

Number System Conversion for Beginners

(Decimal to Binary, Octal and Hexadecimal Conversion)

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Abstract: A number system is the method or system of representing the digits in the computer system. The total number of digits used in a number system is called its base or radix. The base is written after the number as subscript; for example

- Binary number system (Base 2), like $10010_{(2)}$ (10010 base 2).
- Octal number system (Base 8), like $76_{(8)}$ (76 base 8).
- Decimal number system (Base 10), like $521_{(10)}$ (521 to base of 10).
- Hexadecimal number system (Base 16), like $5AE_{(16)}$ (5AE to base of 16).

This paper discusses the decimal to binary, decimal to octal and decimal to hexadecimal conversion that will be useful for digital computers, and the field of computer science.

Keywords: Binary, Octal, Decimal and Hexadecimal.

1. INTRODUCTION

Decimal Number: The decimal is known as base 10 numbering system. Decimal numbers we use in everyday life for counting the numerals from 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9.

Binary Numbers: Binary numbers uses only two values 0 and 1. Each value in binary number has a value of 2's powers as shown below.

2's powers	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Decimal equivalent	1024	512	256	128	64	32	16	8	4	2	1

- If binary number is 10110, its decimal equivalent is equal to $16+4+2=22$.

2's powers	2^4	2^3	2^2	2^1	2^0
Binary number	1	0	1	1	0
Decimal equivalent	16	8	4	2	1

- If binary number is 1110110, its decimal equivalent is equal to $64+32+16+4+2=118$.

2's powers	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary number	1	1	1	0	1	1	0
Decimal equivalent	64	32	16	8	4	2	1

Octal Numbers: The octal numeral system is the base 8 number system which uses the 8 digits from 0 to 7 and again started from 10- 17, 20-27,....90-97, 100-107 etc.

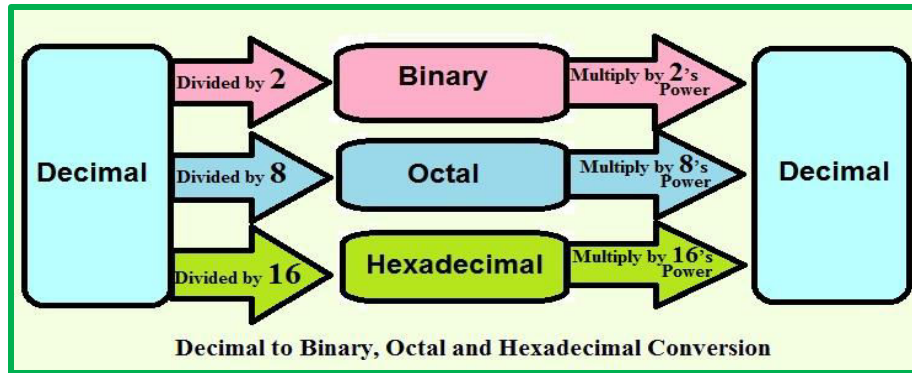
Octal Numbers			
0	10	2090
1	11	21	91
2	12	22	92
3	13	23	93
4	14	24	94
5	15	25	95
6	16	26	96
7	17	27	97

Hexadecimal Numbers: The hexadecimal numeral system is the base 16 number system which uses the 16 digits from 0 to 9,A,B,C,D,E and F. and again started from 10-19, 1A, 1B, 1C, 1D, 1E and 1F etc.

Decimal Number	Hex Number	Decimal Number	Hex Number	Decimal Number	Hex Number
0	0	16	10	32	20
1	1	17	11	33	21
2	2	18	12	34	22
3	3	19	13	35	23
4	4	20	14	36	24
5	5	21	15	37	25
6	6	22	16	38	26
7	7	23	17	39	27
8	8	24	18	41	28
9	9	25	19	42	29
10	A	26	1A	43	2A
11	B	27	1B	44	2B
12	C	28	1C	45	2C
13	D	29	1D	46	2D
14	E	30	1E	47	2E
15	F	31	1F	48	2F

CONVERSIONS:

- **Decimal to Binary conversion:** Divide the decimal number (Dividend) by 2.
- **Decimal to Octal conversion:** Divide the decimal number (Dividend) by 8.
- **Decimal to Hexadecimal conversion:** Divide the decimal number (Dividend) by 16.
- **Binary to Decimal conversion:** Multiply the binary number with 2's power.
- **Octal to Decimal conversion:** Multiply the octal number with 8's power.
- **Hexadecimal to Decimal:** Multiply the hexadecimal number with 16's power.

