PRACTICAL FILE

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Subject: Number Theory & Cryptography

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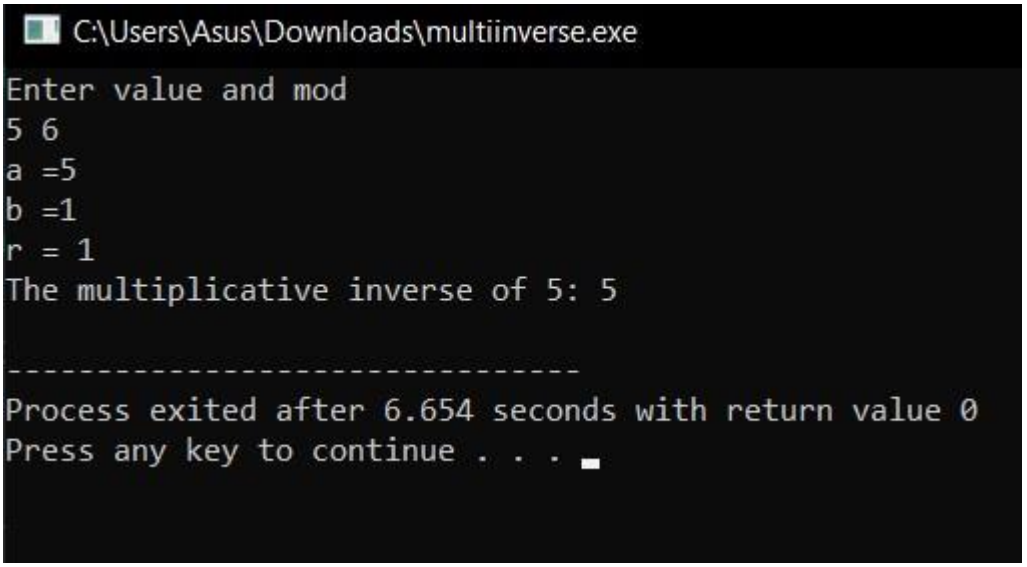
Find the multiplicative inverse using Extended Euclidean Algorithm in modulus n

```
#include<bits/stdc++.h> using
namespace std;

bool isGcd(int a, int b) { int r;
    while(a % b > 0) { r = a % b; a = b; b = r; cout << "a =" << a << "\nb =" << b <<
        "\nr = " << r << endl;
    } if(b == 1) {
    return true;
    } else { return
        false;
    }
}

int inverse(int a, int m)
{ for(int i = 1; i < m; ++i)
        { if((a * i) % m == 1)
                { return
            i;
        }
    } return 0;
}

int main() { int value, mod; cout << "Enter value and
    mod"<<endl; cin >> value >> mod;
    if(isGcd(mod , value))
        {
        cout << "The multiplicative inverse of " << value << ": " <<
inverse(value, mod)<<endl;
    }
        else
        {
        cout << "No multiplicative inverse!"<<endl;
    }

    return 0;
}
```



