DEPARTMENT OF COMPUTER ENGINEERING & APPLICATIONS

Institute of Engineering & Technology

Cryptography & Network Security Lab (BCSE-0071)

Name: Sharad Pal

Section: C (53)

University roll no.: 2115000937

Course: B.Tech CS

Submitted to: Afsaruddin Sir.

INDEX

Experiment 1

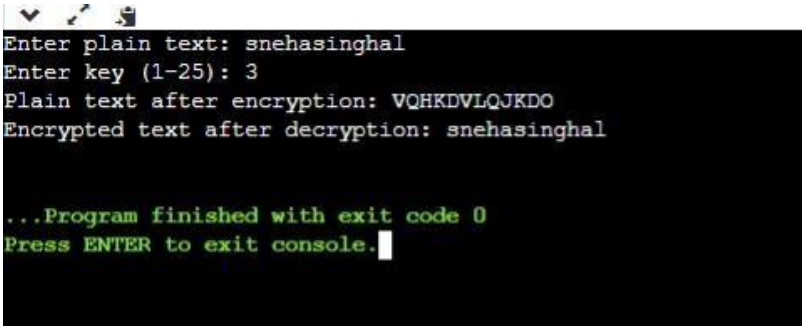
Write a program to implement Additive Cipher (Z_{26}) with the following conditions:

- Plaintext should be in lowercase.
- Ciphertext should be uppercase.
- Brute force attack.

Source Code:

```
import java.util.Scanner;
public class Main {
    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);
        System.out.print("Enter plain text: ");
        String plaintext = sc.nextLine();
        System.out.print("Enter key (1-25): ");
        int key = sc.nextInt();
        String encryptText = encrypt(plaintext, key);
        System.out.print("Plain text after encryption: ");
        System.out.println(encryptText);
        String decryptText = decrypt(encryptText, key);
        System.out.print("Encrypted text after decryption: ");
        System.out.println(decryptText);
    }
    public static String encrypt(String plaintext, int key) {
        StringBuilder encryptText = new StringBuilder();
        for (int i = 0; i < plaintext.length(); i++) {
            char ch = plaintext.charAt(i);
            if (Character.isLowerCase(ch)) {
                char shiftedChar = (char) ((ch - 'a' + key) % 26 + 'A');
                encryptText.append(shiftedChar);
            }
        }
        return encryptText.toString();
    }
    public static String decrypt(String encryptText, int key) {
        StringBuilder decryptText = new StringBuilder();
        for (int i = 0; i < encryptText.length(); i++) {
            char ch = encryptText.charAt(i);
            if (Character.isUpperCase(ch)) {
                char shiftedChar = (char) ((ch - 'A' - key + 26) % 26 + 'a');
                decryptText.append(shiftedChar);
            }
        }
        return decryptText.toString();
    }
}
```

Input & Output:



Experiment 2

Write a program to implement Multiplicative Cipher.

- Plaintext should be in lowercase.
- Ciphertext should be uppercase.
- Brute force attack.

Source Code:

```
import java.util.Scanner;
public class Main {
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        System.out.print("Enter the plaintext: ");
        String plaintext = scanner.nextLine().toUpperCase();
        System.out.print("Enter the key (an integer coprime to 26): ");
        int key = scanner.nextInt();
        if (!isCoprime(key, 26)) {
            System.out.println("Invalid key. Key must be an integer coprime to 26.");
            return;
        }
        String ciphertext = encrypt(plaintext, key);
        System.out.println("Encrypted text: " + ciphertext);
        String decryptedText = decrypt(ciphertext, key);
        System.out.println("Decrypted text: " + decryptedText);
    }
    private static String encrypt(String plaintext, int key) {
        StringBuilder ciphertext = new StringBuilder();
        for (char ch : plaintext.toCharArray()) {
            if (ch == ' ') {
                ciphertext.append(ch);
            } else {
                int charValue = ch - 'A';
                int encryptedValue = (charValue * key) % 26;
                ciphertext.append((char) (encryptedValue + 'A'));
            }
        }
        return ciphertext.toString();
    }
    private static String decrypt(String ciphertext, int key) {
        StringBuilder decryptedText = new StringBuilder();
        int modInverse = modInverse(key, 26);
        for (char ch : ciphertext.toCharArray()) {
            if (ch == ' ') {
                decryptedText.append(ch);
            } else {
                int charValue = ch - 'A';
                int decryptedValue = (charValue * modInverse) % 26;
```

```
                if (decryptedValue < 0) {
                    decryptedValue += 26; // Handle negative values
                }
                decryptedText.append((char) (decryptedValue + 'A'));
            }
        }
        return decryptedText.toString();
    }
    private static boolean isCoprime(int a, int b) {
        return gcd(a, b) == 1;
    }
    private static int gcd(int a, int b) {
        if (b == 0) {
            return a;
        } else {
            return gcd(b, a % b);
        }
    }
    private static int modInverse(int a, int m) {
        a = a % m;
        for (int x = 1; x < m; x++) {
            if ((a * x) % m == 1) {
                return x;
            }
        }
        return 1;
    }
}
```

