Lab Report

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Information Security
M. Hamza Gohar

Lab #1

OBJECTIVE:

To encode and decode a group of digits using **Ceaser Cipher**

DESCRIPTION:

The **Caesar cipher** is a simple encryption technique used in cryptography. It works by shifting each letter in the plaintext by a fixed number of positions in the alphabet.

Formulas:

For encryption

C= E (k,p) = (p+k) Mod

26 For decryption

P= D (k,C) = (C-k) Mod 26

Code:

```
text=str(input("Enter the string that you want to

convert")) key=int(input("Enter the key"))

EncodingDecoding=input("Select e for encoding and d for

decoding") if (EncodingDecoding =="e"):

  def encoding(text,key):

    result=""

    for i in range(len(text)):

      char=text[i]

      if char.isupper():

        # for capital letters

        result+=chr((ord(char) + key -65)%26+65) # ord() returns the unicode of a character
```

```
      else:
        #for small letters

        result+=chr((ord(char)+key -

        97)%26+97)


    return result


  print(encoding(text,key))


#_


elif (EncodingDecoding =="d"):

  def decoding(text,key):

    result=""

    for i in range(len(text)):

      char=text[i]

      if char.isupper():

        # for capital letters

        result+=chr((ord(char) - key -65)%26+65) # ord() returns the unicode of a character


      else:

        # for small letters

        result+=chr((ord(char)- key -97)%26+97)
    return result


  print(decoding(text,key))
```

```
else:
  print("Plz select correct coding pattern")
```

Output:

For capital letters encoding

```
Enter the digit that you want to convertZUBAIR
Enter the key3
Select e for encoding and d for decodinge
CXEDLU
```

For capital letters decoding

```
Enter the digit that you want to convertCXEDLU
Enter the key3
Select e for encoding and d for decodingd
ZUBAIR
```

For small letters encoding

```
Enter the digit that you want to convertzubair
Enter the key3
Select e for encoding and d for decodinge
cxedlu
```

For small letters decoding

```
Enter the digit that you want to convertcxedlu
Enter the key3
Select e for encoding and d for decodingd
zubair
```

Lab #2

Objective:
To convert plain text to cipher text using **Playfair Cipher**

Description:

- The **key word** is converted to a 5x5 matrix with no repeating words and I and J occupy the same space in the matrix
- There are no repeating words in that matrix

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

- But here since we cant represent a 5x5 matrix using simple python we will store the keyword and remaining alphabets in a list (array)
- We will mimic the behavior of 5x5 matrix in array with the help of following formulas
  Row=index//5 // rounds down the numbers after decimal point in python
  Column=index%5
- In the code we will make all the keywords uppercase and replace I with J to keep consistency
- Now for **Plain Text** we need to create pairs for the whole sentence if there are any spaces those spaces will be excluded and the pairs will be made of 2 words
- If a letter repeats itself side by side we will add X to it
  e.g. HELLO in this case LL => LX,LO
- If there are odd number of letters then we will add X to the letter remaining at the end
  e.g. LOL => LO,LX
- Now locate the **pairs** we created from plain text in our array from upper formulas
- If they are in the same rows we will have to move right by using following formulas

  Row1 *5 +
  (column1+1)%5 Row2 *5
  + (column2+1)%5
- If they are in the same column then we will move down by using following formulas