Inverse of a matrix in Modulo N

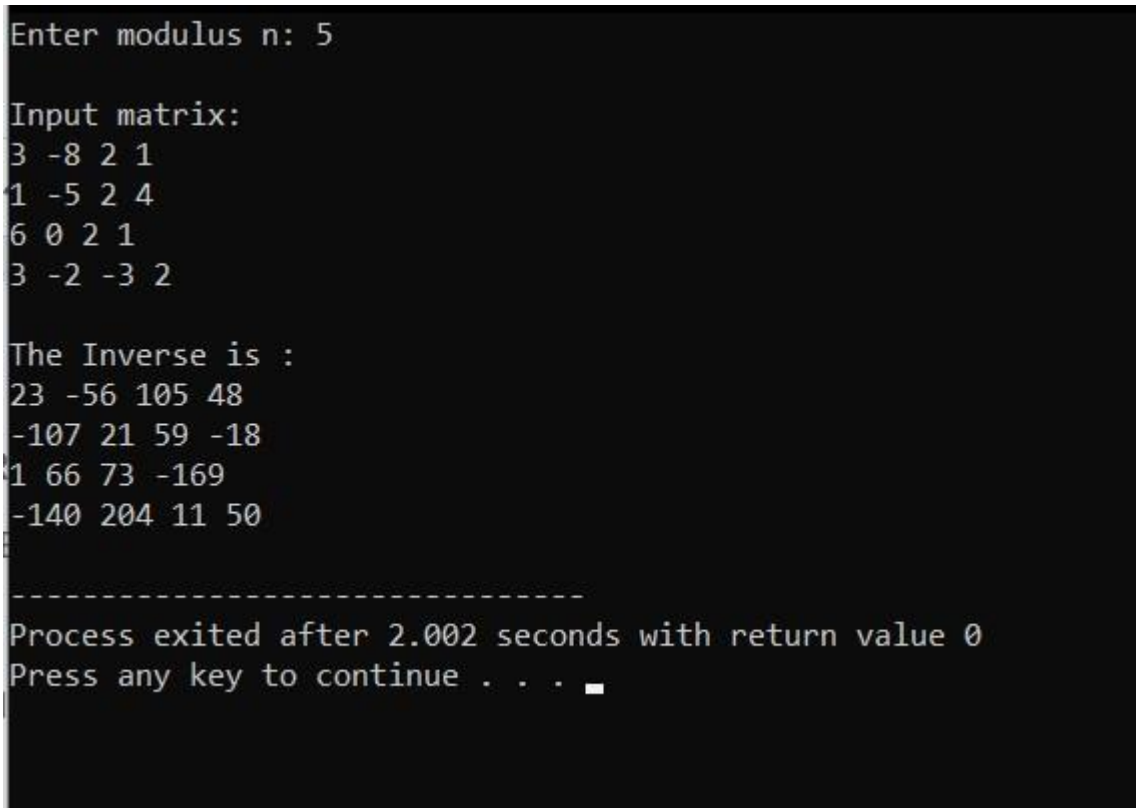
```
#include<bits/stdc++.h>
using namespace std;
#define N 4

int findInverseMod(int b,int
    n){ int t1=0; int t2=1; int
    r1=n;
    int r2=b;

    while(r2>0){
        int q=r1/r2;

        int r=r1-q*r2;
        int t=t1-q*t2;

        r1=r2;
        r2=r;

        t1=t2;
        t2=t;
```

```
    }

    if(r1==1){
        t1=t1<0?t1+n:t1;
        return t1;
    }

    return -1;
} void getCofactor(int A[N][N], int temp[N][N], int p, int q, int
n)
{ int i = 0, j = 0;

    for (int row = 0; row < n; row++)
    { for (int col = 0; col < n; col++)
        { if (row != p && col != q)
            { temp[i][j++] = A[row][col];

                if (j == n - 1)
                { j = 0;
                    i++;
                }
            }
        }
    }
}


int determinant(int A[N][N], int n)
{ int D = 0;
    if (n ==
    1)
        return A[0][0];

    int    temp[N][N];

    int sign = 1;
```

```
    for (int f = 0; f < n; f++)
    { getCofactor(A, temp, 0, f, n);
        D += sign * A[0][f] * determinant(temp, n - 1);

        sign = -sign;
    }

    return D;
}


void adjoint(int A[N][N],int adj[N][N])
{ if (N == 1)
    { adj[0][0] = 1;
        return;
    } int sign = 1,

    temp[N][N];

    for (int i=0; i<N; i++)
    { for (int j=0; j<N; j++)
        { getCofactor(A, temp, i, j, N);

            sign = ((i+j)%2==0)? 1: -1;

            adj[j][i] = (sign)*(determinant(temp, N-1));
        }
    }
}

bool inverseMatrix(int A[N][N], int inverse[N][N],int r)
{
    int det = determinant(A, N);

    if(det==0) return false;

    if(__gcd(det,r)!=1) return false; int

    detInverse=findInverseMod(det,r);
```

```
    int adj[N][N];
    adjoint(A, adj);

    for (int i=0; i<N; i++) for (int j=0; j<N;
        j++) inverse[i][j] =
        adj[i][j]*detInverse;

    return true;
}

void display(int A[N][N])
{
    for (int i=0; i<N; i++)
    { for (int j=0; j<N; j++)
            cout << A[i][j] << " ";
        cout << endl;
    }
}

int main()
{ int arr[N][N] = { {3, -8, 2, 1},
                    {1, -5, 2, 4},
                    {6, 0, 2, 1},
                    {3, -2, -3, 2}};


    int inv[N][N];

    cout<<"Enter modulus n: ";
    int r;
    cin>>r;

    cout <<endl<< "Input matrix:"<<endl;

    display(arr); cout <<endl<< "The
```

```
    Inverse is :"<<endl; if

    (inverseMatrix(arr, inv,r)) display(inv);

    return 0;
}
```



