



# DATA REPRESENTATION

Based on CBSE curriculum  
Class 11

## Chapter - 13

By-

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# Introduction

- As we know that computer system stores any data in binary form that's why we use to add the word DIGITAL with all the work related to computer. The data stored in computer is known as Digital Data.
- In this chapter we will see various techniques to represent data in a computer system.
- Human beings have adopted Decimal Number System in their day to day life. In the same manner, computer system has adopted Binary Number System, Octal Number System and Hexadecimal Number System which are collectively known as Digital Number System.
- These Number Systems are -

Number Systems		
System	Base	Digits
Binary	2	0 1
Octal	8	0 1 2 3 4 5 6 7
Decimal	10	0 1 2 3 4 5 6 7 8 9
Hexadecimal	16	0 1 2 3 4 5 6 7 8 9 A B C D E F

# Decimal number system

- Decimal system is consists of 10 digits which are as under
  - 0,1,2,3,4,5,6,7,8,9
- Base of this system is 10 and it is to be shown as-
  - $(1249)_{10}$
- This techenique is based on positional value where the weightage of a digit is as per its position. For ex- in number 526, the value of 5 is 500, value of 2 is 20 and value of 6 is 6. (it is as per the method of hundreds , tens and ones).

We can write above given example as-

- $526 = 5 \times 10^2 + 2 \times 10^1 + 6 \times 10^0$
- $25.32 = 2 \times 10^1 + 5 \times 10^0 + 3 \times 10^{-1} + 2 \times 10^{-2}$
- The left most digit is called MSD (Most Significant Digit ).
- The right most digit is called LSD (Least Significant Digit ).

# Binary Number System

- Binary system consists of 2 digits 0,1 known as bit.
- Base of this system is 2 and it is to be shown as  $(1001010101)_2$
- In Digital systems, use of decimal system is impossible therefore use of binary system for a computer system is meaningful. Use of circuit to maintain two voltage level is very easy.
- See the examples of binary number method-
- $1010 = 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$
- $10.11 = 1 \times 2^1 + 0 \times 2^0 + 1 \times 2^{-1} + 1 \times 2^{-2}$
- The left most digit is called MSB (Most Significant Bit ).
- The right most digit is called LSB (Least Significant Bit ).

# Octal Number System

- Octal system consists of 8 digits which are as under-
  - 0,1,2,3,4,5,6,7
- Base of this system is 8 and it is to be shown as
  - $(1675)_8$
- Example to show Octal Number method-
- $147 = 1 \times 8^2 + 4 \times 8^1 + 7 \times 8^0$
- $13.46 = 1 \times 8^1 + 3 \times 8^0 + 4 \times 8^{-1} + 6 \times 8^{-2}$

