

Caesar cipher

Classical Encryption Techniques

1. Substitution Technique
2. Transposition Technique



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View key concept



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Classical Encryption Technique

Substitution	Transposition
<ul style="list-style-type: none">❖ Caesar Cipher ←❖ Monoalphabetic Substitution❖ Playfair Cipher❖ Hill Cipher❖ Polyalphabetic Ciphers❖ One-Time Pad	<ul style="list-style-type: none">❖ Rail Fence❖ Row Column Transposition



Caesar Cipher

- ★ Letters are replaced by other letters or symbols.
- ★ The earlier known and simplest method used be Julius Caesar.
- ★ Replacing each letter of the alphabet with the letter standing three places further down the alphabet.

Example:

0	1	2	3	4	5	6	7	8	9	10	11	12
A	B	C	D	E	F	G	H	I	J	K	L	M

13	14	15	16	17	18	19	20	21	22	23	24	25
N	O	P	Q	R	S	T	U	V	W	X	Y	Z



Caesar Cipher

Algorithm:

For each plaintext letter 'p', substitute the ciphertext letter 'C':

$$C = E(p, k) \text{ mod } 26 = (p + k) \text{ mod } 26$$

$$p = D(C, k) \text{ mod } 26 = (C - k) \text{ mod } 26$$

0	1	2	3	4	5	6	7	8	9	10	11	12
A	B	C	D	E	F	G	H	I	J	K	L	M

13	14	15	16	17	18	19	20	21	22	23	24	25
N	O	P	Q	R	S	T	U	V	W	X	Y	Z



View key concept



Caesar Cipher – Example

Question: Encrypt “neso academy” using Caesar cipher.

Solution:

n	e	s	o	a	c	a	d	e	m	y

$$C = (p + k) \bmod 26$$

0	1	2	3	4	5	6	7	8	9	10	11	12
A	B	C	D	E	F	G	H	I	J	K	L	M
13	14	15	16	17	18	19	20	21	22	23	24	25
N	O	P	Q	R	S	T	U	V	W	X	Y	Z



Caesar Cipher – Example

Question: Encrypt “neso academy” using Caesar cipher.

Solution:

n	e	s	o	a	c	a	d	e	m	y
Q										

$$C = (p + k) \bmod 26$$

$$C = (13 + 3) \bmod 26$$

$$C = 16 \bmod 26 \rightarrow$$

$$C = 16$$

$$C = Q$$

0	1	2	3	4	5	6	7	8	9	10	11	12
A	B	C	D	E	F	G	H	I	J	K	L	M
13	14	15	16	17	18	19	20	21	22	23	24	25
N	O	P	Q	R	S	T	U	V	W	X	Y	Z



Caesar Cipher – Example

Question: Encrypt “neso academy” using Caesar cipher.

Solution:

n	e	s	o	a	c	a	d	e	m	y
Q	H	V	R	D	F	D	G	H	P	B

$$C = (p + k) \bmod 26$$

$$C = (24 + 3) \bmod 26$$

$$C = 27 \bmod 26$$

$$C = 1$$

$$C = B$$

0	1	2	3	4	5	6	7	8	9	10	11	12
A	B	C	D	E	F	G	H	I	J	K	L	M
13	14	15	16	17	18	19	20	21	22	23	24	25
N	O	P	Q	R	S	T	U	V	W	X	Y	Z

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Shift Cipher

Key = 2, 3, 4, 5, . . .

Shift Cipher with Key = 3 is called Caesar Cipher.

Example:

Plaintext : Neso

Key : 4

Ciphertext : RIWS

0	1	2	3	4	5	6	7	8	9	10	11	12
A	B	C	D	E	F	G	H	I	J	K	L	M
13	14	15	16	17	18	19	20	21	22	23	24	25
N	Q	P	Q	R	S	T	U	V	W	X	Y	Z



Caesar Cipher – Pros and Cons

Pros

1. Simple
2. Easy to implement.

Cons

1. The encryption and decryption algorithms are known.
2. There are only 25 keys to try. (Vulnerable to Brute-force attack)
3. The language of the plaintext is known and easily recognizable.



