7.2.8 Conversion of Decimal Numbers to any Radix Number

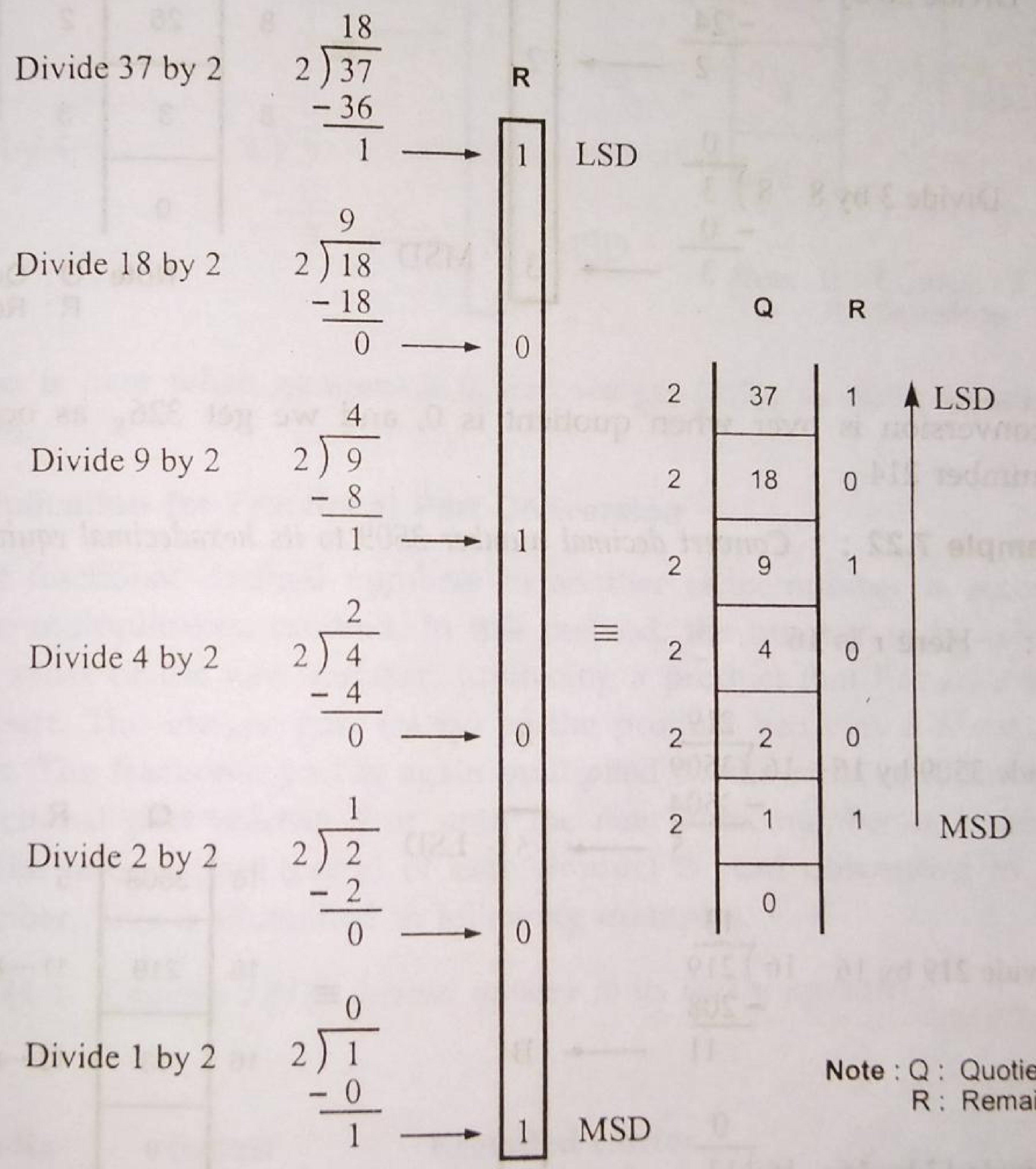
We have to carry out the conversion of decimal number to any radix number in two steps. In step 1, we have to convert integer part and in step 2 we have to convert fractional part. The conversion of integer part is accomplished by successive division method, and the conversion of fractional part is accomplished by successive multiplication method. Let us discuss these two methods.