IMPLEMENTATION OF CIPHERS

Shift Cipher

```
#include<bits/stdc++.h>
using namespace std;

int main()
{
        unordered_map<char,int> map;

        for(int i=0;i<26;i++)
                map[char(97+i)]=i;
```

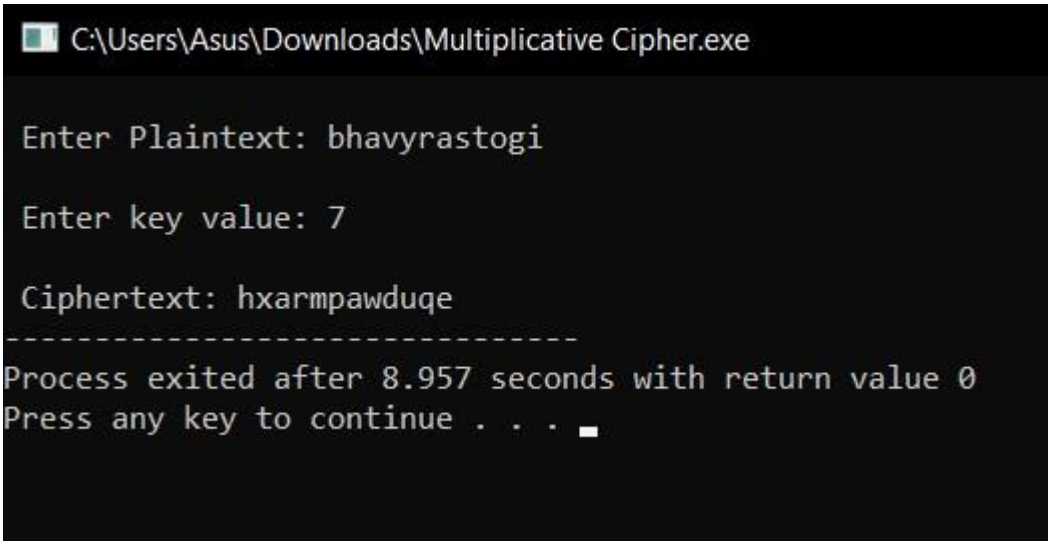
```
        string
        plaintext; int n;
        int k;

        cout<<"\n Enter Plaintext: ";
        cin>>plaintext;
        cout<<"\n Enter key value: ";
        cin>>k;

        string cipher;
        for(int i=0;i<plaintext.size();i++)
        {
                int C=(map[plaintext[i]]+k)%26;
                cipher+=char(C+97);
        }
        cout<<"\n Ciphertext: "<<cipher;

        return(0);
}
```

```
Enter Plaintext: Cryptography
Enter key value: 7
Ciphertext: hyfwavnyhwof
```

Multiplicative Cipher #include<bits/stdc++.h> using namespace std;

```
int main()
{
        map<char,int> map;
        for(int i=0;i<26;i++)
        map[char(97+i)]=i;
```

```
        string
        plain; int n;
        int k;

        cout<<"\n Enter Plaintext: ";
        cin>>plain; cout<<"\n Enter
        key value: "; cin>>k;

        string cipher; for(int
        i=0;i<plain.size();i++)
        {
                int C=(map[plain[i]]*k)%26;
                cipher+=char(C+97);
        }

        cout<<"\n Ciphertext: "<<cipher;
        return 0;
}
```