# Hexadecimal Number System

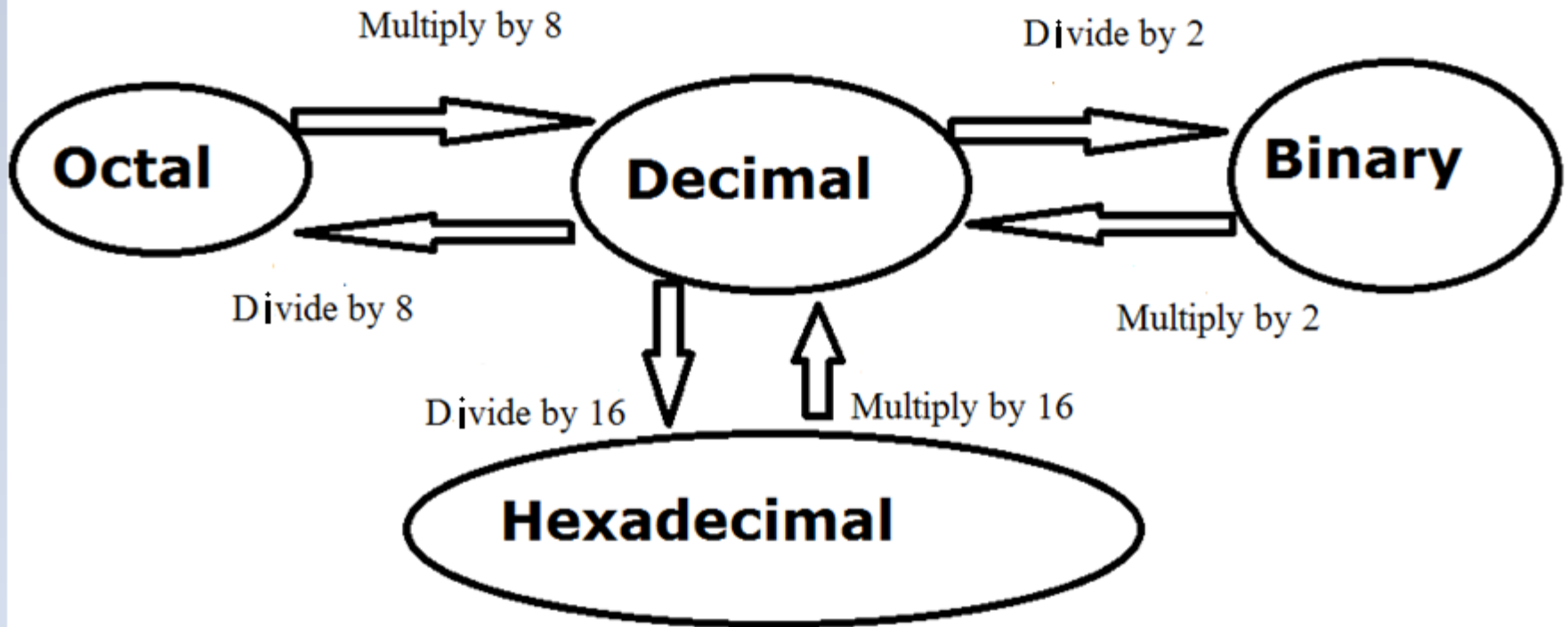
- Hexadecimal system consists of 16 digits which are-  
0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F
- Here A=10, B=11, C=12, D=13, E=14, F=15
- Base of this system is 16 and it is to be shown as
  - $(16A7B5)_{16}$
- Example of Hexadecimal Number method -
- $1A7 = 1 \times 16^2 + 10 \times 16^1 + 7 \times 16^0$
- $1B.A6 = 1 \times 16^1 + 11 \times 16^0 + 10 \times 16^{-1} + 6 \times 16^{-2}$

# Relation between different Number Systems

Hexadecimal	Octal	Decimal	Binary
0	0	0	0000
1	1	1	0001
2	2	2	0010
3	3	3	0011
4	4	4	0100
5	5	5	0101
6	6	6	0110
7	7	7	0111
8	10	8	1000
9	11	9	1001
A	12	10	1010
B	13	11	1011
C	14	12	1100
D	15	13	1101
E	16	14	1110
F	17	15	1111

# Number Conversion

- Follow the following diagram to convert a number from one system to another.





# Decimal to Binary

- For this, decimal value is to be divided by 2 and remainder is to be arranged in order. Quotient is again to be divided by 2 and remainder is to be again kept in order. This process is to be repeated until quotient becomes zero. Remainder is then to be kept in reverse order which results in binary of the given number. (remainder should be either 0 or 1 only).

2	259	Remainder	)-	
2	129	1	LSB	
2	64	1	↑	
2	32	0		
2	16	0		
2	8	0		
2	4	0		
2	2	0		
2	1	0		
	0	1		MSB

$$(259)_{10} = (100000011)_2$$

There is one more method for this.

