Batch: **Roll No.: 16010121045**

Experiment No.: 1

Title: Encryption-Decryption programs using classical cryptography

Objective:

To write a program to convert plain text into cipher text using Caesar cipher and Transposition cipher.

Expected Outcome of Experiment:

CO	Outcome
1	Explain fundamentals of Information Security and cryptography

Books/ Journals/ Websites referred:

https://www.britannica.com/topic/transposition-cipher

Abstract:-

In this experiment we need to write programs to encrypt the plaintext into ciphertext and to decrypt the ciphertext back to the plaintext using Caesar cipher and Transposition cipher.

Related Theory:

Substitutional Cipher:

A. Caesar Cipher

The earliest known, and the simplest, use of a substitution cipher was by Julius Caesar.

The Caesar cipher involves replacing each letter of the alphabet with the letter standing three places further down the alphabet.

For example,

```
plain:  meet me after the toga party
cipher: PHHW PH DIWHU WKH WRJD SDUWB
```

Note that the alphabet is wrapped around, so that the letter following Z is A.

We can define the transformation by listing all possibilities, as follows:

```
plain:  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
cipher: D E F G H I J K L M N O P Q R S T U V W X Y Z A B C
```

Let us assign a numerical equivalent to each letter:

a	b	c	d	e	f	g	h	i	j	k	l	m
0	1	2	3	4	5	6	7	8	9	10	11	12

n	o	p	q	r	s	t	u	v	w	x	y	z
13	14	15	16	17	18	19	20	21	22	23	24	25

The algorithm can be expressed as follows. For each plaintext letter p, substitute the ciphertext letter C:

$C = E(3, p) = (p + 3) \bmod 26$

A shift may be of any amount, so the general Caesar algorithm is

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

where k takes on a value in the range 1 to 25.

The decryption algorithm is simply

$$p = D(k, C) = (C - k) \bmod 26$$

If it is known that a given cipher text is a Caesar cipher, then a brute-force cryptanalysis is easily performed. Simply try all the 25 possible keys.

B. Play fair cipher:

Playfair cipher is an encryption algorithm to encrypt or encode a message. It is the same as a traditional cipher. The only difference is that it encrypts a **digraph** (a pair of two letters) instead of a single letter.

It initially creates a key-table of 5*5 matrix. The matrix contains alphabets that act as the key for encryption of the plaintext. Note that any alphabet should not be repeated. Another point to note that there are 26 alphabets and we have only 25 blocks to put a letter inside it. Therefore, one letter is excess so, a letter will be omitted (usually J) from the matrix. Nevertheless, the plaintext contains J, then **J** is replaced by **I**. It means treat I and J as the same letter, accordingly.

Since Playfair cipher encrypts the message **digraph by digraph**. Therefore, the Playfair cipher is an example of a **digraph substitution cipher**.

Encryption

1. First, split the plaintext into **digraphs** (pair of two letters). If the plaintext has the odd number of letters, append the letter **Z** at the end of the plaintext. It makes the plaintext of **even** For example, the plaintext **MANGO** has five letters. So, it is not possible to make a digraph. Since, we will append a letter **Z** at the end of the plaintext, i.e. **MANGOZ.**

2. After that, break the plaintext into **digraphs** (pair of two letters). If any letter appears twice (side by side), put **X** at the place of the second occurrence. Suppose, the plaintext is **COMMUNICATE** then its digraph becomes **CO MX MU NI CA TE**. Similarly, the digraph for the plaintext **JAZZ** will be **JA ZX ZX**, and for plaintext **GREET**, the digraph will be **GR EX ET.**

3. To determine the cipher (encryption) text, first, build a 5*5 key-matrix or key-table and filled it with the letters of alphabets, as directed below:

- Fill the first row (left to right) with the letters of the given keyword (**ATHENS**). If the keyword has duplicate letters (if any) avoid them. It means a letter will be considered only once. After that, fill the remaining letters in alphabetical order. Let's create a 5*5 key-matrix for the keyword **ATHENS**.

