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Language: JavaScript

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LAB#1

CEASER CIPHER

Introduction:

This program implements the Caesar cipher, a basic form of substitution cipher where each letter in the plaintext is shifted a certain number of places up or down in the alphabet. It provides a simple method of encrypting messages and can be easily decrypted if the shift value is known.

Method of Encryption:

The Caesar cipher encrypts plaintext by shifting each letter in the message by a fixed number of positions to the right in the alphabet. For example, with a shift of 3, 'A' becomes 'D', 'B' becomes 'E', and so on. Both uppercase and lowercase letters are shifted, while non-alphabetic characters remain unchanged.

Method of Decryption:

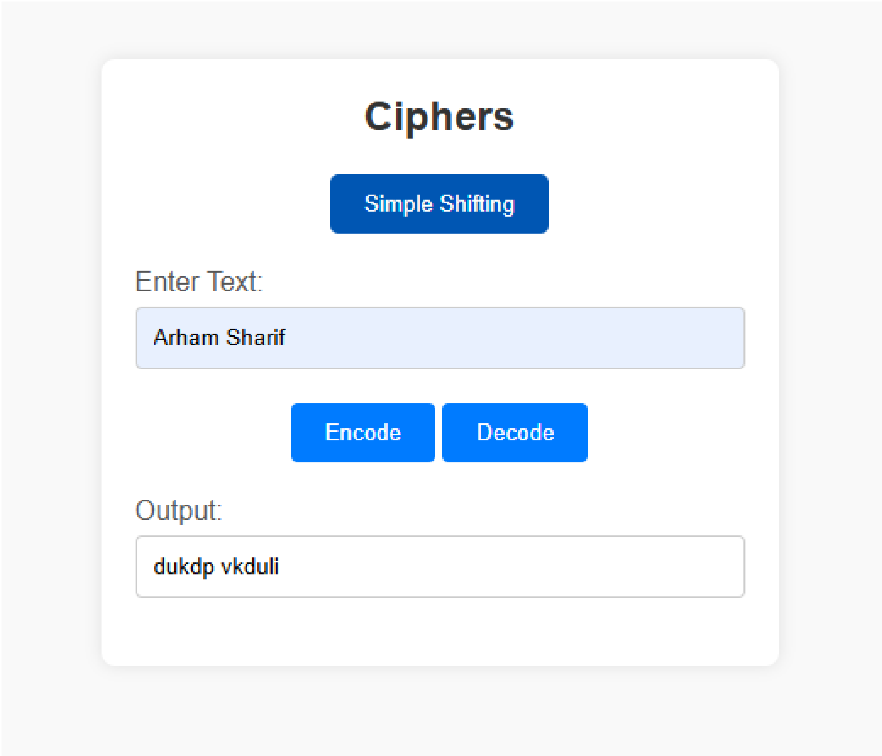
Decryption in the Caesar cipher involves shifting each letter in the encrypted message by the same number of positions to the left in the alphabet to retrieve the original plaintext. For example, with a shift of 3, 'D' becomes 'A', 'E' becomes 'B', and so on. Non-alphabetic characters remain unchanged during decryption.

CODE:

```
const simpleInc = 3;

const simpleCharArr = Array.from({ length: 26 }, (_, i) =>
String.fromCharCode(97 + i));

const simpleLenCharArr = simpleCharArr.length;

"""-----------------ENCODE------------------"""

# Function Can Encode Char

const encodeCharSimple = (char) => {

    let encodeChar = '';

    let index = -1;

    for (let i = 0; i < simpleLenCharArr; i++) {
```

```
        if (simpleCharArr[i] === char) {
            index = i + simpleInc;
            if (index >= simpleLenCharArr) {
                index %= simpleLenCharArr;
            }
            encodeChar = simpleCharArr[index];
            break;
        }
    }
    if (index !== -1) {
        return encodeChar;
    } else {
        return char;
    }
}
```

Output:

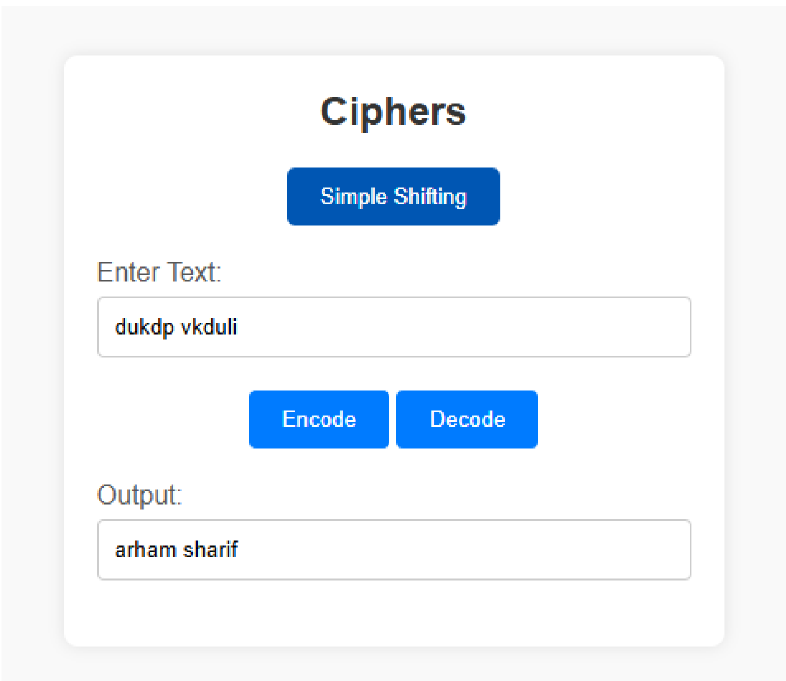


CODE:

```
"""-----------------DECODE------------------"""
# Function to Decode Char
const decodeCharSimple = (char) => {
    let decodeChar = '';
    let index = -1;
    for (let i = 0; i < simpleLenCharArr; i++) {
        if (simpleCharArr[i] === char) {
            index = i - simpleInc;
            if (index < 0) {
                index += simpleLenCharArr;
            }
            decodeChar = simpleCharArr[index];
            break;
        }
    }
```

```
    if (index !== -1) {
        return decodeChar;
    } else {
        return char;
    }
}
```

Output:



LAB#2

OTP CIPHER

Introduction:

This program implements the **One-Time Pad (OTP) cipher**, a theoretically unbreakable encryption method that uses a random key that is as long as the plaintext. Each letter in the plaintext is shifted by a completely random amount determined by the corresponding character in the key. It offers perfect security when the key is truly random, used only once, and kept completely secret.

Method of Encryption:

The OTP cipher encrypts plaintext by shifting each letter based on a completely random key of the same length. Each character in the plaintext is shifted forward by an amount determined by the corresponding character in the key. For example, if the key character is 'C' (position 2 in the alphabet), the plaintext letter is shifted by 2 positions. Both uppercase and lowercase letters are shifted, while non-alphabetic characters remain unchanged. The randomness and uniqueness of the key ensure maximum security.

Method of Decryption:

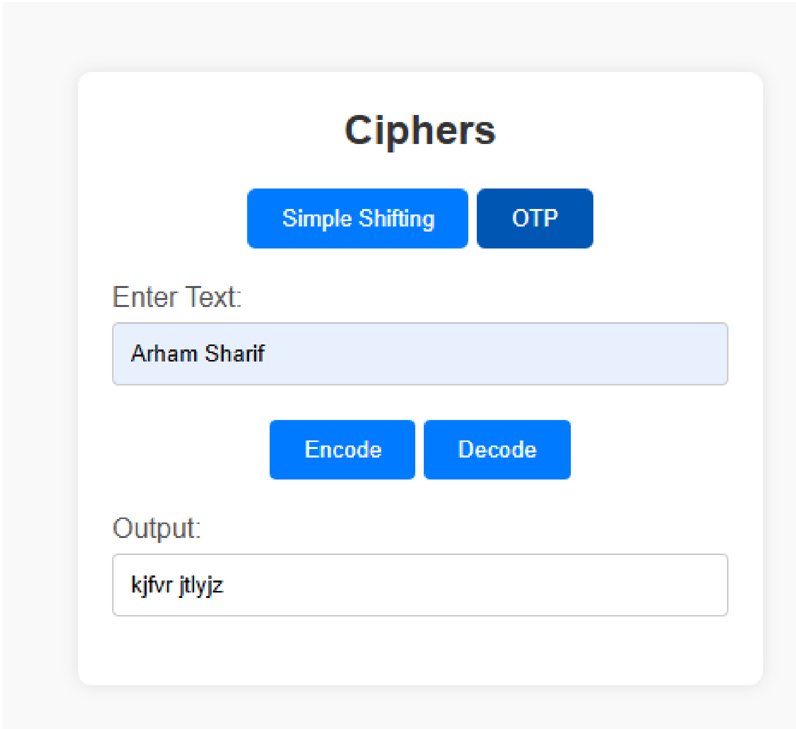
Decryption in the OTP cipher involves reversing the encryption process using the same random key. Each letter in the cipher text is shifted backwards by the value of the corresponding letter in the key to retrieve the original plaintext. Since the key is truly random and used only once, the decryption process perfectly reconstructs the original message. Non-alphabetic characters remain unchanged during decryption.