Input & Output:

```
Enter the plaintext: snehasinghal
Enter the key (an integer coprime to 26): 3
Encrypted text: CNMVACYNSVAH
Decrypted text: SNEHASINGHAL


...Program finished with exit code 0
Press ENTER to exit console.
```

Experiment 3

Write a program to implement Affine Cipher.

- Plaintext should be in lowercase.
- Ciphertext should be uppercase.
- Brute force attack.

Source Code:

```
import java.util.Scanner;
public class Main {
    private static int modInverse(int k1, int m) {
        for (int i = 1; i < m; i++)
            if ((k1 * i) % m == 1)
                return i;
        return -1;
    }
    private static String encrypt(String plaintext, int k1, int k2) {
        StringBuilder ciphertext = new StringBuilder();
        for (char ch : plaintext.toCharArray()) {
            if (Character.isLetter(ch)) {
                int x = (Character.toUpperCase(ch) - 'A');
                int encryptedChar = (k1 * x + k2) % 26;
                ciphertext.append((char) (encryptedChar + 'A'));
            } else {
                ciphertext.append(ch);
            }
        }
        return ciphertext.toString();
    }
    private static String decrypt(String ciphertext, int k1, int k2) {
        StringBuilder decryptedText = new StringBuilder();
        int aInverse = modInverse(k1, 26);
        if (aInverse == -1) {
            System.out.println("Invalid key. The key must be chosen such that 'k1' and 'm' are coprime.");
            return "";
        }
        for (char ch : ciphertext.toCharArray()) {
            if (Character.isLetter(ch)) {
                int y = (Character.toUpperCase(ch) - 'A');
                int decryptedChar = (aInverse * (y - k2 + 26)) % 26;
                decryptedText.append((char) (decryptedChar + 'A'));
            } else {
                decryptedText.append(ch);
            }
        }
        return decryptedText.toString();
    }
```

```
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        System.out.print("Enter the plaintext: ");
        String plaintext = scanner.nextLine().toUpperCase();
        System.out.print("Enter the value of 'k1' (must be coprime with 26): ");
        int k1 = scanner.nextInt();
        System.out.print("Enter the value of 'k2': ");
        int k2 = scanner.nextInt();
        if (k1 < 0 || k1>= 26 || gcd(k1, 26) != 1) {
            System.out.println("Invalid value of 'k1'. It must be coprime with 26.");
            return;
        }
        String encryptedText = encrypt(plaintext, k1, k2);
        System.out.println("Encrypted Text: " + encryptedText);
        String decryptedText = decrypt(encryptedText, k1, k2);
        System.out.println("Decrypted Text: " + decryptedText);
    }
    private static int gcd(int k1, int k2) {
        if (k2 == 0)
            return k1;
        return gcd(k2, k1 % k2);
    }
}
```

Input & Output:

```
Enter the plaintext: snehasinghal
Enter the value of 'k1' (must be coprime with 26): 5
Enter the value of 'k2': 3
Encrypted Text: PQXMDPRQHMDG
Decrypted Text: SNEHASINGHAL


...Program finished with exit code 0
Press ENTER to exit console.
```