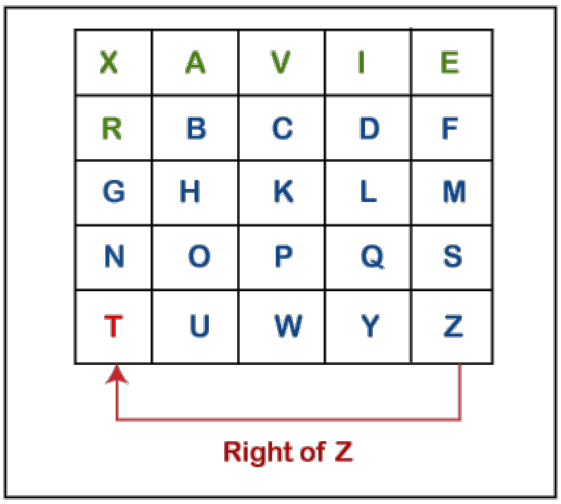
A	T	H	E	N
S	B	C	D	F
G	I/J	K	L	M
O	P	Q	R	U
V	W	X	Y	Z

Note that in the above matrix any letter is not repeated. The letters in the first row (in green color) represent the keyword and the remaining letters sets in alphabetical order.

4. There may be the following three conditions:

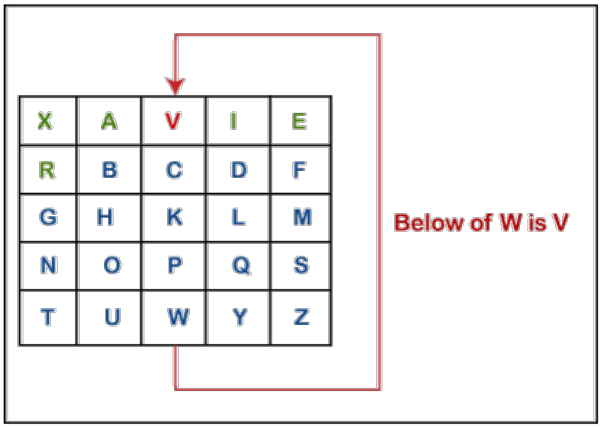
i) If a pair of letters (digraph) appears in the same row

In this case, replace each letter of the digraph with the letters immediately to their right. If there is no letter to the right, consider the first letter of the same row as the right letter. Suppose, **Z** is a letter whose right letter is required, in such case, **T** will be right to Z.



ii) If a pair of letters (digraph) appears in the same column

In this case, replace each letter of the digraph with the letters immediately below them. If there is no letter below, wrap around to the top of the same column. Suppose, **W** is a letter whose below letter is required, in such case, **V** will be below W.



iii) If a pair of letters (digraph) appears in a different row and different column

In this case, select a 3*3 matrix from a 5*5 matrix such that pair of letters appear in the 3*3 matrix. Since they occupy two opposite corners of a square within the matrix. The other corner will be a cipher for the given digraph.

In other words, we can also say that intersection of H and Y will be the cipher for the first letter and

Suppose, a digraph is **HY** and we have to find a cipher for it. We observe that both H and Y are placed in different rows and different columns. In such cases, we have to select a 3*3 matrix in such a way that both H and Y appear in the 3*3 matrix (highlighted with yellow color). Now, we will consider only the selected matrix to find the cipher.

X	A	V	I	E
R	B	C	D	F
G	H	K	L	M
N	O	P	Q	S
T	U	W	Y	Z

Now to find the cipher for HY, we will consider the diagonal **opposite** to HY, i.e. **LU.** Therefore, the cipher for **H** will be **L,** and the cipher for **Y** will be **U**.

X	A	V	I	E
R	B	C	D	F
G	H	K	L	M
N	O	P	Q	S
T	U	W	Y	Z

Decryption

Suppose, the plaintext is **COMMUNICATION** and the key that we will use to encipher the plaintext is **COMPUTER**. The key can be any word or phrase. Let's encipher the message **COMMUNICATION**.