((Row1 +1)%5)*5 + column1 ((Row1 +2)%5) *5+ column2

- For any other possibility **row1 * 5 + col2 row12 * 5 + col1**

PROGRAM

```
# Create the key square from the
keyword def
create_key_square(keyword):
    keyword = keyword.upper().replace("J", "I") # J is usually replaced by I
    key_square = []
    used = []

    # Add letters from keyword to the key square
    for char in keyword:
        if char not in used and char.isalpha(): # Avoid duplicates and non-alphabet chars
            key_square.append(char)
            used.append(char)

    # Add the rest of the letters (A-Z except J)
    for char in "ABCDEFGHIKLMNOPQRSTUVWXYZ": # 'J' is
        omitted if char not in used:
            key_square.append(ch

    ar) return key_square


# Prepare the text for encryption/decryption by making pairs of
letters def prepare_text(plain_text):
    plain_text = plain_text.upper().replace("J", "I") # Replace J with I
    pairs = []
    i = 0

    # Form letter pairs, inserting 'X' if
    needed while i < len(plain_text):
        a = plain_text[i]
        b = plain_text[i + 1] if i + 1 < len(plain_text) else 'X'

        if a == b: # If both letters are the same, add an 'X' between them
            pairs.append(a + 'X')
            i += 1
        else:
```

```
        pairs.append(a +
        b) i += 2

    return pairs


# Find position of a letter in the key
square def find_position(char,
key_square):
    index = key_square.index(char) # Find the index of the character in the key square
    row = index // 5
    col = index
    % 5 return
    row, col


# Encrypt or decrypt a pair of letters based on Playfair
rules def process_pair(pair, key_square, encrypt=True):
    row1, col1 = find_position(pair[0],
    key_square) row2, col2 =
    find_position(pair[1], key_square)

    # Rule 1: Same
    row if row1 ==
    row2:
        if encrypt:
            return key_square[row1 * 5 + (col1 + 1) % 5] + key_square[row2 * 5 + (col2 +
            1)
% 5]
        else:
            return key_square[row1 * 5 + (col1 - 1) % 5] + key_square[row2 * 5 + (col2 - 1)
            %
5]

    # Rule 2: Same
    column elif col1 ==
    col2:
        if encrypt:
            return key_square[((row1 + 1) % 5) * 5 + col1] + key_square[((row2 + 1) % 5) *
            5
+ col2]
        else:
            return key_square[((row1 - 1) % 5) * 5 + col1] + key_square[((row2 - 1) % 5) * 5
+ col2]

    # Rule 3: Rectangle
    rule else:
```

```
        return key_square[row1 * 5 + col2] + key_square[row2 * 5 + col1]


# Main encryption function
def playfair_encrypt(plain_text, keyword):
    key_square =
    create_key_square(keyword) pairs =
    prepare_text(plain_text)
    cipher_text =
    '' for pair in
    pairs:
        cipher_text += process_pair(pair, key_square, encrypt=True)

    return cipher_text


# Main decryption function
def playfair_decrypt(cipher_text,
    keyword): key_square =
    create_key_square(keyword) pairs =
    prepare_text(cipher_text)

    plain_text = ''
    for pair in
    pairs:
        plain_text += process_pair(pair, key_square, encrypt=False)

    return plain_text


# Get user input
keyword = input("Enter the keyword:
") plain_text = input("Enter the
plaintext: ")

# Encrypt and display the result
cipher_text = playfair_encrypt(plain_text, keyword)
print("Encrypted text:", cipher_text)

# Decrypt and display the result
decrypted_text = playfair_decrypt(cipher_text, keyword)
print("Decrypted text:", decrypted_text)
```

OUTPUT

```
Enter the keyword: hamza
Enter the plaintext: hello
Encrypted text: MCNWNI
Decrypted text: HELXLO
```

Lab #3

Objective:

Encrypt and decrypt using hill cipher and vignere cipher

Description:

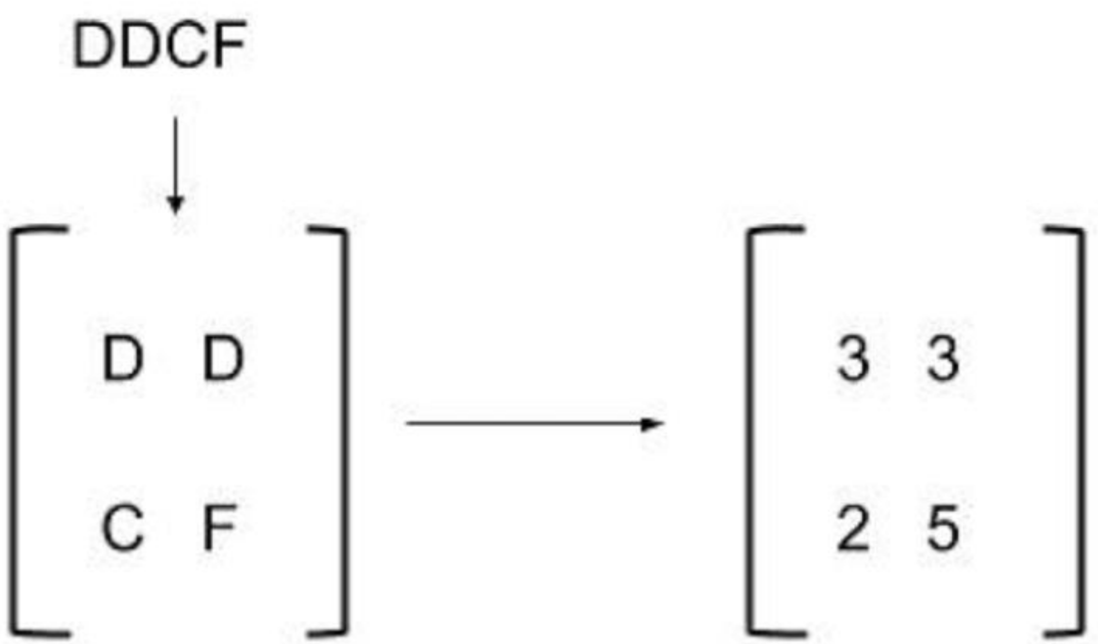
Hill Cipher

Encrypting using the Hill cipher depends on the following operations −

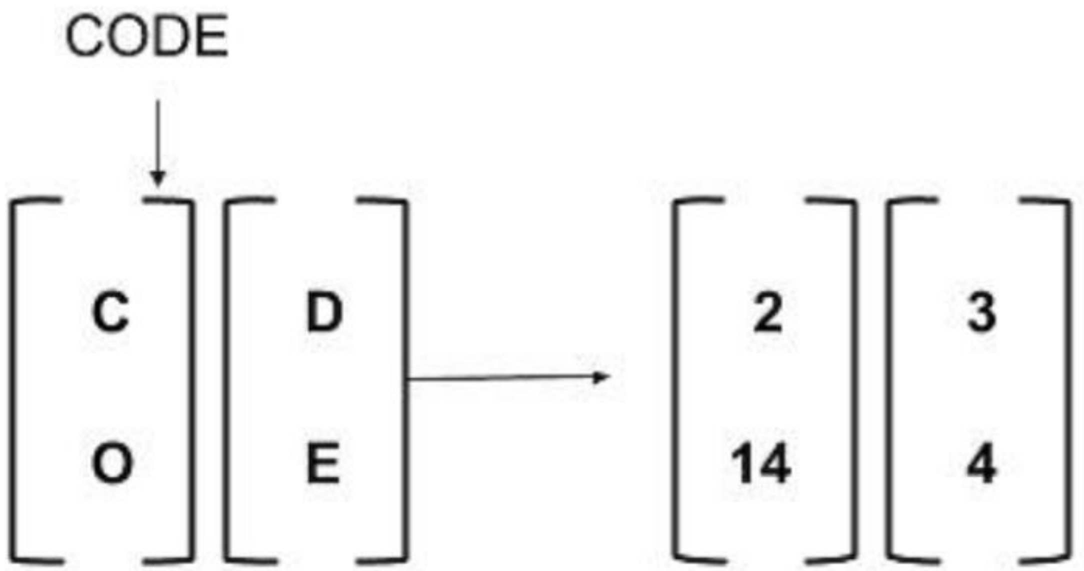
E(K, P) = (K*P) mod 26

Here K is our key matrix, and P is the vectorized plaintext

Our key and plaintext are converted into numbers according to their index in the alphabet. For example



And vectors as



Code:

Encryption

```
# Function to convert a letter to a number (A=0, B=1, ..., Z=25)
def char_to_num(c):
    return ord(c) - ord('A')



# Function to convert a number to a letter (0=A, 1=B, ..., 25=Z)
def num_to_char(n):
    return chr(n + ord('A'))

def hill_cipher_encrypt(plaintext, key_matrix):
    # Padding the plaintext to be a multiple of 3 with 'X'
    while len(plaintext) % 3 != 0:
        plaintext += 'X'

    ciphertext = ""

    # Process the plaintext in blocks of 3 characters
    for i in range(0, len(plaintext), 3):
        block = plaintext[i:i + 3]  # Get 3 characters at a time
        # Convert characters to numbers
        num_block = [char_to_num(c) for c in block]

        # Encrypt using matrix multiplication with key matrix
        encrypted_block = [
            (key_matrix[0][0] * num_block[0] + key_matrix[0][1] * num_block[1] +
key_matrix[0][2] * num_block[2]) % 26,
            (key_matrix[1][0] * num_block[0] + key_matrix[1][1] * num_block[1] +
key_matrix[1][2] * num_block[2]) % 26,
```

```
            (key_matrix[2][0] * num_block[0] + key_matrix[2][1] * num_block[1] +
key_matrix[2][2] * num_block[2]) % 26
        ]

        # Convert numbers back to characters and add to ciphertext
        ciphertext += ''.join([num_to_char(num) for num in encrypted_block])

    return ciphertext
key_matrix = [
     [6, 24, 1],
    [13, 16, 10],
    [20, 17, 15]
]

# Example usage
plaintext = "HELLO"
ciphertext = hill_cipher_encrypt(plaintext, key_matrix)
print(f"Ciphertext:{ciphertext}")
```

Output

```
[Running] python -u "c:\Users\iamha\3D Objects\Old PC\Third Semester\Information Security\practicle\hill-c
Ciphertext:TFJJZX

[Done] exited with code=0 in 0.108 seconds
```