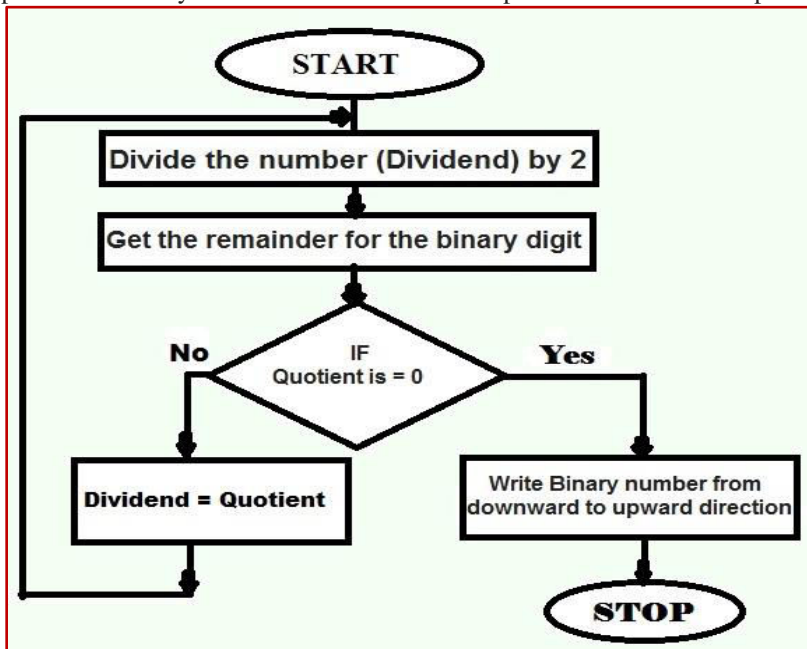


2. OBJECTIVE

1. To study a conversion of decimal number to binary, octal and hexadecimal numbers.
2. To simplify the calculation for better understanding of students.

3. DECIMAL TO BINARY CONVERSION

- Step 1: Divide the number (Dividend) by 2.
 Step 2: Get the remainder for the binary digit.
 Step 3: If quotient is equal to 0 then go to step 4, else repeat step 1 to 3.
 Step 4: Write binary number from downward to upward direction and stop.



SOLVED EXAMPLE OF DECIMAL TO BINARY

Q1. $20_{(10)} = ?_{(2)}$

	Description		Reminder
Step :1	$\begin{array}{r} 2 \overline{) 10} \\ \underline{20} \\ 20 \\ \underline{20} \\ 0 \end{array}$	Quotient of Step:1's will become dividend of Step:2 Step:1's reminder	0 ↑
Step :2	$\begin{array}{r} 2 \overline{) 5} \\ \underline{10} \\ 10 \\ \underline{10} \\ 0 \end{array}$	Quotient of Step:2's will become dividend of Step:3 Step:2's reminder	0
Step :3	$\begin{array}{r} 2 \overline{) 2} \\ \underline{4} \\ 4 \\ \underline{4} \\ 1 \end{array}$	Quotient of Step:3's will become dividend of Step:4 Step:3's reminder	1
Step :4	$\begin{array}{r} 2 \overline{) 1} \\ \underline{2} \\ 2 \\ \underline{2} \\ 0 \end{array}$	Quotient of Step:4's will become dividend of Step:5 Step:4's reminder	0
Step :5	$\begin{array}{r} 2 \overline{) 0} \\ \underline{1} \\ 0 \\ \underline{0} \\ 1 \end{array}$	Dividend is less than deviser ($1 < 2$), thus quotient is=0. Dividend as it is (1) reminder.	0
Answer: $20_{(10)} = 10100_{(2)}$			