CODE:

```
const otpCharArr = Array.from({ length: 26 }, (_, i) =>
String.fromCharCode(97 + i));

// Function to generate a random OTP key of the same length as the
message
const generateOtpKey = (length) => {
  const charset = otpCharArr.join("");
  let key = '';
  for (let i = 0; i < length; i++) {
    const randomIndex = Math.floor(Math.random() * charset.length);
    key += charset[randomIndex];
  }
  return key;
};

// Function to save OTP key to local storage
const saveOtpKeyToLocalStorage = (key) => {
  localStorage.setItem('otpKey', key);
};

// Function to retrieve OTP key from local storage
```

```
const getOtpKeyFromLocalStorage = () => {
  let key = localStorage.getItem('otpKey');
  if (!key) {
    key = -1
  }
  return key;
};

// Function to encrypt message using OTP
const encryptOtp = (message, key) => {
  let result = '';
  for (let i = 0; i < message.length; i++) {
    const char = message.charAt(i);
    if (otpCharArr.includes(char)) {
      const messageIndex = otpCharArr.indexOf(char);
      const keyIndex = otpCharArr.indexOf(key.charAt(i));
      const encryptedChar = otpCharArr[(messageIndex + keyIndex) %
otpCharArr.length];
      result += encryptedChar;
    } else {
      result += char; // Non-alphabet characters remain unchanged
    }
  }
  return result;
};
```

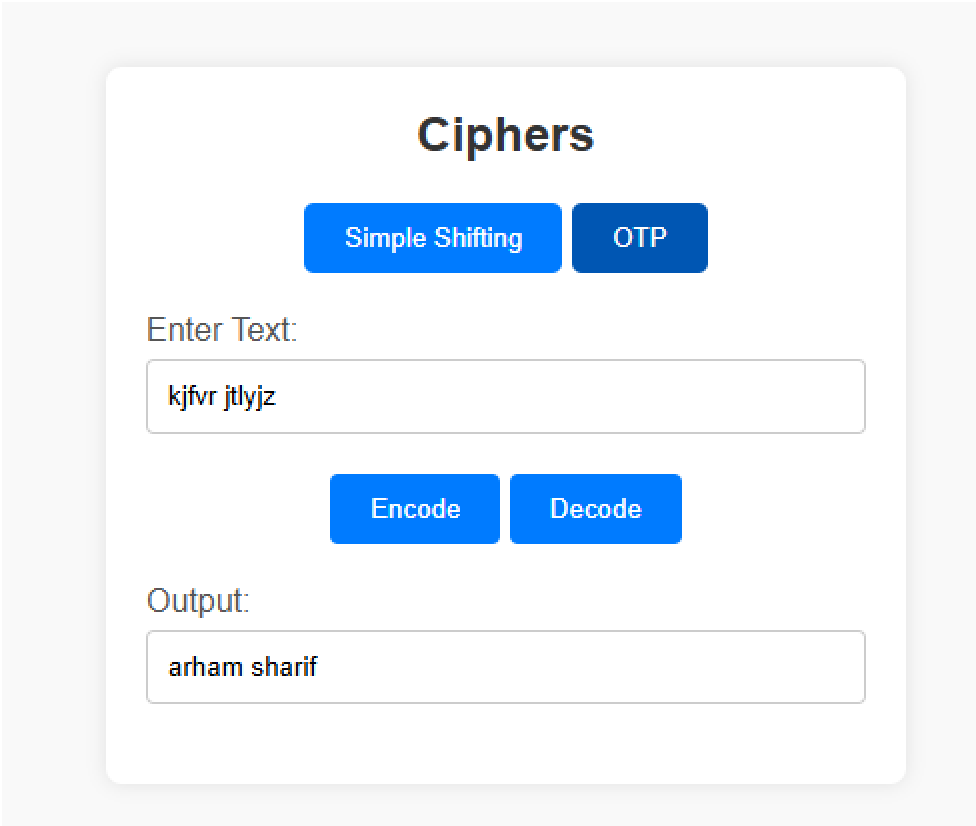
Output:



CODE:

```
// Function to decrypt message using OTP
const decryptOtp = (message, key) => {

  if (key == -1) {
    return "OTP key not found";
  }

  let result = '';
  for (let i = 0; i < message.length; i++) {
    const char = message.charAt(i);
    if (otpCharArr.includes(char)) {
      const messageIndex = otpCharArr.indexOf(char);
      const keyIndex = otpCharArr.indexOf(key.charAt(i));
      const decryptedChar = otpCharArr[(messageIndex - keyIndex +
otpCharArr.length) % otpCharArr.length];
      result += decryptedChar;
    } else {
      result += char; // Non-alphabet characters remain unchanged
    }
  }
  return result;
};
```

Output:



LAB#3

RAIL FENCE CIPHER

Introduction:

This program implements the Rail Fence cipher, a transposition cipher that rearranges the characters of the plaintext into a zigzag pattern across a number of "rails". It offers basic security by altering the order of characters in the message.

Method of Encryption:

The Rail Fence cipher encrypts plaintext by writing it in a zigzag pattern across a specified number of rails. Each character of the plaintext is written into successive rails, moving up and down, until the entire message is encoded. The cipher text is then read row by row to produce the encrypted message.

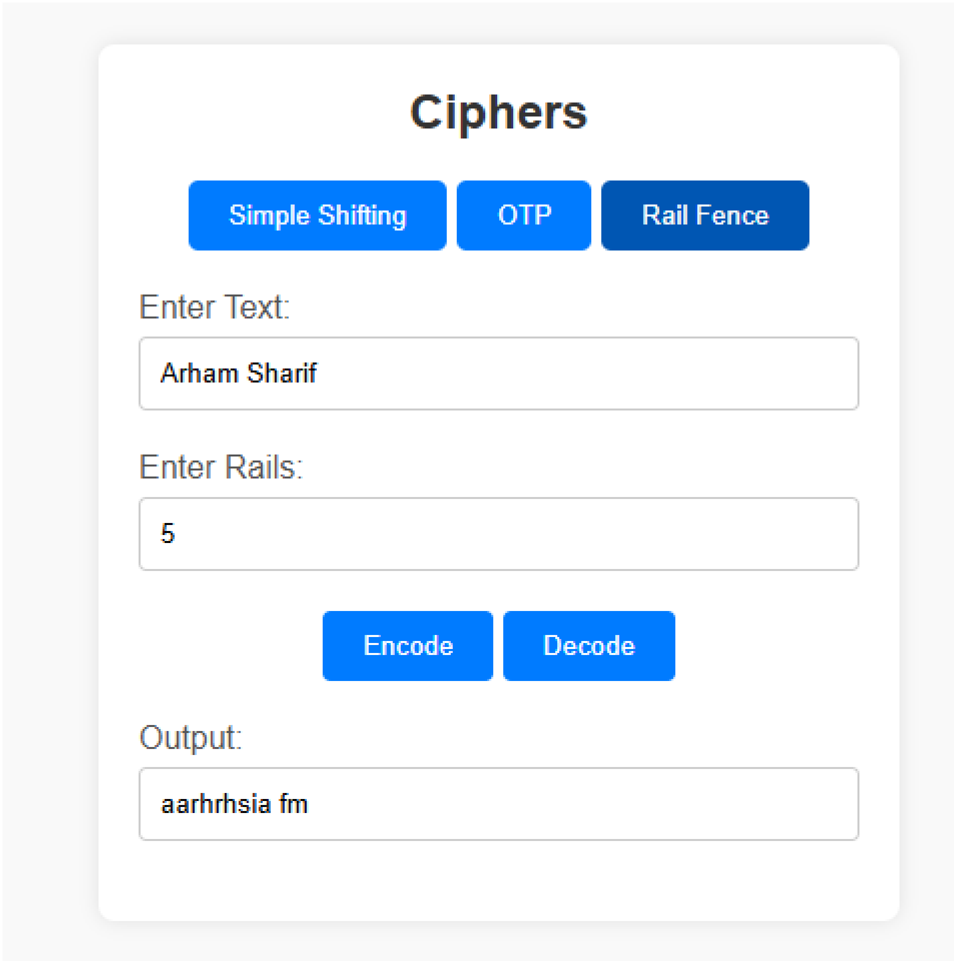
Method of Decryption:

Decryption in the Rail Fence cipher involves reconstructing the zigzag pattern used during encryption. The cipher text is written into the corresponding rails based on the same zigzag pattern, allowing the original plaintext to be retrieved by reading the characters in the order they were originally written.

CODE:

```
// Encrypt using Rail Fence Cipher
function encryptRailFence(text, rails) {
  if (rails <= 1) return text;

  const fence = Array.from({ length: rails }, () => []);
  let rail = 0;
  let direction = 1; // 1 = down, -1 = up

  for (const element of text) {
    fence[rail].push(element);
    rail += direction;

    if (rail === 0 || rail === rails - 1) {
      direction *= -1;
    }
  }

  return fence.flat().join('');
}
```

Output:

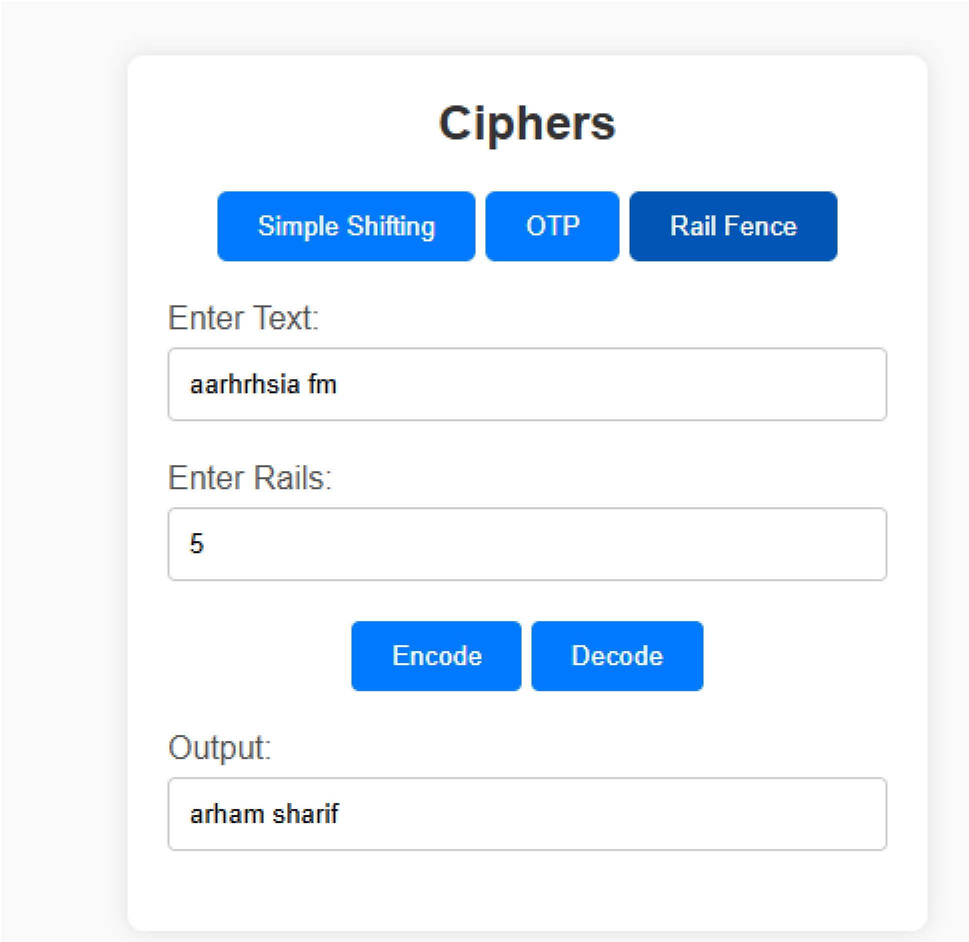


CODE:

```
// Decrypt using Rail Fence Cipher
function decryptRailFence(cipher, rails) {
  if (rails <= 1) return cipher;

  // Step 1: Create an empty matrix with placeholders
  const pattern = Array.from({ length: rails }, () =>
Array(cipher.length).fill(null));
  let rail = 0;
  let direction = 1;

  for (let col = 0; col < cipher.length; col++) {
    pattern[rail][col] = '*';
    rail += direction;

    if (rail === 0 || rail === rails - 1) {
      direction *= -1;
```

```
    }
  }

  // Step 2: Fill the pattern with actual characters
  let index = 0;
  for (let r = 0; r < rails; r++) {
    for (let c = 0; c < cipher.length; c++) {
      if (pattern[r][c] === '*' && index < cipher.length) {
        pattern[r][c] = cipher[index++];
      }
    }
  }

  // Step 3: Read the message by zigzag
  let result = '';
  rail = 0;
  direction = 1;

  for (let col = 0; col < cipher.length; col++) {
    result += pattern[rail][col];
    rail += direction;

    if (rail === 0 || rail === rails - 1) {
      direction *= -1;
    }
  }

  return result;
}
```

Output:



LAB#4

PLAYFAIR CIPHER

Introduction:

This program implements the Playfair cipher, a digraph substitution cipher that operates on pai rs of characters. It uses a 5x5 grid of letters derived from a keyword to encrypt and decrypt messages.

Method of Encryption:

The Playfair cipher encrypts plaintext by first processing it into digraphs (pairs of characters). Each digraph is then mapped to a corresponding pair of cipher text characters based on their positions in the Playfair grid. If the characters of a digraph are in the same row, they are replaced with the characters immediately to their right (wrapping around to the beginning if necessary). If they are in the same column, they are replaced with the characters directly below them. If they form a rectangle, they are replaced with the characters on the same row, but at the opposite corners of the rectangle.

Method of Decryption:

Decryption in the Playfair cipher involves reversing the encryption process. Each digraph in the cipher text is mapped back to its corresponding plaintext digraph using the positions of the characters in the Playfair grid. Each pair of cipher text characters is decrypted based on whether they are in the same row, column, or form a rectangle, thereby reconstructing the original plaintext.

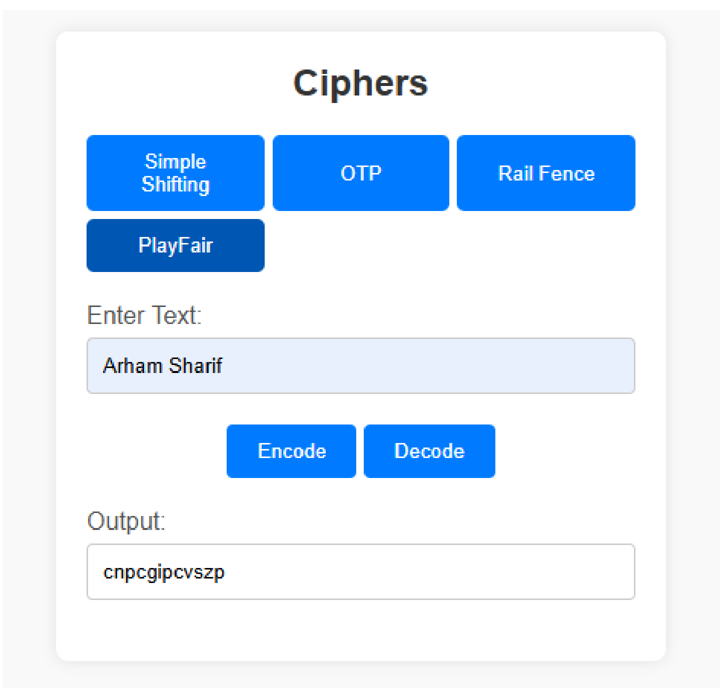
CODE:

```
const alphabetArr = Array.from({ length: 26 }, (_, i) =>
String.fromCharCode(65 + i))
    .filter(c => c !== 'J') // remove 'J'
    .join('');

    // Generate random Playfair key (5x5 grid)
function generatePlayfairKey() {
  const shuffled = [...alphabetArr];
  for (let i = shuffled.length - 1; i > 0; i--) {
    const j = Math.floor(Math.random() * (i + 1));
    [shuffled[i], shuffled[j]] = [shuffled[j], shuffled[i]];
  }
  return shuffled.join('');
}

// Save key to localStorage
function savePlayfairKey(key) {
  localStorage.setItem('playfairKey', key);
}

// Get or generate key from localStorage
function getPlayfairKey() {
  let key = localStorage.getItem('playfairKey');
  if (!key) {
    key = generatePlayfairKey();
    savePlayfairKey(key);
  }
  return key;
}

// Create 5x5 key matrix from key
```

```
function createMatrix(key) {
  const matrix = [];
  for (let i = 0; i < 25; i += 5) {
    matrix.push(key.slice(i, i + 5).split(''));
  }
  return matrix;
}

// Find letter position in key matrix
function findPosition(matrix, letter) {
  for (let row = 0; row < 5; row++) {
    const col = matrix[row].indexOf(letter);
    if (col !== -1) return { row, col };
  }
  return null;
}

// Prepare text for Playfair cipher (remove non-letters, replace J
with I, make pairs)
function prepareText(text) {
  text = text.toUpperCase().replace(/[^A-Z]/g, '').replace(/J/g,
'I');
  let result = '';
  for (let i = 0; i < text.length; i += 2) {
    let a = text[i];
    let b = text[i + 1] || 'X';
    if (a === b) {
      result += a + 'X';
      i--;
    } else {
      result += a + b;
    }
  }
  return result;
}

// Encrypt a pair of letters
function encryptPair(a, b, matrix) {
  const posA = findPosition(matrix, a);
  const posB = findPosition(matrix, b);
  if (posA.row === posB.row) {
    return matrix[posA.row][(posA.col + 1) % 5] +
matrix[posB.row][(posB.col + 1) % 5];
```

```
  } else if (posA.col === posB.col) {
    return matrix[(posA.row + 1) % 5][posA.col] + matrix[(posB.row +
1) % 5][posB.col];
  } else {
    return matrix[posA.row][posB.col] + matrix[posB.row][posA.col];
  }
}

// Encrypt full message
function encryptPlayfair(message) {
  const key = getPlayfairKey();
  const matrix = createMatrix(key);
  const prepared = prepareText(message);
  let encrypted = '';
  for (let i = 0; i < prepared.length; i += 2) {
    encrypted += encryptPair(prepared[i], prepared[i + 1] ?? ‘X’,
matrix);
  }
  return encrypted;
}
```

Output:

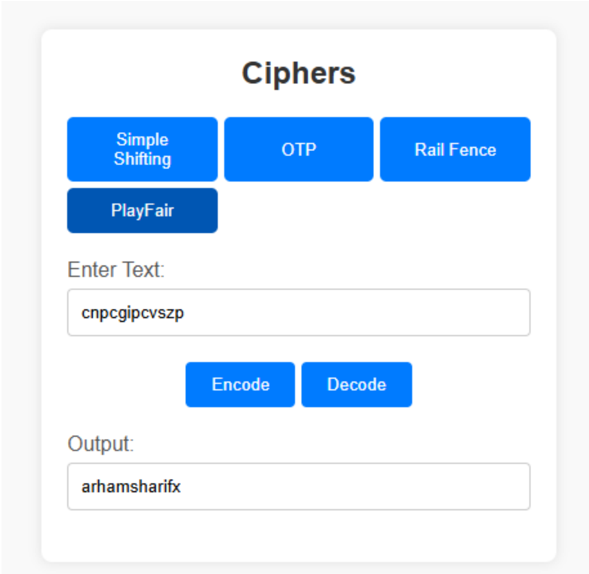


CODE:

```
// Decrypt a pair of letters
```

```
function decryptPair(a, b, matrix) {
  const posA = findPosition(matrix, a);
  const posB = findPosition(matrix, b);
  if (posA.row === posB.row) {
    return matrix[posA.row][(posA.col + 4) % 5] +
matrix[posB.row][(posB.col + 4) % 5];
  } else if (posA.col === posB.col) {
    return matrix[(posA.row + 4) % 5][posA.col] + matrix[(posB.row +
4) % 5][posB.col];
  } else {
    return matrix[posA.row][posB.col] + matrix[posB.row][posA.col];
  }
}

// Decrypt full message
function decryptPlayfair(cipherText) {
  cipherText = cipherText.replace(/[^A-Z]/g, '').toUpperCase();
  const key = getPlayfairKey();
  const matrix = createMatrix(key);
  let decrypted = '';
  for (let i = 0; i < cipherText.length; i += 2) {
    decrypted += decryptPair(cipherText[i], cipherText[i + 1] ?? ‘X’,
matrix);
  }
  return decrypted;
}
```

Output:



LAB#5

VIGINERERE CIPHER

Introduction:

This program implements the Vigenère cipher, a polyalphabetic substitution cipher that uses a keyword to shift letters in the plaintext by varying amounts across different positions. It offers improved security compared to the Caesar cipher by using a keyword to determine multiple shift values.

Method of Encryption:

The Vigenère cipher encrypts plaintext by shifting each letter in the message based on a keyword. The keyword determines the amount of shift applied to each letter in the plaintext cyclically. For example, if the keyword is 'KEY' and the plaintext is 'HELLO', the first letter 'H' is shifted by 'K', 'E' by 'E', 'L' by 'Y', and so on. Both uppercase and lowercase letters are shifted, while non-alphabetic characters remain unchanged.