Decryption

```
import numpy as np
# Function to convert a letter to a number (A=0, B=1, ..., Z=25)
def char_to_num(c):
    return ord(c) - ord('A')

# Function to convert a number to a letter (0=A, 1=B, ..., 25=Z)
def num_to_char(n):
    return chr(n + ord('A'))

def mod_inverse(a,mod):
    a=a%mod
    for x in range(1,mod):
        if (a*x)%26==1:
            return x

def mod_matrix_inverse(key_matrix, mod):
    matrix=np.array(key_matrix)
```

```python
    # Compute the determinant of the matrix
    det = int(round(np.linalg.det(matrix)))
    det_inv = mod_inverse(det, mod)  # Get the modular inverse of the determinant

    # Compute the adjoint of the matrix
    adj = (np.round(np.linalg.inv(matrix) * det)).astype(int)  # Adjugate matrix

    # Multiply the adjoint by the modular inverse of the determinant
    matrix_inv = (det_inv * adj) % mod
    return matrix_inv.tolist()



def hill_cipher_decrypt(ciphertext, key_matrix):

    plaintext = ''
    inverse_key_matrix=mod_matrix_inverse(key_matrix,26)
# Process the plaintext in blocks of 3 characters
    for i in range(0, len(ciphertext), 3):
        block = ciphertext[i:i + 3]  # Get 3 characters at a time
        # Convert characters to numbers
        num_block = [char_to_num(c) for c in block]
# decrypt using matrix multiplication with  inverse key matrix
        encrypted_block = [
            (inverse_key_matrix[0][0] * num_block[0] + inverse_key_matrix[0][1] *
num_block[1] + inverse_key_matrix[0][2] * num_block[2]) % 26,
            (inverse_key_matrix[1][0] * num_block[0] + inverse_key_matrix[1][1] *
num_block[1] + inverse_key_matrix[1][2] * num_block[2]) % 26,
            (inverse_key_matrix[2][0] * num_block[0] + inverse_key_matrix[2][1] *
num_block[1] + inverse_key_matrix[2][2] * num_block[2]) % 26
        ]

        # Convert numbers back to characters and add to plaintext
        plaintext += ''.join([num_to_char(num) for num in encrypted_block])

    return plaintext
key_matrix = [
     [6, 24, 1],
    [13, 16, 10],
    [20, 17, 15]
]

# Example usage
ciphertext = "TFJJZX"
plaintext = hill_cipher_decrypt(ciphertext, key_matrix)
print(f"plaintext:{plaintext}")
```

Output

```
PROBLEMS    OUTPUT    DEBUG CONSOLE    TERMINAL    PORTS

[Running] python -u "c:\Users\iamha\3D Objects\Old PC\Third Semester\Information
plaintext:HELLOX

[Done] exited with code=0 in 0.966 seconds
```

VIGENÈRE CIPHER

In this scheme, the 26 Caesar ciphers with shifts of 0 through 25 are used. Which cipher is to be applied at a specific point in text is determined by the key. Each cipher is denoted by a key letter, which is the ciphertext letter that substitutes for the plain text letter a. The encryption and decryption formulas for this cipher are

$C_i = (p_i + k_{i \bmod m}) \bmod 26$

$p_i = (C_i - k_{i \bmod m}) \bmod 26$

Code

Encryption

```
# Function to convert a letter to a number (A=0, B=1, ..., Z=25)
def char_to_num(c):
    return ord(c) - ord('A')



# Function to convert a number to a letter (0=A, 1=B, ..., 25=Z)
def num_to_char(n):
    return chr(n + ord('A'))
# Function to repeat the key to match the length of the plaintext
def repeat_key(plaintext, key):
    repeated_key = ""
    key_length = len(key)
    for i in range(len(plaintext)):
        repeated_key += key[i % key_length]  # Repeat the key characters
    return repeated_key
def vignere_cipher_encrypt(plaintext, key):
    plaintext = plaintext.upper()  # Ensure all letters are uppercase
    key = key.upper()  # Ensure the key is uppercase
    repeated_key = repeat_key(plaintext, key)  # Repeat the key

    ciphertext = ""
```

```python
    # Encrypt each character in the plaintext
    for i in range(len(plaintext)):
        if plaintext[i].isalpha():  # Ignore non-alphabet characters
            # Shift the plaintext character by the key character
            shift = (char_to_num(plaintext[i]) +char_to_num(repeated_key[i])) % 26
            ciphertext += num_to_char(shift)
        else:
            ciphertext += plaintext[i]  # Keep non-alphabet characters unchanged

    return ciphertext
# Example usage
plaintext = "HELLO WORLD"
key = "KEY"
ciphertext = vignere_cipher_encrypt(plaintext, key)
print(f"Ciphertext:{ciphertext}")
```

Output

```
[Running] python -u "c:\Users\iamha\3D Objects\Old PC\Third Semester\Information Security\practic
Ciphertext:RIJVS GSPVH

[Done] exited with code=0 in 0.085 seconds
```