	Divisor	Dividend	Binary No.	Description
Step :1	2	20	0 ↑	$2 \times 10 = 20$, quotient is=10, and $(20-20)$ reminder is =0
Step :2	2	10	0	$2 \times 5 = 10$, quotient is= 5, and $(10-10)$ reminder is =0
Step :3	2	5	1	$2 \times 2 = 4$, quotient is=2, and $(5-4)$ reminder is =1
Step :4	2	2	0	$2 \times 1 = 2$, quotient is=1, and $(2-2)$ reminder is =0
Step :5	2	1	1	$1 < 2$ thus quotient is= 0 , and reminder as it is 1
	--	0	--	Answer: $20_{(10)} = 10100_{(2)}$

Q2. $81_{(10)} = ?_{(2)}$

	Description		Reminder
Step :1	$\begin{array}{r} 2 \overline{) 81} \\ \underline{- 80} \\ 1 \end{array}$	Quotient of Step:1's will become dividend of Step:2 Step:1's reminder	1 ↑
Step :2	$\begin{array}{r} 2 \overline{) 40} \\ \underline{- 40} \\ 0 \end{array}$	Quotient of Step:2's will become dividend of Step:3 Step:2's reminder	0
Step :3	$\begin{array}{r} 2 \overline{) 20} \\ \underline{- 20} \\ 0 \end{array}$	Quotient of Step:3's will become dividend of Step:4 Step:3's reminder	0
Step :4	$\begin{array}{r} 2 \overline{) 10} \\ \underline{- 10} \\ 0 \end{array}$	Quotient of Step:4's will become dividend of Step:5 Step:4's reminder	0
Step :5	$\begin{array}{r} 2 \overline{) 5} \\ \underline{- 4} \\ 1 \end{array}$	Quotient of Step:4's will become dividend of Step:5 Step:5's reminder	1
Step :6	$\begin{array}{r} 2 \overline{) 2} \\ \underline{- 2} \\ 0 \end{array}$	Quotient of Step:4's will become dividend of Step:5 Step:6's reminder	0
Step :7	$\begin{array}{r} 2 \overline{) 1} \\ \underline{- 0} \\ 1 \end{array}$	Dividend is less than deviser ($1 < 2$), thus quotient is=0. Dividend as it is (1) reminder	1
Answer: $81_{(10)} = 1010001_{(2)}$			

	Divisor	Dividend	Binary No.	Description
Step :1	2	81	1 ↑	$2 \times 40 = 80$, quotient is=40, and (81-80) reminder is =1
Step :2	2	40	0	$2 \times 20 = 40$, quotient is=20, and (40-40) reminder is =0
Step :3	2	20	0	$2 \times 10 = 20$, quotient is=20, and (20-20) reminder is =0
Step :4	2	10	0	$2 \times 5 = 10$, quotient is=5, and (10-10) reminder is =0
Step :5	2	5	1	$2 \times 2 = 4$, quotient is=2, and (5-4) reminder is =1
Step :6	2	2	0	$2 \times 1 = 2$, quotient is=1, and (2-2) reminder is =0
Step :7	2	1	1	$1 < 2$ thus quotient is= 0 , and reminder as it is 1
	--	0	--	Answer: $81_{(10)} = 1010001_{(2)}$

Q3. $97_{(10)} = ?_{(2)}$

	Description		Reminder
Step :1	$\begin{array}{r} 2 \overline{) 97} \\ \underline{- 96} \\ 1 \end{array}$	Quotient of Step:1's will become dividend of Step:2 Step:1's reminder	1 ↑
Step :2	$\begin{array}{r} 2 \overline{) 48} \\ \underline{- 48} \\ 0 \end{array}$	Quotient of Step:2's will become dividend of Step:3 Step:2's reminder	0
Step :3	$\begin{array}{r} 2 \overline{) 24} \\ \underline{- 24} \\ 0 \end{array}$	Quotient of Step:3's will become dividend of Step:4 Step:3's reminder	0
Step :4	$\begin{array}{r} 2 \overline{) 12} \\ \underline{- 12} \\ 0 \end{array}$	Quotient of Step:4's will become dividend of Step:5 Step:4's reminder	0
Step :5	$\begin{array}{r} 2 \overline{) 6} \\ \underline{- 6} \\ 0 \end{array}$	Quotient of Step:4's will become dividend of Step:5 Step:5's reminder	0
Step :6	$\begin{array}{r} 2 \overline{) 3} \\ \underline{- 2} \\ 1 \end{array}$	Quotient of Step:4's will become dividend of Step:5 Step:6's reminder	1
Step :7	$\begin{array}{r} 2 \overline{) 1} \\ \underline{- 0} \\ 1 \end{array}$	Dividend is less than deviser ($1 < 2$), thus quotient is=0. Dividend as it is (1) reminder	1
Answer: $97_{(10)} = 1100001_{(2)}$			