# Decimal to Binary

You need to develop a table of  $2^n$

$2^n$	n	$2^{-n}$
1	0	1.00000000000000000000000000000000
2	1	0.50000000000000000000000000000000
4	2	0.25000000000000000000000000000000
8	3	0.12500000000000000000000000000000
16	4	0.06250000000000000000000000000000
32	5	0.03125000000000000000000000000000
64	6	0.01562500000000000000000000000000
128	7	0.00781250000000000000000000000000
256	8	0.00390625000000000000000000000000
512	9	0.00195312500000000000000000000000
1024	10	0.00097656250000000000000000000000
2048	11	0.00048828125000000000000000000000
4096	12	0.00024414062500000000000000000000
8192	13	0.00012207031250000000000000000000
16384	14	0.00006103515625000000000000000000
32768	15	0.00003051757812500000000000000000
65536	16	0.00001525878906250000000000000000
131072	17	0.00000762939453125000000000000000
262144	18	0.00000381469726562500000000000000
524288	19	0.00000190734863281250000000000000
1048576	20	0.00000095367431640625000000000000
2097152	21	0.00000047683715820312500000000000
4194304	22	0.00000023841857910156200000000000
8388608	23	0.00000011920928955078100000000000

$2^n$	n	$2^{-n}$
16777216	24	0.00000005960464477539060000000000
33554432	25	0.00000002980232238769530000000000
67108864	26	0.00000001490116119384770000000000
134217728	27	0.00000000745058059692383000000000
268435456	28	0.00000000372529029846191000000000
536870912	29	0.00000000186264514923096000000000
1073741824	30	0.00000000093132257461547900000000

Now, to convert  $(200)_{10}$  to binary-

**Solution-**

In  $2^n$  table, the biggest value lower to 200 is 128

$$128 = 10000000$$

$$200 - 128 = 72, \quad 64 \text{ (lower to 72)} = 1000000$$

$$72 - 64 = 8 = 1000$$

$$\begin{array}{r} \text{total} \\ \hline 200 = 11001000 \end{array}$$

Therefore  $(200)_{10} = (11001000)_2$

# Decimal to Binary

- If decimal value is with fractional part, the method for the integer part will be same as before. Fractional part is to be multiplied by 2 and the digit before (.) is to be written with binary after applying (.). This process is to be repeated until we get the desired result.
- For example- to convert  $(259.25)_{10}$  in to Binary-

2	259	Remainder
2	129	1
2	64	1
2	32	0
2	16	0
2	8	0
2	4	0
2	2	0
2	1	0
	0	1

LSB

MSB

$$(259.25)_{10} = (100000011.01)_2$$

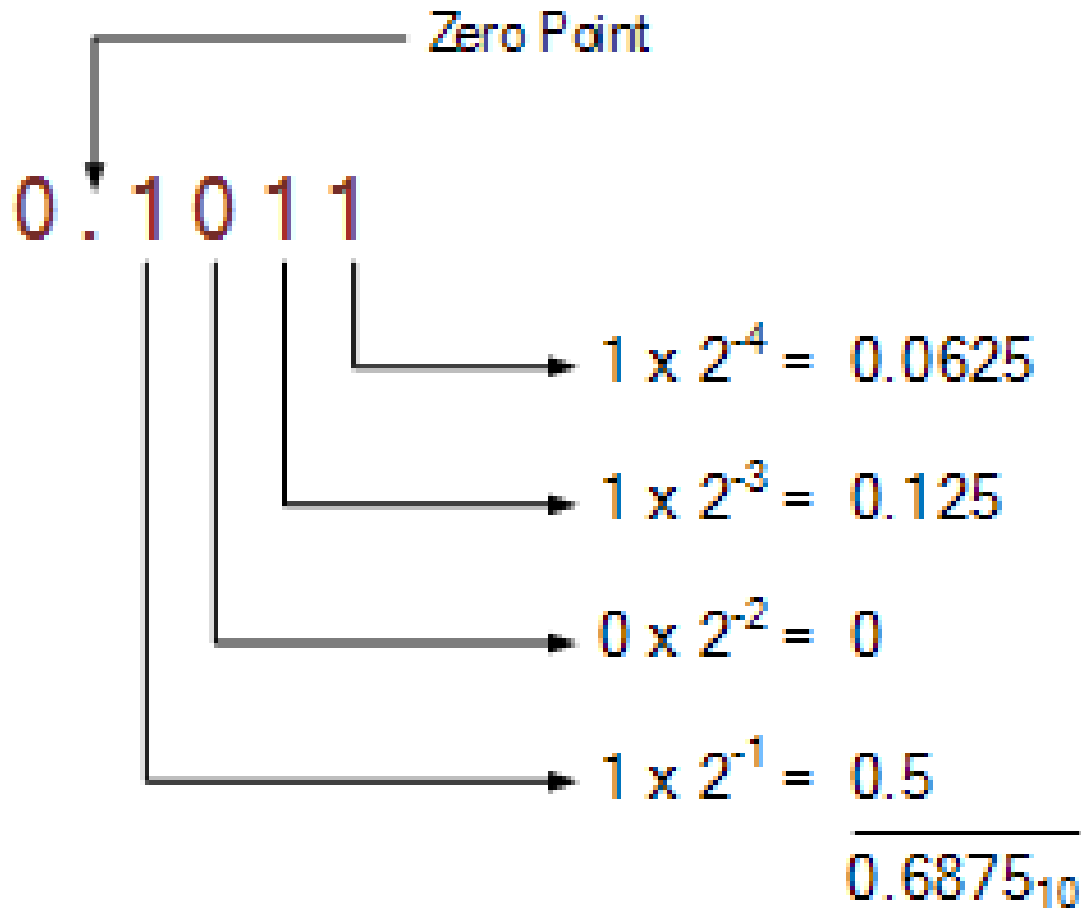
$0.25 \times 2 = \mathbf{0}.50$ , pick the 0 before decimal from here and write with the binary part.