Decryption:

```python
# Function to convert a letter to a number (A=0, B=1, ..., Z=25)
def char_to_num(c):
    return ord(c) - ord('A')



# Function to convert a number to a letter (0=A, 1=B, ..., 25=Z)
def num_to_char(n):
    return chr(n + ord('A'))
# Function to repeat the key to tongue the length of the ciphertext
def repeat_key(ciphertext, key):
    repeated_key = ""
    key_length = len(key)
    for i in range(len(ciphertext)):
        repeated_key += key[i % key_length]  # Repeat the key characters
    return repeated_key
def vignere_cipher_decrypt(ciphertext, key):
    ciphertext = ciphertext.upper()  # Ensure all letters are uppercase
    key = key.upper()  # Ensure the key is uppercase
    repeated_key = repeat_key(ciphertext, key)  # Repeat the key



    plaintext = ""
```

```
    # decrypt each character in the ciphertext
    for i in range(len(ciphertext)):
        if ciphertext[i].isalpha():  # Ignore non-alphabet characters
            # Shift the ciphertext character by the key character
            shift = (char_to_num(ciphertext[i]) -char_to_num(repeated_key[i])) % 26
            plaintext += num_to_char(shift)
        else:
            plaintext += ciphertext[i]  # Keep non-alphabet characters unchanged

    return plaintext
# Example usage
ciphertext = "RIJVS GSPVH"
key = "KEY"
plaintext= vignere_cipher_decrypt(ciphertext, key)
print(f"plaintext:{plaintext}")
```

Output

```
[Running] python -u "c:\Users\iamha\3D Objects\Old PC\Third Semester\Information Security\practicle\temp
plaintext:HELLO WORLD

[Done] exited with code=0 in 0.106 seconds
```

Lab #4

Objective:

- To encrypt and decrypt using rotor machine
- Use steganography to encode a message into the image and decode it

Description(Rotor Machine):

- A **rotor** is basically a scrambled sequence of alphabets that is used to encode a text in a cyclic manner
- The letter to be encoded is mapped to the letter with the same index in the rotor . Rotor is then rotated one alphabet from its previous position and the resulting alphabet is the encoding .It may be kept in mind that as we encrypt letters in the plaintext the rotor moves(rotate) one unit backwards from its previous position for each encryption

- When two rotors are used the concept of a **notch** arises. A notch is a letter associated with a rotor. When the rotation count of the first rotor has not yet reached the index number of the notch the second encryption using the second rotor happens without rotation of the second rotor. However when the notch is reached the second rotor is triggered and starts rotating . Same is the case with three or four rotors . The notch for each rotor determines when the next rotor would start rotating.

Code for encryption

```
class Rotor:
    def __init__(self, wiring, notch):
        self.wiring = wiring  # Scrambled alphabet (like 'EKMFLGDQVZNTOWYHXUSPAIBRCJ')
        self.notch = notch  # Notch position where the rotor will trigger the next rotor to
rotate
        self.position = 0  # Initial rotor position (0 to 25)

    def rotate(self):
        # Rotates the rotor by one position
        self.position = (self.position + 1) % 26

    def encrypt_letter(self, letter):
        # Encrypt the letter by adjusting it with the rotor's current position
        index = (ord(letter) - ord('A') + self.position) % 26
        encrypted_letter = self.wiring[index]
        return encrypted_letter

class SimpleRotorMachine:
    def __init__(self, rotors):
        self.rotors = rotors  # List of Rotor objects

    def rotate_rotors(self):
        # Rotate the first rotor, and others if necessary (if the first reaches its notch)
        self.rotors[0].rotate()
        if self.rotors[0].position == ord(self.rotors[0].notch) - ord('A'):
            self.rotors[1].rotate()

    def encrypt_message(self, message):
        encrypted_message = ""
        for letter in message:
            if letter.isalpha():
                self.rotate_rotors()
                letter = letter.upper()
```

```python
                # Pass the letter through each rotor
                for rotor in self.rotors:
                    letter = rotor.encrypt_letter(letter)

                encrypted_message += letter
            else:
                encrypted_message += letter  # Skip spaces or punctuation
        return encrypted_message

# Example usage:

# Create rotors with wiring (scrambled alphabets) and notch positions
rotor1 = Rotor('EKMFLGDQVZNTOWYHXUSPAIBRCJ', 'Q')  # Rotor I with notch at Q
rotor2 = Rotor('AJDKSIRUXBLHWTMCQGZNPYFVOE', 'E')  # Rotor II with notch at E

# Create the rotor machine with 2 rotors
simple_rotor_machine = SimpleRotorMachine([rotor1, rotor2])

# Encrypt a message
message = "HAMZA"
encrypted_message = simple_rotor_machine.encrypt_message(message)
print(f"Encrypted message: {encrypted_message}")
```

