**18CA314-Cryptography and Network Security**

**ASSIGNMENT-1**

**Part -B**

1. **Write a program to implement Extended Euclidean Algorithm and find multiplicative inverse for following values.**

**(a) 53947−1mod 56211 (b) 19385−1mod 43159**

#include<iostream>

using namespace std;

int Exteuc(int a, int b, int \*x, int \*y)

{

    if (a == 0)

    {

        \*x = 0, \*y = 1;

        return b;

    }

    int x1, y1;

    int gcd = Exteuc(b%a, a, &x1, &y1);

    \*x = y1 - (b/a) \* x1;

    \*y = x1;

    return gcd;

}

int main()

{

    int a, m;

    cin>>a>>m;

    int x, y;

    int g = Exteuc(a, m, &x, &y);

    if (g != 1)

        cout << "\n Inverse does not exist. ";

    else

    {

        int res = (x%m + m) % m;

        cout << "\nMultiplicative inverse of( "<<a<<","<<m<<") is "<< res;

    }

    return 0;

}

(a) 53947-1mod 56211

(b) 19385-1 mod 431592.

**2.In cryptography, a brute-force attack consists of an attacker submitting many passwords or passphrases with the hope of eventually guessing correctly. Implement a DES algorithm in any programming language(You are free to use language libraries). and decrypt the following cipher text using brute-force attack. Convert the hexadecimal value to string in the final stage. Cipher text: 0x4B518774A408E3E5**

**import** java.util.\*;

**public** **class** DES1 {

**private** **static** **final** **byte**[] ***IP*** = {

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

};

**private** **static** **final** **byte**[] ***PC1*** = {

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

};

**private** **static** **final** **byte**[] ***PC2*** = {

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

};

**private** **static** **final** **byte**[] ***rotations*** = {

1, 1, 2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 1

};

**private** **static** **final** **byte**[] ***E*** = {

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

};

**private** **static** **final** **byte**[][] ***S*** = { {

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

} };

**private** **static** **final** **byte**[] ***P*** = {

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

};

**private** **static** **final** **byte**[] ***FP*** = {

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

};

**private** **static** **int**[] *C* = **new** **int**[28];

**private** **static** **int**[] *D* = **new** **int**[28];

**private** **static** **int**[][] *subkey* = **new** **int**[16][48];

**public** **static** **void** main(String args[]) {

System.***out***.println("Enter the input as a 16 character hexadecimal value:");

String input = **new** Scanner(System.***in***).nextLine();

**int** inputBits[] = **new** **int**[64];

**for**(**int** i=0 ; i < 16 ; i++) {

String s = Integer.*toBinaryString*(Integer.*parseInt*(input.charAt(i) + "", 16));

**while**(s.length() < 4) {

s = "0" + s;

}

**for**(**int** j=0 ; j < 4 ; j++) {

inputBits[(4\*i)+j] = Integer.*parseInt*(s.charAt(j) + "");

}

}

System.***out***.println("Enter the key as a 16 character hexadecimal value:");

String key = **new** Scanner(System.***in***).nextLine();

**int** keyBits[] = **new** **int**[64];

**for**(**int** i=0 ; i < 16 ; i++) {

String s = Integer.*toBinaryString*(Integer.*parseInt*(key.charAt(i) + "", 16));

**while**(s.length() < 4) {

s = "0" + s;

}

**for**(**int** j=0 ; j < 4 ; j++) {

keyBits[(4\*i)+j] = Integer.*parseInt*(s.charAt(j) + "");

}

}

System.***out***.println("\n ENCRYPTION ");

**int** outputBits[] = *permute*(inputBits, keyBits, **false**);

System.***out***.println("\n DECRYPTION");

*permute*(outputBits, keyBits, **true**);

}

**private** **static** **int**[] permute(**int**[] inputBits, **int**[] keyBits, **boolean** isDecrypt) {

**int** newBits[] = **new** **int**[inputBits.length];

**for**(**int** i=0 ; i < inputBits.length ; i++) {

newBits[i] = inputBits[***IP***[i]-1];

}

**int** L[] = **new** **int**[32];

**int** R[] = **new** **int**[32];

**int** i;

**for**(i=0 ; i < 28 ; i++) {

*C*[i] = keyBits[***PC1***[i]-1];

}

**for**( ; i < 56 ; i++) {

*D*[i-28] = keyBits[***PC1***[i]-1];

}

System.*arraycopy*(newBits, 0, L, 0, 32);

System.*arraycopy*(newBits, 32, R, 0, 32);

System.***out***.print("\nL0 = ");

*displayBits*(L);

System.***out***.print("R0 = ");

*displayBits*(R);

**for**(**int** n=0 ; n < 16 ; n++) {

System.***out***.println("\n-------------");

System.***out***.println("Round " + (n+1) + ":");

**int** newR[] = **new** **int**[0];

**if**(isDecrypt) {

newR = *fiestel*(R, *subkey*[15-n]);