Successive Division for Integer Part Conversion

In this method we repeatedly divide the integer part of the decimal number by r (the new radix) until quotient is zero. The remainder of each division becomes the numeral in the new radix. The remainders are taken in the reverse order to form a new radix number. This means that the first remainder is the least significant digit (LSD) and the last remainder is the most significant digit (MSD) in the new radix number. This procedure is illustrated in following examples.

Example 7.20 : *Convert decimal number 37 to its binary equivalent.*

Solution : Here r is 2

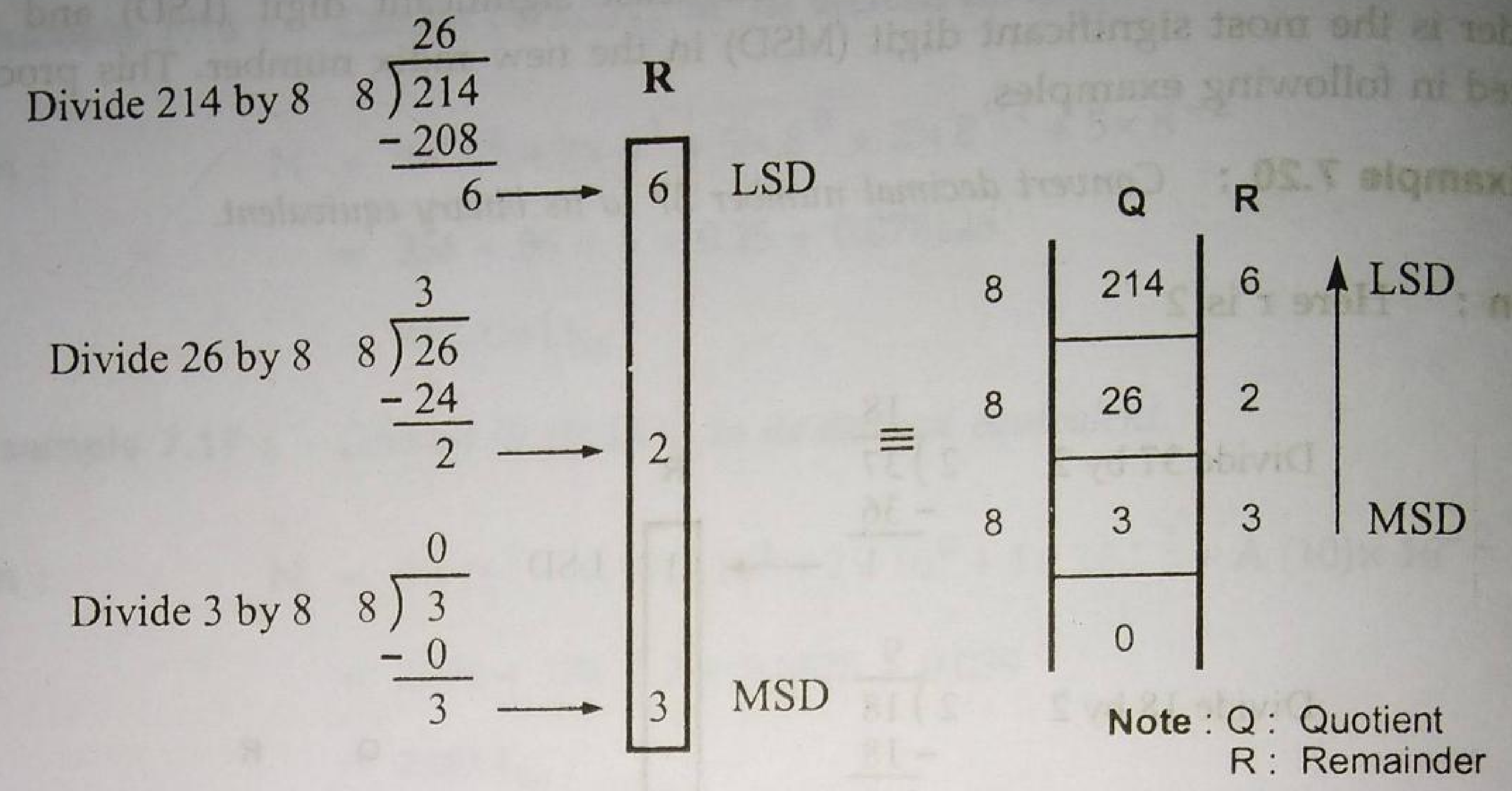


Note : Q : Quotient
R : Remainder

Binary equivalent = 100101_2

Example 7.21 : *Convert decimal number 214 to its octal equivalent*

Solution : Here r is 8

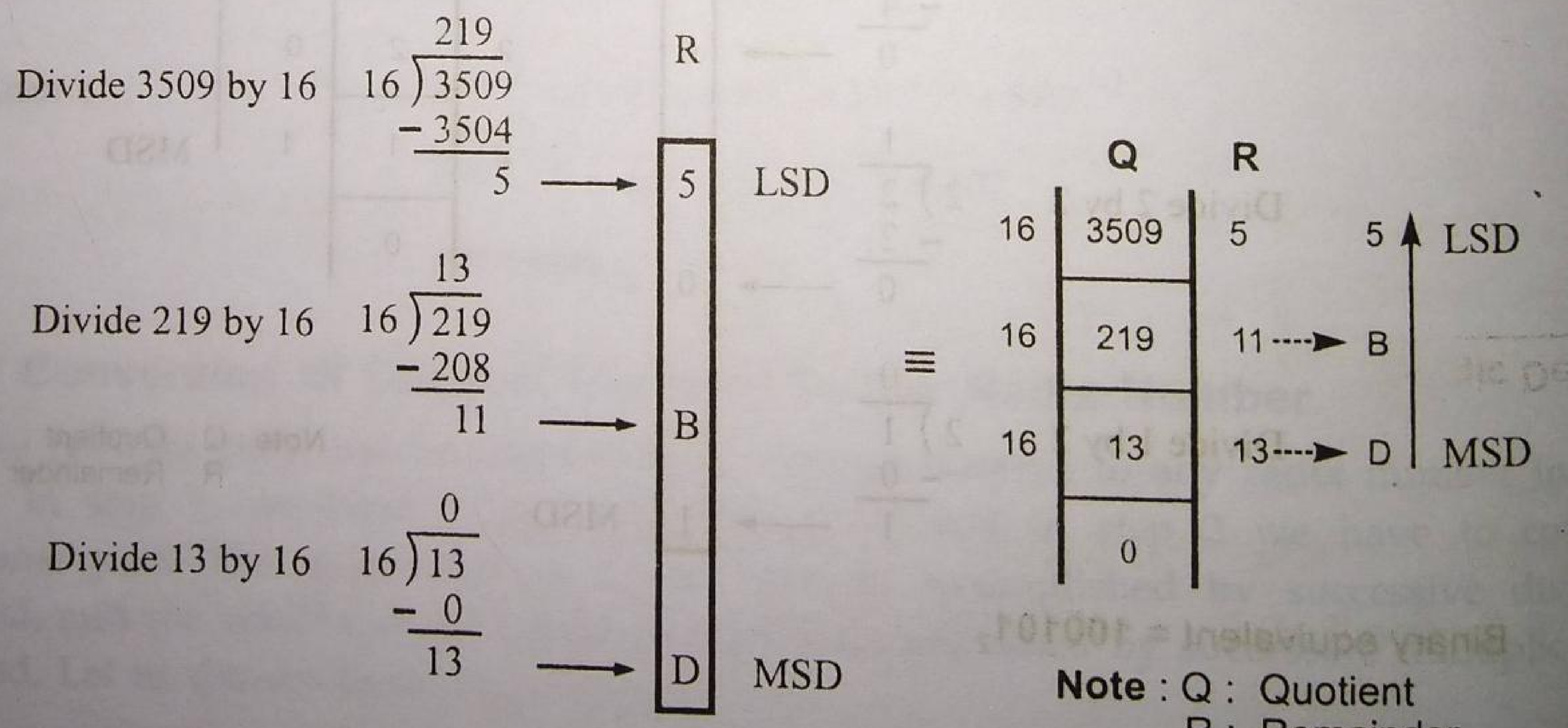


Note : Q : Quotient
R : Remainder

The conversion is over when quotient is 0, and we get 326_8 as octal equivalent to decimal number 214.