	Divisor	Dividend	Binary No.	Description
Step :1	2	97	1 ↑	$2 \times 48 = 96$, quotient is=48, and (97-96) reminder is =1
Step :2	2	48	0	$2 \times 24 = 48$, quotient is=24, and (48-48) reminder is =0
Step :3	2	24	0	$2 \times 12 = 24$, quotient is=12, and (24-24) reminder is =0
Step :4	2	12	0	$2 \times 6 = 12$, quotient is=6, and (12-12) reminder is =0
Step :5	2	6	0	$2 \times 3 = 6$, quotient is=3, and (6-6) reminder is =0
Step :6	2	3	1	$2 \times 1 = 2$, quotient is=1, and (3-2) reminder is =1
Step :7	2	1	1	$1 < 2$ thus quotient is= 0 , and reminder as it is 1
	--	0	--	Answer: $97_{(10)} = 1100001_{(2)}$

Practice questions of decimal to binary conversion

	PRACTICE QUESTIONS	ANSWERES
1	$58_{(10)}$	$111010_{(2)}$
2	$105_{(10)}$	$1101001_{(2)}$
3	$229_{(10)}$	$11100101_{(2)}$
4	$373_{(10)}$	$101110101_{(2)}$
5	$524_{(10)}$	$1000001100_{(2)}$

DECIMAL TO OCTAL CONVERSION

Step 1: Given number is Dividend.

Step 2: If Divide is less than 8, then go to Step 6, 7 and stop, else go to step 3 to 5.

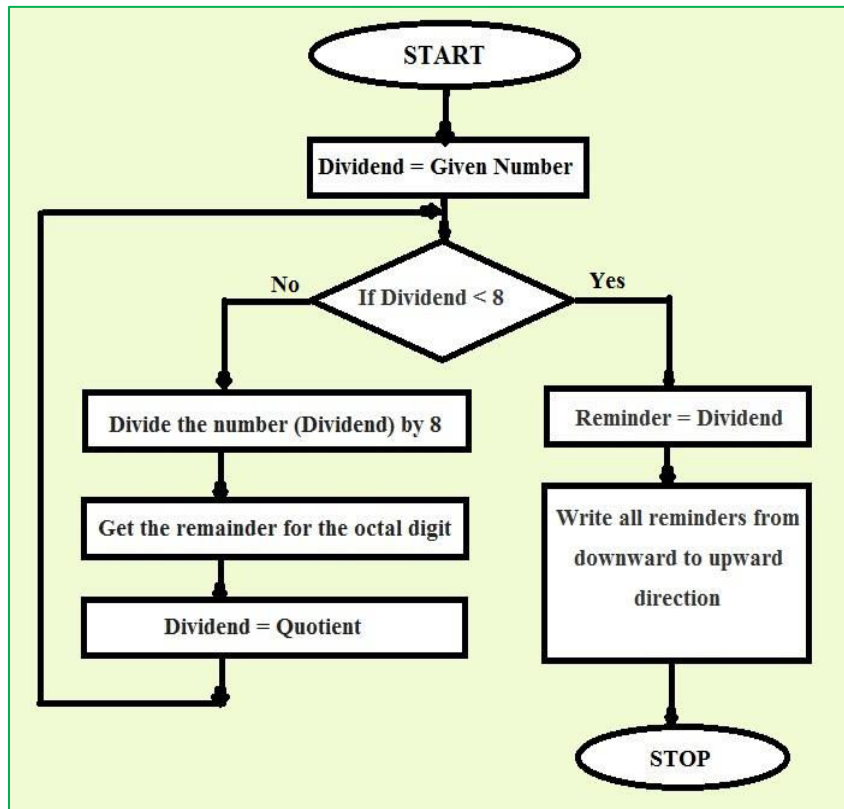
Step 3: Divide dividend by 8.

Step 4: Get the remainder for the octal digit.

Step 5: Assign quotient to dividend.

Step 6: Remainder is equal to dividend.

Step 7: Write octal number from downward to upward direction and stop.



