Number System
Code Conversions

Number System Conversion

Decimal to Binary Number System
Decimal to Octal Number System
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Conversion of Decimal to Any Base

Divide Number N by base R until quotient is 0. Remainder at EACH step is a digit in base R, from Least Significant digit to Most significant digit.

Convert 53 to binary

53/2 = 26, rem = 1
26/2 = 13, rem = 0
13/2 = 6 , rem = 1
6 /2 = 3, rem = 0
3/2 = 1, rem = 1
1/2 = 0, rem = 1

53 = % 110101
$= 1x2^5 + 1x2^4 + 0x2^3 + 1x2^2 + 0x2^1 + 1x2^0$
$= 32 + 16 + 0 + 4 + 0 + 1 = 53$

Decimal-to-Radix-r Conversions: Integer Part

- Successively divide number by r, taking remainder as result.
- Example: Convert 57_{10} to binary.

57 / 2 = 28 remainder 1 (LSB)

/2 = 14 remainder 0

/2 = 7 remainder 0

/2 = 3 remainder 1

/2 = 1 remainder 1

/2 = 0 remainder 1 (MSB)

Answer: 111001_2

For Understanding Decimal to Binary Conversion

In this method decimal number is successively divided by 2 and remainder is noted after each division. Then reminder is recorded in the reverse order.

12 is successively divided by 2 and remainder is recorded. The process is depicted in tabular form for easy understanding.

Divider	Dividend	Quotient	Remainder	Remark
2	12	6	0	6 is dividend for next division
2	6	3	0	3 is dividend for next division
2	3	1	1	Read in the reverse order

2	12	Remainder
2	6	0
2	3	0
	1	1

Read Up

The binary equivalent of decimal number 12 is 1100.

Thus $(12)_{10} = (1100)_2$

Decimal-to-Radix-r Conversions: Fractional Part

- Successively multiply number by r, taking integer part as result and chopping off integer part before next iteration.

- May be unending!

- Example: convert $.3_{10}$ to binary.

.3 * 2 = .6 integer part = 0

.6 * 2 = 1.2 integer part = 1

.2 * 2 = .4 integer part = 0

.4 * 2 = .8 integer part = 0

.8 * 2 = 1.6 integer part = 1

.6 * 2 = 1.2 integer part = 1, etc.

Answer = **.01001**

For Understanding Fractional Number

Convert $(0.37)_{10}$ into its binary equivalent.

Multiplier	Multiplicand	Result	Integer	Remark
2	0.37	0.74	0	The fractional part 0.74 is taken up as next multiplicand
2	0.74	1.48	1	The fractional part 0.48 is taken up as next multiplicand
2	0.48	0.96	0	The fractional part 0.96 is taken up as next multiplicand
2	0.96	1.92	1	The fractional part 0.92 is taken up as next multiplicand
2	0.92	1.84	1 Read Down	The fractional part 0.84 is taken up as next multiplicand or halt

Least Significant Digit Most Significant Digit

53 = % 110101

Most Significant Digit (has weight of 2^5 or 32). For base 2, also called Most Significant Bit (MSB). Always LEFTMOST digit.

Least Significant Digit (has weight of 2^0 or 1). For base 2, also called Least Significant Bit (LSB). Always RIGHTMOST digit.

Decimal to Octal Conversion

In decimal to octal conversion the decimal number is divided by 8 which is the base of Octal Number. The remainder is noted down and is read in reverse order as done previously in the conversion of decimal to binary.

Convert $(137)_{10}$ into its Octal equivalent.

137 is successively divided by 8 and remainder is recorded. The process is depicted in tabular form for easy understanding.

Divider	Dividend	Quotient	Remainder	Remark
8	137	17	1	17 is dividend for next division
8	17	2	1	Conversion is complete, read up to get answer

The octal equivalent of decimal number 137 is 211.

Convert $(0.62)_{10}$ into its Octal equivalent.