Brute force attack

Ciphertext: SQDYMZK

Shifts	Back	Result	Shifts	Back	Result
0	[26]	SQDYMZK	13	[13]	FDQLZMX
1	[25]	TREZNAL	14	[12]	GERMANY
2	[24]	USFAOBM	15	[11]	HFSNBOZ
3	[23]	VTGBPCN	16	[10]	IGTOCPA
4	[22]	WUHCQDO	17	[9]	JHUPDQB
5	[21]	XVIDREP	18	[8]	KIVQERC
6	[20]	YWJESFQ	19	[7]	LJWRFSD
7	[19]	ZXKFTGR	20	[6]	MKXSGTE
8	[18]	AYLGUHS	21	[5]	NLYTHUF
9	[17]	BZMHVIT	22	[4]	OMZUIVG
10	[16]	CANIWJU	23	[3]	PNAVJWH
11	[15]	DBOJXKV	24	[2]	QOBWKXI
12	[14]	ECPKYLW	25	[1]	RPCXLJY
13	[13]	FDQLZMX			



Vignere Cipher

Classical Encryption Technique

Substitution	Transposition
<ul style="list-style-type: none">❖ Caesar Cipher❖ Monoalphabetic Cipher❖ Playfair Cipher❖ Hill Cipher❖ Polyalphabetic Ciphers❖ One-Time Pad	<ul style="list-style-type: none">❖ Rail Fence❖ Row Column Transposition



Polyalphabetic Cipher

- ★ To improve on the simple monoalphabetic technique.
- ★ General name: Polyalphabetic substitution cipher.

Common features

1. A set of related monoalphabetic substitution rules is used.
2. A key determines which particular rule is chosen for a given transformation.



Vigenere Cipher

- ★ It consists of the 26 Caesar ciphers with shifts of 0 through 25.

Encryption process:

$$C_i = (P_i + K_{i \bmod m}) \bmod 26$$

Decryption process:

$$P_i = (C_i - K_{i \bmod m}) \bmod 26$$



Vigenere Cipher

Key : deceptivedeceptivedeceptive

Plaintext : wearediscoveredsaveyourself

Ciphertext : ZICVTWQNGRZGVTWAVZHCQYGLMGJ



Vigenere Cipher

Key : deceptivedeceptivedeceptive

Plaintext : wearediscoveredsaveyourself

Ciphertext : ZICVTWQNGRZGVTWAVZHCQYGLMGJ

Key	3	4	2	4	15	19	8	21	4	3	4	2	4
PT	22	4	0	17	4	3	8	18	2	14	21	4	17
CT													

Key	15	19	8	21	4	3	4	2	4	15	19	8	21	4
PT	4	3	18	0	21	4	24	14	20	17	18	4	11	5
CT														



Vigenere Cipher

Key : deceptivedeceptivedeceptive

Plaintext : wearediscoveredsaveyourself

Ciphertext : ZICVTWQNGRZGVTWAVZHCQYGLMGJ

Key	3	4	2	4	15	19	8	21	4	3	4	2	4
PT	22	4	0	17	4	3	8	18	2	14	21	4	17
CT	25												

Key	15	19	8	21	4	3	4	2	4	15	19	8	21	4
PT	4	3	18	0	21	4	24	14	20	17	18	4	11	5
CT														



Vigenere Cipher

Key : deceptivedeceptivedeceptive

Plaintext : wearediscoveredsaveyourself

Ciphertext : ZICVTWQNGRZGVTWAVZHCQYGLMGJ

Key	3	4	2	4	15	19	8	21	4	3	4	2	4
PT	22	4	0	17	4	3	8	18	2	14	21	4	17
CT	25	8	2	21	19	22	16	13	6	17	25	6	21

Key	15	19	8	21	4	3	4	2	4	15	19	8	21	4
PT	4	3	18	0	21	4	24	14	20	17	18	4	11	5
CT	19	22	0	21	25	7	2	16	24	6	11	12	6	9



Vigenere Cipher – Cryptanalysis

- ★ Determining the length of the keyword.
- ★ Key and the plaintext share the same frequency distribution of letters, a statistical technique can be applied.



Autokey system

- ★ The periodic nature of the keyword can be eliminated by using a non-repeating keyword that is as long as the message itself.
- ★ Vigenère proposed autokey system, in which a keyword is concatenated with the plaintext itself to provide a running key.