Example 7.22 : *Convert decimal number 3509 to its hexadecimal equivalent.*

Sloution : Here r is 16



Note : Q : Quotient
R : Remainder

The conversion is over when quotient is 0, and we get $DB5_{16}$ as hexadecimal equivalent to decimal number 3509.

Successive Multiplication for Fractional Part Conversion

Conversion of fractional decimal numbers to another radix number is accomplished using a successive multiplication method. In this method, the number to be converted is multiplied by the radix of the new number, producing a product that has an integer part and a fractional part. The integer part (carry) of the product becomes a numeral in the new radix number. The fractional part is again multiplied by the radix and this process is repeated until fractional part reaches 0 or until the new radix number is carried out to sufficient digits. The integer part (carry) of each product is read downward to represent the new radix number. This is illustrated in following examples.

Example 7.24 : *Convert 0.8125 decimal number to its binary equivalent.*

Solution :

Fraction		Radix		Result			Recorded carries	
0.8125	×	2	=	1.625	=	0.625	with a carry of 1	MSD
0.625	×	2	=	1.25	=	0.25	with a carry of 1	↓
0.25	×	2	=	0.5	=	0.5	with a carry of 0	↓
0.5	×	2	=	1.0	=	0.0	with a carry of 1	LSD

Reading carries downward we get,

Binary fraction = 0.1101, which is equivalent to 0.8125 decimal.

Example 7.25 : *Convert 0.95 decimal number to its binary equivalent*

Solution :

Fraction		Radix		Result			Recorded carries	
0.95	×	2	=	1.9	=	0.9	with a carry of 1	MSD
0.9	×	2	=	1.8	=	0.8	with a carry of 1	
0.8	×	2	=	1.6	=	0.6	with a carry of 1	
0.6	×	2	=	1.2	=	0.2	with a carry of 1	
0.2	×	2	=	0.4	=	0.4	with a carry of 0	
0.4	×	2	=	0.8	=	0.8	with a carry of 0	
0.8	×	2	=	1.6	=	0.6	with a carry of 1	LSD

In this case, 0.8 is repeated and if we multiply further, we will get repeated sequence. If we stop here, we get 7 binary digits, 1111001. This answer is an approximate answer. To get more accurate answer we have to continue multiplying by 2 until we have as many digits as necessary for our application.

Example 7.26 : *Convert 0.640625 decimal number to its octal equivalent.*

Solution :

Fraction		Radix		Result			Recorded carries	
0.640625	×	8	=	5.125	=	0.125	with a carry of 5	MSD
0.125	×	8	=	1.0	=	0	with a carry of 1	LSD

Reading carries downward we get octal fraction = 0.51, which is equivalent to 0.640625 decimal.

✓ **Example 7.27 :** *Convert 0.1289062 decimal number to its hex equivalent*

Solution :

Fraction		Radix		Result			Recorded carries	
0.1289062	×	16	=	2.0625	=	0.0625	with carry of 2	MSD
0.0625	×	16	=	1.0	=	0	with carry of 1	LSD

Reading carries downward we get hexadecimal fraction = 0.21_{16}, which is equivalent to 0.1289062 decimal.

Now we see the conversion examples of numbers having both integer part and fractional part.