Affine Cipher

```
#include<bits/stdc++.h>
using namespace std;
main()
{
	map<char,int> map;
	for(int i=0;i<26;i++)
	map[char(97+i)]=i;

	string
	plain; int n;
	int k1,k2;

	cout<<"\n Enter Plaintext: "; cin>>plain;
	cout<<"\n Enter key value k1 (multiplication):
	"; cin>>k1; cout<<"\n Enter key value k2
	(addition): "; cin>>k2;

	string cipher;
	for(int i=0;i<plain.size();i++)
	{
		int t = ((map[plain[i]]*k1)+k2)%26;
		cipher += 'a'+t;
	}
	cout<<"\n Ciphertext: "<<cipher;
}
```

```
Enter Plaintext: FreeGaza
Enter key value k1 (multiplication): 15
Enter key value k2 (addition): 20
Ciphertext: upccuufu
```

Playfair Cipher using the key as “Shadow”

```
#include<bits/stdc++.h>
using namespace std;


int main()
{
        char key[5][5]=
        {
                {'s','h','a','d','o'},
                {'w','v','b','c','d'},
                {'f','e','i','k','l'},
                {'m','n','p','q','t'},
                {'u','g','x','y','z'}
        };
    unordered_map<char, pair<int,int>> map;

    for(int i=0;i<5;i++)
    { for(int j=0;j<5;j++)
          map[key[i][j]] = make_pair(i,j);
    }


        string plain,temp,cipher;
        cout<<"\n Enter Plain Text: ";
        cin>>plain;

        for(int i=0;i<plain.size();i++)
        { if(plain[i]=='j') plain[i]='i'; if(i>0 &&
                plain[i]==plain[i-1]) temp+='x';

                temp+=plain[i];
        }

        if((temp.size())%2 != 0) temp+='x';
```

```
        for(int t=0;t<temp.size()-1;t+=2)
        { int x1= map[temp[t]].first; int y1=
                map[temp[t]].second; int x2=
                map[temp[t+1]].first; int y2=
                map[temp[t+1]].second;

                if(x1==x2)
                {
                        cipher+=key[x1][(y1+1)%5];
                        cipher+=key[x1][(y2+1)%5];
                }
                else if(y1==y2)
                {
                        cipher+=key[(x1+1)%5][y1];
                        cipher+=key[(x2+1)%5][y1];
                }
                else
                {
                        cipher+=key[x1][y2];
                        cipher+=key[x2][y1];
                }
        }
        cout<<"\n converted Ciphertext is: "<<cipher;

    return(0);
}
```

```
Enter Plain Text: indiaWonWorldCup
converted Ciphertext is: epbldhhthsofwoxm
```

Hill Cipher

```
#include<bits/stdc++.h>
using namespace std; float encrymatrix[3][1],

a[3][3], msg[3][1], m[3][3];

void getKeyMatrix()
{ int i, j;
   char mes[3]; cout<<"Enter 3x3 matrix for
   key: "<<endl;

   for(i = 0; i < 3; i++)
   { for(j = 0; j < 3;
     j++)
     { cin>>a[i][j];
        m[i][j] =
        a[i][j];
     }
   }

   cout<<"\nEnter a string of 3 letter: ";
   cin>>mes;

   for(i = 0; i < 3; i++)
               msg[i][0] = mes[i] - 65;
}

void encrypt()
{ int i, j, k; for(i = 0; i < 3; i++) for(j = 0; j < 1; j++) for(k = 0; k <
   3; k++) encrymatrix[i][j] = encrymatrix[i][j] + a[i][k] *
msg[k][j];

   cout<<"\nEncrypted string is: ";
   for(i = 0; i < 3; i++)
   cout<<(char)(fmod(encrymatrix[i][0
   ], 26) + 65);
```

```
}


int main()
{
   getKeyMatrix();
   encrypt();
   return(0);
}
```

```
Enter 3x3 matrix for key:
3 5 7
1 2 4
6 9 10
Enter a string of 3 letter: Car
Encrypted string is: PCK
```

Vignere Cipher

```
#include<bits/stdc++.h>
using namespace std;

int main()
{
        unordered_map<char,int> map;
        for(int i=0;i<26;i++)
        { map[i+'a'] = i;
        } string plain, key,

        cipher;
```

```
        cout<<"Enter Plaintext(a-z) :
        "; cin>>plain; cout<<"Enter
        Key Text(a-z) : "; cin>>key;

        int i=0,j=0;

        while(i!=plain.size())
        { if(j==key.size()) j=0;

                int t = (map[plain[i]] +
                map[key[j]])%26; char code = t +'a';
                cipher += code; i++; j++;
        }
        cout<<"\n Ciphertext: "<<cipher;
    return(0);
}
```