Example

Key : deceptivewearediscoveredsav

Plaintext : wearediscoveredsaveyourself

Ciphertext : ZICVTWQNGKZEIIGASXSTSLVVWLA
 ↓



Affine Cipher

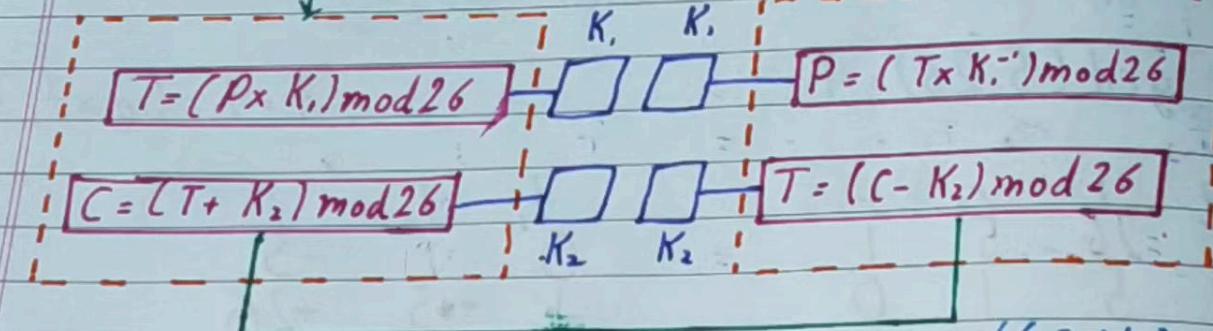
Affine Cipher

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Date _____
Page _____

Plain text

Cipher text



$$\text{Encryption: } C = ((P \times K_1) + K_2) \bmod 26 \quad \text{Decryption: } ((C - K_2) \times K_1^{-1}) \bmod 26$$

Q) Encrypt & Decrypt "hello" with keys (7,2).

$K_1 = 7$

$K_2 = 2$

Affine Cipher

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Date _____
Page _____

Plain text

Cipher text

$$T = (P \times K_1) \bmod 26$$

$$C = (T + K_2) \bmod 26$$

A B C D E F
O I 2 3 4 5

G H I J K L
6 7 8 9 10 11

M N O P Q R
12 13 14 15 16 17

S T U V W X
18 19 20 21 22 23

Q) Encrypt & Decrypt "hell"

$$K_1 = 7$$

$$K_2 = 2$$

Plain text = h e l y = 24 z = 25

$$C = (T + K_2) \bmod 26$$

K_1 K_2

M N O P
12 13 14 15

$$\text{Encryption: } C = ((P \times K_1) + K_2) \bmod 26$$

Decr. S T U V
18 19 20 21

Q Encrypt & Decrypt "hello" with

$$y = 24$$

$$K_1 = 7 \quad K_2 = 2$$

Plain text = h e l l o
7 4 11 11 14
P₁ P₂ P₃

$$T_1 = (7 \times 7) \bmod 26$$

$$T_2 = (4 \times 7) \bmod 26$$

$$T_3 = (11 \times 7) \bmod 26$$

$$T_4 = (11 \times 7) \bmod 26$$

$$T_5 = (14 \times 7) \bmod 26 =$$

$$C = (T + K_1) \bmod 26$$

$$C = ((P \times K_1) + K_2) \bmod 26$$

$$\text{Encryption: } C = ((P \times K_1) + K_2) \bmod 26 \quad \text{Decr.}$$

Q Encrypt & Decrypt "hello" with

$$K_1 = 7 \quad K_2 = 2$$

M N O P
12 13 14 15

S T U V
18 19 20 21

$$y = 24$$

$$\begin{array}{c} \text{Plain text} = h \ e \ l \ l \ o \\ \quad 7 \ 4 \ 11 \ 11 \ 14 \\ \quad P_1 \ P_2 \ P_3 \ P_4 \ P_5 \end{array}$$