Output

```
Encrypted message: YWUIR

=== Code Execution Successful ===
```

Code for decryption

class Rotor:
    def __init__(self, wiring, notch):
        self.wiring = wiring # Scrambled alphabet (like 'EKMFLGDQVZNTOWYHXUSPAIBRCJ')
        self.notch = notch # Notch position where the rotor will trigger the next rotor to rotate
        self.position = 0 # Initial rotor position (0 to 25)

    def rotate(self):
        # Rotates the rotor by one position
        self.position = (self.position + 1) % 26

```
    def decrypt_letter(self, letter):
        # decrypt the letter by adjusting it with the rotor's current position
        index = (self.wiring.index(letter)-self.position) % 26
        decrypted_letter = chr(index+ord('A'))
        return decrypted_letter

class SimpleRotorMachine:
    def __init__(self, rotors):
        self.rotors = rotors  # List of Rotor objects

    def rotate_rotors(self):
        # Rotate the first  rotor, and others if necessary (if the first reaches its notch)
        self.rotors[1].rotate()
        if self.rotors[1].position == ord(self.rotors[1].notch) - ord('A'):
            self.rotors[0].rotate()

    def decrypt_message(self, message):
        encrypted_message = ""
        for letter in message:
            if letter.isalpha():
                self.rotate_rotors()
                letter = letter.upper()

                # Pass the letter through each rotor
                for rotor in self.rotors:
                    letter = rotor.decrypt_letter(letter)

                encrypted_message += letter
            else:
                encrypted_message += letter  # Skip spaces or punctuation
        return encrypted_message
# Example usage:

# Create rotors with wiring (scrambled alphabets) and notch positions
rotor1 = Rotor('EKMFLGDQVZNTOWYHXUSPAIBRCJ', 'Q')  # Rotor I with
notch at Q
rotor2 = Rotor('AJDKSIRUXBLHWTMCQGZNPYFVOE', 'E')  # Rotor II with
notch at E
```

```
# Create the rotor machine with 2 rotors
simple_rotor_machine = SimpleRotorMachine([rotor2, rotor1])

# Encrypt a message
message = "YJWHFNQ"
decrypted_message = simple_rotor_machine.decrypt_message(message)
print(f"Encrypted message:{decrypted_message}")
```

Output

```
HAMZA

=== Code Execution Successful ===
```

Stenography:

- **Steganography** is the practice of hiding secret information within another non-secret medium in such a way that the presence of the information is concealed.
- The most common form of steganography is hiding information in digital media, such as images, audio, or video files. The secret message is embedded in such a way that it doesn't alter the appearance or quality of the media to the human eye or ear.
- One popular method of steganography is to hide information in images by manipulating the **Least Significant Bit (LSB)** of the pixel values in an image.
- Digital images consist of pixels, each represented by a set of bits (e.g., 8 bits for grayscale or 24 bits for RGB images). The idea behind LSB steganography is that changing the last (least significant) bit of a pixel's color value only introduces a tiny, nearly imperceptible change in the color.

Effectively, the least significant bit of pixel color is changed in such a way that taken together they spell out the message in binary form

This is done by comparing the LSB of the pixel color with the current bit of the message if they are the same the bit is left unchanged however if they are different the LSB is changed to match the current bit

Secret key

A secret key is a binary sequence that is appended at the end of the message. This key is only known by the receiver and the sender. When the receiver reaches the secret key in the process of decryption he knows that now the message has ended and beyond that point the pixel values do not represent message

Implementation

In the following code the blue color value of pixels is changed in sequence until the whole message is embedded into the image . The secret key of 11111110 is used