SOLVED EXAMPLE OF DECIMAL TO BINARY

Q1. $20_{(10)} = ?_{(8)}$

	Description	Reminder
Step :1	$\begin{array}{r} 8 \overline{) 20} \\ \underline{16} \\ 4 \end{array}$ Quotient of Step:1's will become dividend of Step:2 Step:1's reminder	4 ↑
Step :2	$\begin{array}{r} 8 \overline{) 2} \\ \underline{0} \\ 2 \end{array}$ Dividend is less than deviser ($2 < 8$), thus quotient is=0. Dividend as it is deviser (2)	2
Answer: $20_{(10)} = 24_{(8)}$		

	Divisor	Dividend	Octal No.	Description
Step :1	8	20	4 ↑	$8 \times 2 = 16$, quotient is=2, and $(20-16)$ reminder is =4
Step :2	8	2	2	$2 < 8$, quotient is=0, and $(2-0)$ reminder is =2
	--	0	--	Answer: $20_{(10)} = 24_{(8)}$

Q2. $32_{(10)} = ?_{(8)}$

	Description	Reminder
Step :1	$\begin{array}{r} 8 \overline{) 32} \\ \underline{32} \\ 0 \end{array}$ Quotient of Step:1's will become dividend of Step:2 Step:1's reminder	0 ↑
Step :2	$\begin{array}{r} 8 \overline{) 4} \\ \underline{0} \\ 4 \end{array}$ Dividend is less than deviser ($4 < 8$), thus quotient is=0. Dividend as it is deviser (4)	4
Answer: $32_{(10)} = 40_{(8)}$		

	Divisor	Dividend	Octal No.	Description
Step :1	8	32	0 ↑	$8 \times 4 = 32$, quotient is=4, and $(32-32)$ reminder is =0
Step :2	8	4	4	$4 < 8$, quotient is=0, and $(4-0)$ reminder is =4
	--	0	--	Answer: $32_{(10)} = 40_{(8)}$

Q3. $120_{(10)} = ?_{(8)}$

	Description		Reminder
Step :1	$\begin{array}{r} 8 \overline{) 120} \\ \underline{120} \\ 0 \end{array}$	Quotient of Step:1's will become dividend of Step:2 Step:1's reminder	0 ↑
Step :2	$\begin{array}{r} 8 \overline{) 15} \\ \underline{8} \\ 7 \end{array}$	Quotient of Step:2's will become dividend of Step:3 Step:2's reminder	7
Step :3	$\begin{array}{r} 8 \overline{) 1} \\ \underline{0} \\ 1 \end{array}$	Dividend is less than deviser ($1 < 8$), thus quotient is=0. Dividend as it is deviser (1)	1
Answer: $120_{(10)} = 170_{(8)}$			

	Divisor	Dividend	Octal No.	Description
Step :1	8	120	0	$8 \times 15 = 120$, quotient is=15, and $(120-120)$ reminder is =0
Step :2	8	15	7	$8 \times 1 = 8$, quotient is=1, and $(15-8)$ reminder is =7
Step :3	8	1	1	$1 < 8$, quotient is=0, and $(1-0)$ reminder is =1
	--	0	--	Answer: $120_{(10)} = 170_{(8)}$

Q4. $619_{(10)} = ?_{(8)}$

	Description		Reminder
Step :1	$\begin{array}{r} 8 \overline{) 619} \\ \underline{616} \\ 3 \end{array}$	Quotient of Step:1's will become dividend of Step:2 Step:1's reminder	3 ↑
Step :2	$\begin{array}{r} 8 \overline{) 39} \\ \underline{32} \\ 5 \end{array}$	Quotient of Step:2's will become dividend of Step:3 Step:2's reminder	5
Step :3	$\begin{array}{r} 8 \overline{) 59} \\ \underline{48} \\ 1 \end{array}$	Quotient of Step:3's will become dividend of Step:4 Step: 3's reminder	1

Step :4	8	0	Dividend is less than deviser (1<8), thus quotient is=0.	1
	—	1		
	—	0		
	—	1	Dividend as it is deviser (1)	
Answer: $619_{(10)} = 1153_{(8)}$				