Experiment 4

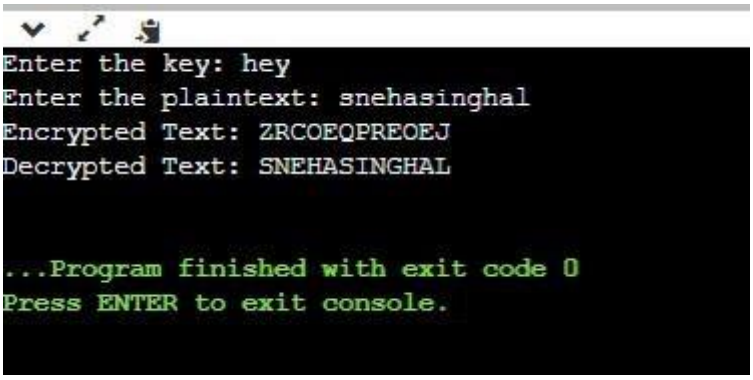
Write a program in to implement Autokey Cipher.

- Plaintext should be in lowercase.
- Ciphertext should be uppercase.
- Brute force attack.

Source Code:

```
import java.util.Scanner;
public class Main {
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        System.out.print("Enter the key: ");
        String key = scanner.nextLine().toUpperCase();
        System.out.print("Enter the plaintext: ");
        String plaintext = scanner.nextLine().toUpperCase();
        String ciphertext = encrypt(plaintext, key);
        System.out.println("Encrypted Text: " + ciphertext);
        String decryptedText = decrypt(ciphertext, key);
        System.out.println("Decrypted Text: " + decryptedText);
    }
    private static String encrypt(String plaintext, String key) {
        StringBuilder ciphertext = new StringBuilder();
        int keyIndex = 0;
        for (char c : plaintext.toCharArray()) {
            if (Character.isLetter(c)) {
                char encryptedChar = (char) ((c + key.charAt(keyIndex) - 2 * 'A') % 26 + 'A');
                ciphertext.append(encryptedChar);
                keyIndex = (keyIndex + 1) % key.length();
            } else {
                ciphertext.append(c);
            }
        }
        return ciphertext.toString();
    }
    private static String decrypt(String ciphertext, String key) {
        StringBuilder decryptedText = new StringBuilder();
        int keyIndex = 0;
        for (char c : ciphertext.toCharArray()) {
            if (Character.isLetter(c)) {
                char decryptedChar = (char) ((c - key.charAt(keyIndex) + 26) % 26 + 'A');
                decryptedText.append(decryptedChar);
                keyIndex = (keyIndex + 1) % key.length();
            } else {
                decryptedText.append(c);
            }
        }
        return decryptedText.toString();
    }
}
```

Input & Output:



Experiment 5

Write a program to implement Playfair Cipher to encrypt & decrypt the given message where the key matrix can be formed by using a given keyword.