1. First, split the plaintext into digraph (by rule 2) i.e. **CO MX MU NI CA TE**.

2. Construct a 5*5 key-matrix (by rule 3). In our case, the key is **COMPUTER**.

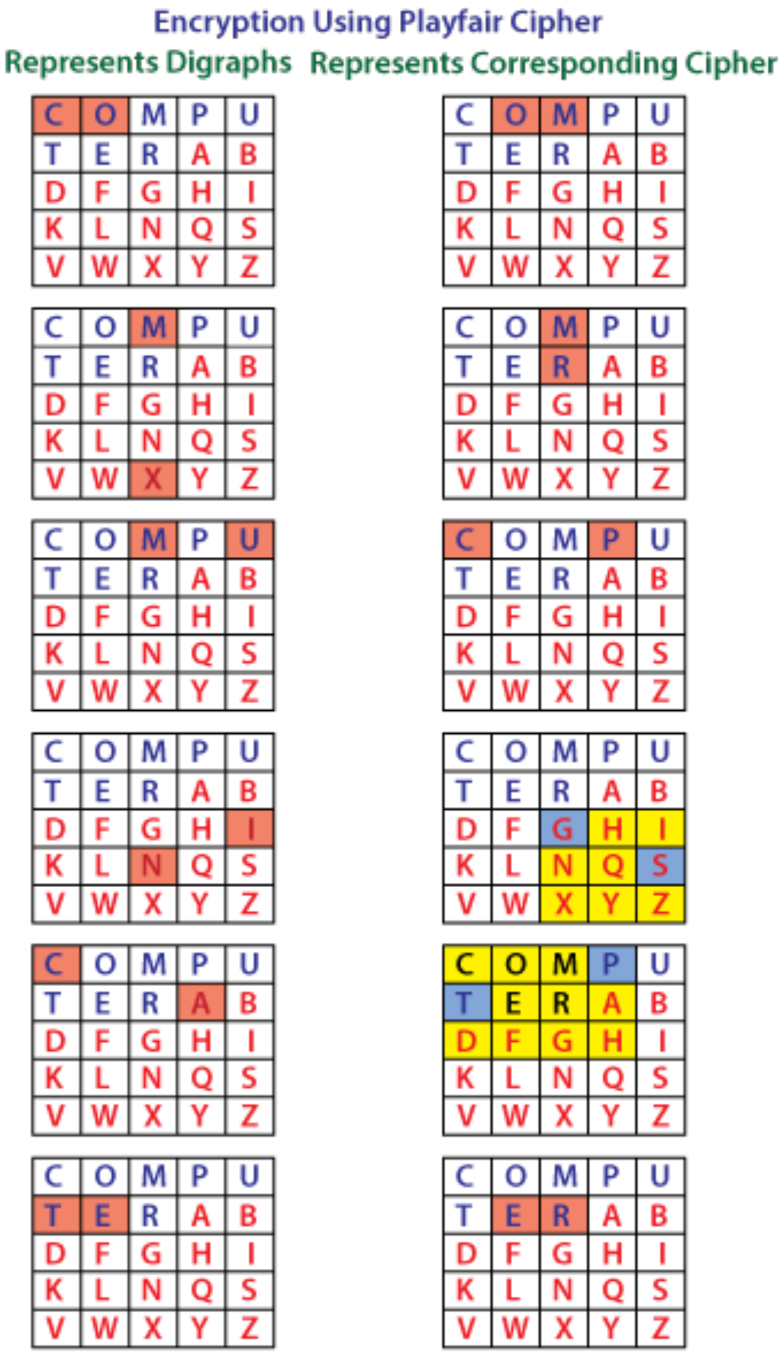
C	O	M	P	U
T	E	R	A	B
D	F	G	H	I
K	L	N	Q	S
V	W	X	Y	Z

3. Now, we will traverse in key-matrix pair by pair and find the corresponding encipher for the pair.

- The first digraph is **CO**. The pair appears in the same row. By using **Rule 4(i) CO** gets encipher into **OM**.
- The second digraph is **MX**. The pair appears in the same column. By using **Rule 4(ii) MX** gets encipher into **RM**.
- The third digraph is **MU**. The pair appears in the same row. By using **Rule 4(i) MU** gets encipher into **PC**.
- The fourth digraph is **NI**. The pair appears in different rows and different columns. By using **Rule 4(iii) NI** gets encipher into **SG**.