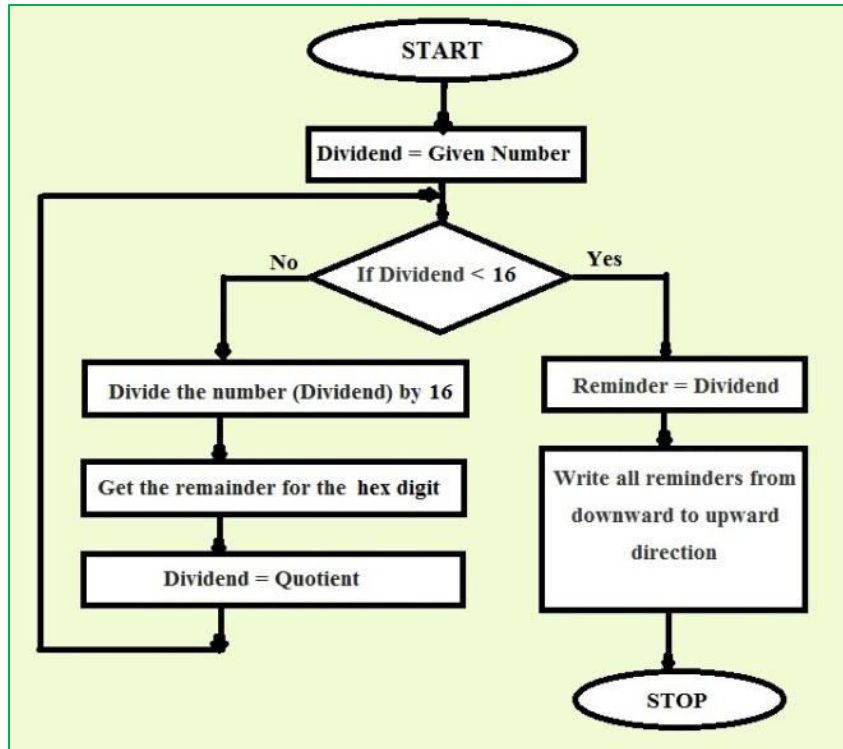
	Divisor	Dividend	Octal No.	Description
Step :1	8	619	3	$8 \times 77 = 616$, quotient is= 77 , and (619-616) remainder is =3
Step :2	8	77	5	$8 \times 9 = 72$, quotient is= 9 , and (77-72) remainder is =5
Step :3	8	9	1	$8 \times 1 = 8$, quotient is= 1 , and (9-8) remainder is =1
Step :4	8	1	1	$1 < 8$, quotient is= 0 , and (1-0) remainder is =1
	--	0	--	Answer: $619_{(10)} = 1153_{(8)}$

Practice questions of decimal to octal conversion

	PRACTICE QUESTIONS	ANSWERES
1	$58_{(10)}$	$72_{(8)}$
2	$105_{(10)}$	$151_{(8)}$
3	$229_{(10)}$	$345_{(8)}$
4	$373_{(10)}$	$565_{(8)}$
5	$524_{(10)}$	$1014_{(8)}$

DECIMAL TO HEXADECIMAL CONVERSION

- Step 1: Given number is Dividend.
- Step 2: If Divide is less than 16, then go to Step 6, 7 and stop, else go to step 3 to 5.
- Step 3: Divide dividend by 16.
- Step 4: Get the remainder for the Hex digit.
- Step 5: Assign quotient to dividend.
- Step 6: Remainder is equal to dividend.
- Step 7: Write Hex number from downward to upward direction and stop.



SOLVED EXAMPLE OF DECIMAL TO BINARY

Q1. $20_{(10)} = ?_{(16)}$

	Description	Reminder
Step :1	$\begin{array}{r} 1 \\ 16 \overline{) 20} \\ \underline{16} \\ 4 \end{array}$ Quotient of Step:1's will become dividend of Step:2 Step:1's reminder	4 ↑
Step :2	$\begin{array}{r} 0 \\ 16 \overline{) 1} \\ \underline{0} \\ 1 \end{array}$ Dividend is less than deviser ($1 < 16$), thus quotient is=0. Dividend as it is deviser (1)	1
Answer: $20_{(10)} = 14_{(16)}$		

	Divisor	Dividend	Octal No.	Description
Step :1	16	20	4 ↑	$16 \times 1 = 16$, quotient is=1, and $(20-16)$ reminder is =4
Step :2	16	1	1	$1 < 16$, quotient is=0, and $(1-0)$ reminder is =1
	--	0	--	Answer: $20_{(10)} = 14_{(16)}$

