	2^3	2^2	2^1	2^0	Positional value
64	32	16	8	4	2	1	Resolved positional value

$100001111_2 = 271_{10}$

256 128 64 32 16 8 4 2 1 2

The positional values are first shown in the powers of 2 and then as the resolved number - in other words, 2 to the 6th is equal to 64.

Converting binary to decimal:
In the previous example to find the decimal equivalent for the number 1011011, we do the following:

$1 \times 2^6 = 1 \times 64 =$	64
$0 \times 2^5 = 0 \times 32 =$	0
$1 \times 2^4 = 1 \times 16 =$	16
$1 \times 2^3 = 1 \times 8 =$	8
$0 \times 2^2 = 0 \times 4 =$	0
$1 \times 2^1 = 1 \times 2 =$	2
$1 \times 2^0 = 1 \times 1 =$	1
	91

256
8
4
2
1
271

Converting decimal to binary:
Before doing this it is important that we review the decimal equivalent for the frequently used powers of 2:

$2^0 = 1$	$2^1 = 2$	$2^2 = 4$	$2^3 = 8$	$2^4 = 16$	$2^5 = 32$
$2^6 = 64$	$2^7 = 128$	$2^8 = 256$	$2^9 = 512$	$2^{10} = 1024$	etc.

To convert 91 from decimal to binary, you can follow the following steps:

1. Look at 91 and see what power of 2 can be taken from it. The highest power that can be subtracted is 2 to the 6th which is 64. Therefore we put a 1 in the 2 to the 6th position. Then we subtract: 91 - 64 = 27

12:54 PM 10/23/2018

Numbering Systems and Compute

www.pgrocer.net/Cis17/notes/numbers.html

SMART Ink

The positional values are first shown in the powers of 2 and then as the resolved number - in other words, 2 to the 6th is equal to 64.

Converting binary to decimal:
In the previous example to find the decimal equivalent for the number 1011011, we do the following:

$1 \times 2^6 = 1 \times 64 =$	64
$0 \times 2^5 = 0 \times 32 =$	0
$1 \times 2^4 = 1 \times 16 =$	16
$1 \times 2^3 = 1 \times 8 =$	8
$0 \times 2^2 = 0 \times 4 =$	0
$1 \times 2^1 = 1 \times 2 =$	2
$1 \times 2^0 = 1 \times 1 =$	1
	91

271

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

$$\begin{array}{r} 271 \\ -256 \\ \hline 15 \\ -8 \\ \hline 7 \\ -4 \\ \hline 3 \\ -2 \\ \hline 1 \\ -1 \\ \hline 0 \end{array}$$

Converting decimal to binary:
Before doing this it is important that we review the decimal equivalent for the frequently used powers of 2:

$2^0 = 1$	$2^1 = 2$	$2^2 = 4$	$2^3 = 8$	$2^4 = 16$	$2^5 = 32$
$2^6 = 64$	$2^7 = 128$	$2^8 = 256$	$2^9 = 512$	$2^{10} = 1024$	etc.

To convert 91 from decimal to binary, you can follow the following steps:

1. Look at 91 and see what power of 2 can be taken from it. The highest power that can be subtracted is 2 to the 6th which is 64. Therefore we put a 1 in the 2 to the 6th position. Then we subtract: 91 - 64 = 27

1	___	___	___	___	___	___
2^6	2^5	2^4	2^3	2^2	2^1	2^0
64	32	16	8	4	2	1

2. Now we look at what is left, 27 and see if the next power of 2 (moving to the right) which is 2 to the 5th or 32 can be subtracted from 27. It can't, therefore we didn't use the 2 to the 5th position so we put a 0 in the 2 to the 5th position. Since we didn't use the 32, there is no subtraction.

1	0	___	___	___	___	___
2^6	2^5	2^4	2^3	2^2	2^1	2^0
64	32	16	8	4	2	1

12:57 PM 10/23/2018

Numbering Systems and Compute

www.pgrocer.net/Cis17/notes/numbers.html

The positional values are first shown in the powers of 2 and then as the resolved number - in other words, 2 to the 6th is equal to 64.

