Security Lab T21
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**Aim:**
Breaking shift cipher and Mono-alphabetic Substitution Cipher using Frequency analysis method.

## LO Mapping: LO1

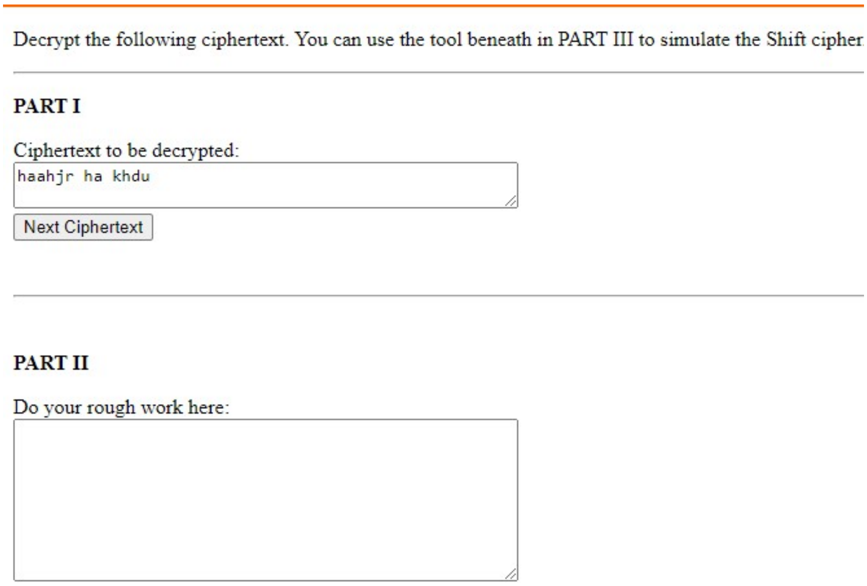
## Theory:

## Symmetric Cryptography:

- In cryptography, symmetric cryptography is a type of encryption where a single secret key is used for both encryption and decryption.
- The sender encrypts the message (plaintext) with the key, resulting in ciphertext (unreadable form).
- The receiver, who possesses the same key, can decrypt the ciphertext back to the original plaintext message.

## Shift Cipher:

- A Shift cipher is a very basic substitution cipher, a classic example of a symmetric cipher.
- It works by shifting each letter in the plaintext a fixed number of positions down the alphabet.



Decrypt the following ciphertext. You can use the tool beneath in PART III to simulate the Shift cipher

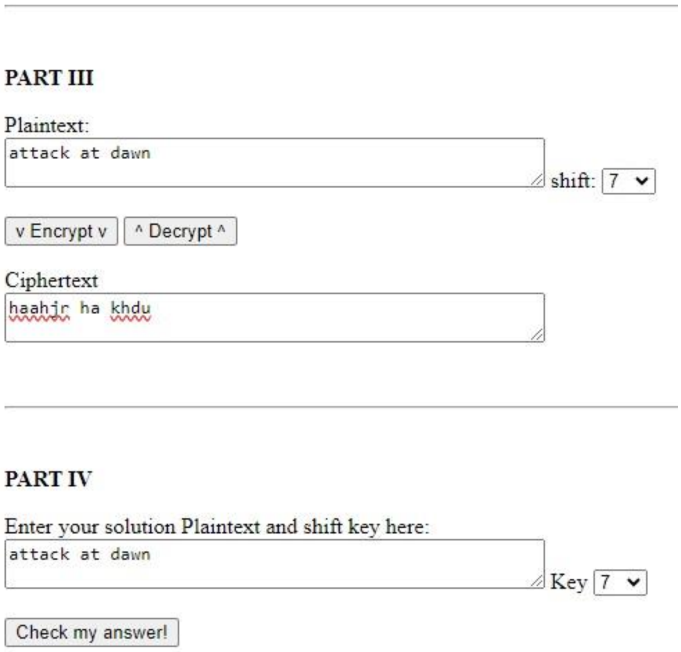
**PART I**

Ciphertext to be decrypted:

```
haahjr ha khdu
```

**PART II**

Do your rough work here:



PART III

Plaintext:

attack at dawn

shift: 7

Ciphertext

haahjr ha khdu

PART IV

Enter your solution Plaintext and shift key here:

attack at dawn

Key 7

Hence we discovered that every letter in the ciphertext was shifted by 7 and we used that to decrypt the cipher and get the original message.