$$T_1 = (7 \times 7) \bmod 26 = 23$$

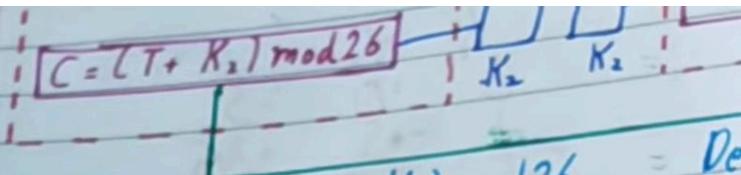
$$T_2 = (4 \times 7) \bmod 26 = 2$$

$$T_3 = (11 \times 7) \bmod 26 = 25$$

$$T_4 = (11 \times 7) \bmod 26 = 25$$

$$T_5 = (14 \times 7) \bmod 26 = 20$$

$$C = (T + K_2) \bmod 26$$



M N O P
12 13 14 15

S T U V
18 19 20 21

$$\text{Encryption: } C = ((P \times K_1) + K_2) \bmod 26$$

Decr

Q Encrypt & Decrypt "hello" with

y = 24

$$K_1 = 7 \quad K_2 = 2$$

Plain text = h e l l o
7 4 11 11 14
P₁ P₂ P₃ P₄ P₅

$$T_1 = (7 \times 7) \bmod 26 = 23 + 2 = 25 = Z$$

$$T_2 = (4 \times 7) \bmod 26 = 2 + 2 = 4 = E$$

$$T_3 = (11 \times 7) \bmod 26 = 25 + 2 = 27 = B \quad (2)$$

$$T_4 = (11 \times 7) \bmod 26 = 25 + 2 = 27 = B \quad (2)$$

$$T_5 = (14 \times 7) \bmod 26 = 20 + 2 = 22 = W$$

Plain text = h e l l o
P₁ P₂ P₃ P₄ P₅

$$\begin{aligned}T_1 &= (7 \times 7) \bmod 26 = 23 + 2 = 25 &= Z \\T_2 &= (4 \times 7) \bmod 26 = 2 + 2 = 4 &= E \\T_3 &= (11 \times 7) \bmod 26 = 25 + 2 = 27 &= B \\T_4 &= (11 \times 7) \bmod 26 = 25 + 2 = 27 &= G \\T_5 &= (14 \times 7) \bmod 26 = 20 + 2 = 22 &= W\end{aligned}$$

Decryption

$$K_1 = 7$$

$$K_2 = 2$$

$$K^{-1} = ?$$

$$\begin{aligned}T'_1 &= (25-2) \bmod 26 = 23 \\T'_2 &= (4-2) \bmod 26 = 2 \\T'_3 &= (1-2) \bmod 26 = 25 \\T'_4 &= (1-2) \bmod 26 = 25 \\T'_5 &= (22-2) \bmod 26 = 20\end{aligned}$$

$$\begin{aligned}7^{-1} \bmod 26 \\7 \times x \bmod 26 = 1\end{aligned}$$

Plain Text = $\begin{matrix} h & e & l & l & o \\ P_1 & P_2 & P_3 & P_4 & P_5 \end{matrix}$

$$\begin{aligned} T_1 &= (7 \times 7) \bmod 26 = 23 + 2 = 25 &= Z \\ T_2 &= (4 \times 7) \bmod 26 = 2 + 2 = 4 &= E \\ T_3 &= (11 \times 7) \bmod 26 = 25 + 2 = 27 &= B \\ T_4 &= (11 \times 7) \bmod 26 = 25 + 2 = 27 &= G \\ T_5 &= (14 \times 7) \bmod 26 = 20 + 2 = 22 &= W \end{aligned}$$