- The fifth digraph is **CA**. The pair appears in different rows and different columns. By using **Rule 4(iii) CA** gets encipher into **PT**.
- The sixth digraph is **TE**. The pair appears in the same row. By using **Rule 4(i) TE** gets encipher into **ER**.

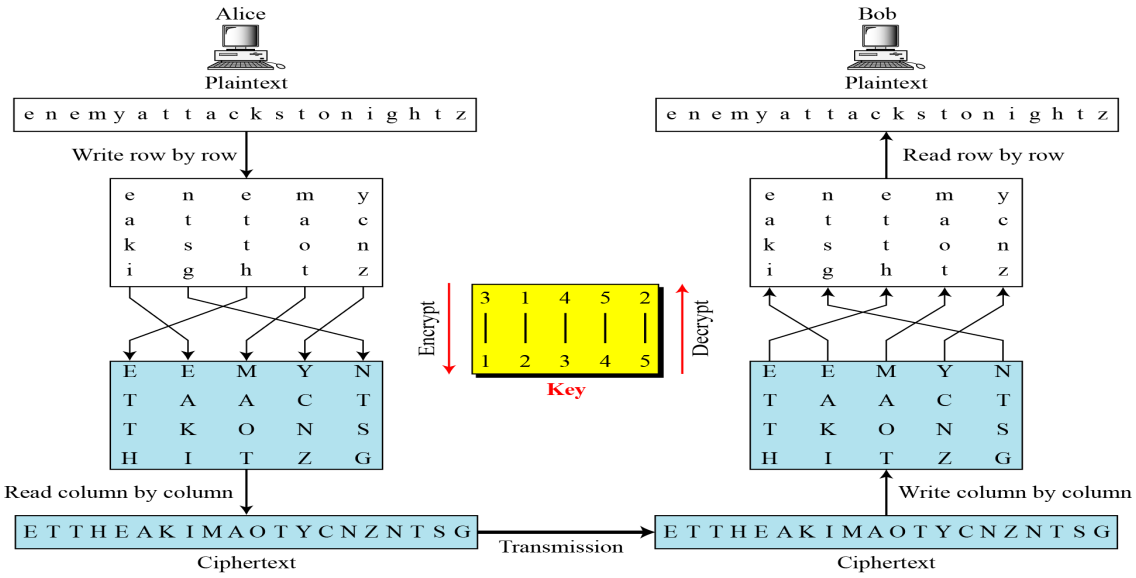
Therefore, the plaintext **COMMUNICATE** gets encipher (encrypted) into **OMRMPCSGPTER.**



Transposition cipher

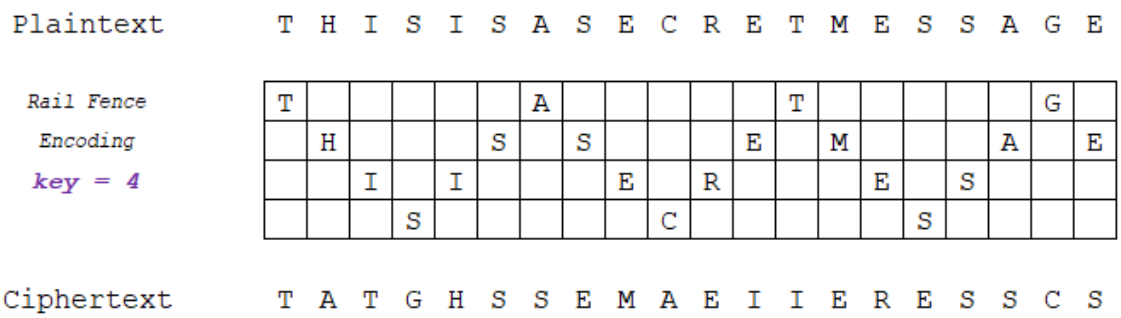
A. Columnar Cipher:

The logic behind transposition cipher is as shown in the given figure:



B. Rail Fence Cipher:

The logic behind Rail Fence cipher is as shown in the given figure:



Implementation Details:

Code:

Rail fence Cipher

```
def encrypt(msg, key):
    arr = [['\n' for i in range(key)]for j in
range(len(msg))]
    dir = True
    j = 0
    for i in range(len(msg)):
        arr[i][j] = msg[i]
        if (j == key-1):
            dir = False
        elif (j == 0):
            dir = True
        if (dir):
            j += 1
        else:
            j -= 1
    eMsg = ''
    for j in range(key):
        for i in range(len(msg)):
            if (arr[i][j] != '\n'):
                eMsg += arr[i][j]
    return eMsg


def decrypt(eMsg, key):
    arr = [['\n' for i in range(key)]for j in
range(len(eMsg))]
    dir = True
    j = 0
    for i in range(len(eMsg)):
        arr[i][j] = '#'
        if j == 0:
            dir = True
        elif j == key-1:
            dir = False
```

```
        if dir:
            j += 1
        else:
            j -= 1
    msg = ''
    pos = 0
    for j in range(key):
        for i in range(len(eMsg)):
            if (arr[i][j] == '#'):
                arr[i][j] = eMsg[pos]
                pos += 1

    j = 0
    for i in range(len(eMsg)):
        msg += arr[i][j]
        if (j == 0):
            dir = True
        elif (j == key-1):
            dir = False
        if (dir):
            j += 1
        else:
            j -= 1
    return msg
print('''Select an Option
      (1) Encrypt Using Rail Fence Cipher
      (2) Decrypt Using Rail Fence Cipher
      (3) Exit''')
n = input()
msg = input('Enter Message: ')
key = int(input('Enter Key: '))
if (n == '1'):
    print("Encrypted Message:", encrypt(msg, key))
elif (n == '2'):
    pass
    print("Decrypted Message:", decrypt(msg, key))
else:
    print("Quitting application")
```

Columnar Keyed cipher

```
import math

def eSorting(key, seq):
    sortedKey = ''.join(sorted(key))
    for i in range(len(key)):
        seq.append(key.find(sortedKey[i]))

def dSorting(key, seq):
    sortedKey = ''.join(sorted(key))
    for i in range(len(key)):
        seq.append(sortedKey.find(key[i]))

def encrypt(msg, key):
    x = int(len(key))  # No of columns
    y = int(math.ceil((len(msg)/len(key))))  # No of rows
    arr = [['\n' for i in range(x)]for j in range(y)]
    padding = 'ABCDEFGHIJKLMNOPQRSTUVWXYZ'
    pos, pPos = 0, 0
    for i in range(y):
        for j in range(x):
            try:
                arr[i][j] = msg[pos]
                pos += 1
            except:
                arr[i][j] = padding[pPos]
                pPos += 1
    seq = []
    eSorting(key, seq)
    eMsg = ''
    for i in seq:
        for j in range(y):
            eMsg += arr[j][i]
    return eMsg


def decrypt(msg, key):
    x = int(len(key))  # No of columns
```

```
    y = int(math.ceil((len(msg)/len(key))))  # No of rows
    arr = [['\n' for i in range(x)]for j in range(y)]
    pos = 0
    for i in range(x):
        for j in range(y):
            arr[j][i] = msg[pos]
            pos += 1
    seq = []
    dSorting(key, seq)
    dMsg = ''
    for i in range(y):
        for j in seq:
            dMsg += arr[i][j]
    return dMsg


print('''Select an Option
      (1) Encrypt Using Columnar Fence Cipher
      (2) Decrypt Using Columnar Fence Cipher
      (3) Exit''')
n = input()
msg = input('Enter Message: ').upper()
key = input('Enter Keyword: ').upper()
if (n == '1'):
    try:
        print("Encrypted Message:", encrypt(msg, key))
    except:
        print("The Give Message cannot be encrypted using the
given key")
elif (n == '2'):
    try:
        print("Decrypted Message:", decrypt(msg, key))
    except:
        print("The Give Message cannot be decrypted using the
given key")
else:
    print("Quitting application")
```