Method of Decryption:

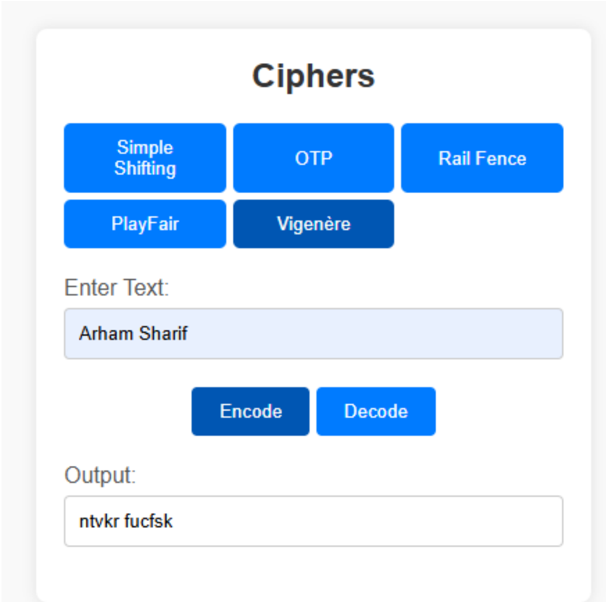
Decryption in the Vigenère cipher involves reversing the encryption process using the same keyword. Each letter in the cipher text is shifted backwards by the corresponding letter in the keyword to retrieve the original plaintext. Non-alphabetic characters remain unchanged during decryption.

CODE:

```
// Function to generate a random Vigenère key of given length
const vigenereCharArr = Array.from({ length: 26 }, (_, i) =>
String.fromCharCode(97 + i));
function generateVigenereRandomKey(length) {
  const charset = vigenereCharArr.join("");
  let key = '';
  for (let i = 0; i < length; i++) {
    const randomIndex = Math.floor(Math.random() * charset.length);
    key += charset[randomIndex];
  }
  return key;
}

// Function to generate the Vigenère character array based on the key
function generateVigenereCharArr(key) {
  const charArr = [];
  for (let i = 0; i < key.length; i++) {
    const shift = key.charCodeAt(i) - 97; // Get the shift amount for
each character in the key
    const shiftedChars =
vigenereCharArr.slice(shift).concat(vigenereCharArr.slice(0, shift));
    charArr.push(shiftedChars);
  }
  return charArr;
}

// Function to save Vigenère key and character array to local storage
function saveVigenereToLocalStorage(key, charArr) {
  localStorage.setItem('vigenereKey', key);
  localStorage.setItem('vigenereCharArr', JSON.stringify(charArr));
}

// Function to retrieve Vigenère key and character array from local
storage
function getVigenereFromLocalStorage() {
  let key = localStorage.getItem('vigenereKey');
  let charArr = JSON.parse(localStorage.getItem('vigenereCharArr'));

  if (!key || !charArr) {
    key = generateVigenereRandomKey(6); // Change the length as
needed
```

```
    charArr = generateVigenereCharArr(randomKey);
    saveVigenereToLocalStorage(key, charArr);
  }

  return { key, charArr };
}

// Generate random key and character array
const randomKey = generateVigenereRandomKey(6); // Change the length
as needed
const randomCharArr = generateVigenereCharArr(randomKey);

// Save them to local storage
saveVigenereToLocalStorage(randomKey, randomCharArr);

// Function to encrypt message using Vigenère shifting
function encryptVigenereShifting(message) {
  const { key, charArr } = getVigenereFromLocalStorage();

  let result = '';

  for (let i = 0, j = 0; i < message.length; i++) {
    const c = message.charAt(i);
    const index = vigenereCharArr.indexOf(c);
    if (index !== -1) {
      result += charArr[j % key.length][index];
      j++;
    } else {
      result += c;
    }
  }
  return result;
}
```

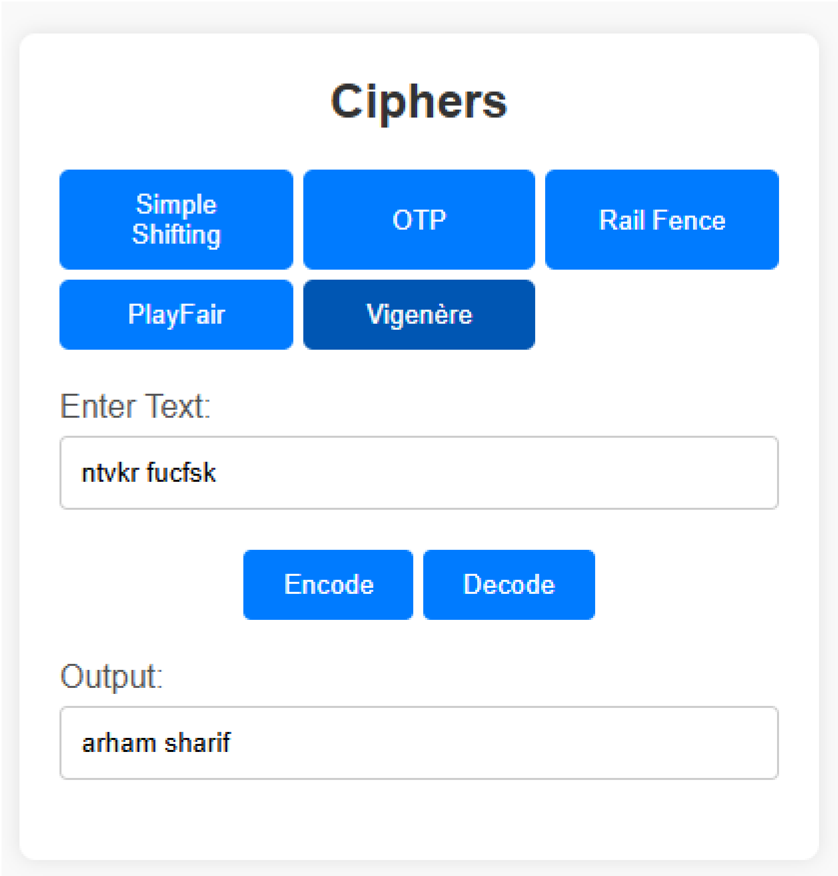
Output:



CODE:

```
// Function to decrypt message using Vigenère shifting
function decryptVigenereShifting(message) {
  const { key, charArr } = getVigenereFromLocalStorage();

  let result = '';

  for (let i = 0, j = 0; i < message.length; i++) {
    const c = message.charAt(i);
    const rowIndex = j % key.length;
    const charIndex = charArr[rowIndex].indexOf(c);
    if (charIndex !== -1) {
      result += vigenereCharArr[charIndex];
      j++;
    } else {
      result += c;
    }
  }
  return result;
}
```

Output:



LAB#6

HILL CIPHER

Introduction:

This program implements the Hill cipher, a polygraphic substitution cipher that operates on blocks of plaintext characters. It uses matrix multiplication with a key matrix to transform the plaintext into cipher text and vice versa.

Method of Encryption:

The Hill cipher encrypts plaintext by dividing it into blocks of size determined by the key matrix. Each block is transformed into cipher text by multiplying it with the key matrix modulo the size of the alphabet. The resulting cipher text blocks represent the encrypted message.

Method of Decryption:

Decryption in the Hill cipher involves the inverse operation of encryption. Each cipher text block is multiplied by the inverse of the key matrix modulo the size of the alphabet. This yields the original plaintext blocks, which are then combined to retrieve the original message.

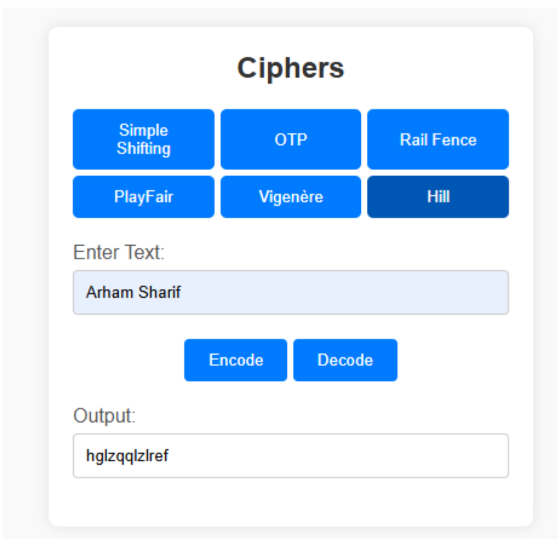
CODE:

```
// Define alphabet and modulus
const hillAlphabet = Array.from({ length: 26 }, (_, i) =>
String.fromCharCode(65 + i));
const hillMod = hillAlphabet.length; // for mod 26 arithmetic (A-Z)

// Convert a character to its index (A=0, B=1, ..., Z=25)
const hillCharToIndex = char => hillAlphabet.indexOf(char);

// Convert an index to a character
const hillIndexToChar = index => {
  return hillAlphabet[(index + hillMod) % hillMod];
};

// Compute GCD (used for checking if determinant is invertible mod
26)
function hillGCD(a, b) {
  return b === 0 ? a : hillGCD(b, a % b);
}

// Compute modular inverse of a number mod m
function hillModInverse(a, m) {
  a = ((a % m) + m) % m;
  for (let x = 1; x < m; x++) {
    if ((a * x) % m === 1) return x;
  }
  return null;
}

// Generate a valid 2x2 key matrix and save to localStorage
function hillGenerateKeyMatrix() {
  let matrix, det;
  do {
    // Random 2x2 matrix
    matrix = [
      [Math.floor(Math.random() * 26), Math.floor(Math.random() *
26)],
```

```
      [Math.floor(Math.random() * 26), Math.floor(Math.random() *
26)]
    ];
    // Calculate determinant
    det = (matrix[0][0] * matrix[1][1] - matrix[0][1] * matrix[1][0])
% hillMod;
  } while (hillGCD(det, hillMod) !== 1); // Repeat if matrix not
invertible

  // Save key to localStorage
  localStorage.setItem("hillKeyMatrix", JSON.stringify(matrix));
  return matrix;
}

// Get the key matrix from localStorage or generate one
function hillGetKeyMatrix() {
  return JSON.parse(localStorage.getItem("hillKeyMatrix")) ||
hillGenerateKeyMatrix();
}

// Invert a 2x2 matrix mod 26
function hillInvertMatrix(matrix) {
  const [[a, b], [c, d]] = matrix;
  const det = (a * d - b * c + hillMod) % hillMod;
  const invDet = hillModInverse(det, hillMod);
  if (invDet === null) throw new Error("Matrix not invertible");

  // Return inverse matrix mod 26
  return [
    [(d * invDet) % hillMod, (-b * invDet + hillMod) % hillMod],
    [(-c * invDet + hillMod) % hillMod, (a * invDet) % hillMod]
  ];
}

// Encrypt plaintext using Hill Cipher
function hillEncrypt(plaintext) {
  const matrix = hillGetKeyMatrix();
  plaintext = plaintext.replace(/[^A-Z]/g, ''); // Remove non-
alphabetic characters

  // Ensure even length by padding with 'X'
  if (plaintext.length % 2 !== 0) plaintext += 'X';
```

```
  let result = "";
  for (let i = 0; i < plaintext.length; i += 2) {
    const p1 = hillCharToIndex(plaintext[i]);
    const p2 = hillCharToIndex(plaintext[i + 1]);
    // Matrix multiplication: C = K × P mod 26
    const c1 = (matrix[0][0] * p1 + matrix[0][1] * p2) % hillMod;
    const c2 = (matrix[1][0] * p1 + matrix[1][1] * p2) % hillMod;
    result += hillIndexToChar(c1) + hillIndexToChar(c2);
  }
  return result;
}
```