Multiplier	Multiplicand	Result	Integer	Remark
8	0.62	**4.96**	**4**	The fractional part 0.96 is taken up as next multiplicand
8	0.96	**7.68**	**7**	The fractional part 0.68 is taken up as next multiplicand
8	0.68	**5.44**	**5**	The fractional part 0.44 is taken up as next multiplicand
8	0.44	**3.52**	**3**	The fractional part 0.52 is taken up as next multiplicand
8	0.52	**4.16**	**4** **Read Down**	The fractional part 0.16 is taken up as next multiplicand or halt

The octal equivalent of decimal number 0.62 is 0.47534

The repeated multiplication method is shown below.

	Integer Part	
$8 \times 0.62 = 4.96$	4	
$8 \times 0.96 = 7.68$	7	
$8 \times 0.68 = 5.44$	5	
$8 \times 0.44 = 3.52$	3	
$8 \times 0.52 = 4.16$	4	**Read Down**

Thus $(0.62)_{10} = (0.47534)_8$

Decimal to Hexadecimal Conversion

To convert a decimal number into hexadecimal equivalent number, divide the integer number with the base of hexadecimal number i.e. 16. The process of conversion is same as done in the earlier conversions.

For the fractional part the number is multiplied with 16 and the integer is noted down.

Convert $(148)_{10}$ into its Hexadecimal equivalent.

Divider	Dividend	Quotient	Remainder	Remark
16	148	9	4	Conversion is complete

The hexadecimal equivalent of decimal number 148 is 94

16 | 148

Remainder

16 | 9 4

Read Up

The hexadecimal equivalent of decimal number 148 is 94

Thus $(148)_{10} = (94)_{16}$

Convert $(0.57)_{10}$ into its Hexadecimal equivalent.

Repeatedly multiplying the fractional decimal number with the base 16 and recording down the integer part.

	Integer
$16X\ 0.57 = 9.12$	**9**
$16X\ 0.12 = 1.92$	**1**
$16X\ 0.92 = 14.72$	14=**E**
$16X\ 0.72 = 11.52$	11=**B**
	Read Down

The hexadecimal equivalent of decimal number 0.570 is 0.91EB

Thus $(0.57)_{10} = (0.91EB)_{16}$

Binary to Any Number Conversion

$$(\ )_2 \longleftrightarrow (\ )_4 \longleftrightarrow (\ )_8 \longleftrightarrow (\ )_{16}$$

- To convert a binary number to a system which is base-2^z, group digits together by z and convert each group separately
- 100111.1010 ---> ( )16

$$\begin{array}{ccccc} 10 & 0111 & . & 1010 \\ \downarrow & \downarrow & & \downarrow \\ 2 & 7 & . & A \end{array}$$

Converting from binary base hex as an example of base 2^Z

Binary to Decimal Conversion

Conversion of Any Base to Decimal : Converting from ANY base to decimal is done by multiplying each digit by its weight and summing.

Convert: 110111 to Decimal equivalent

Number (N)	1	1	0	1	1	1
Position (a)	5	4	3	2	1	0
$NX(Base)^a$ (Base = 2)	1×2^5	1×2^4	0×2^3	1×2^2	1×2^1	1×2^0
Weightage	32	16	0	4	2	1
Decimal Equivalent	32+16+4+2+1 = 55					

Binary to Decimal

$$\% \, 1011.11 = 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 1 \times 2^{-2}$$

$$= 8 + 0 + 2 + 1 + 0.5 + 0.25$$

$$= 11.75$$

Conversion $(\ )_I \quad (\ )_{10}$

- express number as a power series in I, and add all terms using decimal addition

Converting from base I to decimal

Convert the number 0.1101 into decimal number

Number (N)	1	1	0	1
Position (a)	-1	-2	-3	-4
NX(Base)^a (Base = 2)	1×2^{-1}	1×2^{-2}	0×2^{-3}	1×2^{-4}
Weightage	½ = 0.5	¼=0.25	0	1/16=0.0625
Decimal Equivalent	0.5+0.25+0.0625= **0.8125**			

Binary to Octal Number Conversion

Octal digit is a three bit number, because the highest digit in octal is 7 which can be represented by minimum of three bits as 111, therefore to convert binary number to octal number make the group of three bits starting from LSB (least significant bit) and then writing its decimal equivalent number.

