CRYPTOGRAPHY LABORATORY FILE
CS-511

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Assignment 9

Write a program to implement encryption and decryption process using ElGamal Algorithm.

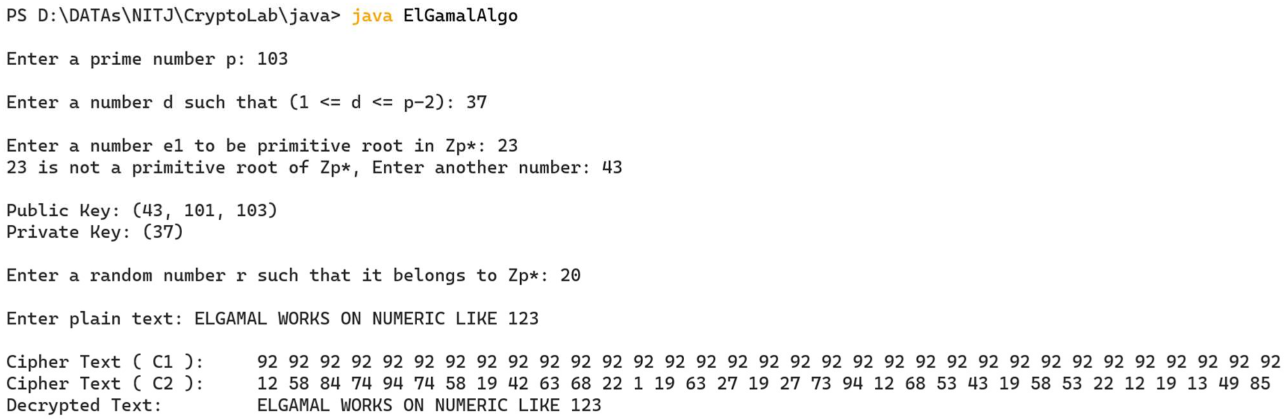
ElGamal Code:

```
import java.util.Scanner;
import java.util.HashSet;
import java.util.Set;
class ElGamalAlgo {
    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);
        long p = 0, d = 0, e1 = 1, e2 = 0, r;
        char plainText[];
        System.out.print("\nEnter a prime number p: ");
        p = sc.nextLong();
        while (!isPrime(p)) {
            System.out.print(p + " is not a prime number, Enter prime number: ");
            p = sc.nextLong();
        }
        System.out.print("\nEnter a number d such that (1 <= d <= p-2): ");
        d = sc.nextLong();
        while (!isGroupMember(d, p)) {
            System.out.print(d + " is not a member of Zp*, Enter another number: ");
            d = sc.nextLong();
        }
        System.out.print("\nEnter a number e1 to be primitive root in Zp*: ");
        e1 = sc.nextLong();
        while (!isPrimitiveRoot(e1, p)) {
            System.out.print(e1 + " is not a primitive root of Zp*, Enter another number: ");
            e1 = sc.nextLong();
        }
        /// Key generation
        e2 = powerMod(e1, d, p);
        System.out.println("\nPublic Key: (" + e1 + ", " + e2 + ", " + p + ")");
        System.out.println("Private Key: (" + d + ")");
        /// Encryption process
        System.out.print("\nEnter a random number r such that it belongs to Zp*: ");
        r = sc.nextLong();
        while (!isGroupMember(r, p)) {
            System.out.print(r + " is not a member of Zp*, Enter another number: ");
            r = sc.nextLong();
        }
        sc.nextLine();
        System.out.print("\nEnter plain text: ");
        plainText = sc.nextLine().toUpperCase().toCharArray();
        long[] cipherText1 = new long[plainText.length];
        long[] cipherText2 = new long[plainText.length];
        long[] decipheredText = new long[plainText.length];
        /// Encryption process
        for (int i = 0; i < plainText.length; i++) {
            long[] ans = encrypt(plainText[i], e1, e2, r, p);
            cipherText1[i] = ans[0];
            cipherText2[i] = ans[1];
        }
        System.out.print("\nCipher Text ( C1 ):\t");
        for (int i = 0; i < cipherText1.length; i++) {
            System.out.print(cipherText1[i] + " ");
        }
        System.out.print("\nCipher Text ( C2 ):\t");
        for (int i = 0; i < cipherText2.length; i++) {
            System.out.print(cipherText2[i] + " ");
        }
        /// Decryption process
        for (int i = 0; i < plainText.length; i++) {
            decipheredText[i] = decrypt(cipherText1[i], cipherText2[i], d, p);
        }
        System.out.print("\nDecrypted Text:\t\t");
        for (int i = 0; i < decipheredText.length; i++) {
            System.out.print((char) (decipheredText[i] % 97));
        }
        System.out.println("\n");
        sc.close();
    }