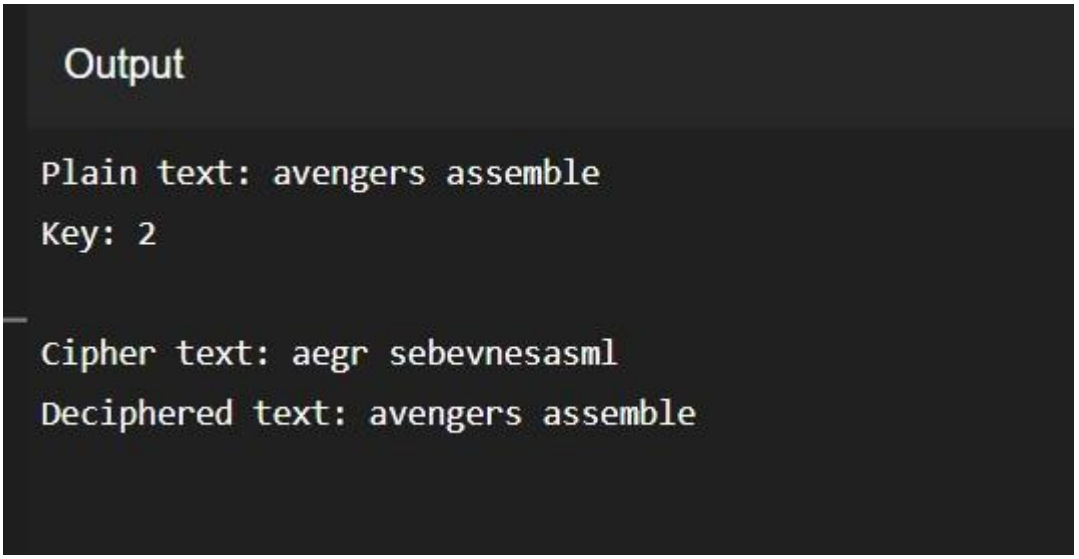
```
Enter Plaintext(a-z) : Cryptography
Enter Key Text(a-z) : number
Ciphertext: nlkqxftlmqlp
```

Rail fence - row and column transformation

```
#include <bits/stdc++.h>
using namespace std;

string encryptRailFence(string text, int key) {
    char rail[key][(text.length())];
    for (int i=0; i < key; i++)
        for (int j = 0; j < text.length(); j++)
            rail[i][j] = '\n';
```

```
    bool dir_down = false; int row =
    0, col = 0; for (int i=0; i <
    text.length(); i++) {
        if (row == 0 || row == key-1)
            dir_down = !dir_down;
        rail[row][col++] = text[i];
        dir_down?row++ : row--;
    } string
    result; for
    (int i=0; i <
    key; i++)
        for (int j=0; j < text.length(); j++)
            if (rail[i][j]!='\n')
                result.push_back(rail[i][j]);
    return result;
}

string decryptRailFence(string cipher, int key) {
    char rail[key][cipher.length()];
    for (int i=0; i < key; i++)
        for (int j=0; j < cipher.length(); j++)
            rail[i][j] = '\n';
    bool dir_down; int row = 0, col = 0;
    for (int i=0; i < cipher.length(); i++)
    {
        if (row == 0)
            dir_down = true;
        if (row == key-1)
            dir_down = false;
        rail[row][col++] = '*';
        dir_down?row++ : row--;
    } int index = 0; for (int
    i=0; i<key; i++)
        for (int j=0; j<cipher.length(); j++) if (rail[i][j]
            == '*' && index<cipher.length())
                rail[i][j] = cipher[index++];
```

```
    string result; row = 0, col = 0; for
    (int i=0; i< cipher.length(); i++) {
        if (row == 0)
            dir_down = true;
        if (row == key-1)
            dir_down = false;
        if (rail[row][col] != '*')
            result.push_back(rail[row][col++]);
        dir_down?row++: row--;
    }
    return result;
}

int main() { string text = "avengers assemble", cipher; int key
    = 2; cout << "Plain text: " << text<<endl; cout << "Key: " <<
    key<<endl; cipher =  encryptRailFence(text, key); cout
    <<"\nCipher text: " << cipher << endl; cout <<"Deciphered
    text: " << decryptRailFence(cipher,key)
<< endl;
    return 0;
}
```