$0.50 \times 2 = \mathbf{1}.00$ , pick the 1 before decimal from here and write with the binary part.



# Binary to Decimal

- To solve binary with fractional part, consider the following example-



# Decimal to Octal

- For this, decimal value is to be divided by 8 and remainder is to be arranged in order. Quotient is again to be divided by 8 and remainder is to be again kept in order. This process is to be repeated until quotient becomes zero. Remainder is then to be kept in reverse order which results in octal of the given number. (remainder should come in between 0 to 7 only.)
- For ex- to convert  $(239)_{10}$  into Octal-

8	239	
8	29	
8	3	
	0	

↑

Read Up

4 ← First Remainder

5 ← Second Remainder

3 ← Third Remainder

$$(239)_{10} = (354)_8$$

$0.513 \times 8 = 4.104$	4	
$0.104 \times 8 = 0.832$	0	
$0.832 \times 8 = 6.656$	6	
$0.656 \times 8 = 5.248$	5	
$0.248 \times 8 = 1.984$	1	

↓

$(0.513)_{10} = (0.40651...)_8$

Complete answer is  $(152.512)_{10} = (230.40651...)_8$

Decimal Number:  $(540.125)_{10}$

8	540	
8	67	4
8	8	3
8	1	0
	0	1

↑

$0.125 \times 8 = 0$  with a carry of 1

$(0.125)_{10} = (0.1)_8$

$(540)_{10} = (1034.1)_8$  Octal Number

# Octal to Decimal

- For this, every digit of octal is multiplied by 8 after applying power as per its position.
- The resultant expression is then to be solved mathematically.
- For ex- to convert 345 octal to decimal \_

$$\begin{aligned} 345 \text{ octal} &= (3 * 8^2) + (4 * 8^1) + (5 * 8^0) \\ &= (3 * 64) + (4 * 8) + (5 * 1) \\ &= 229 \text{ decimal} \end{aligned}$$

- Another example -

$$24.6_8 = 2 \times 8^1 + 4 \times 8^0 + 6 \times 8^{-1} = 20.75_{10}$$

# Decimal to Hexadecimal

- For this, decimal value is to be divided by 16 and remainder is to be arranged in order. Quotient is again to be divided by 16 and remainder is to be again kept in order. This process is to be repeated until quotient becomes zero. Remainder is then to be kept in reverse order which results in hexadecimal of the given number. (remainder should come in between 0 to 15 only). A is to be written for 10, B for 11..... F for 15.