Convert the number 110101001111011 into octal number

Number	1	1	0	1	0	1	0	0	1	1	1	1	0	1	1
Decimal Equivalent	6			5			1			7			3		
Octal Number	65173														

Thus the octal equivalent of the given binary number is $(65173)_8$

Convert $(001101.111110)_2$ into its octal equivalent.

For integer value group of three bits is made starting from left side of decimal point and for fractional part, group of three bits is made starting from right side of decimal point.

Number	**0**	**0**	**1**	**1**	**0**	**1**	**.**	**1**	**1**	**1**	**1**	**1**	**0**
Decimal Equivalent		1			5 ←		.		→ 7			6	
Octal Number							15 . 76						

Thus the octal equivalent of the binary number *$(001101.111110)_2$* *is* *$(15.76)_8$*

Binary to Hexadecimal Conversion

Hexadecimal numbers are four bit numbers, the highest digit in hexadecimal is F(i.e. 15) which can be represented by minimum of four bits as 1111. Therefore to convert binary number to hexadecimal number we make the group of four bits starting from LSB (least significant bit) and then writing its decimal equivalent number.

Let the binary number 1100100111111011 is to be converted into hexadecimal number system.

Number	1	1	0	0	1	0	0	1	1	1	1	1	1	0	1	1
Decimal Equivalent	12				9				15				11			
Hexadecimal Equivalent	C				9				F				B			
Hexadecimal Number	C9FB															

Octal to Decimal Conversion

Octal numbers can be converted into decimal number by the positional weightage method. The positional weightage method same as that is adopted in binary to decimal conversion with the difference that here the base is 8. Let us see how conversion takes place with the help of an example.

Converting the octal number 237 into decimal equivalent.

Number (N)	**2**	**3**	**7**
Position (a)	2	1	0
NX(Base)^a (Base = 8)	2×8^2	3×8^1	7×8^0
Weightage	128	24	7
Decimal Equivalent	128 + 24 + 7 =159		

Thus the decimal equivalent of octal number 237 is 159

Convert $(25.61)_8$ into decimal equivalent .

Converting 25 into decimal equivalent

Number :	**2**	**5**	
Position :	1	0	
Weightage:	$2X8^1$	$5X8^0$	
Decimal Equivalent:	16	+ 5	= 21

Converting 0.61 into decimal equivalent

Number :	**6**	**1**	
Position :	-1	-2	
Weightage:	$6X8^{-1}$	$1X8^{-2}$	
Decimal Equivalent:	6/8 +	1/64	= 0.765625

Thus the decimal equivalent of octal number $(25.61)_8$ is $(21.\ 765625)_{16}$

Octal to Binary Conversion

Octal numbers can be converted into binary number by changing each binary digit into three bit binary number. Following examples will make the statement more clear.

Convert $(572.16)_8$ into binary equivalent .

Number:		5			7			2		.		1			6	
Three bit binary Equivalent :	1	0	1	1	1	1	0	1	0	.	0	0	1	1	1	0

Thus the binary equivalent of octal number $(572.16)_8$ is (101 111 010 . 001 110)[illegible]

Octal to Hexadecimal Conversion

Octal number can be converted in hexadecimal by first convert the octal number into three bit binary number and then making the group of four bits starting from LSB

Octal Number	3			5			4		
3 bit Binary Equivalent	0	1	1	1	0	1	1	0	0
Hexadecimal Equivalent	0	14 = E				12 = C			

Thus the hexadecimal equivalent of octal number $(354)_8$ is $(EC)_{16}$

Convert $(703.14\ )_8$ into hexadecimal equivalent .

Number :	7	0	3	.	1	4
Three bit binary Equivalent :	1 1 1	0 0 0	0 1 1	.	0 0 1	1 0 0

Hexadecimal Equivalent	1	7	10=A	.	3	0

As the MSB bit 1 stands alone, to make it a four bit number adding three 0's before it this won't make any difference . In the fraction part the last two digits are converted into four bit number by adding two 0's after the binary number 10 , the number becomes 1000 which is equal to 8 in hexadecimal number.

Thus the hexadecimal equivalent of octal number $(703.14)_8$ is $(17A.30_{16}$

Hexadecimal to Decimal Conversion

Hexadecimal numbers can be converted to decimal number by the method of positional weightage. The method of positional weightage has been previously used in binary to decimal and octal to decimal conversion therefore it needs no elaboration.