Q2. $32_{(10)} = ?_{(16)}$

		Description	Reminder
Step :1	$\begin{array}{r} 16 \overline{) 32} \\ \underline{- 32} \\ 0 \end{array}$	Quotient of Step:1's will become dividend of Step:2 Step:1's reminder	0 ↑
Step :2	$\begin{array}{r} 16 \overline{) 2} \\ \underline{- 0} \\ 2 \end{array}$	Dividend is less than deviser ($2 < 16$), thus quotient is=0. Dividend as it is deviser (2)	2
Answer: $32_{(10)} = 20_{(16)}$			

	Divisor	Dividend	Octal No.	Description
Step :1	16	32	0 ↑	$16 \times 2 = 32$, quotient is=2, and $(32-32)$ reminder is =0
Step :2	16	2	2	$2 < 16$, quotient is=0, and $(2-0)$ reminder is =2
	--	0	--	Answer: $32_{(10)} = 20_{(16)}$

Q3. $120_{(10)} = ?_{(16)}$

		Description	Reminder
Step :1	$\begin{array}{r} 16 \overline{) 120} \\ \underline{- 112} \\ 8 \end{array}$	Quotient of Step:1's will become dividend of Step:2 Step:1's reminder	8 ↑
Step :2	$\begin{array}{r} 16 \overline{) 7} \\ \underline{- 0} \\ 7 \end{array}$	Dividend is less than deviser ($7 < 16$), thus quotient is=0. Dividend as it is deviser (7)	7
Answer: $120_{(10)} = 78_{(16)}$			

	Divisor	Dividend	Octal No.	Description
Step :1	16	120	8 ↑	$16 \times 7 = 112$, quotient is=7, and $(120-112)$ reminder is =8
Step :2	16	7	7	$7 < 16$, quotient is=0, and $(7-0)$ reminder is =7
	--	0	--	Answer: $120_{(10)} = 78_{(16)}$

Q4. $619_{(10)} = ?_{(16)}$

	Description	Reminder
Step :1	$\begin{array}{r} 16 \overline{) 619} \\ \underline{608} \\ 11 \end{array}$ Quotient of Step:1's will become dividend of Step:2 Step:1's reminder	11(B)↑
Step :2	$\begin{array}{r} 16 \overline{) 38} \\ \underline{32} \\ 6 \end{array}$ Quotient of Step:2's will become dividend of Step:3 Step:2's reminder	6
Step :3	$\begin{array}{r} 16 \overline{) 2} \\ \underline{0} \\ 2 \end{array}$ Dividend is less than deviser ($2 < 16$), thus quotient is=0. Dividend as it is deviser (2)	2
Answer: $619_{(10)} = 26B_{(16)}$		

	Divisor	Dividend	Octal No.	Description
Step :1	16	619	11(B)↑	$16 \times 38 = 608$, quotient is=38, and $(619-608)$ reminder is =11 (B)
Step :2	16	38	6	$16 \times 2 = 32$, quotient is=2, and $(38-32)$ reminder is =6
Step :3	16	2	2	$2 < 16$, quotient is=0, and $(2-0)$ reminder is =2
	--	0	--	Answer: $619_{(10)} = 26B_{(16)}$

Practice questions of decimal to hexadecimal conversion

	PRACTICE QUESTIONS	ANSWERES
1	$58_{(10)}$	$3A_{(16)}$
2	$105_{(10)}$	$69_{(16)}$
3	$229_{(10)}$	$D5_{(16)}$
4	$373_{(10)}$	$175_{(16)}$
5	$524_{(10)}$	$20C_{(16)}$

CONCLUSION

Number system is the technique to represent and work with numbers. Decimal number system is the most common number system which we used in mathematics and computer science. Other number systems include in computer science are binary number system, octal number system and hexadecimal number system. In this paper I try to represent simple technique to convert decimal to binary, octal and hexadecimal number.

I encourage you to become very familiar with number conversion. I hope you've learned a lot from this article with easy and graphical presentation.

REFERENCES

<https://www.researchgate.net/publication/320677641> Number System

<https://www.tutorialspoint.com>

https://swayam.gov.in/nc_details/NPTEL