Output:

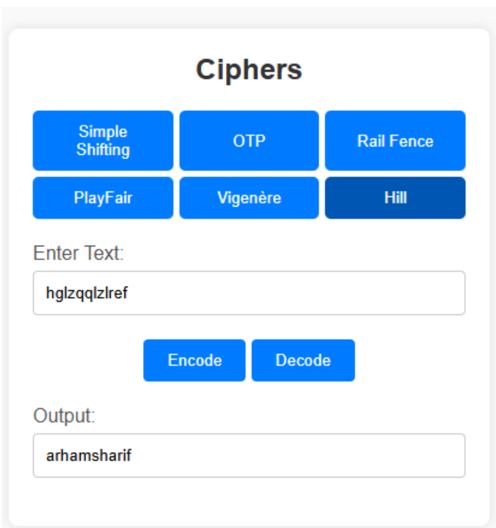


CODE:

```
// Decrypt ciphertext using Hill Cipher
function hillDecrypt(ciphertext) {
  const matrix = hillGetKeyMatrix();
  const inverseMatrix = hillInvertMatrix(matrix);
  ciphertext = ciphertext.replace(/[^A-Z]/g, ''); // Remove non-
alphabetic characters

  let result = "";
  for (let i = 0; i < ciphertext.length; i += 2) {
    const c1 = hillCharToIndex(ciphertext[i]);
    const c2 = hillCharToIndex(ciphertext[i + 1]);
```

```
    // Matrix multiplication: P = K⁻¹ × C mod 26
    const p1 = (inverseMatrix[0][0] * c1 + inverseMatrix[0][1] * c2) % hillMod;
    const p2 = (inverseMatrix[1][0] * c1 + inverseMatrix[1][1] * c2) % hillMod;
    result += hillIndexToChar(p1) + hillIndexToChar(p2);
  }

  // Remove padding 'X' if it's at the end
  return result.replace(/X$/, '');
}
```

Output:



LAB#7

TRANSPOSITION CIPHER

Introduction:

This program implements the Row Column Transposition cipher, a transposition cipher where the plaintext is reordered based on a sequence generated by a key. It offers moderate security by rearranging the order of characters without altering their identities.

Method of Encryption:

The Row Column Transposition cipher encrypts plaintext by arranging it into a grid based on the length of the key. The columns are then reordered according to the alphabetical order of the key, producing the cipher text as the rows are read sequentially.

Method of Decryption:

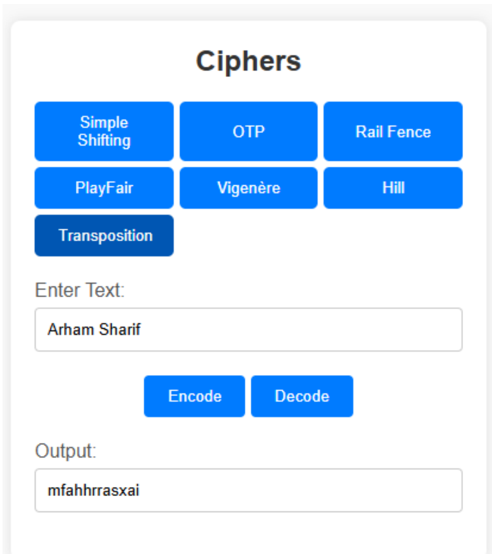
Decryption in the Row Column Transposition cipher involves rearranging the cipher text grid based on the key's original order. The columns are reordered to match the alphabetical order of the key, allowing the original plaintext to be reconstructed by reading rows sequentially.

CODE:

```
const TRANS_KEY_STORAGE = "transpositionKey"; // Key storage name in
localStorage

// Generate a random key of given length (e.g., 6 unique A-Z
characters)
function generateTranspositionKey(length = 6) {
  const chars = Array.from({ length: 26 }, (_, i) =>
String.fromCharCode(65 + i)).join('');
  let key = "";
  while (key.length < length) {
    const char = chars[Math.floor(Math.random() * chars.length)];
    if (!key.includes(char)) {
      key += char;
    }
  }
  return key;
}

// Save generated key to localStorage
function saveTranspositionKeyToLocalStorage(key) {
  localStorage.setItem(TRANS_KEY_STORAGE, key);
}

// Retrieve key from localStorage or generate one if not present
function getTranspositionKeyFromLocalStorage(length = 6) {
  let key = localStorage.getItem(TRANS_KEY_STORAGE);
  if (!key) {
    key = generateTranspositionKey(length);
    saveTranspositionKeyToLocalStorage(key);
  }
  return key;
```

```
}

// Get column order based on alphabetical sorting of key characters
function getTranspositionKeyOrder(key) {
  return key
    .split('')
    .map((char, index) => ({ char, index }))     // Keep original
index
    .sort((a, b) => a.char.localeCompare(b.char)) // Sort
alphabetically
    .map(obj => obj.index);                        // Extract sorted
indexes
}

// === ENCRYPTION ===
function encryptTranspositionCipher(plaintext) {
  plaintext = plaintext.replace(/[^A-Z]/g, '');
  const key = getTranspositionKeyFromLocalStorage();
  const numCols = key.length;
  const keyOrder = getTranspositionKeyOrder(key);
  const numRows = Math.ceil(plaintext.length / numCols);

  // Fill matrix row by row
  const matrix = [];
  let index = 0;
  for (let r = 0; r < numRows; r++) {
    matrix[r] = [];
    for (let c = 0; c < numCols; c++) {
      matrix[r][c] = plaintext[index++] || 'X'; // Fill with 'X' if
not enough chars
    }
  }

  // Read matrix column-wise in key order
  let ciphertext = '';
  for (const colIndex of keyOrder) {
    for (let r = 0; r < numRows; r++) {
      ciphertext += matrix[r][colIndex];
    }
  }

  return ciphertext;
}
```

Output:

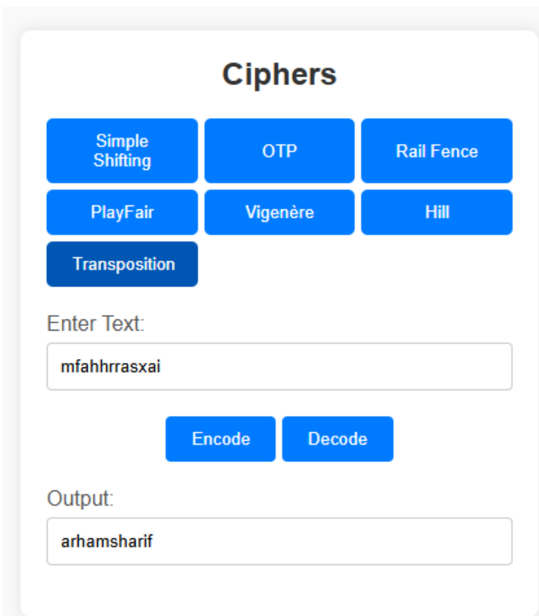


CODE:

```
function decryptTranspositionCipher(ciphertext) {
  ciphertext = ciphertext.replace(/[^A-Z]/g, '');
  const key = getTranspositionKeyFromLocalStorage();
  const numCols = key.length;
  const numRows = Math.ceil(ciphertext.length / numCols);
  const keyOrder = getTranspositionKeyOrder(key);

  // Determine how many full columns there are (some may be shorter)
  const totalChars = ciphertext.length;
  const shortCols = (numCols * numRows) - totalChars;

  // Determine how many characters in each column
  const colLengths = Array(numCols).fill(numRows);
  for (let i = numCols - shortCols; i < numCols; i++) {
    colLengths[keyOrder[i]] = numRows - 1;
  }

  // Fill the matrix column-wise
  const matrix = Array.from({ length: numRows }, () => []);
  let index = 0;
  for (let i = 0; i < numCols; i++) {
    const colIndex = keyOrder[i];
```

```
    const colLen = colLengths[colIndex];
    for (let r = 0; r < colLen; r++) {
      matrix[r][colIndex] = ciphertext[index++];
    }
  }

  // Read the matrix row-wise to reconstruct plaintext
  const plaintext = matrix.map(row => row.join('')).join('');
  return plaintext.replace(/X+$/g, ''); // Remove trailing 'X'
padding
}
```

Output:



LAB#8

DES CIPHER

Introduction:

This program implements the Data Encryption Standard (DES), a symmetric key block cipher that uses a 56-bit key to encrypt and decrypt data in blocks of 64 bits. It was widely used before being replaced by more secure algorithms.

Method of Encryption:

DES encrypts plaintext by first dividing it into blocks of 64 bits and then performing a series of transformations, including permutation, substitution, and transposition, based on a 56-bit key. These operations are repeated multiple times (16 rounds) to produce the cipher text.

Method of Decryption:

Decryption in DES involves applying the inverse of the encryption process. Each round of decryption uses the sub keys derived from the original key to reverse the transformations applied during encryption, ultimately retrieving the original plaintext from the cipher text.