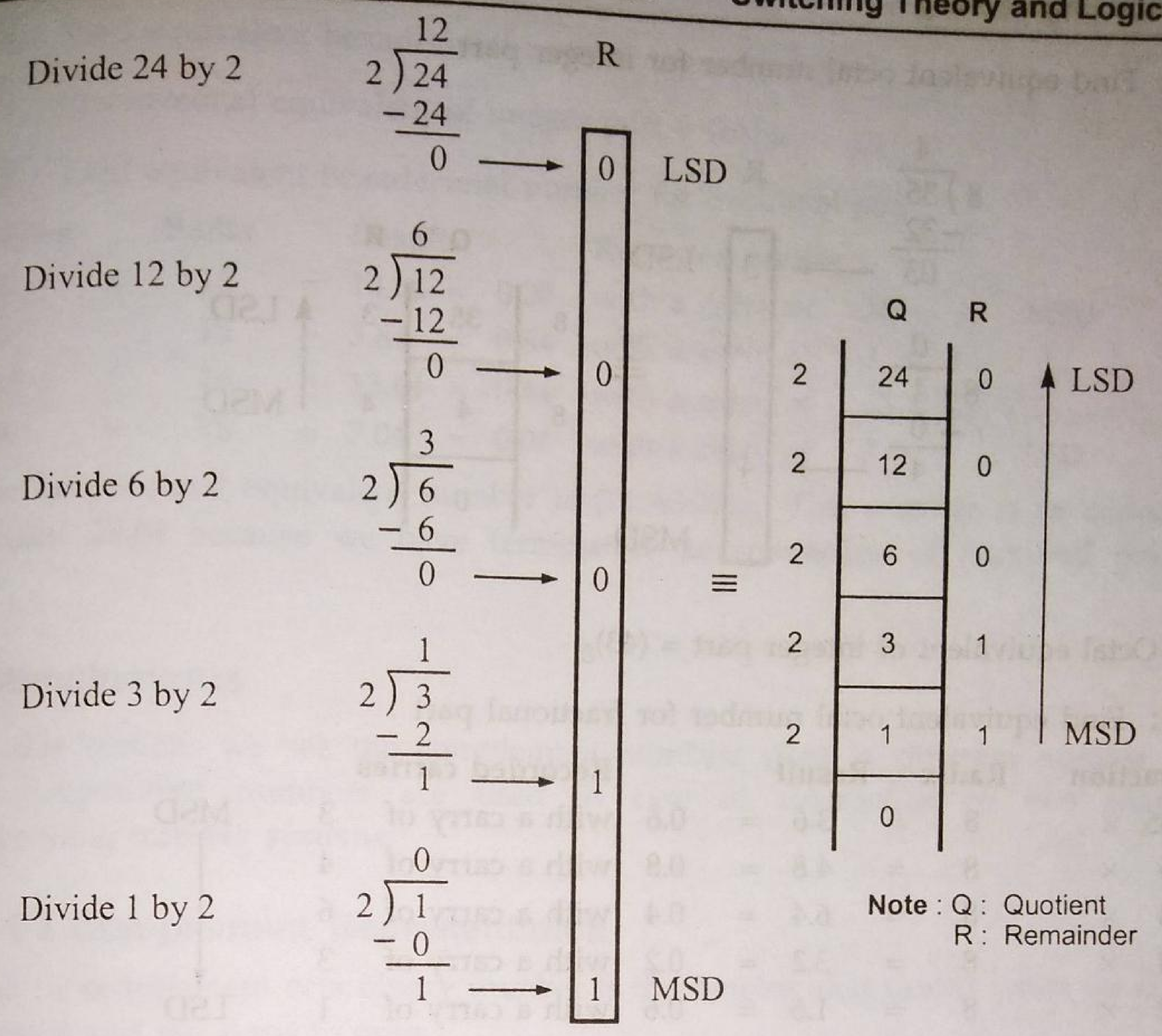
Example 7.28 : *Convert decimal number 24.6 to a binary number.*

Solution :

Step 1 : Separate out integer part and fractional part

Integer part : 24 Fractional part : 0.6

Step 2 : Find equivalent binary number for integer part



Binary equivalent of integer part = 11000_2

Step 3 : Find equivalent binary number for fractional part

Fraction	Radix	Result	Recorded carries	
0.6	× 2 =	1.2 = 0.2	with a carry of 1	MSD
0.2	× 2 =	0.4 = 0.4	with a carry of 0	↓
0.4	× 2 =	0.8 = 0.8	with a carry of 0	↓
0.8	× 2 =	1.6 = 0.6	with a carry of 1	↓
0.6	× 2 =	1.2 = 0.2	with a carry of 1	LSD

The binary equivalent number is 11000.10011. This number is an approximation of decimal 24.6, because we have terminated the conversion of fractional part after 5 digits.