Source Code:

```
import java.util.Scanner;
public class Main {
    private static char[][] keyMatrix;
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        System.out.print("Enter the keyword: ");
        String keyword = scanner.nextLine().toUpperCase().replaceAll("[^A-Z]", "");
        System.out.print("Enter the message to encrypt: ");
        String message = scanner.nextLine().toUpperCase().replaceAll("[^A-Z]", "");
        generateKeyMatrix(keyword);
        System.out.println("Key Matrix:");
        printKeyMatrix();
        String encryptedMessage = encrypt(message);
        System.out.println("Encrypted Message: " + encryptedMessage);
        String decryptedMessage = decrypt(encryptedMessage);
        System.out.println("Decrypted Message: " + decryptedMessage);
    }
    private static void generateKeyMatrix(String keyword) {
        keyMatrix = new char[5][5];
        String key = keyword + "ABCDEFGHIKLMNOPQRSTUVWXYZ";
        key = key.replaceAll("J", "I");
        boolean[] used = new boolean[26];
        int row = 0, col = 0;
        for (char c : key.toCharArray()) {
            if (!used[c - 'A']) {
                keyMatrix[row][col] = c;
                used[c - 'A'] = true;
                col++;
                if (col == 5) {
                    col = 0;
                    row++;
                }
            }
        }
    }
```

```
    private static void printKeyMatrix() {
        for (int i = 0; i < 5; i++) {
            for (int j = 0; j < 5; j++) {
                System.out.print(keyMatrix[i][j] + " ");
            }
            System.out.println();
        }
    }
    private static String formatMessage(String message) {
        message = message.replaceAll("J", "I");
        StringBuilder formattedMessage = new StringBuilder();
        for (int i = 0; i < message.length(); i += 2) {
            formattedMessage.append(message.charAt(i));
            if (i + 1 < message.length()) {
                if (message.charAt(i) == message.charAt(i + 1)) {
                    formattedMessage.append('X');
                    i--;
                } else {
                    formattedMessage.append(message.charAt(i + 1));
                }
            } else {
                formattedMessage.append('X');
            }
        }
        return formattedMessage.toString();
    }
    private static String encrypt(String message) {
        message = formatMessage(message);
        StringBuilder encryptedMessage = new StringBuilder();
        for (int i = 0; i < message.length(); i += 2) {
            char c1 = message.charAt(i);
            char c2 = message.charAt(i + 1);
            int[] pos1 = findPosition(c1);
            int[] pos2 = findPosition(c2);
            int row1 = pos1[0];
            int col1 = pos1[1];
            int row2 = pos2[0];
            int col2 = pos2[1];
            if (row1 == row2) {
```

```
                encryptedMessage.append(keyMatrix[row1][(col1 + 1) % 5]);
                encryptedMessage.append(keyMatrix[row2][(col2 + 1) % 5]);
            } else if (col1 == col2) {
                encryptedMessage.append(keyMatrix[(row1 + 1) % 5][col1]);
                encryptedMessage.append(keyMatrix[(row2 + 1) % 5][col2]);
            } else {
                encryptedMessage.append(keyMatrix[row1][col2]);
                encryptedMessage.append(keyMatrix[row2][col1]);
            }
        }
        return encryptedMessage.toString();
    }
    private static String decrypt(String message) {
        StringBuilder decryptedMessage = new StringBuilder();
        for (int i = 0; i < message.length(); i += 2) {
            char c1 = message.charAt(i);
            char c2 = message.charAt(i + 1);
            int[] pos1 = findPosition(c1);
            int[] pos2 = findPosition(c2);
            int row1 = pos1[0];
            int col1 = pos1[1];
            int row2 = pos2[0];
            int col2 = pos2[1];
            if (row1 == row2) {
                decryptedMessage.append(keyMatrix[row1][(col1 + 4) % 5]);
                decryptedMessage.append(keyMatrix[row2][(col2 + 4) % 5]);
            } else if (col1 == col2) {
                decryptedMessage.append(keyMatrix[(row1 + 4) % 5][col1]);
                decryptedMessage.append(keyMatrix[(row2 + 4) % 5][col2]);
            } else {
                decryptedMessage.append(keyMatrix[row1][col2]);
                decryptedMessage.append(keyMatrix[row2][col1]);
            }
        }
        return decryptedMessage.toString();
    }
```

```
    private static int[] findPosition(char c) {
        int[] position = new int[2];
        for (int i = 0; i < 5; i++) {
            for (int j = 0; j < 5; j++) {
                if (keyMatrix[i][j] == c) {
                    position[0] = i;
                    position[1] = j;
                    return position;
                }
            }
        }
        return position;
    }
}
```

Input & Output:

```
Enter the keyword: keyword
Enter the message to encrypt: snehasinghal
Key Matrix:
K E Y W O
R D A B C
F G H I L
M N P Q S
T U V X Z
Encrypted Message: MPYGCPGQHICH
Decrypted Message: SNEHASINGHAL


...Program finished with exit code 0
Press ENTER to exit console.
```

Experiment 6

Write a program to implement Hill Cipher to encrypt & decrypt the given message by using a given key matrix. Show the values for key and its corresponding key inverse values.