## Frequency Analysis:

- This is a cryptanalysis technique used to break ciphers by analyzing the frequency of letters in the ciphertext.
- The English language has a well-known distribution of letter frequencies, with letters like 'e' and 't' appearing more often than others.
- By comparing the letter frequencies in the ciphertext to the expected frequencies in English, cryptanalysts can try to identify the shift value used in the Caesar cipher.

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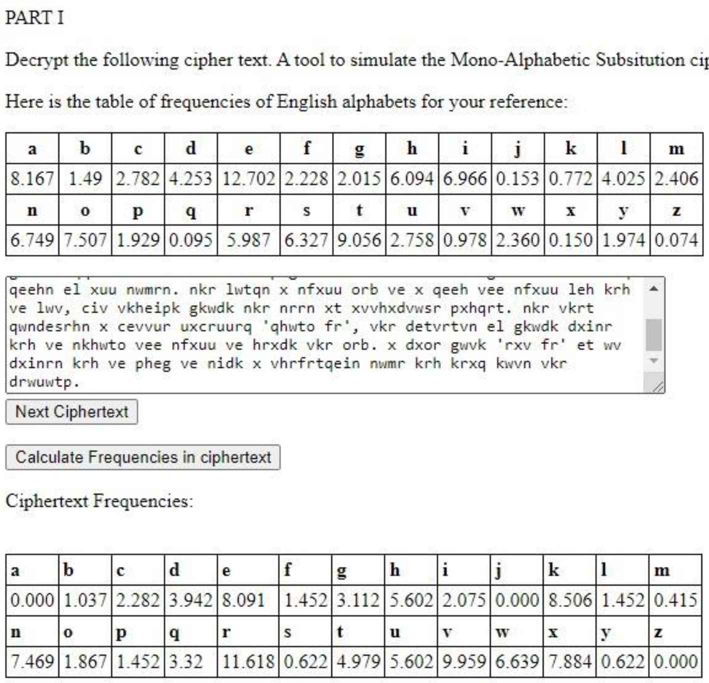


PART I

Decrypt the following cipher text. A tool to simulate the Mono-Alphabetic Subsitution cipher is provided beneath for your assistance.

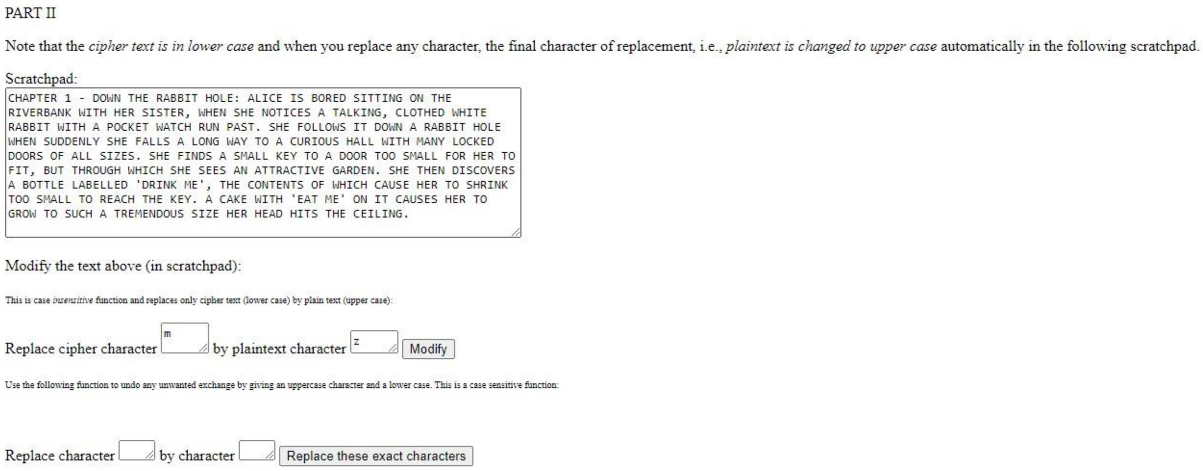
Here is the table of frequencies of English alphabets for your reference:

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **a** | **b** | **c** | **d** | **e** | **f** | **g** | **h** | **i** | **j** | **k** | **l** | **m** |
| 8.167 | 1.49 | 2.782 | 4.253 | 12.702 | 2.228 | 2.015 | 6.094 | 6.966 | 0.153 | 0.772 | 4.025 | 2.406 |
| **n** | **o** | **p** | **q** | **r** | **s** | **t** | **u** | **v** | **w** | **x** | **y** | **z** |
| 6.749 | 7.507 | 1.929 | 0.095 | 5.987 | 6.327 | 9.056 | 2.758 | 0.978 | 2.360 | 0.150 | 1.974 | 0.074 |

```
qeehn el xuu nwmrn. nkr lwtqn x nfxuu orb ve x qeeh vee nfxuu leh krh
ve lwv, civ vkheipk gkwdk nkr nrrn xt xvvhxdvwsr pxhqrt. nkr vkrt
qwndesrhn x cevvur uxcruurq 'qhwto fr', vkr detvrtvn el gkwdk dxinr
krh ve nkhwto vee nfxuu ve hrxdk vkr orb. x dxor gwvk 'rxv fr' et wv
dxinrn krh ve pheg ve nidk x vhrfrtqein nwmr krh krxq kwvn vkr
drwuwtp.
```

Ciphertext Frequencies:

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **a** | **b** | **c** | **d** | **e** | **f** | **g** | **h** | **i** | **j** | **k** | **l** | **m** |
| 0.000 | 1.037 | 2.282 | 3.942 | 8.091 | 1.452 | 3.112 | 5.602 | 2.075 | 0.000 | 8.506 | 1.452 | 0.415 |
| **n** | **o** | **p** | **q** | **r** | **s** | **t** | **u** | **v** | **w** | **x** | **y** | **z** |
| 7.469 | 1.867 | 1.452 | 3.32 | 11.618 | 0.622 | 4.979 | 5.602 | 9.959 | 6.639 | 7.884 | 0.622 | 0.000 |



PART II

Note that the *cipher text is in lower case* and when you replace any character, the final character of replacement, i.e., *plaintext is changed to upper case* automatically in the following scratchpad.

Scratchpad:

```
CHAPTER 1 - DOWN THE RABBIT HOLE: ALICE IS BORED SITTING ON THE
RIVERBANK WITH HER SISTER, WHEN SHE NOTICES A TALKING, CLOTHED WHITE
RABBIT WITH A POCKET WATCH RUN PAST. SHE FOLLOWS IT DOWN A RABBIT HOLE
WHEN SUDDENLY SHE FALLS A LONG WAY TO A CURIOUS HALL WITH MANY LOCKED
DOORS OF ALL SIZES. SHE FINDS A SMALL KEY TO A DOOR TOO SMALL FOR HER TO
FIT, BUT THROUGH WHICH SHE SEES AN ATTRACTIVE GARDEN. SHE THEN DISCOVERS
A BOTTLE LABELLED 'DRINK ME', THE CONTENTS OF WHICH CAUSE HER TO SHRINK
TOO SMALL TO REACH THE KEY. A CAKE WITH 'EAT ME' ON IT CAUSES HER TO
GROW TO SUCH A TREMENDOUS SIZE HER HEAD HITS THE CEILING.
```

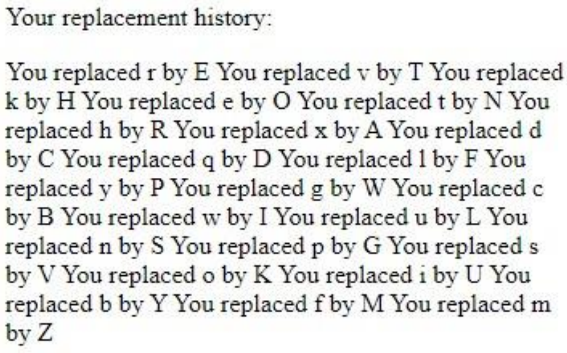
Modify the text above (in scratchpad):

This is case *insensitive* function and replaces only cipher text (lower case) by plain text (upper case):

Replace cipher character m by plaintext character z

Use the following function to undo any unwanted exchange by giving an uppercase character and a lower case. This is a case sensitive function:

Replace character by character



Your replacement history:

You replaced r by E You replaced v by T You replaced k by H You replaced e by O You replaced t by N You replaced h by R You replaced x by A You replaced d by C You replaced q by D You replaced l by F You replaced y by P You replaced g by W You replaced c by B You replaced w by I You replaced u by L You replaced n by S You replaced p by G You replaced s by V You replaced o by K You replaced i by U You replaced b by Y You replaced f by M You replaced m by Z

From this we figured out which letter in cipher was mapped to which letter and were able to decrypt the original message.

## Conclusion:

In conclusion, frequency analysis is a powerful tool for breaking both shift ciphers and mono-alphabetic substitution ciphers. By analyzing the frequency of letters and comparing them to known language frequency distributions, we can effectively reverse-engineer the encryption. This method exploits the inherent weaknesses in these ciphers, particularly their lack of variation in letter substitution, making them vulnerable to cryptographic attacks.