**Find the Hex equivalent for the Decimal 3509**

<i>Divisor</i>	16	3509	5	<i>Remainder</i>	↑ <b>LSD</b>
	16	219	11		
	16	13	13		
		0			
		<i>Quotient</i>			

**MSD - most significant digit**  
**LSD - least significant digit**  
**MSD**  
For Hex value 13 = D, 11 = B & 5 = 5  
Therefore, the equivalent Hex number for decimal 3509 is **DB5**



# Hex to Decimal

- For this, every digit of Hex is multiplied by 16 after applying power as per its position.
- The resultant expression is then to be solved mathematically.

For ex-

$$356_{16} = 3 \times 16^2 + 5 \times 16^1 + 6 \times 16^0 = 768 + 80 + 6 = 854_{10}$$

$$\begin{aligned} 2AF_{16} &= 2 \times 16^2 + 10 \times 16^1 + 15 \times 16^0 \\ &= 512 + 160 + 15 \\ &= 687_{10} \end{aligned}$$

Another example-

$$\begin{aligned} 56.08_{16} &= 5 \times 16^1 + 6 \times 16^0 + 0 \times 16^{-1} + 8 \times 16^{-2} \\ &= 80 + 6 + 0 + 8/256 \\ &= 86 + 0.03125 \\ &= 86.03125 \end{aligned}$$

# Octal $\longleftrightarrow$ binary

- For this, first convert the octal to decimal and then the received decimal to binary.
- Another method is with the help of Octal Table-

Octal	Binary
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

$$(235)_8 = (\underline{0100} \overline{111} \underline{101})_2$$

Every digit of octal is to be replaced by its relevant binary value.

$$\overline{(101110100)}_2 = (564)_8$$

First, combine three-three digits from right and then write their concerned octal value from table.

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

# Hex binary

- For this, first convert the hex to decimal and then the received decimal to binary.
- Another method is with the help of Hex Table-

$$(2A5)_{16} = (001010100101)_2$$

Just write binary of each hex digit at its place.

$$(000101110100)_2 = (174)_{16}$$

First, combine four-four digits from right and then write their concerned hex value from table.

# Octal ↔ Hex

- For this, you can write binary from octal table and then convert it to hex. Reverse the process to convert from hex to octal.
- Another method with table-

Octal	Binary
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

$$(347)_8 = ( \quad )_{16}$$

First convert to binary-

$$(347)_8 = (011100111)_2$$

Now, prepare four digits group from right and write their Hex-

$$(011100111)_2 = (E7)_{16}$$

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

# Binary - Unsigned Integers

- An unsigned integer can be any positive value or 0 (Zero).
- Any negative (-ve) value can't be unsigned integer.
- Unsigned Integer can be from 0 से  $2^n - 1$ .

n (bits)	Minimum Value	Maximum Value
8	0	$2^8-1$ (=255)
16	0	$2^{16}-1$ (=65535)
32	0	$2^{32}-1$ (=4,294,967,295)
64	0	$2^{64}-1$ (=18,446,744,073,709,551,615)

# Binary Addition

- Consider following during Binary Addition-

$$0 + 0 = 0$$

$$0 + 1 = 1$$

$$1 + 0 = 1$$

$1 + 1 = 11$  , important point to notice here is that 1 goes for carry which is to be added with next place bit.

# ASCII Code

- The ability of a computer system to understand signals or letters depends on its character set.
- Character set has its standards known as character set code like - ASCII, ISCII, UNICODE etc.
- ASCII ( American Standard Code for Information Interchange) most of the micro computers, mini computers and some mainframe computers uses this code.
- ASCII code has two versions - ASCII – 7 and ASCII – 8.
- ASCII – 7 code use 7 bits for one signal or character. By this,  $2^7 = 128$  , different characters can be used.
- ASCII – 8 code use 8 bits for one signal or character. By this,  $2^8 = 256$  , different characters can be used.