Source Code:

```
import java.util.Scanner;
public class Main {
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        System.out.println("Hill Cipher Implementation");
        System.out.println("Enter the key matrix size (n x n): ");
        int n = scanner.nextInt();
        int[][] keyMatrix = new int[n][n];
        System.out.println("Enter the key matrix elements:");
        for (int i = 0; i < n; i++) {
            for (int j = 0; j < n; j++) {
                keyMatrix[i][j] = scanner.nextInt() % 26;
            }
        }
        int[][] keyInverse = getKeyInverse(keyMatrix, n);
        System.out.println("Key Matrix:");
        displayMatrix(keyMatrix);
        System.out.println("Key Inverse:");
        displayMatrix(keyInverse);
        System.out.println("Enter the plaintext (in uppercase):");
        scanner.nextLine();
        String input = scanner.nextLine();
        String ciphertext = encrypt(input, keyMatrix, n);
        System.out.println("Encrypted Text: " + ciphertext);
        String decryptedText = decrypt(ciphertext, keyInverse, n);
        System.out.println("Decrypted Text: " + decryptedText);
    }
    private static String encrypt(String plaintext, int[][] keyMatrix, int n) {
        StringBuilder ciphertext = new StringBuilder();
        while (plaintext.length() % n != 0) {
            plaintext += 'X';
        }
        for (int i = 0; i < plaintext.length(); i += n) {
            String block = plaintext.substring(i, i + n);
            for (int j = 0; j < n; j++) {
                int sum = 0;
                for (int k = 0; k < n; k++) {
                    sum += (keyMatrix[j][k] * (block.charAt(k) - 'A')) % 26;
                    sum %= 26;
                }
                ciphertext.append((char) ('A' + sum));
```

```
                ciphertext.append((char) ('A' + sum));
            }
        }
        return ciphertext.toString();
    }
    private static String decrypt(String ciphertext, int[][] keyInverse, int n) {
        StringBuilder plaintext = new StringBuilder();
        for (int i = 0; i < ciphertext.length(); i += n) {
            String block = ciphertext.substring(i, i + n);
            for (int j = 0; j < n; j++) {
                int sum = 0;
                for (int k = 0; k < n; k++) {
                    sum += (keyInverse[j][k] * (block.charAt(k) - 'A' + 26)) % 26;
                    sum %= 26;
                }
                plaintext.append((char) ('A' + sum));
            }
        }
        return plaintext.toString();
    }
    private static int[][] getKeyInverse(int[][] keyMatrix, int n) {
        int det = determinant(keyMatrix, n);
        int detInverse = modInverse(det, 26);
        int[][] adjugate = adjugate(keyMatrix, n);
        int[][] keyInverse = new int[n][n];
        for (int i = 0; i < n; i++) {
            for (int j = 0; j < n; j++) {
                keyInverse[i][j] = (adjugate[i][j] * detInverse) % 26;
                if (keyInverse[i][j] < 0) {
                    keyInverse[i][j] += 26;
                }
            }
        }
        return keyInverse;
    }
    private static int determinant(int[][] matrix, int n) {
        if (n == 1) {
            return matrix[0][0];
        }
        if (n == 2) {
            return (matrix[0][0] * matrix[1][1] - matrix[0][1] * matrix[1][0] + 26) % 26;
```

```
            return (matrix[0][0] * matrix[1][1] - matrix[0][1] * matrix[1][0] + 26) % 26;
        }
        int det = 0;
        for (int i = 0; i < n; i++) {
            int[][] submatrix = new int[n - 1][n - 1];
            for (int j = 1; j < n; j++) {
                for (int k = 0, l = 0; k < n; k++) {
                    if (k != i) {
                        submatrix[j - 1][l++] = matrix[j][k];
                    }
                }
            }
            int sign = (i % 2 == 0) ? 1 : -1;
            det = (det + sign * matrix[0][i] * determinant(submatrix, n - 1) + 26) % 26;
        }
        return det;
    }
    private static int[][] adjugate(int[][] matrix, int n) {
        int[][] adjugate = new int[n][n];

        for (int i = 0; i < n; i++) {
            for (int j = 0; j < n; j++) {
                int[][] submatrix = new int[n - 1][n - 1];
                for (int k = 0, l = 0; k < n; k++) {
                    if (k != i) {
                        for (int m = 0, n1 = 0; m < n; m++) {
                            if (m != j) {
                                submatrix[l][n1++] = matrix[k][m];
                            }
                        }
                        l++;
                    }
                }
                int sign = ((i + j) % 2 == 0) ? 1 : -1;
                adjugate[j][i] = (sign * determinant(submatrix, n - 1) + 26) % 26;
            }
        }
        return adjugate;
    }
```

```
    private static int modInverse(int a, int m) {
        a = a % m;
        for (int x = 1; x < m; x++) {
            if ((a * x) % m == 1) {
                return x;
            }
        }
        return 1;
    }
    private static void displayMatrix(int[][] matrix) {
        for (int[] row : matrix) {
            for (int element : row) {
                System.out.print(element + " ");
            }
            System.out.println();
        }
        System.out.println();
    }
}
```