Implementing DES algorithm

```
#include <bits/stdc++.h> using
namespace std; string hex2bin(string
s) { unordered_map<char, string>
map; map['0'] = "0000";
    map['1'] = "0001"; map['2'] =
    "0010"; map['3'] = "0011";
    map['4'] = "0100"; map['5'] =
    "0101"; map['6'] = "0110";
    map['7'] = "0111"; map['8'] =
    "1000"; map['9'] = "1001";
    map['A'] = "1010"; map['B'] =
    "1011"; map['C'] = "1100";
    map['D'] = "1101"; map['E'] =
    "1110"; map['F'] = "1111";
    string bin = ""; for (int i = 0; i
    < s.size(); i++) {
        bin += map[s[i]];
    } return
    bin;
} string bin2hex(string s) {
unordered_map<string, string> map;
map["0000"] = "0"; map["0001"] = "1";
map["0010"] = "2"; map["0011"] = "3";
map["0100"] = "4"; map["0101"] = "5";
map["0110"] = "6"; map["0111"] = "7";
map["1000"] = "8"; map["1001"] = "9";
map["1010"] = "A"; map["1011"] = "B";
map["1100"] = "C"; map["1101"] = "D";
    map["1110"] = "E"; map["1111"] =
    "F"; string hex = ""; for (int i = 0; i
    < s.length(); i += 4) {
        string ch = "";
        ch += s[i]; ch +=
        s[i + 1]; ch +=
        s[i + 2]; ch +=
```

```
        s[i + 3]; hex +=
        map[ch];
    }
    return hex;
}

string permute(string k, int* arr, int n) {
    string per = ""; for (int i
    = 0; i < n; i++) {
        per += k[arr[i] - 1];
    } return
    per;
}

string shift_left(string k, int shifts) {
    string s = ""; for (int i = 0; i
    < shifts; i++) {
        for (int j = 1; j < 28; j++) {
            s += k[j];
        } s +=
k[0]; k = s; s =
""; } return k; }

string xor_(string a, string b) {
    string ans = "";
    for (int i = 0; i < a.size(); i++) {
        if (a[i] == b[i]) { ans += "0";
        } else { ans
        += "1";
        }
    }
    return ans;
} string encrypt(string pt, vector<string> rkb, vector<string>
rk) { pt = hex2bin(pt); int initial_perm[64] = { 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 };

pt = permute(pt, initial_perm, 64); cout << "After initial
permutation: " << bin2hex(pt) << endl; string left =
pt.substr(0, 32); string right = pt.substr(32, 32); cout <<
"After splitting: L0=" << bin2hex(left)
    << " R0=" << bin2hex(right) << endl;
int exp_d[48] = { 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 };

int s[8][4][16] = { { 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 } };

    int per[32] = { 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 };

    cout << endl;
    for (int i = 0; i < 16; i++) { string right_expanded = permute(right,
        exp_d, 48); string x = xor_(rkb[i], right_expanded); string op =
        ""; for (int i = 0; i < 8; i++) { int row = 2 * int(x[i * 6] - '0') + int(x[i
        * 6 + 5] - '0'); int col = 8 * int(x[i * 6 + 1] - '0') + 4 * int(x[i * 6 +
        2] - '0') + 2 *
int(x[i * 6 + 3] - '0') + int(x[i * 6 + 4] - '0');
            int val = s[i][row][col];
            op += char(val / 8 +
            '0'); val = val % 8; op
            += char(val / 4 + '0');
            val = val % 4; op +=
            char(val / 2 + '0'); val =
```

```
            val % 2; op += char(val
            + '0');
        }
        op = permute(op, per,
        32); x = xor_(op, left); left
        = x; if (i != 15) { swap(left,
        right);
        }
        cout << "Round " << i + 1 << " " << bin2hex(left) << " "
            << bin2hex(right) << " " << rk[i] << endl;
    } string combine = left + right; int final_perm[64] =
    { 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 };
    string cipher = bin2hex(permute(combine, final_perm, 64));
    return cipher;
}

int main() {
    string pt, key;
    pt = "123456ABCD132536"; key =
    "AABB09182736CCDD"; key =
    hex2bin(key); int keyp[56] = { 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 };
key = permute(key, keyp, 56); int
shift_table[16] = { 1, 1, 2, 2,
                    2, 2, 2, 2,
                    1, 2, 2, 2,
                    2, 2, 2, 1 };

int key_comp[48] = { 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 };

string left = key.substr(0, 28);
string right = key.substr(28, 28);
vector<string> rkb; vector<string>
rk; for (int i = 0; i < 16; i++) { left =
shift_left(left, shift_table[i]); right =
shift_left(right, shift_table[i]); string
combine = left + right; string
RoundKey = permute(combine,
key_comp, 48);
rkb.push_back(RoundKey);
rk.push_back(bin2hex(RoundKey)
);
}
cout << "*****Encryption*****"<<endl; string
cipher = encrypt(pt, rkb, rk); cout << "Cipher
Text: " << cipher << endl; cout << endl
<<"*****Decryption*****"<<endl;
reverse(rkb.begin(), rkb.end());
reverse(rk.begin(), rk.end()); string text =
encrypt(cipher, rkb, rk); cout << "Plain Text: "
<< text << endl;
```