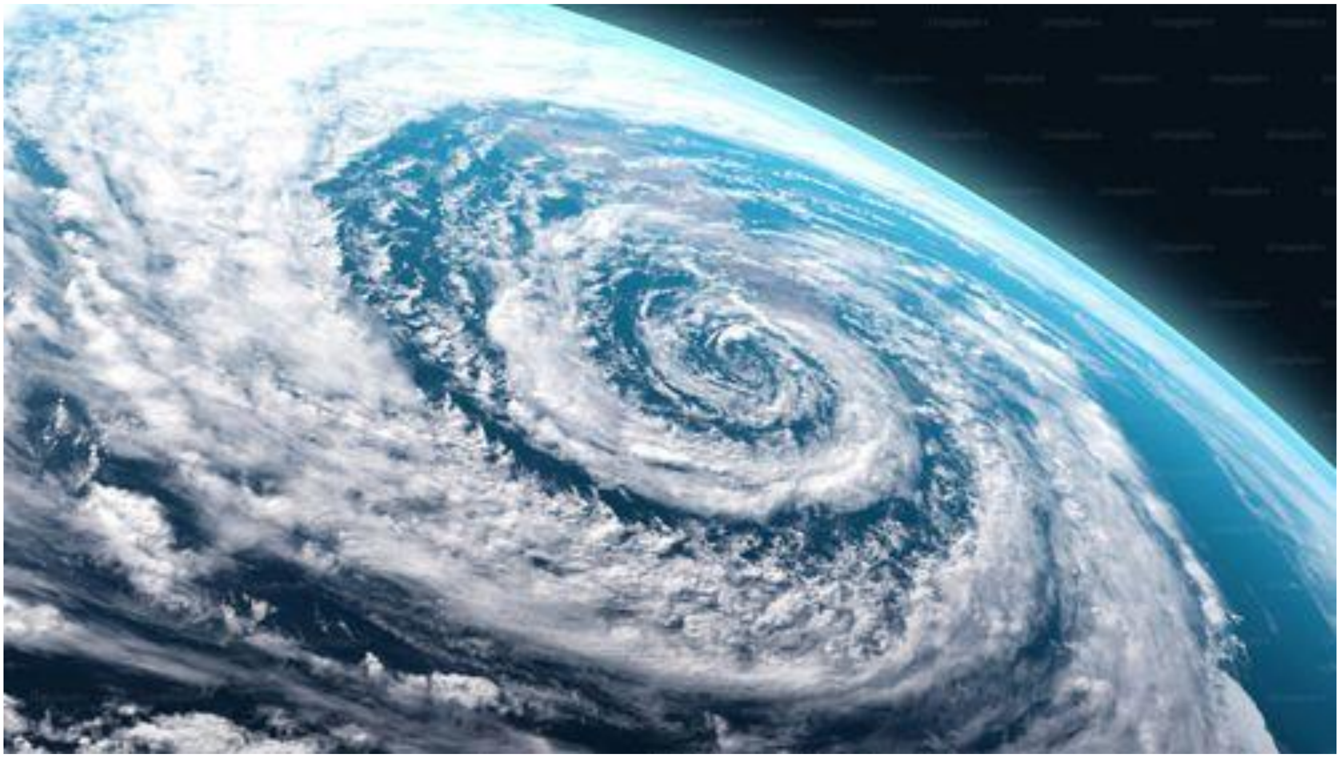
Code for embedding the message in the image

```
from PIL import Image
def encrypt_message(input_image_path,ouput_image_path,message):
    image=Image.open(input_image_path)
    encoded_image=image
    height,width=image.size

    binary_message=''.join(format(ord(char),'08b') for char in message) +'11111110'
    pixels=list(encoded_image.getdata())
    pixel_index=0
    for value in binary_message:
        pixel=list(pixels[pixel_index])
        pixel[2]=pixel[2]& ~1|int(value)
        encoded_image.putpixel((pixel_index%height,pixel_index//height),tuple(pixel
))
        pixel_index+=1

    encoded_image.save(ouput_image_path)

#example
input_image_address="input_image.png"
output_image_address="output_image.png"
message="huzaifa"
encrypt_message(input_image_address,output_image_address,message)
```



The above image is the input image

The above image is the output image

Code for getting the message

```
from PIL import Image
def decrypt_message(input_image_path):
    image=Image.open(input_image_path)
```

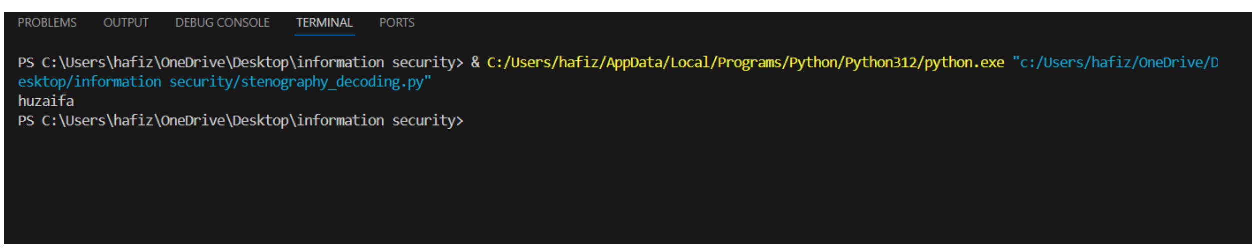
```
    height,width=image.size

    pixels=list(image.getdata())

    binary_message=""
    for pixel in pixels:
        binary_message+=str(pixel[2]&1)
    bytes_message=[binary_message[i:i+8]for i in range(0,len(binary_message),8)]
    decrypted_message=""
    for byte in bytes_message:
        if byte=='11111110':
            break
        decrypted_message +=chr(int(byte,2))
    return decrypted_message

#example
#input_image_address="input_image.png"
output_image_address="output_image.png"
message=decrypt_message(output_image_address)
print(message)
```

Output



Lab #5

Objective:

To encrypt and decrypt using fiestal cipher

Description

Encryption

In the fiestal cipher the byte to be encoded is split into two halves. These halves go through a specified number of rounds(4 in our example) and then are combined back together in the end which is the encrypted form. In each round the current right half is added with the key for that round and is XOR with the current left half .This new value is set as the new right half and the new left half is set to the current right half.