CODE:

```
function getDynamicChars() {
  let chars = '';
  for (let i = 65; i <= 90; i++) chars += String.fromCharCode(i);  //
A-Z
  for (let i = 97; i <= 122; i++) chars += String.fromCharCode(i); //
a-z
  for (let i = 48; i <= 57; i++) chars += String.fromCharCode(i);  //
0-9
  return chars;
}

const DES_KEY_STORAGE = "desEncryptionKey";

// Generate random 8-character key from A-Z, a-z, 0-9
function generateDesKey() {
  const chars = getDynamicChars();
  let key = '';
  for (let i = 0; i < 8; i++) {
    key += chars.charAt(Math.floor(Math.random() * chars.length));
  }
  return key;
}

// Save key to localStorage
function saveDesKeyToLocalStorage(key) {
  localStorage.setItem(DES_KEY_STORAGE, key);
}

// Retrieve key from localStorage or generate if not present
```

```
function getDesKeyFromLocalStorage() {
  let key = localStorage.getItem(DES_KEY_STORAGE);
  if (!key) {
    key = generateDesKey();
    saveDesKeyToLocalStorage(key);
  }
  return key;
}

// DES constants: permutations, S-boxes, etc.

const IP = [ // Initial Permutation
  58, 50, 42, 34, 26, 18, 10, 2,
  60, 52, 44, 36, 28, 20, 12, 4,
  62, 54, 46, 38, 30, 22, 14, 6,
  64, 56, 48, 40, 32, 24, 16, 8,
  57, 49, 41, 33, 25, 17, 9, 1,
  59, 51, 43, 35, 27, 19, 11, 3,
  61, 53, 45, 37, 29, 21, 13, 5,
  63, 55, 47, 39, 31, 23, 15, 7
];

const FP = [ // Final Permutation (inverse IP)
  40, 8, 48, 16, 56, 24, 64, 32,
  39, 7, 47, 15, 55, 23, 63, 31,
  38, 6, 46, 14, 54, 22, 62, 30,
  37, 5, 45, 13, 53, 21, 61, 29,
  36, 4, 44, 12, 52, 20, 60, 28,
  35, 3, 43, 11, 51, 19, 59, 27,
  34, 2, 42, 10, 50, 18, 58, 26,
  33, 1, 41, 9, 49, 17, 57, 25
];

const E = [ // Expansion permutation (32 to 48 bits)
  32, 1, 2, 3, 4, 5,
  4, 5, 6, 7, 8, 9,
  8, 9, 10, 11, 12, 13,
  12, 13, 14, 15, 16, 17,
  16, 17, 18, 19, 20, 21,
  20, 21, 22, 23, 24, 25,
  24, 25, 26, 27, 28, 29,
  28, 29, 30, 31, 32, 1
];
```

```
const P = [ // Permutation after S-box
  16, 7, 20, 21,
  29, 12, 28, 17,
  1, 15, 23, 26,
  5, 18, 31, 10,
  2, 8, 24, 14,
  32, 27, 3, 9,
  19, 13, 30, 6,
  22, 11, 4, 25
];

const PC1 = [ // Permuted Choice 1 (64 to 56 bits)
  57, 49, 41, 33, 25, 17, 9,
  1, 58, 50, 42, 34, 26, 18,
  10, 2, 59, 51, 43, 35, 27,
  19, 11, 3, 60, 52, 44, 36,
  63, 55, 47, 39, 31, 23, 15,
  7, 62, 54, 46, 38, 30, 22,
  14, 6, 61, 53, 45, 37, 29,
  21, 13, 5, 28, 20, 12, 4
];

const PC2 = [ // Permuted Choice 2 (56 to 48 bits)
  14, 17, 11, 24, 1, 5,
  3, 28, 15, 6, 21, 10,
  23, 19, 12, 4, 26, 8,
  16, 7, 27, 20, 13, 2,
  41, 52, 31, 37, 47, 55,
  30, 40, 51, 45, 33, 48,
  44, 49, 39, 56, 34, 53,
  46, 42, 50, 36, 29, 32
];

const SHIFTS = [ // Left shifts for each round
  1, 1, 2, 2, 2, 2, 2, 2,
  1, 2, 2, 2, 2, 2, 2, 1
];

// S-boxes (8 boxes, 4x16 each)
const SBOX = [
  [
    [14, 4, 13, 1, 2, 15, 11, 8, 3, 10, 6, 12, 5, 9, 0, 7],
```

```
    [0, 15, 7, 4, 14, 2, 13, 1, 10, 6, 12, 11, 9, 5, 3, 8],
    [4, 1, 14, 8, 13, 6, 2, 11, 15, 12, 9, 7, 3, 10, 5, 0],
    [15, 12, 8, 2, 4, 9, 1, 7, 5, 11, 3, 14, 10, 0, 6, 13],
  ],
  [
    [15, 1, 8, 14, 6, 11, 3, 4, 9, 7, 2, 13, 12, 0, 5, 10],
    [3, 13, 4, 7, 15, 2, 8, 14, 12, 0, 1, 10, 6, 9, 11, 5],
    [0, 14, 7, 11, 10, 4, 13, 1, 5, 8, 12, 6, 9, 3, 2, 15],
    [13, 8, 10, 1, 3, 15, 4, 2, 11, 6, 7, 12, 0, 5, 14, 9],
  ],
  [
    [10, 0, 9, 14, 6, 3, 15, 5, 1, 13, 12, 7, 11, 4, 2, 8],
    [13, 7, 0, 9, 3, 4, 6, 10, 2, 8, 5, 14, 12, 11, 15, 1],
    [13, 6, 4, 9, 8, 15, 3, 0, 11, 1, 2, 12, 5, 10, 14, 7],
    [1, 10, 13, 0, 6, 9, 8, 7, 4, 15, 14, 3, 11, 5, 2, 12],
  ],
  [
    [7, 13, 14, 3, 0, 6, 9, 10, 1, 2, 8, 5, 11, 12, 4, 15],
    [13, 8, 11, 5, 6, 15, 0, 3, 4, 7, 2, 12, 1, 10, 14, 9],
    [10, 6, 9, 0, 12, 11, 7, 13, 15, 1, 3, 14, 5, 2, 8, 4],
    [3, 15, 0, 6, 10, 1, 13, 8, 9, 4, 5, 11, 12, 7, 2, 14],
  ],
  [
    [2, 12, 4, 1, 7, 10, 11, 6, 8, 5, 3, 15, 13, 0, 14, 9],
    [14, 11, 2, 12, 4, 7, 13, 1, 5, 0, 15, 10, 3, 9, 8, 6],
    [4, 2, 1, 11, 10, 13, 7, 8, 15, 9, 12, 5, 6, 3, 0, 14],
    [11, 8, 12, 7, 1, 14, 2, 13, 6, 15, 0, 9, 10, 4, 5, 3],
  ],
  [
    [12, 1, 10, 15, 9, 2, 6, 8, 0, 13, 3, 4, 14, 7, 5, 11],
    [10, 15, 4, 2, 7, 12, 9, 5, 6, 1, 13, 14, 0, 11, 3, 8],
    [9, 14, 15, 5, 2, 8, 12, 3, 7, 0, 4, 10, 1, 13, 11, 6],
    [4, 3, 2, 12, 9, 5, 15, 10, 11, 14, 1, 7, 6, 0, 8, 13],
  ],
  [
    [4, 11, 2, 14, 15, 0, 8, 13, 3, 12, 9, 7, 5, 10, 6, 1],
    [13, 0, 11, 7, 4, 9, 1, 10, 14, 3, 5, 12, 2, 15, 8, 6],
    [1, 4, 11, 13, 12, 3, 7, 14, 10, 15, 6, 8, 0, 5, 9, 2],
    [6, 11, 13, 8, 1, 4, 10, 7, 9, 5, 0, 15, 14, 2, 3, 12],
  ],
  [
    [13, 2, 8, 4, 6, 15, 11, 1, 10, 9, 3, 14, 5, 0, 12, 7],
    [1, 15, 13, 8, 10, 3, 7, 4, 12, 5, 6, 11, 0, 14, 9, 2],
```