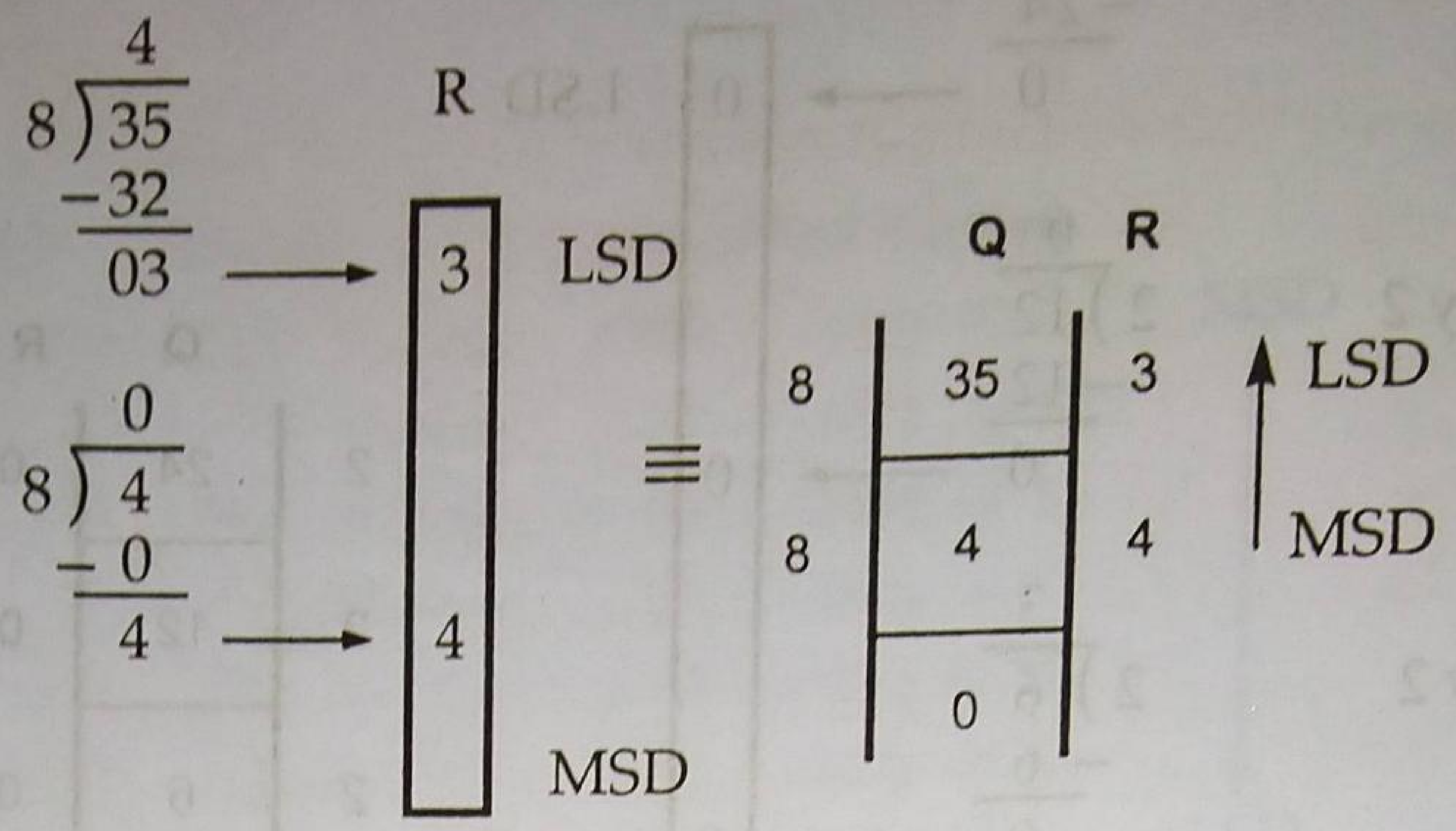
➠ **Example 7.29 :** *Convert decimal number 35.45 to octal number.*

Solution :

Step 1 : Separate the integer part and the fractional part.