Decryption

In the fiestal cipher decryption the cipher text goes through round but the roles of left and right halves are reversed. The order of keys is also reversed to get the correct answer

Details

To get the left half we right shift the original byte by 8. To get the right half we AND the byte with the number FFh(in hexadecimal). To combine both halves at the end we simply left shift the left half and OR it with the right half

Code for encryption and decryption

```
import random

# Round function: A simple function that operates on the right half and the key
# In this case, we add the right half to the key and take modulo 256 to keep it in 8-
bit range
def round_function(right_half, key):
    return (right_half + key) % 256
# Feistel Cipher Encryption
def feistel_encrypt(plaintext, keys, num_rounds=4):
```

```
    L = plaintext >> 8  # Left 8 bits
    R = plaintext & 0xFF  # Right 8 bits

    # Print the initial values of L and R for better understanding
    print(f"Initial Left Half (L): {bin(L)}")
    print(f"Initial Right Half (R): {bin(R)}")

    # Step 2: Perform the encryption for a specified number of rounds
    for i in range(num_rounds):
        print(f"\n--- Round {i + 1} ---")

        # Save the current value of R to a temporary variable (temp) before swapping
        temp = R

          # Step 3: Apply the round function to the right half (R) and the round key
(keys[i])
        # Then XOR the result with the left half (L), and store the result in the new R
        R= L^ round_function(temp, keys[i])

        # Step 4: Swap the halves: set L to the old value of R (stored in temp)
        L= temp

        # Print the new values of L and R after this round
        print(f"Round {i + 1} Left Half (L): {bin(L)}")
        print(f"Round {i + 1} Right Half (R): {bin(R)}")

    # Step 5: Combine the two 8-bit halves (L and R) back into a single 16-bit
ciphertext
    # L is shifted 8 bits to the left, and R is added to form the final 16-bit ciphertext
    ciphertext = (L << 8) | R

    # Return the resulting ciphertext
    return ciphertext
# Example usage of Feistel Cipher encryption
def feistel_decrypt(ciphertext, keys, num_rounds=4):

    L = ciphertext >> 8  # Left 8 bits
    R = ciphertext & 0xFF  # Right 8 bits

    # Print the initial values of L and R for better understanding
```

```
    print(f"Initial Left Half (L): {bin(L)}")
    print(f"Initial Right Half (R): {bin(R)}")

    # Step 2: Perform the decryption
    for i in range(num_rounds):
        print(f"\n--- Round {i + 1} ---")

        # Save the current value of R to a temporary variable (temp) before swapping
        temp = L

         # Step 3: Apply the round function to the right half (R) and the round key
(keys[i])
        # Then XOR the result with the left half (L), and store the result in the new R
        L= R^ round_function(temp, keys[i])

        # Step 4: Swap the halves: set L to the old value of R (stored in temp)
        R= temp

        # Print the new values of L and R after this round
        print(f"Round {i + 1} Left Half (L): {bin(L)}")
        print(f"Round {i + 1} Right Half (R): {bin(R)}")

    # Step 5: Combine the two 8-bit halves (L and R) back into a single 16-bit
plaintext
    # L is shifted 8 bits to the left, and R is added to form the final 16-bit plaintext
    plaintext = (L << 8) | R

    # Return the resulting ciphertext
    return plaintext
# A 16-bit example plaintext in binary
plaintext = 0b1101011101001010  # 16-bit binary input

# Generate random 8-bit round keys (for 4 rounds)
keys = [random.randint(0, 255) for _ in range(4)] # Example keys

print(f"Plaintext: {bin(plaintext)}")  # Print the original plaintext
print("Encryption")
# Encrypt the plaintext using Feistel Cipher
ciphertext = feistel_encrypt(plaintext, keys)
#reverse the keys for decryption
keys.reverse()
```

```
#decrypt the ciphertext
print("\nDecryption")
decoded_plaintext=feistel_decrypt(ciphertext,keys)

# Print the resulting ciphertext alongside with plaintext in binary

print(f"\nCiphertext: {bin(ciphertext)}")
print(f"decoded plaintext: {bin(decoded_plaintext)}")
```

Output

```
Plaintext: 0b1101011101001010
Encryption
Initial Left Half (L): 0b11010111
Initial Right Half (R): 0b1001010

--- Round 1 ---
Round 1 Left Half (L): 0b1001010
Round 1 Right Half (R): 0b10000100

--- Round 2 ---
Round 2 Left Half (L): 0b10000100
Round 2 Right Half (R): 0b1110100

--- Round 3 ---
Round 3 Left Half (L): 0b1110100
Round 3 Right Half (R): 0b11001101

--- Round 4 ---
Round 4 Left Half (L): 0b11001101
Round 4 Right Half (R): 0b1010000

Decryption
Initial Left Half (L): 0b11001101
Initial Right Half (R): 0b1010000

--- Round 1 ---
Round 1 Left Half (L): 0b1110100
Round 1 Right Half (R): 0b11001101

--- Round 2 ---
Round 2 Left Half (L): 0b10000100
Round 2 Right Half (R): 0b1110100

--- Round 3 ---
Round 3 Left Half (L): 0b1001010
Round 3 Right Half (R): 0b10000100

--- Round 4 ---
Round 4 Left Half (L): 0b11010111
Round 4 Right Half (R): 0b1001010

Ciphertext: 0b1100110101010000
decoded plaintext: 0b1101011101001010
```
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