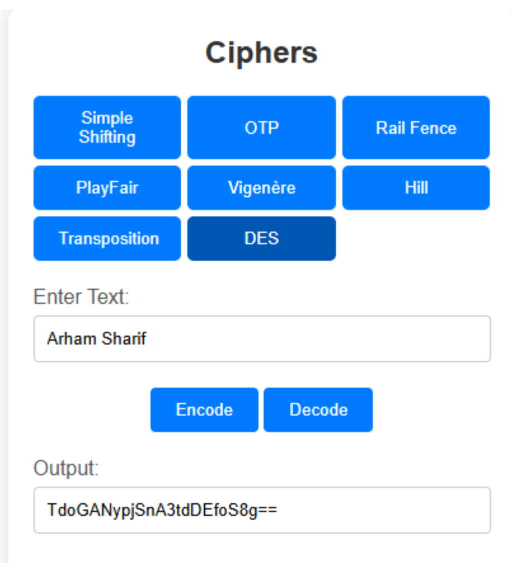
```
    [7, 11, 4, 1, 9, 12, 14, 2, 0, 6, 10, 13, 15, 3, 5, 8],
    [2, 1, 14, 7, 4, 10, 8, 13, 15, 12, 9, 0, 3, 5, 6, 11],
  ]
];

// Utility functions

// Convert string to array of bits (array of 0/1), length 64 bits per
block
function stringToBits(str) {
  const bits = [];
  for (let i = 0; i < str.length; i++) {
    let ch = str.charCodeAt(i);
    for (let j = 7; j >= 0; j--) {
      bits.push((ch >> j) & 1);
    }
  }
  // Pad to 64 bits blocks
  while (bits.length % 64 !== 0) {
    bits.push(0);
  }
  return bits;
}

// Convert bits array to string
function bitsToString(bits) {
  let str = '';
  for (let i = 0; i < bits.length; i += 8) {
    let ch = 0;
    for (let j = 0; j < 8; j++) {
      ch = (ch << 1) | bits[i + j];
    }
    str += String.fromCharCode(ch);
  }
  return str;
}

// Permutation function - apply table to bits array
function permute(bits, table) {
  return table.map(pos => bits[pos - 1]);
}

// Left rotate bits array by n positions
```

```
function leftRotate(arr, n) {
  return arr.slice(n).concat(arr.slice(0, n));
}

// XOR two bit arrays
function xor(arr1, arr2) {
  return arr1.map((b, i) => b ^ arr2[i]);
}

// Split array into two halves
function splitInHalf(arr) {
  const mid = arr.length / 2;
  return [arr.slice(0, mid), arr.slice(mid)];
}

// Generate 16 subkeys of 48 bits from original 64-bit key
function generateSubkeys(keyBits) {
  // Apply PC1 (64 -> 56 bits)
  let permutedKey = permute(keyBits, PC1);
  // Split into C and D (28 bits each)
  let [C, D] = splitInHalf(permutedKey);

  const subkeys = [];
  for (let i = 0; i < 16; i++) {
    // Left shifts
    C = leftRotate(C, SHIFTS[i]);
    D = leftRotate(D, SHIFTS[i]);
    // Combine
    let CD = C.concat(D);
    // Apply PC2 (56 -> 48 bits)
    let subkey = permute(CD, PC2);
    subkeys.push(subkey);
  }
  return subkeys;
}

// Feistel function f(R, K)
function feistel(R, K) {
  // Expand R from 32 to 48 bits using E table
  let ER = permute(R, E);
  // XOR with subkey
  let xorResult = xor(ER, K);
  // Split into 8 groups of 6 bits
```

```
  let output = [];
  for (let i = 0; i < 8; i++) {
    let block = xorResult.slice(i * 6, i * 6 + 6);
    let row = (block[0] << 1) | block[5];
    let col = (block[1] << 3) | (block[2] << 2) | (block[3] << 1) |
block[4];
    let sboxVal = SBOX[i][row][col]; // 4 bits output
    for (let j = 3; j >= 0; j--) {
      output.push((sboxVal >> j) & 1);
    }
  }
  // Permute output with P table (32 bits)
  return permute(output, P);
}

// DES encrypt/decrypt block (64 bits) with 16 subkeys
function desBlock(blockBits, subkeys, decrypt = false) {
  // Initial Permutation
  let permutedBlock = permute(blockBits, IP);
  // Split into L and R halves
  let [L, R] = splitInHalf(permutedBlock);

  for (let i = 0; i < 16; i++) {
    let roundKey = decrypt ? subkeys[15 - i] : subkeys[i];
    let fRes = feistel(R, roundKey);
    let newR = xor(L, fRes);
    L = R;
    R = newR;
  }

  // Combine R and L (note the swap)
  let combined = R.concat(L);
  // Final Permutation (inverse IP)
  return permute(combined, FP);
}

// Main DES encrypt/decrypt function for strings
function encryptDes(plaintext, decrypt = false) {
  const key = getDesKeyFromLocalStorage();
  // Convert input string and key to bits
  let textBits = stringToBits(plaintext);
  let keyBits = stringToBits(key);
  keyBits = keyBits.slice(0, 64); // Use only first 64 bits for key
```

```
  // Generate subkeys
  let subkeys = generateSubkeys(keyBits);

  let resultBits = [];
  // Process each 64-bit block
  for (let i = 0; i < textBits.length; i += 64) {
    let block = textBits.slice(i, i + 64);
    let resBlock = desBlock(block, subkeys, decrypt);
    resultBits = resultBits.concat(resBlock);
  }

  if (decrypt) {
    // Convert bits back to string
    return bitsToString(resultBits);
  } else {
    // Return Base64 encoded ciphertext
    let str = bitsToString(resultBits);
    return btoa(str);
  }
}
```

Output:

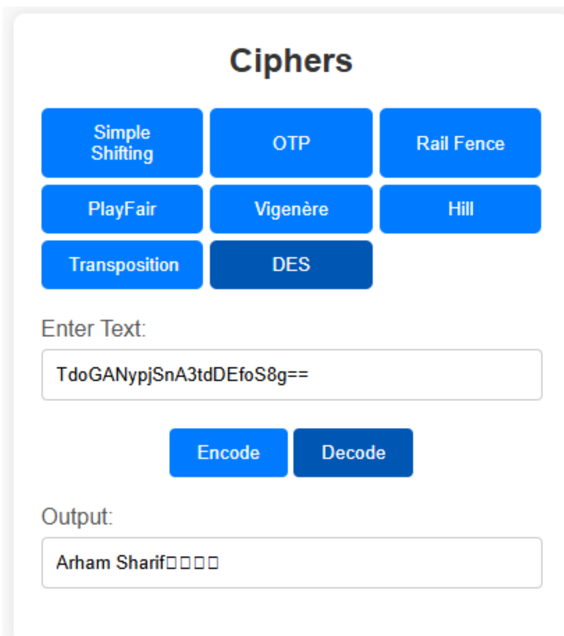


CODE:

```
// For decrypt, input ciphertext should be base64 string
```

```
function decryptDes(ciphertextBase64) {
  try {
    const ciphertext = atob(ciphertextBase64);
    return encryptDes(ciphertext, true); // assuming this decrypts
  } catch (e) {
    return e.message;
  }
}
```

Output:



LAB#9

RSA CIPHER

Introduction:

This program implements the RSA cipher, a public-key cryptographic algorithm used for secure data transmission. It uses a pair of keys (public and private) for encryption and decryption, providing secure communication over insecure channels.

Method of Encryption:

RSA encrypts plaintext by encoding it using the recipient's public key, which consists of two large prime numbers. The plaintext is converted into a numerical value and raised to the power of the public key's exponent modulo the product of the two prime numbers, producing cipher text.

Method of Decryption:

Decryption in RSA requires the recipient's private key, which is mathematically related to the public key. The cipher text is decoded using the private key's exponent and the same modulo operation, resulting in the retrieval of the original plaintext. RSA's security is based on the difficulty of factoring large prime numbers.

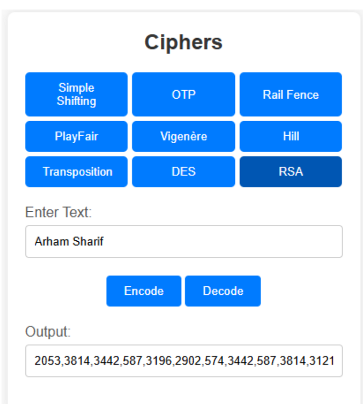
CODE:

```
// Utility functions
function gcd(a, b) {
  return b === 0 ? a : gcd(b, a % b);
}

function modInverse(e, phi) {
  let [m0, x0, x1] = [phi, 0, 1];
  while (e > 1) {
    const q = Math.floor(e / phi);
    [e, phi] = [phi, e % phi];
    [x0, x1] = [x1 - q * x0, x0];
  }
  return x1 < 0 ? x1 + m0 : x1;
}

function isPrime(n) {
  if (n < 2) return false;
  for (let i = 2; i <= Math.sqrt(n); i++) {
    if (n % i === 0) return false;
  }
  return true;
}

function getRandomPrime(min = 50, max = 100) {
  let p;
  do {
    p = Math.floor(Math.random() * (max - min)) + min;
```

```
  } while (!isPrime(p));
  return p;
}

// RSA Key Generation
function generateRsaKeys() {
  const p = getRandomPrime();
  let q;
  do {
    q = getRandomPrime();
  } while (q === p);

  const n = p * q;
  const phi = (p - 1) * (q - 1);
  let e = 3;
  while (gcd(e, phi) !== 1) e++;

  const d = modInverse(e, phi);

  const publicKey = { e, n };
  const privateKey = { d, n };
  const keys = { p, q, n, e, d, publicKey, privateKey };

  localStorage.setItem("rsa_keys", JSON.stringify(keys));
  return keys;
}

function getRsaKeys() {
  const keys = localStorage.getItem("rsa_keys");
  return keys ? JSON.parse(keys) : generateRsaKeys();
}

function modPow(base, exp, mod) {
  let result = 1;
  base = base % mod;
  while (exp > 0) {
    if (exp % 2 === 1) result = (result * base) % mod;
    base = (base * base) % mod;
    exp = Math.floor(exp / 2);
  }
  return result;
}
```

```
function textToNumbers(text) {
  return Array.from(text).map(char => char.charCodeAt(0));
}

function numbersToText(nums) {
  return nums.map(num => String.fromCharCode(num)).join('');
}

function encryptRSA(m) {
  const publicKey = getRsaKeys().publicKey;
  const { e, n } = publicKey;
  return modPow(m, e, n);
}

function encryptTextRSA(text) {
  const numbers = textToNumbers(text);
  return numbers.map(num => encryptRSA(num));
}
```

Output:

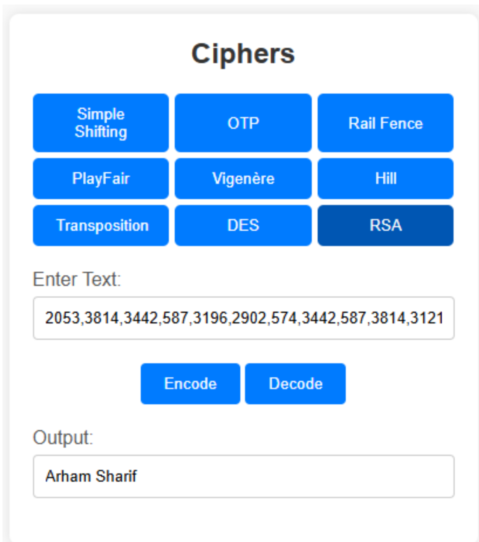


CODE:

```
function decryptRSA(c) {
  const privateKey = getRsaKeys().privateKey;
  const { d, n } = privateKey;
  return modPow(c, d, n);
}

function decryptTextRSA(cipherArray) {
  const decryptedNums = cipherArray.map(c => decryptRSA(c));
```

```
  return numbersToText(decryptedNums);
}
```

Output:



RSA NUMERICAL

Q: In RSA cryptographic system a particular. A user two prime no. 5 P=13 and q=17 to generate this public and private key. If the public key of A is 35, then find the private key of A.