}

Output

```
*****Encryption*****
After initial permutation: 14A7D67818CA18AD
After splitting: L0=14A7D678 R0=18CA18AD

Round 1 18CA18AD 5A78E394 194CD072DE8C
Round 2 5A78E394 4A1210F6 4568581ABCCE
Round 3 4A1210F6 B8089591 06EDA4ACF5B5
Round 4 B8089591 236779C2 DA2D032B6EE3
Round 5 236779C2 A15A4B87 69A629FEC913
Round 6 A15A4B87 2E8F9C65 C1948E87475E
Round 7 2E8F9C65 A9FC20A3 708AD2DDB3C0
Round 8 A9FC20A3 308BEE97 34F822F0C66D
```

```
Round 9 308BEE97 10AF9D37 84BB4473DCCC
Round 10 10AF9D37 6CA6CB20 02765708B5BF
Round 11 6CA6CB20 FF3C485F 6D5560AF7CA5
Round 12 FF3C485F 22A5963B C2C1E96A4BF3
Round 13 22A5963B 387CCDAA 99C31397C91F
Round 14 387CCDAA BD2DD2AB 251B8BC717D0
Round 15 BD2DD2AB CF26B472 3330C5D9A36D
Round 16 19BA9212 CF26B472 181C5D75C66D
Cipher Text: C0B7A8D05F3A829C

*****Decryption*****
After initial permutation: 19BA9212CF26B472
```

```
After splitting: L0=19BA9212 R0=CF26B472

Round 1 CF26B472 BD2DD2AB 181C5D75C66D
Round 2 BD2DD2AB 387CCDAA 3330C5D9A36D
Round 3 387CCDAA 22A5963B 251B8BC717D0
Round 4 22A5963B FF3C485F 99C31397C91F
Round 5 FF3C485F 6CA6CB20 C2C1E96A4BF3
Round 6 6CA6CB20 10AF9D37 6D5560AF7CA5
Round 7 10AF9D37 308BEE97 02765708B5BF
Round 8 308BEE97 A9FC20A3 84BB4473DCCC
Round 9 A9FC20A3 2E8F9C65 34F822F0C66D
Round 10 2E8F9C65 A15A4B87 708AD2DDB3C0
```

```
Round 11 A15A4B87 236779C2 C1948E87475E
Round 12 236779C2 B8089591 69A629FEC913
Round 13 B8089591 4A1210F6 DA2D032B6EE3
Round 14 4A1210F6 5A78E394 06EDA4ACF5B5
Round 15 5A78E394 18CA18AD 4568581ABCCE
Round 16 14A7D678 18CA18AD 194CD072DE8C
Plain Text: 123456ABCD132536
```