Converting binary to decimal:
In the previous example to find the decimal equivalent for the number 1011011, we do the following:

$1 \times 2^6 = 1 \times 64 =$	64
$0 \times 2^5 = 0 \times 32 =$	0
$1 \times 2^4 = 1 \times 16 =$	16
$1 \times 2^3 = 1 \times 8 =$	8
$0 \times 2^2 = 0 \times 4 =$	0
$1 \times 2^1 = 1 \times 2 =$	2
$1 \times 2^0 = 1 \times 1 =$	1
	91

$586_{10} = \underline{\qquad\qquad}_2$

$$
\begin{array}{r}
586 \\
-512 \\
\hline
74 \\
-64 \\
\hline
10 \\
-8 \\
\hline
2 \\
-2 \\
\hline
0
\end{array}
$$

1	0	0	1	0	0	1	0	1	0
512	256	128	64	32	16	8	4	2	1

Converting decimal to binary:
Before doing this it is important that we review the decimal equivalent for the frequently used powers of 2:

$2^0 = 1$	$2^1 = 2$	$2^2 = 4$	$2^3 = 8$	$2^4 = 16$	$2^5 = 32$
$2^6 = 64$	$2^7 = 128$	$2^8 = 256$	$2^9 = 512$	$2^{10} = 1024$	etc.

To convert 91 from decimal to binary, you can follow the following steps:

1. Look at 91 and see what power of 2 can be taken from it. The highest power that can be subtracted is 2 to the 6th which is 64. Therefore we put a 1 in the 2 to the 6th position. Then we subtract: 91 - 64 = 27

1	___	___	___	___	___	___
2^6	2^5	2^4	2^3	2^2	2^1	2^0
64	32	16	8	4	2	1

2. Now we look at what is left, 27 and see if the next power of 2 (moving to the right) which is 2 to the 5th or 32 can be subtracted from 27. It can't, therefore we didn't use the 2 to the 5th position so we put a 0 in the 2 to the 5th position. Since we didn't use the 32, there is no subtraction.

1	0	___	___	___	___	___
2^6	2^5	2^4	2^3	2^2	2^1	2^0
64	32	16	8	4	2	1

1:01 PM 10/23/2018

Numbering Systems and Computer

www.pgrocer.net/Cis17/notes/numbers.html

Binary counting:
Now, we are going to learn to count in binary and relate counting in binary to counting in decimal. 0 and 1 are the same values in binary and decimal but then we come to add 1 to 1 and we discover that there is no 2 in binary. Essentially we have run out of digits. We stop and think what we do in decimal when we run out of digits and we get the pattern to use in binary. For example, in decimal when we try to add 1 to 9, we run out of digits.

In decimal:	9	In binary:	1
	+1		+1
	10		10

What we find is that when we run out of digits, we simply go to the next position - we call this putting down the 0 and carrying the 1.

Continuing along:

10	11	100	101	110	111	1000
+ 1	+ 1	+ 1	+ 1	+ 1	+ 1	+ 1
11	100	101	110	111	1000	1001

This means that when we count, we get the following:

Decimal	Binary
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010
11	1011
12	1100

1
+1
10
+1
11
+1
100
+1
101
+1
110

110
+1
111
+1
1000
8 4 2 1

1:05 PM 10/23/2018

Numbering Systems and Compute

www.pgrocer.net/Cis17/notes/numbers.html

16	10000

Hexadecimal Numbering System:

The next numbering system is the hexadecimal numbering system. This is the base 16 numbering system, therefore there are 16 digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F). The letter A carries the same value as decimal 10, the letter B carries the same value as decimal 11, the letter C carries the same value as decimal 12, the letter D carries the same value as decimal 13, the letter E carries the same value as decimal 14, and the letter F carries the same value as decimal 15. Hexadecimal, like any other numbering system has the face value of digits and the positional value. The positional value is based on the powers of 16 since hexadecimal is the base 16 numbering system.

Example: Hexadecimal number A359

A	3	5	9	face value
16^3	16^2	16^1	16^0	positional value (powers of 16)
4096	256	16	1	resolved positional value

9
+1
A dec 10
+1
B dec 11

Converting hexadecimal to decimal:
To convert hexadecimal to its decimal equivalent, we multiply the face value times the positional value:

A x 16^3 =	10 x 4096 =	40960	(note A is equivalent to decimal 10)
3 x 16^2 =	3 x 256 =	768	
5 x 16^1 =	5 x 16 =	80	
9 x 16^0 =	9 x 1 =	9	
		41817	

The equivalent of hexadecimal A359 in decimal is 41817.

Converting decimal to hexadecimal:

Now we will take the decimal number 41817 and convert it back to hexadecimal. To do this, we will follow the same steps we used in converting decimal to binary with one change Ð this time we are concerned with multiplying by the face value (in binary this was not a concern because multiplying by 1 doesnÕt change anything).