Input & Output:

```
Enter the key matrix size (n x n):
3 3
Enter the key matrix elements:
1 2 3 4 5 6 7 8 9
Key Matrix:
3 1 2
3 4 5
6 7 8

Key Inverse:
9 8 9
8 16 1
9 19 25

Enter the plaintext or ciphertext (in uppercase):
SNEHASINGHAL
Encrypted Text: XWXFHEXCFRYA
Decrypted Text: SNEHASINGHAL


...Program finished with exit code 0
Press ENTER to exit console.
```

Experiment 7

Write a program to implement Elgamal Cryptosystem to generate the pair of keys and then show the encryption & decryption of a given message.

Source Code:

```
import java.math.BigInteger;
import java.security.SecureRandom;
import java.util.Scanner;
public class Main {
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        BigInteger p = generatePrime();
        BigInteger g = generatePrimitiveRoot(p);
        BigInteger x = generatePrivateKey(p);
        BigInteger h = g.modPow(x, p);
        System.out.println("Public Key (p, g, h):");
        System.out.println("p = " + p);
        System.out.println("g = " + g);
        System.out.println("h = " + h);
        System.out.println("\nPrivate Key (x):");
        System.out.println("x = " + x);
        System.out.println("\nEnter a message to encrypt:");
        String message = scanner.nextLine();
        BigInteger k = generateRandomK(p);
        BigInteger c1 = g.modPow(k, p);
        BigInteger c2 = h.modPow(k, p).multiply(messageToBigInteger(message)).mod(p);
        System.out.println("\nEncrypted Message (c1, c2):");
        System.out.println("c1 = " + c1);
        System.out.println("c2 = " + c2);
        BigInteger s = c1.modPow(x, p);
        BigInteger sInverse = s.modInverse(p);
        BigInteger decryptedMessage = c2.multiply(sInverse).mod(p);
        System.out.println("Decrypted Message: " + decryptedMessage);
    }
    private static BigInteger generatePrime() {
        return new BigInteger("101");
    }
    private static BigInteger generatePrimitiveRoot(BigInteger p) {
        return new BigInteger("2");
    }
    private static BigInteger generatePrivateKey(BigInteger p) {
        return new BigInteger(p.bitLength() - 2, new SecureRandom()).add(BigInteger.valueOf(2));
    }
    private static BigInteger generateRandomK(BigInteger p) {
        return new BigInteger(p.bitLength() - 2, new SecureRandom()).add(BigInteger.valueOf(2));
    }
    private static BigInteger messageToBigInteger(String message) {
        byte[] bytes = message.getBytes();
        return new BigInteger(bytes);
    }
}
```

Input & Ouput:


Public Key (p, g, h):
p = 101
g = 2
h = 14
Private Key (x):
x = 10
Enter a message to encrypt:
12
Encrypted Message (c1, c2):
c1 = 20
c2 = 30
Decrypted Message: 70
...Program finished with exit code 0
Press ENTER to exit console.

Experiment 8

Write a program to implement Rabin Miller Primality Test to check whether given number is prime or composite.

Source Code:

```
import java.util.Random;
import java.util.Scanner;
public class Main {
    private static long power(long a, long b, long m) {
        long result = 1;
        a = a % m;
        while (b > 0) {
            if (b % 2 == 1)
                result = (result * a) % m;
            b = b >> 1;
            a = (a * a) % m;
        }
        return result;
    }
    private static boolean isPrime(long n, int k) {
        if (n <= 1 || n == 4)
            return false;
        if (n <= 3)
            return true;
        long d = n - 1;
        while (d % 2 == 0)
            d /= 2;
        for (int i = 0; i < k; i++) {
            if (!millerTest(n, d))
                return false;
        }
        return true;
    }
    private static boolean millerTest(long n, long d) {
        Random rand = new Random();
        long a = 2 + rand.nextInt((int) (n - 4));
        long x = power(a, d, n);
        if (x == 1 || x == n - 1)
            return true;
```

```
        while (d != n - 1) {
            x = (x * x) % n;
            d *= 2;
            if (x == 1)
                return false;
            if (x == n - 1)
                return true;
        }
        return false;
    }
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        System.out.print("Enter a number to check for primality: ");
        long number = scanner.nextLong();
        System.out.print("Enter the number of iterations (k) for the Rabin-Miller test: ");
        int k = scanner.nextInt();
        if (isPrime(number, k)) {
            System.out.println(number + " is prime.");
        } else {
            System.out.println(number + " is composite.");
        }
        scanner.close();
    }
}
```