Integer part : 35, Fractional part : 0.45

Step 2 : Find equivalent octal number for integer part



∴ Octal equivalent of integer part = $(43)_8$

Step 3 : Find equivalent octal number for fractional part

Fraction		Radix		Result			Recorded carries		
0.45	×	8	=	3.6	=	0.6	with a carry of	3	MSD
0.6	×	8	=	4.8	=	0.8	with a carry of	4	
0.8	×	8	=	6.4	=	0.4	with a carry of	6	
0.4	×	8	=	3.2	=	0.2	with a carry of	3	
0.2	×	8	=	1.6	=	0.6	with a carry of	1	LSD

The octal equivalent number is $(43.34631)_8$. This number is an approximation of decimal 35.45, because we have terminated the conversion of fractional part after 5 digits.

7.2.1 Binary to Octal Conversion

We know that base for octal numbers is 8 and the base for binary numbers is 2. The base for octal number is the third power of the base for binary numbers. Therefore, by grouping 3 digits of binary numbers and then converting each group digit to its octal equivalent we can convert binary number to its octal equivalent.

Example 7.7 : *Convert* $(1\ 1\ 1\ 1\ 0\ 1\ 1\ 0\ 0)_2$ *to octal equivalent.*

Solution :

111	101	100
7	5	4

$\therefore$ Octal number = $(754)_8$

7.2.2 Octal to Binary Conversion

Conversion from octal to binary is a reversal of the process explained in the previous section. Each digit of the octal number is individually converted to its binary equivalent to get octal to binary conversion of the number.

Example 7.8 : *Convert* $(634)_8$ *to binary.*

Solution :

6	3	4
110	011	100

$\therefore$ Binary number = 110 011 100

Example 7.9 : *Convert* $(725.63)_8$ *to binary.*

Solution :

7	2	5	•	6	3
111	010	101	•	110	011

$\therefore$ Binary number = 111010101 . 110 011

7.2.3 Binary to Hexadecimal Conversion

We know that base for hexadecimal numbers is 16 and the base for binary numbers is 2. The base for hexadecimal number is the fourth power of the base for binary numbers. Therefore, by grouping 4 digits of binary numbers and then converting each group digit to its hexadecimal equivalent we can convert binary number to its hexadecimal equivalent.

Example 7.10 : *Convert* $(1\,1\,0\,1\,1\,0\,0\,0\ 1\,0\,0\,1\ 1\,0\,1\,1)_2$ *to hexadecimal equivalent.*

Solution :

1 1 0 1	1 0 0 0	1 0 0 1	1 0 1 1
D	8	9	B

$\therefore$ Hexadecimal number = $(D8\ 9B)_H$

7.2.4 Hexadecimal to Binary Conversion

Conversion from hexadecimal to binary is a reversal of the process explained in the previous section. Each digit of the hexadecimal number is individually converted to its binary equivalent to get hexadecimal to binary conversion of the number.

Example 7.11 : *Convert $(3FD)_H$ to binary.*

Solution :

3	F	D
0011	1111	1101

∴ Binary number = **0011 1111 1101**

Example 7.12 : *Convert $(5A9.B4)_H$ to binary.*

Solution :

5	A	9	•	B	4
0101	1010	1001	•	1011	0100

∴ Binary number = **0101 1010 1001 . 1011 0100**

7.2.5 Octal to Hexadecimal Conversion

The easiest way to convert octal number to hexadecimal number is given below.

1. Convert octal number to its binary equivalent.
2. Convert binary number to its hexadecimal equivalent.

Example 7.13 : *Convert $(615)_8$ to its hexadecimal equivalent.*

Solution :

Step 1 : Octal to binary

6	1	5
110	001	101

∴ Binary number = 110001101

Step 2 : Binary to hexadecimal

0001	1000	1101
1	8	D

∴ Hexadecimal number = **$18D_H$**

7.2.6 Hexadecimal to Octal Conversion

The easiest way to convert hexadecimal number to octal number is given below.

1. Convert hexadecimal number to its binary equivalent.
2. Convert binary number to its octal equivalent.

Example 7.14 : *Convert $(25B)_H$ to its octal equivalent.*

Solution :

Step 1 : Hexadecimal to binary

2	5	B
0010	0101	1011

$\therefore$ Binary number = 0010 0101 1011

Step 2 : Binary to octal

0 0 1	0 0 1	0 1 1	0 1 1
1	1	3	3

$\therefore$ Octal number = 1133_8