The following are the decimal equivalents for some of the commonly used powers of 16:

1:09 PM 10/23/2018

Title: Oct 23-1:09 PM (10 of 20)

Numbering Systems and Computer

www.pgrocer.net/Cis17/notes/numbers.html

16	10000

Hexadecimal Numbering System:

The next numbering system is the hexadecimal numbering system. This is the base 16 numbering system, therefore there are 16 digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F). The letter A carries the same value as decimal 10, the letter B carries the same value as decimal 11, the letter C carries the same value as decimal 12, the letter D carries the same value as decimal 13, the letter E carries the same value as decimal 14, and the letter F carries the same value as decimal 15. Hexadecimal, like any other numbering system has the face value of digits and the positional value. The positional value is based on the powers of 16 since hexadecimal is the base 16 numbering system.

Example: Hexadecimal number A359

A	3	5	9	face value
16^3	16^2	16^1	16^0	positional value (powers of 16)
4096	256	16	1	resolved positional value

Converting hexadecimal to decimal:
To convert hexadecimal to its decimal equivalent, we multiply the face value times the positional value:

A x 16^3 =	10 x 4096 =	40960	(note A is equivalent to decimal 10)
3 x 16^2 =	3 x 256 =	768	
5 x 16^1 =	5 x 16 =	80	
9 x 16^0 =	9 x 1 =	9	
		41817	

$5BE_{16}$ 1470_{10}

5 B E
16^2 16^1 16^0
256 16 1

256 x 5 = 1280

16 x 11 = 16, 16 → 176

14 x 1 = 14

1280 + 176 + 14 = 1470

The equivalent of hexadecimal A359 in decimal is 41817.

Converting decimal to hexadecimal:

Now we will take the decimal number 41817 and convert it back to hexadecimal. To do this, we will follow the same steps we used in converting decimal to binary with one change Ð this time we are concerned with multiplying by the face value (in binary this was not a concern because multiplying by 1 doesnÕt change anything).

The following are the decimal equivalents for some of the commonly used powers of 16:

1:14 PM 10/23/2018

Numbering Systems and Compute

www.pgrocer.net/Cis17/notes/numbers.html

A x 16^3 =	10 x 4096 =	40960 (note A is equivalent to decimal 10)
3 x 16^2 =	3 x 256 =	768
5 x 16^1 =	5 x 16 =	80
9 x 16^0 =	9 x 1 =	9
		41817

The equivalent of hexadecimal A359 in decimal is 41817.

$5BE_{16}$ $\underline{1470}_{10}$

Converting decimal to hexadecimal:

Now we will take the decimal number 41817 and convert it back to hexadecimal. To do this, we will follow the same steps we used in converting decimal to binary with one change Ð this time we are concerned with multiplying by the face value (in binary this was not a concern because multiplying by 1 doesnÕt change anything).

The following are the decimal equivalents for some of the commonly used powers of 16:

$16^0 = 1$ $16^1 = 16$ $16^2 = 256$ $16^3 = 4096$ $16^4 = 65536$

The following steps convert decimal 41817 to hexadecimal:

1. First we need to find out the highest base of 16 that can be subtracted from our number, 41817. Clearly 16 to the 4th which is equivalent to 65536 is too big. However, 16 to the 3rd which is equivalent to 4096 will work. Our next question is how many 16 to the 3rd s can be subtracted from 41817. Through trying different calculations, we discover that 10 x 4096 or 40960 is the most powers of 16 to the 3rd that we can subtract so we place A (the equivalent of 10) in the 16 to the 3rd position.
   We subtract: 41817 Ð 40960 = 857

A	____	____	____
16^3	16^2	16^1	16^0
4096	256	16	1

$$\begin{array}{r} 256 \\ \times\ 5 \\ \hline 1280 \end{array} \qquad \begin{array}{r} 1470 \\ -1280 \\ \hline 190 \\ -176 \\ \hline 14 \end{array}$$

5	B	E
256	16	1

2. Now, we have established the first power of 16 that we can use. We now move over to 16 to the 2nd power which has the equivalent of 256 and ask how many times can 256 be subtracted from 857. Again, we try the calculations and discover 3 256s (768) can be subtracted from 857 which means we enter a 3 in the 16 to the 2nd position.
   We subtract: 857-768 = 89

A	3	____	____
16^3	16^2	16^1	16^0
4096	256	16	1

1:18 PM 10/23/2018

Numbering Systems and Computer

www.pgrocer.net/Cis17/notes/numbers.html

Counting in hexadecimal:
Counting in hexadecimal is the same as in decimal through decimal 9. But once we reach 9, we have run out of digits in decimal but we have 6 digits (A, B, C, D, E, F) left in hexadecimal. Therefore when we reach 9 in hexadecimal we can keep counting through A, B, C, D, E and F. Note that 9 + 1 = A in hexadecimal and A + 1 = B, etc. When we add 1 to F, we see that there are no more digits so we have to put down the 0 and carry the one over to the next position Ð therefore, 1 + F = 10.