Input & Output:

```
Enter a number to check for primality: 561
Enter the number of iterations (k) for the Rabin-Miller test: 2
561 is composite.


...Program finished with exit code 0
Press ENTER to exit console.
```

```
Enter a number to check for primality: 61
Enter the number of iterations (k) for the Rabin-Miller test: 2
61 is prime.


...Program finished with exit code 0
Press ENTER to exit console.
```

Experiment 9

Write a program to implement Diffie-Hellman key exchange Algorithm to exchange the symmetric key and show the encryption & decryption.

Source Code:

```
import java.math.BigInteger;
import java.util.Scanner;
public class Main {
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        System.out.print("Enter a prime number (p): ");
        BigInteger p = new BigInteger(scanner.nextLine());
        System.out.print("Enter a primitive root modulo p (g): ");
        BigInteger g = new BigInteger(scanner.nextLine());
        System.out.print("Enter private key for Alice (a): ");
        BigInteger a = new BigInteger(scanner.nextLine());
        System.out.print("Enter private key for Bob (b): ");
        BigInteger b = new BigInteger(scanner.nextLine());
        BigInteger A = g.modPow(a, p);
        BigInteger B = g.modPow(b, p);
        BigInteger secretKeyA = B.modPow(a, p);
        BigInteger secretKeyB = A.modPow(b, p);
        System.out.println("Shared Secret Key (Alice): " + secretKeyA);
        System.out.println("Shared Secret Key (Bob): " + secretKeyB);
        String message = "Sneha Singhal";
        System.out.println("Original Message: " + message);
        BigInteger symmetricKey = secretKeyA;
        String encryptedMessage = encrypt(message, symmetricKey);
        System.out.println("Encrypted Message: " + encryptedMessage);
        String decryptedMessage = decrypt(encryptedMessage, symmetricKey);
        System.out.println("Decrypted Message: " + decryptedMessage);
    }
    private static String encrypt(String message, BigInteger key) {
        StringBuilder encrypted = new StringBuilder();
        for (int i = 0; i < message.length(); i++) {
            char c = message.charAt(i);
            encrypted.append((char) (c ^ key.intValue()));
        }
        return encrypted.toString();
    }
    private static String decrypt(String encryptedMessage, BigInteger key) {
        return encrypt(encryptedMessage, key);
    }
}
```

Input & Output:

```
Enter a prime number (p): 7
Enter a primitive root modulo p (g): 3
Enter private key for Alice (a): 2
Enter private key for Bob (b): 3
Shared Secret Key (Alice): 1
Shared Secret Key (Bob): 1
Original Message: Sneha Singhal
Encrypted Message: Rodi`!Rhofi`m
Decrypted Message: Sneha Singhal


...Program finished with exit code 0
Press ENTER to exit console.
```

Experiment 10

Write a program to implement RSA Algorithm to generate a pair of keys and show the encryption and decryption by using a given key pair.