Let the hexadecimal number E5A is to be converted into decimal equivalent

Number (N)	E	5	A
Position (a)	2	1	0
NX(Base)^a (Base → 16)	$14X16^2$ (E = 14)	$5X16^1$	$10X16^0$ (A = 10)
Weightage	3584	80	10
Decimal Equivalent	3674		

Convert $(B4.16)_{16}$ into decimal equivalent .

Converting B4 into decimal equivalent

Number :	**B=11**		**4**		
Position :	1		0		
Weightage:	11×16^{1}		4×16^{0}		
Decimal Equivalent:	176	+	4	=	180

Converting 0.16 into decimal equivalent

Number :	**1**		**6**	
Position :	-1		-2	
Weightage:	1×16^{-1}		6×16^{-2}	
Decimal: Equivalent	1/16	+	6/256	= 0.0859

Thus the decimal equivalent of hexadecimal number $(B4.16)_{16}$ is $(180.0859)_{10}$

Hexadecimal to Binary Conversion

As previously affirmed that hexadecimal numbers are represented by four bit binary numbers. Therefore for converting any hexadecimal number to its binary equivalent we convert it in four bit binary number. For example, here shows one such conversion.

Hexadecimal Number	C				8				9				5			
Decimal Equivalent	12				8				9				5			
Binary Number	1	1	0	0	1	0	0	0	1	0	0	1	0	1	0	1

The binary equivalent of hexadecimal number C895 is 1100 1000 1001 0101

Convert $(F14.16)_{16}$ into binary equivalent.

Number:	F	1	4	.	1	6
Four bit binary Equivalent:	1 1 1 1	0 0 0 1	0 1 0 0		0 0 0 1	0 1 1 0

Thus the binary equivalent of hexadecimal number $(F14.16)_{16}$ is $(1111\ 0001\ 0100.0001\ 0110)_2$

Hexadecimal to Octal Conversion

In this form of conversion, the hexadecimal number is first converted into four bit binary number, then these binary numbers are grouped into three bits. These three bit binary numbers are finally converted into its decimal equivalent number.

Let us convert the hexadecimal 5DB2 into its octal equivalent.

<table>
<tr><td>Hexadecimal Number</td><td colspan="4">5</td><td colspan="4">D</td><td colspan="4">B</td><td colspan="4">2</td></tr>
<tr><td>Decimal Equivalent</td><td colspan="4">5</td><td colspan="4">13</td><td colspan="4">11</td><td colspan="4">2</td></tr>
<tr><td>Four bit Binary Number</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>Octal Equivatent</td><td>0</td><td colspan="3">5</td><td colspan="3">6</td><td colspan="3">6</td><td colspan="3">6</td><td colspan="3">2</td></tr>
</table>

The octal equivalent of hexadecimal number 5DB2 is 056662

Convert (F16.16)$_{16}$ into octal equivalent.

Number:	**F**	**1**		**6**	**.**	**1**		**6**
Four bit binary Equivalent :	1 1 1 1	0 0 0 1		0 1 1 0		0 0 0 1		0 1 1 0
Octal Equivalent :	7	4	2	6	.	0	5	4

Thus the octal equivalent of hexadecimal number $(F16.16)_{16}$ is $(7426.054)_8$

Binary Data in your life

The computer screen on your Win 98 PC can be configured for different resolutions. One resolution is 600 x 800 x 8, which means that you have 600 dots vertically x 800 dots horizontally, with each dot using 8 bits to take on 256 different colors. (actually, a dot is called a pixel).

Need 8 bits to represent 256 colors ($2^8 = 256$). Total number of bits needed to represent the screen is then:

$600 \times 800 \times 8 = 3{,}840{,}000$ bits (or just under 4 Mbits)

Windows 8 also allows devices with larger screens (the 4 confirmed sizes are "WVGA 800×480 15:9","WXGA 1280×768 15:9","720p 1280×720 16:9","1080p 1920x1080 16:9"

Your video card must have at least this much memory on it.

1 Mbits = $1024 \times 1024 = 2^{10} \times 2^{10} = 2^{20}$.
1 Kbits = $1024 = 2^{10}$.