Binary	Decimal	Hexadecimal
0	0	0
1	1	1
10	2	2
11	3	3
100	4	4
101	5	5
110	6	6
111	7	7
1000	8	8
1001	9	9
1010	10	A
1011	11	B
1100	12	C
1101	13	D
1110	14	E
1111	15	F
10000	16	10
10001	17	11
10010	18	12

Dec

$$\begin{array}{r} 9 \\ +\ 1 \\ \hline 10 \end{array}$$

Bin

$$\begin{array}{r} 1 \\ +1 \\ \hline 10 \end{array}$$

Hex

$$\begin{array}{r} F \\ +1 \\ \hline 10 \end{array}$$

$$\begin{array}{r} {}^{1}\ \ \\ FF \\ +\ \ 1 \\ \hline 100 \end{array}$$

Conversion from binary to hexadecimal:

Binary	Hexadecimal
0000	0

1:21 PM
10/23/2018

Numbering Systems and Computer

www.pgrocer.net/Cis17/notes/numbers.html

Counting in hexadecimal:

Counting in hexadecimal is the same as in decimal through decimal 9. But once we reach 9, we have run out of digits in decimal but we have 6 digits (A, B, C, D, E, F) left in hexadecimal. Therefore when we reach 9 in hexadecimal we can keep counting through A, B, C, D, E and F. Note that 9 + 1 = A in hexadecimal and A + 1 = B, etc. When we add 1 to F, we see that there are no more digits so we have to put down the 0 and carry the one over to the next position Ð therefore, 1 + F = 10.

Binary	Decimal	Hexadecimal
0	0	0
1	1	1
10	2	2
11	3	3
100	4	4
101	5	5
110	6	6
111	7	7
1000	8	8
1001	9	9
1010	10	A
1011	11	B
1100	12	C
1101	13	D
1110	14	E
1111	15	F
10000	16	10
10001	17	11
10010	18	12

4 binary bits can be represented with 1 hex digit

And every hex digit can be represented with 4 binary bits

Conversion from binary to hexadecimal:

Binary	Hexadecimal
0000	0

1:23 PM 10/23/2018

Title: Oct 23-1:23 PM (14 of 20)

Numbering Systems and Compute

www.pgrocer.net/Cis17/notes/numbers.html

1111	15	F
10000	16	10
10001	17	11
10010	18	12

Conversion from binary to hexadecimal:

Binary	Hexadecimal
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

1010 | 1000

A | 8

As you can see from the chart above, every hexadecimal digit can be represented by 4 binary digits (bits) and every combination of 4 binary digits can be represented by a single hexadecimal digit. Because of this, any string of 4 binary digits can be converted to its hexadecimal equivalent by either checking the chart above or doing the conversion. If I have a string of binary digits, it can be divided into groups of four starting at the far right and each group can be converted to its hexadecimal equivalent.

Examples:

1:25 PM 10/23/2018

Title: Oct 23-1:25 PM (15 of 20)

1110	14	E
1111	15	F
10000	16	10
10001	17	11
10010	18	12

Conversion from binary to hexadecimal:

Binary	Hexadecimal
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

1 | 0000 | 0111 | 0001 | 0001 | 1110

8421 8421 8421

$10000011100010001 1110_2 = 11711E_{16}$

F C A C 7 F

1111 | 1100 | 1010 | 1100 | 0111 | 1111

8421 84 21 8421 8421

15 12 10

$111111001010110001111111_2 = FCAC7F_{16}$

As you can see from the chart above, every hexadecimal digit can be represented by 4 binary digits (bits) and every combination of 4 binary digits can be represented by a single hexadecimal digit. Because of this, any string of 4 binary digits can be converted to its hexadecimal equivalent by either checking the chart above or doing the conversion. If I have a string of binary digits, it can be divided into groups of four starting at the far right and each group can be converted to its hexadecimal equivalent.

Numbering Systems and Compute

www.pgrocer.net/Cis17/notes/numbers.html

SMART Ink

Conversion from binary to hexadecimal:

Binary	Hexadecimal
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

$$8DE5A_{16} = 10001101111001011010_2$$

1000 1101 1110 0101 1010

8421 8421 8421 8421 8421

As you can see from the chart above, every hexadecimal digit can be represented by 4 binary digits (bits) and every combination of 4 binary digits can be represented by a single hexadecimal digit. Because of this, any string of 4 binary digits can be converted to its hexadecimal equivalent by either checking the chart above or doing the conversion. If I have a string of binary digits, it can be divided into groups of four starting at the far right and each group can be converted to its hexadecimal equivalent.