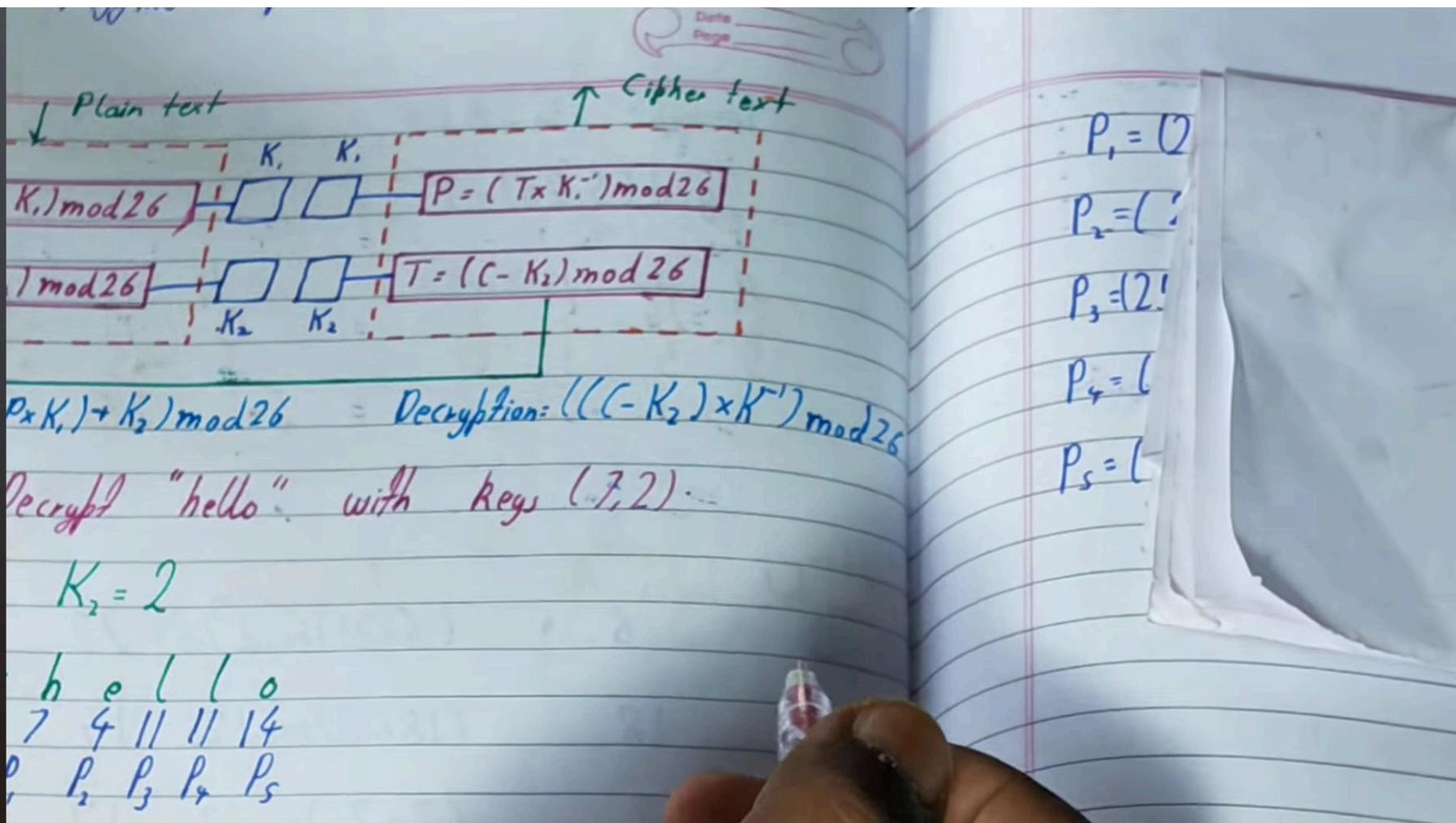
Decryption

$$K_1 = 7 \quad K_2 = 2$$

$$K^{-1} = ?$$

$$\begin{aligned} T_1 &= (25-2) \bmod 26 = 23 \\ T_2 &= (4-2) \bmod 26 = 2 \\ T_3 &= (1-2) \bmod 26 = 25 \\ T_4 &= (1-2) \bmod 26 = 25 \\ T_5 &= (22-2) \bmod 26 = 20 \end{aligned}$$

$$\begin{aligned} 7^{-1} \bmod 26 \\ 7 \times x \bmod 26 = 1 \\ \frac{105}{105} \end{aligned}$$



$\hat{P}_1 \hat{P}_2 \hat{P}_3 \hat{P}_4 \hat{P}_5$

$$\begin{aligned} T_1 &= (7 \times 7) \bmod 26 = 49 \bmod 26 = 23 + 2 = 25 = Z \\ T_2 &= (4 \times 7) \bmod 26 = 28 \bmod 26 = 2 + 2 = 4 = E \\ T_3 &= (11 \times 7) \bmod 26 = 77 \bmod 26 = 25 + 2 = 27 = B \quad (27 \bmod 26) \\ T_4 &= (11 \times 7) \bmod 26 = 77 \bmod 26 = 25 + 2 = 27 = B \quad (27 \bmod 26) \\ T_5 &= (14 \times 7) \bmod 26 = 98 \bmod 26 = 20 + 2 = 22 = W \end{aligned}$$

Decryption

$$K_1 = 7$$

$$K_2 = 2$$

$$T_1 = (25-2) \bmod 26 = 23$$

$$K^{-1} = ?$$

$$T_2 = (4-2) \bmod 26 = 2$$

$$T_3 = (1-2) \bmod 26 = 25$$

$$7^{-1} \bmod 26$$

$$T_4 = (1-2) \bmod 26 = 25$$

$$7x \bmod 26 = 1 \quad x = ?$$

$$T_5 = (22-2) \bmod 26 = 20$$

$$\cancel{7 \mid 105} \quad \cancel{105 \mid 13}$$

ext

$T \xrightarrow{K_1} K_1^{-1} \xrightarrow{K_2} P = (T \times K_1^{-1}) \text{mod } 26$

$T \xrightarrow{K_2} K_2^{-1} \xrightarrow{K_1} T = (C - K_2) \text{mod } 26$

d26 Decryption: $((-K_2) \times K_1^{-1}) \text{mod } 26$

"lo" with Regs (7,2)

$$P_1 = (23 \times 15) \text{mod } 26 = 7$$

$$P_2 = (2 \times 15) \text{mod } 26 = 4$$

$$P_3 = (25 \times 15) \text{mod } 26 = 11$$

$$P_4 = (25 \times 15) \text{mod } 26 = 11$$

$$P_5 = (20 \times 15) \text{mod } 26 = 14$$

0

4

7

2

12:27 PM

4G

Row column Transposition Cipher

Classical Encryption Technique

Substitution	Transposition
<ul style="list-style-type: none">❖ Caesar Cipher❖ Monoalphabetic Cipher❖ Playfair Cipher❖ Hill Cipher❖ Polyalphabetic Ciphers❖ One-Time Pad	<ul style="list-style-type: none">❖ Rail Fence❖ Row Column Transposition