Solution:

P = 13

Q = 17

n = p x q
= 13 x 17
n = 221

ϕn = (p - 1) x (q – 1)
= (13 - 1) x (17 - 1)
ϕn = 192

e = 35

gcd (35, 192) = **1**

de = 1 + kϕn

d = (1 + kϕn)/ e

for k = 0

d = [1 + 0 (192)]/35 = **0.028**

for k = 1

d = [1 + 1 (192)]/35 = **5.514**

for k = 2

d = [1 + 2 (192)]/35 = **11**

Private Key of A = 11

DES NUMERICAL

Given:

Plaintext (M) = 0123456789ABCDEF

Key (K) = 133457799BBCDFF1

Solution:

Plain Text (in Binary 64-bit) = 0000 0001 0010 0011 0100 0101 0110 0111 1000 1001 1010 1011 1100 1101 1110 1111

Key (in Binary 64-bit) = 0001 0011 0011 0100 0101 0111 0111 1001 1001 1011 1011 1100 1101 1111 1111 0001

Key without Parity (in Binary 56 bit) = 00010010011010101011110011001001101101111011011111111000

Round	Shift	C (28 bits)	D (28 bits)	K (48 bits Round Key)
1	1	0010010011010101 011110011000	0011011011110110111 111110001	10010010011101100010010001111001110 1011110111001
2	1	0100100110101010 111100110000	0110110111101101111 111100010	01110100100011000100011110111111011 11111010111100
3	2	0010011010101011 110011000001	1011011110110111111 110001001	01100011111000000110010001110010 1 0111111110111
4	2	1001101010101111 001100000100	1101111011011111111 000100110	10101100100001011011011010011111 11 10100010110011
5	2	0110101010111100 110000010010	0111101101111111100 010011011	11110110000000100001101111100111 01 10111101010101
6	2	1010101011110011 000001001001	1110110111111110001 001101101	00101111100100100011000010111011 10 10001111011110
7	2	1010101111001100 000100100110	1011011111111000100 110110111	10001110000110001101111011110101 11 01011110000111
8	2	1010111100110000 010010011010	1101111111100010011 011011110	00111110011000100101100001011110 00 10011011101111
9	1	0101111001100000 100100110101	1011111111000100110 110111101	01110101010110011001010101110000 11 11010111110111
10	2	0111100110000010 010011010101	1111111100010011011 011110110	00010111101000011100000101101111 10 10110010101111
11	2	1110011000001001 001101010101	1111110001001101101 111011011	00011011010001001011011111101110 01 11110111011011

Round	Shift	C (28 bits)	D (28 bits)	K (48 bits Round Key)
12	2	1001100000100100110101010111	1111000100110110111101101111	111111010000000110001100001011111101001101111111
13	2	0110000010010011010101011110	1100010011011011110110111111	000100101000001010101101110101111101110111100010
14	2	1000001001001101010101111001	0001001101101111011011111111	100110010001100000110110110011001000111101111101
15	2	0000100100110101010111100110	0100110110111101101111111100	101001000010101011101100110110111111111011011100
16	1	0001001001101010101111001100	1001101101111011011111111000	011000001011010110010110110010011011111001101111

Initial Permutation (IP) Table:

| 58 50 42 34 26 18 10 2 |
| 60 52 44 36 28 20 12 4 |
| 62 54 46 38 30 22 14 6 |
| 64 56 48 40 32 24 16 8 |
| 57 49 41 33 25 17 9 1 |
| 59 51 43 35 27 19 11 3 |
| 61 53 45 37 29 21 13 5 |
| 63 55 47 39 31 23 15 7 |

Result after IP (64 bits, ready to paste):

1100110000000000110011001111111111110000101010101111000010101010

After IP, we split it into:

- **L0 (first 32 bits):** 11001100000000001100110011111111
- **R0 (last 32 bits):** 11110000101010101111000010101010

E-bit Selection Table (48 bits):

32	1	2	3	4	5
4	5	6	7	8	9
8	9	10	11	12	13
12	13	14	15	16	17
16	17	18	19	20	21
20	21	22	23	24	25
24	25	26	27	28	29
28	29	30	31	32	1

E(R0) = 011110100001010101010101011110100001010101010101

A (48 bits) = E(R0) ⊕ K1:

111010000110001101110001000000111100110011101100

By Using A, for each group, find the row & column:

Group	6 Bits	Row Bits (1st & 6th)	Row (decimal)	Column Bits (middle 4)	Column (decimal)
1	111010	1 and 0	2	1101	13
2	000110	0 and 0	0	0011	3
3	001101	0 and 1	1	0110	6
4	110001	1 and 1	3	1000	8
5	000000	0 and 0	0	0000	0
6	111100	1 and 0	2	1110	14
7	110011	1 and 1	3	1001	9
8	101100	1 and 0	2	0110	6

S-boxes:

S-box	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
S1	14	4	13	1	2	15	11	8	3	10	6	12	5	9	0	7
	0	15	7	4	14	2	13	1	10	6	12	11	9	5	3	8
	4	1	14	8	13	6	2	11	15	12	9	7	3	10	5	0
	15	12	8	2	4	9	1	7	5	11	3	14	10	0	6	13
S2	15	1	8	14	6	11	3	4	9	7	2	13	12	0	5	10
	3	13	4	7	15	2	8	14	12	0	1	10	6	9	11	5
	0	14	7	11	10	4	13	1	5	8	12	6	9	3	2	15
	13	8	10	1	3	15	4	2	11	6	7	12	0	5	14	9
S3	10	0	9	14	6	3	15	5	1	13	12	7	11	4	2	8
	13	7	0	9	3	4	6	10	2	8	5	14	12	11	15	1
	13	6	4	9	8	15	3	0	11	1	2	12	5	10	14	7
	1	10	13	0	6	9	8	7	4	15	14	3	11	5	2	12
S4	7	13	14	3	0	6	9	10	1	2	8	5	11	12	4	15
	13	8	11	5	6	15	0	3	4	7	2	12	1	10	14	9
	10	6	9	0	12	11	7	13	15	1	3	14	5	2	8	4
	3	15	0	6	10	1	13	8	9	4	5	11	12	7	2	14
S5	2	12	4	1	7	10	11	6	8	5	3	15	13	0	14	9
	14	11	2	12	4	7	13	1	5	0	15	10	3	9	8	6

S-box	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	4	2	1	11	10	13	7	8	15	9	12	5	6	3	0	14
	11	8	12	7	1	14	2	13	6	15	0	9	10	4	5	3
S6	12	1	10	15	9	2	6	8	0	13	3	4	14	7	5	11
	10	15	4	2	7	12	9	5	6	1	13	14	0	11	3	8
	9	14	15	5	2	8	12	3	7	0	4	10	1	13	11	6
	4	3	2	12	9	5	15	10	11	14	1	7	6	0	8	13
S7	4	11	2	14	15	0	8	13	3	12	9	7	5	10	6	1
	13	0	11	7	4	9	1	10	14	3	5	12	2	15	8	6
	1	4	11	13	12	3	7	14	10	15	6	8	0	5	9	2
	6	11	13	8	1	4	10	7	9	5	0	15	14	2	3	12
S8	13	2	8	4	6	15	11	1	10	9	3	14	5	0	12	7
	1	15	13	8	10	3	7	4	12	5	6	11	0	14	9	2
	7	11	4	1	9	12	14	2	0	6	10	13	15	3	5	8
	2	1	14	7	4	10	8	13	15	12	9	0	3	5	6	11

S-box output for each group:

Group	Row	Col	S-box value (decimal)	Binary (4 bits)
1 (S1)	2	13	11	1011
2 (S2)	0	3	14	1110
3 (S3)	1	6	6	0110
4 (S4)	3	8	1	0001
5 (S5)	0	0	2	0010
6 (S6)	2	14	11	1011
7 (S7)	3	9	11	1011
8 (S8)	2	6	14	1110

B (32 bits) = 1011 1110 0110 0001 0010 1011 1011 1110

P-box (32 bits):

16	7	20	21	29	12	28	17
1	15	23	26	5	18	31	10
2	8	24	14	32	27	3	9
19	13	30	6	22	11	4	25

Step	Binary Value
B (input to P)	10111110011000010010101110111110
R1 (after P)	01011010011010101001110101100111

IP^{-1} Table

40	**8**	**48**	**16**	**56**	**24**	**64**	**32**
39	7	47	15	55	23	63	31
38	6	46	14	54	22	62	30
37	5	45	13	53	21	61	29
36	4	44	12	52	20	60	28
35	3	43	11	51	19	59	27
34	2	42	10	50	18	58	26
33	1	41	9	49	17	57	25

Ln = Rn−1

Rn = Ln−1⊕f(Rn−1,Kn)R_n = L_{n-1} \oplus f(R_{n-1}, K_n)Rn=Ln−1⊕f(Rn−1,Kn)

Round	L (binary)	L (hex)	R (binary)	R (hex)
1	11110000101010101111000010101010	F0AAF0AA	11101111010010100110010101000100	EF4A6544
2	11101111010010100110010101000100	EF4A6544	11001100000000010111011100001001	CC017709
3	11001100000000010111011100001001	CC017709	10100010010111000000101111110100	A25C0BF4
4	10100010010111000000101111110100	A25C0BF4	01110111001000100000000001000101	77220045
5	01110111001000100000000001000101	77220045	10001010010011111010011000110111	8A4FA637
6	10001010010011111010011000110111	8A4FA637	11101001011001111100110101101001	E967CD69
7	11101001011001111100110101101001	E967CD69	00000110010010101011101000010000	064ABA10
8	00000110010010101011101000010000	064ABA10	11010101011010010100101110010000	D5694B90
9	11010101011010010100101110010000	D5694B90	00100100011111001100011001111010	247CC67A

Round	L (binary)	L (hex)	R (binary)	R (hex)
10	00100100011111001100011001111010	247CC67A	10110111110101011101011110110010	B7D5D7B2
11	10110111110101011101011110110010	B7D5D7B2	11000101011110000011110001111000	C5783C78
12	11000101011110000011110001111000	C5783C78	01110101101111010001100001011000	75BD1858
13	01110101101111010001100001011000	75BD1858	00011000110000110001010101011010	18C3155A
14	00011000110000110001010101011010	18C3155A	11000010100011001001011000001101	C28C960D
15	11000010100011001001011000001101	C28C960D	01000011010000100011001000110100	43423234
16	01000011010000100011001000110100	43423234	00001010010011001101100110010101	0A4CD995

Cipher Text (binary):
1000010111110100000010011010101000000111100001010101101000000000101

Cipher Text (hex):
85F093A0F0A5B405