Examples:

1. 11001111 can be divided into groups of 4

   1100/ 1111 1100 is C and 1111 is F

   C F

   therefore the hexadecimal equivalent of 11001111 is CF

1:38 PM 10/23/2018

Numbering Systems and Compute

www.pgrocer.net/Cis17/notes/numbers.html

Example: binary number 1011011

1	0	1	1	0	1	1	Face value
2^6	2^5	2^4	2^3	2^2	2^1	2^0	Positional value
64	32	16	8	4	2	1	Resolved positional value

The positional values are first shown in the powers of 2 and then as the resolved number - in other words, 2 to the 6th is equal to 64.

Converting binary to decimal:
In the previous example to find the decimal equivalent for the number 1011011, we do the following:

$1 \times 2^6 = 1 \times 64 =$	64
$0 \times 2^5 = 0 \times 32 =$	0
$1 \times 2^4 = 1 \times 16 =$	16
$1 \times 2^3 = 1 \times 8 =$	8
$0 \times 2^2 = 0 \times 4 =$	0
$1 \times 2^1 = 1 \times 2 =$	2
$1 \times 2^0 = 1 \times 1 =$	1
	91

Converting decimal to binary:
Before doing this it is important that we review the decimal equivalent for the frequently used powers of 2:

$2^0 = 1$	$2^1 = 2$	$2^2 = 4$	$2^3 = 8$	$2^4 = 16$	$2^5 = 32$
$2^6 = 64$	$2^7 = 128$	$2^8 = 256$	$2^9 = 512$	$2^{10} = 1024$	etc.

To convert 91 from decimal to binary, you can follow the following steps:

1. Look at 91 and see what power of 2 can be taken from it. The highest power that can be subtracted is 2 to the 6th which is 64. Therefore we put a 1 in the 2 to the 6th position. Then we subtract: 91 - 64 = 27

1	___	___	___	___	___	___
2^6	2^5	2^4	2^3	2^2	2^1	2^0
64	32	16	8	4	2	1

1:38 PM 10/23/2018

Numbering Systems and Computer

www.pgrocer.net/Cis17/notes/numbers.html

1011	B
1100	C
1101	D
1110	E
1111	F

As you can see from the chart above, every hexadecimal digit can be represented by 4 binary digits (bits) and every combination of 4 binary digits can be represented by a single hexadecimal digit. Because of this, any string of 4 binary digits can be converted to its hexadecimal equivalent by either checking the chart above or doing the conversion. If I have a string of binary digits, it can be divided into groups of four starting at the far right and each group can be converted to its hexadecimal equivalent.

Examples:

1. 11001111 can be divided into groups of 4

   1100/ 1111 1100 is C and 1111 is F

   C F

   therefore the hexadecimal equivalent of 11001111 is CF

2. the hexadecimal equivalent of 11010101110101 is 3575

   11010101110101 = 11/ 0101/ 0111/ 0101

   3 5 7 5

Note that if there are not enough digits to make groups of 4, then you start at the right and the group with less than 4 digits is the leftmost group Ð in translating that group, assume leading 0s.

Conversion from hexadecimal to binary:
To convert from hexadecimal to binary, you express each hexadecimal character as 4 binary digits Ð either use the chart above or figure out the equivalent.

Example:
Convert the hexadecimal number 5E49 to binary:

5	E	4	9
0101	1110	0100	1001

Hexadecimal 5E49 is equal to binary 0101111001001001 (note, the leading 0 could be omitted without hurting the validity of the number)

1:39 PM 10/23/2018

Title: Oct 23-1:39 PM (19 of 20)

Numbering Systems and Compute

www.pgrocer.net/Cis17/notes/numbers.html

hexadecimal. Therefore when we reach 9 in hexadecimal we can keep counting through A, B, C, D, E and F. Note that 9 + 1 = A in hexadecimal and A + 1 = B, etc. When we add 1 to F, we see that there are no more digits so we have to put down the 0 and carry the one over to the next position Ð therefore, 1 + F = 10.

Binary	Decimal	Hexadecimal
0	0	0
1	1	1
10	2	2
11	3	3
100	4	4
101	5	5
110	6	6
111	7	7
1000	8	8
1001	9	9
1010	10	A
1011	11	B
1100	12	C
1101	13	D
1110	14	E
1111	15	F
10000	16	10
10001	17	11
10010	18	12

Conversion from binary to hexadecimal:

Binary	Hexadecimal
0000	0
0001	1
0010	2

File

1:40 PM
10/23/2018