Row Column Transposition

- ★ A more complex scheme.
- ★ Rectangle.
- ★ Write : Row by row.
- ★ Read : Column by column.
- ★ Key : Order of the column



Row Column Transposition

Example: Encrypt the message "Kill Corona Virus at twelve am tomorrow"



Row Column Transposition

Plaintext : "Kill Corona Virus at twelve am tomorrow"

K	i	l	I	c	o	r
o	n	a	v	i	r	u
s	a	t	t	w	e	l
v	e	a	m	t	o	m
o	r	r	o	w		



Row Column Transposition

Plaintext : "Kill Corona Virus at twelve am tomorrow"

Plaintext (Input) →

K	i	l		c	o	r
o	n	a	v	i	r	u
s	a	t	t	w	e	
v	e	a	m	t	o	m
o	r	r	o	w	y	z



Row Column Transposition

Plaintext : "Kill Corona Virus at twelve am tomorrow"

Key → 4 3 1 2 5 6 7

Plaintext (Input) →

K	i	l	I	c	o	r
o	n	a	v	i	r	u
s	a	t	t	w	e	l
v	e	a	m	t	o	m
o	r	r	o	w	y	z



Row Column Transposition

Plaintext : "Kill Corona Virus at twelve am tomorrow"

Key → 4 3 1 2 5 6 7

Plaintext (Input) →

K	i	l	l	c	o	r
o	n	a	v	i	r	u
s	a	t	t	w	e	l
v	e	a	m	t	o	m
o	r	r	o	w	y	z

Ciphertext: LATARLVTMOINAERKOSVOCIWTWOREOYRULMZ
NESO ACADEMY



$$35/7=5$$

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LATARLVTMOINAERKOSVOCIWTWOREOYRULMZ

LATAR key 1

LVTMO key 2

INAER key 3

KOSVO key 4

CIWTW key 5

OREOY key 6

RULMZ key 7

4 3 1 2 5 6 7

K T L L C O R

O N A V I R U

S A T T W E L ← decrypted

V E A M T O M

O R R O W Y Z

**Columnar
Transposition
(Very similar
to Row-column
transposition)**



Column Cipher

=> Use the key "ENCRYPT" to encrypt
the Plaintext "Save the king from attack".

Sol:

E N C R Y P T
2 3 1 5 7 4 6

a f
b g
c h
d i
e j
f k
g l
h m
i n
j o
k p
l q
m r
n s
o t
p u
q v
r w
s x
t y
u z



Column Cipher

=> USE the Key "ENCRYPT" to encrypt
the Plaintext "Save the king from attack".

Sol:

H	E	T	S	R	Z	C	T	P	T	G	E	O	K
F	2	S	a	i	o	U	R	Y	T	+	f	r	c
T	1	R	m	n	t	V	S	Y	7	+t	a	e	k
E	3	A	a	o	+	N	E	7	+	f	c	o	h
S	4	I	m	a	t	G	T	4	7	+	a	e	o
R	5	A	n	o	+	O	T	4	7	+	c	o	k
Z	6	I	t	o	+	A	G	4	7	+	r	e	h
C	7	M	a	o	+	T	E	4	7	+	a	o	k
T	8	A	m	o	+	S	T	4	7	+	c	e	h
E	9	H	a	o	+	R	E	4	7	+	r	o	k
O	10	R	h	o	+	E	G	4	7	+	a	e	h
K	11	E	c	o	+	T	O	4	7	+	c	o	k
G	12	T	g	o	+	G	E	4	7	+	r	e	h
E	13	G	e	o	+	E	T	4	7	+	a	o	k
O	14	E	o	o	+	T	G	4	7	+	c	e	h
K	15	E	h	o	+	G	E	4	7	+	r	o	k
H	16	E	h	o	+	E	T	4	7	+	a	o	k
A	17	E	h	o	+	G	E	4	7	+	c	e	h
M	18	E	h	o	+	T	G	4	7	+	r	o	k
A	19	E	h	o	+	E	T	4	7	+	a	o	k
I	20	E	h	o	+	G	E	4	7	+	c	e	h
O	21	E	h	o	+	T	G	4	7	+	r	o	k
A	22	E	h	o	+	E	T	4	7	+	a	o	k
M	23	E	h	o	+	G	E	4	7	+	c	e	h
A	24	E	h	o	+	T	G	4	7	+	r	o	k
H	25	E	h	o	+	E	T	4	7	+	a	o	k
E	26	E	h	o	+	G	E	4	7	+	c	e	h
T	27	E	h	o	+	T	G	4	7	+	r	o	k
G	28	E	h	o	+	E	T	4	7	+	a	o	k
E	29	E	h	o	+	G	E	4	7	+	c	e	h
O	30	E	h	o	+	T	G	4	7	+	r	o	k
K	31	E	h	o	+	E	T	4	7	+	a	o	k
H	32	E	h	o	+	G	E	4	7	+	c	e	h
A	33	E	h	o	+	T	G	4	7	+	r	o	k
M	34	E	h	o	+	E	T	4	7	+	a	o	k
A	35	E	h	o	+	G	E	4	7	+	c	e	h
H	36	E	h	o	+	T	G	4	7	+	r	o	k
E	37	E	h	o	+	E	T	4	7	+	a	o	k
T	38	E	h	o	+	G	E	4	7	+	c	e	h
G	39	E	h	o	+	T	G	4	7	+	r	o	k
E	40	E	h	o	+	E	T	4	7	+	a	o	k
O	41	E	h	o	+	G	E	4	7	+	c	e	h
K	42	E	h	o	+	T	G	4	7	+	r	o	k
H	43	E	h	o	+	E	T	4	7	+	a	o	k
A	44	E	h	o	+	G	E	4	7	+	c	e	h
M	45	E	h	o	+	T	G	4	7	+	r	o	k
A	46	E	h	o	+	E	T	4	7	+	a	o	k
H	47	E	h	o	+	G	E	4	7	+	c	e	h
E	48	E	h	o	+	T	G	4	7	+	r	o	k
T	49	E	h	o	+	E	T	4	7	+	a	o	k
G	50	E	h	o	+	G	E	4	7	+	c	e	h
E	51	E	h	o	+	T	G	4	7	+	r	o	k
O	52	E	h	o	+	E	T	4	7	+	a	o	k
K	53	E	h	o	+	G	E	4	7	+	c	e	h
H	54	E	h	o	+	T	G	4	7	+	r	o	k
A	55	E	h	o	+	E	T	4	7	+	a	o	k
M	56	E	h	o	+	G	E	4	7	+	c	e	h
A	57	E	h	o	+	T	G	4	7	+	r	o	k
H	58	E	h	o	+	E	T	4	7	+	a	o	k
E	59	E	h	o	+	G	E	4	7	+	c	e	h
T	60	E	h	o	+	T	G	4	7	+	r	o	k
G	61	E	h	o	+	E	T	4	7	+	a	o	k
E	62	E	h	o	+	G	E	4	7	+	c	e	h
O	63	E	h	o	+	T	G	4	7	+	r	o	k
K	64	E	h	o	+	E	T	4	7	+	a	o	k
H	65	E	h	o	+	G	E	4	7	+	c	e	h
A	66	E	h	o	+	T	G	4	7	+	r	o	k
M	67	E	h	o	+	E	T	4	7	+	a	o	k
A	68	E	h	o	+	G	E	4	7	+	c	e	h
H	69	E	h	o	+	T	G	4	7	+	r	o	k
E	70	E	h	o	+	E	T	4	7	+	a	o	k
T	71	E	h	o	+	G	E	4	7	+	c	e	h
G	72	E	h	o	+	T	G	4	7	+	r	o	k
E	73	E	h	o	+	E	T	4	7	+	a	o	k
O	74	E	h	o	+	G	E	4	7	+	c	e	h
K	75	E	h	o	+	T	G	4	7	+	r	o	k