# ASCII Code

Name	Hex	Dec
.(period)	2E	046
0	30	048
1	31	049
2	32	050
3	33	051
4	34	052
5	35	053
6	36	054
7	37	055
8	38	056
9	39	057

Name	Hex	Dec
A	41	065
B	42	066
C	43	067
D	44	068
E	45	069
F	46	070
G	47	071
H	48	072
I	49	073
J	4A	074
K	4B	075

Name	Hex	Dec
L	4C	076
M	4D	077
N	4E	078
O	4F	079
P	50	080
Q	51	081
R	52	082
S	53	083
T	54	084
U	55	085
V	56	086

Name	Hex	Dec
W	57	087
X	58	088
Y	59	089
Z	5A	090

Characters can be identified by this



# ISCII Code

- Indian Standard Code for Information Interchange is developed in India.
- It identifies signals and characters of almost all Indian languages
- It identifies ASCII script along with subscripts of various Indian languages.
- It also works in the 8 bit group.

~	ओ	!	ँ	@	~	#	\$	°	%	ज्ञ	^	त्र	&	क्ष	*	श्र	(	)	_	:	+ऋ					
'	ो	1		2		3		4		5		6		7		8		9		0	.	=				
	Q	औ	W	ऐ	E	आ	R	ई	T	ऊ	Y	भ	U	ळ	I	घ	O	ध	P	झ	{	ढ	}	ज		ऑ
		ौ	ऐ	आ	ई	ऊ	भ	ह	ग	द	ज	ड	ढ	ञ	ऑ											ँ
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		ौ	ए	अ	इ	उ	प	र	क	त	च	ट														
Shift	Z	ँ	X	°	C	ण	V	न	B	ळ	N	ळ	M	श	<	ष	>		?	य					Shift	
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# Unicode

- This is Universal Character Set which represents a signal or a character in a group of 32 bit.
- It has the capability to include signals and characters from all scripts of all languages of world.
- Before the development of Unicode, various encoding system were in use.
- Problems related to language on internet has been resolved by the use of Unicode.

Unicode uses various encoding systems to represent characters. Like-

1. UTF – 8 (Unicode Transformation Format) – 8
  - a) UTF – 8 – 1 Octet (8 bits) Representation
  - b) UTF – 8 – 2 Octet (16 bits) Representation
  - c) UTF – 8 – 3 Octet (24 bits) Representation
  - d) UTF – 8 – 4 Octet (32 bits) Representation
2. UTF – 32

क	ख	ग	घ	ङ	च	छ	ज	झ	
ka	kha	ga	gha	ṅa	ca	cha	ja	jha	
[k <sup>h</sup> Λ]	[k <sup>h</sup> Λ]	[gΛ]	[g <sup>h</sup> Λ]	[ŋΛ]	[tsΛ]	[ts <sup>h</sup> Λ]	[dzΛ]	[dz <sup>h</sup> Λ]	
ट	ठ	ड	ढ	ण	त	थ	द	ध	न
ṭa	ṭha	ḍa	ḍha	ṇa	ta	tha	da	dha	na
[t <sup>h</sup> Λ]	[t <sup>h</sup> Λ]	[dΛ]	[d <sup>h</sup> Λ]	[ṇΛ]	[tΛ]	[t <sup>h</sup> Λ]	[dΛ]	[d <sup>h</sup> Λ]	[nΛ]
प	फ	ब	भ	म	य	र	ल	व	
pa	pha	ba	bha	ma	ya	ra	la	va	
[pΛ]	[p <sup>h</sup> Λ]	[bΛ]	[b <sup>h</sup> Λ]	[mΛ]	[jΛ]	[rΛ]	[lΛ]	[vΛ]	
श	ष	स	ह	क्ष	त्र	ज्ञ			
śa	ṣa	sa	ha	kṣa	tra	gya			
[ʃΛ]	[ʃΛ]	[sΛ]	[hΛ]	[kʃΛ]	[trΛ]	[gyΛ]			

# Thank you

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