System.***out***.print("Round key = ");

*displayBits*(*subkey*[15-n]);

} **else** {

newR = *fiestel*(R, *KS*(n, keyBits));

System.***out***.print("Round key = ");

*displayBits*(*subkey*[n]);

}

**int** newL[] = *xor*(L, newR);

L = R;

R = newL;

System.***out***.print("L = ");

*displayBits*(L);

System.***out***.print("R = ");

*displayBits*(R);

}

**int** output[] = **new** **int**[64];

System.*arraycopy*(R, 0, output, 0, 32);

System.*arraycopy*(L, 0, output, 32, 32);

**int** finalOutput[] = **new** **int**[64];

**for**(i=0 ; i < 64 ; i++) {

finalOutput[i] = output[***FP***[i]-1];

}

String hex = **new** String();

**for**(i=0 ; i < 16 ; i++) {

String bin = **new** String();

**for**(**int** j=0 ; j < 4 ; j++) {

bin += finalOutput[(4\*i)+j];

}

**int** decimal = Integer.*parseInt*(bin, 2);

hex += Integer.*toHexString*(decimal);

}

**if**(isDecrypt) {

System.***out***.print("Decrypted text: ");

} **else** {

System.***out***.print("Encrypted text: ");

}

System.***out***.println(hex.toUpperCase());

**return** finalOutput;

}

**private** **static** **int**[] KS(**int** round, **int**[] key) {

**int** C1[] = **new** **int**[28];

**int** D1[] = **new** **int**[28];

**int** rotationTimes = (**int**) ***rotations***[round];

C1 = *leftShift*(*C*, rotationTimes);

D1 = *leftShift*(*D*, rotationTimes);

**int** CnDn[] = **new** **int**[56];

System.*arraycopy*(C1, 0, CnDn, 0, 28);

System.*arraycopy*(D1, 0, CnDn, 28, 28);

**int** Kn[] = **new** **int**[48];

**for**(**int** i=0 ; i < Kn.length ; i++) {

Kn[i] = CnDn[***PC2***[i]-1];

}

*subkey*[round] = Kn;

*C* = C1;

*D* = D1;

**return** Kn;

}

**private** **static** **int**[] fiestel(**int**[] R, **int**[] roundKey) {

**int** expandedR[] = **new** **int**[48];

**for**(**int** i=0 ; i < 48 ; i++) {

expandedR[i] = R[***E***[i]-1];

}

**int** temp[] = *xor*(expandedR, roundKey);

**int** output[] = *sBlock*(temp);

**return** output;

}

**private** **static** **int**[] xor(**int**[] a, **int**[] b) {

**int** answer[] = **new** **int**[a.length];

**for**(**int** i=0 ; i < a.length ; i++) {

answer[i] = a[i]^b[i];

}

**return** answer;

}

**private** **static** **int**[] sBlock(**int**[] bits) {

**int** output[] = **new** **int**[32];

**for**(**int** i=0 ; i < 8 ; i++) {

**int** row[] = **new** **int** [2];

row[0] = bits[6\*i];

row[1] = bits[(6\*i)+5];

String sRow = row[0] + "" + row[1];

**int** column[] = **new** **int**[4];

column[0] = bits[(6\*i)+1];

column[1] = bits[(6\*i)+2];

column[2] = bits[(6\*i)+3];

column[3] = bits[(6\*i)+4];

String sColumn = column[0] +""+ column[1] +""+ column[2] +""+ column[3];

**int** iRow = Integer.*parseInt*(sRow, 2);

**int** iColumn = Integer.*parseInt*(sColumn, 2);

**int** x = ***S***[i][(iRow\*16) + iColumn];

String s = Integer.*toBinaryString*(x);

**while**(s.length() < 4) {

s = "0" + s;

}

**for**(**int** j=0 ; j < 4 ; j++) {

output[(i\*4) + j] = Integer.*parseInt*(s.charAt(j) + "");

}

}

**int** finalOutput[] = **new** **int**[32];

**for**(**int** i=0 ; i < 32 ; i++) {

finalOutput[i] = output[***P***[i]-1];

}

**return** finalOutput;

}

**private** **static** **int**[] leftShift(**int**[] bits, **int** n) {

**int** answer[] = **new** **int**[bits.length];

System.*arraycopy*(bits, 0, answer, 0, bits.length);

**for**(**int** i=0 ; i < n ; i++) {

**int** temp = answer[0];

**for**(**int** j=0 ; j < bits.length-1 ; j++) {

answer[j] = answer[j+1];

}

answer[bits.length-1] = temp;

}

**return** answer;

}

**private** **static** **void** displayBits(**int**[] bits) {

**for**(**int** i=0 ; i < bits.length ; i+=4) {

String output = **new** String();

**for**(**int** j=0 ; j < 4 ; j++) {

output += bits[i+j];

}

System.***out***.print(Integer.*toHexString*(Integer.*parseInt*(output, 2)));

}

System.***out***.println();

}

}