H	76	E	h	o	+	E	T	4	7	+	a	o	k
A	77	E	h	o	+	G	E	4	7	+	c	e	h
M	78	E	h	o	+	T	G	4	7	+	r	o	k
A	79	E	h	o	+	E	T	4	7	+	a	o	k
H	80	E	h	o	+	G	E	4	7	+	c	e	h
E	81	E	h	o	+	T	G	4	7	+	r	o	k
T	82	E	h	o	+	E	T	4	7	+	a	o	k
G	83	E	h	o	+	G	E	4	7	+	c	e	h
E	84	E	h	o	+	T	G	4	7	+	r	o	k
O	85	E	h	o	+	E	T	4	7	+	a	o	k
K	86	E	h	o	+	G	E	4	7	+	c	e	h
H	87	E	h	o	+	T	G	4	7	+	r	o	k
A	88	E	h	o	+	E	T	4	7	+	a	o	k
M	89	E	h	o	+	G	E	4	7	+	c	e	h
A	90	E	h	o	+	T	G	4	7	+	r	o	k
H	91	E	h	o	+	E	T	4	7	+	a	o	k
E	92	E	h	o	+	G	E	4	7	+	c	e	h
T	93	E	h	o	+	T	G	4	7	+	r	o	k
G	94	E	h	o	+	E	T	4	7	+	a	o	k
E	95	E	h	o	+	G	E	4	7	+	c	e	h
O	96	E	h	o	+	T	G	4	7	+	r	o	k
K	97	E	h	o	+	E	T	4	7	+	a	o	k
H	98	E	h	o	+	G	E	4	7	+	c	e	h
A	99	E	h	o	+	T	G	4	7	+	r	o	k
M	100	E	h	o	+	E	T	4	7	+	a	o	k
A	101	E	h	o	+	G	E	4	7	+	c	e	h
H	102	E	h	o	+	T	G	4	7	+	r	o	k
E	103	E	h	o	+	E	T	4	7	+	a	o	k
T	104	E	h	o	+	G	E	4	7	+	c	e	h
G	105	E	h	o	+	T	G	4	7	+	r	o	k
E	106	E	h	o	+	E	T	4	7	+	a	o	k
O	107	E	h	o	+	G	E	4	7	+	c	e	h
K	108	E	h	o	+	T	G	4	7	+	r	o	k
H	109	E	h	o	+	E	T	4	7	+	a	o	k
A	110	E	h	o	+	G	E	4	7	+	c	e	h
M	111	E	h	o	+	T	G	4	7	+	r	o	k
A	112	E	h	o	+	E	T	4	7	+	a	o	k
H	113	E	h	o	+	G	E	4	7	+	c	e	h
E	114	E	h	o	+	T	G	4	7	+	r	o	k
T	115	E	h	o	+	E	T	4	7	+	a	o	k
G	116	E	h	o	+	G	E	4	7	+	c	e	h
E	117	E	h	o	+	T	G	4	7	+	r	o	k
O	118	E	h	o	+	E	T	4	7	+	a	o	k
K	119	E	h	o	+	G	E	4	7	+	c	e	h
H	120	E	h	o	+	T	G	4	7	+	r	o	k
A	121	E	h	o	+	E	T	4	7	+	a	o	k
M	122	E	h	o	+	G	E	4	7	+	c	e	h
A	123	E	h	o	+	T	G	4	7	+	r	o	k
H	124	E	h	o	+	E	T	4	7	+	a	o	k
E	125	E	h	o	+	G	E	4	7	+	c	e	h
T	126	E	h	o	+	T	G	4	7	+	r	o	k
G	127	E	h	o	+	E	T	4	7	+	a	o	k
E	128	E	h	o	+	G	E	4	7	+	c	e	h
O	129	E	h	o	+	T	G	4	7	+	r	o	k
K	130	E	h	o	+	E	T	4	7	+	a	o	k
H	131	E	h	o	+	G	E	4	7	+	c	e	h
A	132	E	h	o	+	T	G	4	7	+	r	o	k
M	133	E	h	o	+	E	T	4	7	+	a	o	k
A	134	E	h	o	+	G	E	4	7	+	c	e	h
H	135	E	h	o	+	T	G	4	7	+	r	o	k
E	136	E	h	o	+	E	T	4	7	+	a	o	k
T	137	E	h	o	+	G	E	4	7	+	c	e	h
G	138	E	h	o	+	T	G	4	7	+	r	o	k
E	139	E	h	o	+	E	T	4	7	+	a	o	k
O	140	E	h	o	+	G	E	4	7	+	c	e	h
K	141	E	h	o	+	T	G	4	7	+	r	o	k
H	142	E	h	o	+	E	T	4	7	+	a	o	k
A	143	E	h	o	+	G	E	4	7	+	c	e	h
M	144	E	h	o	+	T	G	4	7	+	r	o	k
A	145	E	h	o	+	E	T	4	7	+	a	o	k
H	146	E	h	o	+	G	E	4	7	+	c	e	h
E	147	E	h	o	+	T	G	4	7	+	r	o	k
T	148	E	h	o	+	E	T	4	7	+	a	o	k</

~~a b c d e f g h i j k l m n o p q r s t u v w x y z~~