Sample Output screenshots:

Rail Fence Cipher

```
pargat@Pargats-MacBook-Air AC % python3 -u "/Use
Select an Option
      (1) Encrypt Using Rail Fence Cipher
      (2) Decrypt Using Rail Fence Cipher
      (3) Exit
1
Enter Message: Hello World this is Pargat!
Enter Key: 3
Encrypted Message: Hort Pael ol hsi agtlWdisr!
pargat@Pargats-MacBook-Air AC % python3 -u "/Use
Select an Option
      (1) Encrypt Using Rail Fence Cipher
      (2) Decrypt Using Rail Fence Cipher
      (3) Exit
2
Enter Message: Hort Pael ol hsi agtlWdisr!
Enter Key: 4
Decrypted Message: HPsiiaoe salr grtotll!W  hd
pargat@Pargats-MacBook-Air AC % python3 -u "/Use
Select an Option
      (1) Encrypt Using Rail Fence Cipher
      (2) Decrypt Using Rail Fence Cipher
      (3) Exit
2
Enter Message: Hort Pael ol hsi agtlWdisr!
Enter Key: 3
Decrypted Message: Hello World this is Pargat!
pargat@Pargats-MacBook-Air AC %
```

Columnar Cipher

```
pargat@Pargats-MacBook-Air AC % python3 -u "/Users/
Select an Option
      (1) Encrypt Using Columnar Fence Cipher
      (2) Decrypt Using Columnar Fence Cipher
      (3) Exit
1
Enter Message: Hello world this is Pargat!
Enter Keyword: SINGH
Encrypted Message: LRHSGBOLI ACEW  A!LOTIRAH DSPT
pargat@Pargats-MacBook-Air AC % python3 -u "/Users/
Select an Option
      (1) Encrypt Using Columnar Fence Cipher
      (2) Decrypt Using Columnar Fence Cipher
      (3) Exit
2
Enter Message: LRHSGBOLI ACEW  A!LOTIRAH DSPT
Enter Keyword: jake
The Give Message cannot be decrypted using the give
pargat@Pargats-MacBook-Air AC % python3 -u "/Users/
Select an Option
      (1) Encrypt Using Columnar Fence Cipher
      (2) Decrypt Using Columnar Fence Cipher
      (3) Exit
2
Enter Message: LRHSGBOLI ACEW  A!LOTIRAH DSPT
Enter Keyword: SINGH
Decrypted Message: HELLO WORLD THIS IS PARGAT!ABC
pargat@Pargats-MacBook-Air AC %
```

Vlab:

Solve the following using TOOL given below:

- Encrypt the following plain text using key k = 7.
  Plain Text : Lord Rama was a good king.
- Given a plain text and its corresponding cipher text, find out the key used for the encryption of the plain text.

  Plain Text : abcdefghijklmnopqrstuvwxyz
  Cipher Text : TDNUCBZROHLGYVFPWIXSEKAMQJ

- How many different keys are possible with an n-letter alphabet?
- Given a cipher text, find out the corresponding plain text using brute force attack.
  Cipher text : HAAHJR HA KHDU

Ans 1)

svyk yhth dhz h nvvk rpun.

Ans 2)

The Given Combination for Plain Text and Cypher Text is not a Shift Cipher. Hence there is no shift key for the problem.

Ans 3)

25 keys are possible for any shift cipher as there are only 26 alphabets in the English language that we can shift around.

Ans 4)

ATTACK AT DAWN.

Conclusion:-

Learnt about the various techniques which can be used to Encrypt and Decypt a given plain or Cypher Text.