Source Code:

```
import java.util.*;
public class Main {
    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);
        System.out.print("Enter I prime number (p): ");
        int p = sc.nextInt();
        System.out.print("Enter II prime number (q): ");
        int q = sc.nextInt();
        int n = p * q;
        int phiN = (p - 1) * (q - 1);
        int e = 0;
        ArrayList<Integer> list = new ArrayList<Integer>();
        ArrayList<Integer> dList = new ArrayList<Integer>();
        for (int i = 2; i < phiN; i++) {
            if (findGCD(i, phiN) == 1) {
                e = i;
                list.add(e);
            }
        }
        for (int i = 1; i < phiN; i++) {
            for (int j = 0; j < list.size(); j++) {
                if ((i * list.get(j)) % phiN == 1) {
                    dList.add(i);
                    break;
                }
            }
        }
        for (int i = 0; i < list.size(); i++) {
            System.out.println("Public key: " + list.get(i) + " " + n);
        }
        System.out.println();
        for (int i = 0; i < dList.size(); i++) {
            System.out.println("Private key: " + dList.get(i) + " " + n);
        }
```

```
        int plaintext = 42;
        int ciphertext = encrypt(plaintext, list.get(0), n);
        System.out.println("Encrypted: " + ciphertext);
        int decryptedText = decrypt(ciphertext, dList.get(0), n);
        System.out.println("Decrypted: " + decryptedText);
    }
    public static int encrypt(int message, int publicKey, int n) {
        return (int) (Math.pow(message, publicKey) % n);
    }
    public static int decrypt(int ciphertext, int privateKey, int n) {
        return (int) (Math.pow(ciphertext, privateKey) % n);
    }
    public static int findGCD(int e, int phiN) {
        while (phiN != 0) {
            if (e > phiN) {
                e = e - phiN;
            } else {
                phiN = phiN - e;
            }
        }
        return e;
    }
}
```

Input & Output:

```
Enter I prime number (p): 3
Enter II prime number (q): 5
Public key: 3 15
Public key: 5 15
Public key: 7 15

Private key: 3 15
Private key: 5 15
Private key: 7 15
Encrypted: 3
Decrypted: 12


...Program finished with exit code 0
Press ENTER to exit console.
```

Experiment 11

Write a program to implement Elgamal algorithm for implementing digital signature.

Source Code:

```
import java.math.BigInteger;
import java.security.SecureRandom;
import java.util.Scanner;
public class Main {
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        System.out.println("Enter a prime number (p):");
        BigInteger p = scanner.nextBigInteger();
        System.out.println("Enter a primitive root modulo p (g):");
        BigInteger g = scanner.nextBigInteger();
        System.out.println("Enter the private key (a):");
        BigInteger privateKey = scanner.nextBigInteger();
        BigInteger publicKey = g.modPow(privateKey, p);
        System.out.println("Public Key (A): " + publicKey);
        System.out.println("Enter the message to be signed:");
        String message = scanner.next();
        BigInteger k = generateRandomK(p.subtract(BigInteger.ONE));
        BigInteger r = g.modPow(k, p);
        BigInteger hashMessage = new BigInteger(HashFunction.hash(message.getBytes()));
        BigInteger inverseK = k.modInverse(p.subtract(BigInteger.ONE));
        BigInteger s = inverseK.multiply(hashMessage.subtract(privateKey.multiply(r))).mod(p.subtract(BigInteger.ONE));
        System.out.println("Signature (r, s): (" + r + ", " + s + ")");
        BigInteger v1 = g.modPow(hashMessage, p);
        BigInteger v2 = publicKey.modPow(r, p).multiply(r.modPow(s, p)).mod(p);
        if (v1.equals(v2)) {
            System.out.println("Signature is valid.");
        } else {
            System.out.println("Signature is invalid.");
        }
    }
```

```
    private static BigInteger generateRandomK(BigInteger max) {
        SecureRandom random = new SecureRandom();
        BigInteger k;
        do {
            k = new BigInteger(max.bitLength(), random);
        } while (k.compareTo(BigInteger.ONE) <= 0 || k.compareTo(max) >= 0 || !k.gcd(max).equals(BigInteger.ONE));
        return k;
    }
}
class HashFunction {
    public static byte[] hash(byte[] input) {
        try {
            java.security.MessageDigest digest = java.security.MessageDigest.getInstance("SHA-256");
            return digest.digest(input);
        } catch (java.security.NoSuchAlgorithmException e) {
            e.printStackTrace();
        }
        return null;
    }
}
```

Input & Output:

```
Enter a prime number (p):
5
Enter a primitive root modulo p (g):
3
Enter the private key (a):
7
Public Key (A): 2
Enter the message to be signed:
snehasinghal
Signature (r, s): (2, 1)
Signature is valid.


...Program finished with exit code 0
Press ENTER to exit console.
```