    private static long[] encrypt(long pt, long e1, long e2, long r, long p) {
        long[] cipherText = new long[2];
        cipherText[0] = powerMod(e1, r, p);
        long x = powerMod(e2, r, p);
        cipherText[1] = (pt * x) % p;
        return cipherText;
```

```
}
private static long decrypt(long c1, long c2, long d, long p) {
    long deciphered = 0;
    long x = powerMod(c1, d, p);
    deciphered = (c2 * multiplicativeInverse(x, p)) % p;
    return deciphered;
}
public static boolean isPrime(long n) {
    if (n <= 1) {
        return false;
    }
    for (long i = 2; i <= Math.sqrt(n); i++) {
        if (n % i == 0) {
            return false;
        }
    }
    return true;
}
public static boolean isGroupMember(long n, long p) {
    if (n < 1 || n > p || p % n == 0) {
        return false;
    }
    return true;
}
public static boolean isPrimitiveRoot(long g, long p) {
    if (g < 2 || p < 2) {
        return false;
    }
    if (!isCoprime(g, p)) {
        return false;
    }
    long phi = p - 1;
    Set<Long> factors = new HashSet<>();
    long tempPhi = phi;
    for (int i = 2; i <= Math.sqrt(phi); i++) {
        if (tempPhi % i == 0) {
            factors.add((long) i);
            while (tempPhi % i == 0) {
                tempPhi /= i;
            }
        }
    }
    if (tempPhi > 1) {
        factors.add(tempPhi);
    }
    for (long factor : factors) {
        if (powerMod(g, phi / factor, p) == 1) {
            return false;
        }
    }
    return true;
}
public static boolean isCoprime(long a, long b) {
    while (b != 0) {
        long temp = b;
        b = a % b;
        a = temp;
    }
    return a == 1;
}
public static long powerMod(long base, long exponent, long modulus) {
    long result = 1;
    while (exponent > 0) {
        if (exponent % 2 == 1) {
            result = (result * base) % modulus;
        }
        base = (base * base) % modulus;
        exponent /= 2;
    }
    return result;
}
static long multiplicativeInverse(long a, long b) {
    long min = Math.min(a, b);
    long max = Math.max(a, b);
    a = max;
    b = min;
    long t1 = 0, t2 = 1;
    long t = 0, q = 0, r = 1;
```

```
        while (r != 0) {
            q = a / b;
            r = a % b;
            t = t1 - (t2 * q);
            a = b;
            b = r;
            t1 = t2;
            t2 = t;
        }
        if (t1 < 0) {
            t1 += t;
        }
        return t1;
    }
}
```

Output:



```
PS D:\DATAs\NITJ\CryptoLab\java> java ElGamalAlgo

Enter a prime number p: 103

Enter a number d such that (1 <= d <= p-2): 37

Enter a number e1 to be primitive root in Zp*: 23
23 is not a primitive root of Zp*, Enter another number: 43

Public Key: (43, 101, 103)
Private Key: (37)

Enter a random number r such that it belongs to Zp*: 20

Enter plain text: ELGAMAL WORKS ON NUMERIC LIKE 123

Cipher Text ( C1 ):     92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92 92
Cipher Text ( C2 ):     12 58 84 74 94 74 58 19 42 63 68 22 1 19 63 27 19 27 73 94 12 68 53 43 19 58 53 22 12 19 13 49 85
Decrypted Text:         ELGAMAL WORKS ON NUMERIC LIKE 123
```