Implementing AES algorithm

```
#include <bits/stdc++.h>

using namespace std;

#define Nb 4

int Nr = 0; int Nk = 0; unsigned char in[1024],

out[1024], state[4][Nb]; unsigned char

RoundKey[240]; unsigned char Key[32];

int getSBoxValue(int num)
{ int sbox[256] = {

        0x63, 0x7c, 0x77, 0x7b, 0xf2, 0x6b, 0x6f, 0xc5,
        0x30, 0x01, 0x67, 0x2b, 0xfe, 0xd7, 0xab, 0x76,
        0xca, 0x82, 0xc9, 0x7d, 0xfa, 0x59, 0x47, 0xf0,
        0xad, 0xd4, 0xa2, 0xaf, 0x9c, 0xa4, 0x72, 0xc0,
        0xb7, 0xfd, 0x93, 0x26, 0x36, 0x3f, 0xf7, 0xcc,
        0x34, 0xa5, 0xe5, 0xf1, 0x71, 0xd8, 0x31, 0x15,
        0x04, 0xc7, 0x23, 0xc3, 0x18, 0x96, 0x05, 0x9a,
        0x07, 0x12, 0x80, 0xe2, 0xeb, 0x27, 0xb2, 0x75,
        0x09, 0x83, 0x2c, 0x1a, 0x1b, 0x6e, 0x5a, 0xa0,
        0x52, 0x3b, 0xd6, 0xb3, 0x29, 0xe3, 0x2f, 0x84,
        0x53, 0xd1, 0x00, 0xed, 0x20, 0xfc, 0xb1, 0x5b,
        0x6a, 0xcb, 0xbe, 0x39, 0x4a, 0x4c, 0x58, 0xcf,
        0xd0, 0xef, 0xaa, 0xfb, 0x43, 0x4d, 0x33, 0x85,
        0x45, 0xf9, 0x02, 0x7f, 0x50, 0x3c, 0x9f, 0xa8,
        0x51, 0xa3, 0x40, 0x8f, 0x92, 0x9d, 0x38, 0xf5,
        0xbc, 0xb6, 0xda, 0x21, 0x10, 0xff, 0xf3, 0xd2,
        0xcd, 0x0c, 0x13, 0xec, 0x5f, 0x97, 0x44, 0x17,
        0xc4, 0xa7, 0x7e, 0x3d, 0x64, 0x5d, 0x19, 0x73,
        0x60, 0x81, 0x4f, 0xdc, 0x22, 0x2a, 0x90, 0x88,
        0x46, 0xee, 0xb8, 0x14, 0xde, 0x5e, 0x0b, 0xdb,
```

```
        0xe0, 0x32, 0x3a, 0x0a, 0x49, 0x06, 0x24, 0x5c,
        0xc2, 0xd3, 0xac, 0x62, 0x91, 0x95, 0xe4, 0x79,
        0xe7, 0xc8, 0x37, 0x6d, 0x8d, 0xd5, 0x4e, 0xa9,
        0x6c, 0x56, 0xf4, 0xea, 0x65, 0x7a, 0xae, 0x08,
        0xba, 0x78, 0x25, 0x2e, 0x1c, 0xa6, 0xb4, 0xc6,
        0xe8, 0xdd, 0x74, 0x1f, 0x4b, 0xbd, 0x8b, 0x8a,
        0x70, 0x3e, 0xb5, 0x66, 0x48, 0x03, 0xf6, 0x0e,
        0x61, 0x35, 0x57, 0xb9, 0x86, 0xc1, 0x1d, 0x9e,
        0xe1, 0xf8, 0x98, 0x11, 0x69, 0xd9, 0x8e, 0x94,
        0x9b, 0x1e, 0x87, 0xe9, 0xce, 0x55, 0x28, 0xdf,
        0x8c, 0xa1, 0x89, 0x0d, 0xbf, 0xe6, 0x42, 0x68,
        0x41, 0x99, 0x2d, 0x0f, 0xb0, 0x54, 0xbb, 0x16
    };
    return sbox[num];
}

int Rcon[255] = {
    0x8d, 0x01, 0x02, 0x04, 0x08, 0x10, 0x20,
    0x40, 0x80, 0x1b, 0x36, 0x6c, 0xd8, 0xab, 0x4d,
    0x9a, 0x2f, 0x5e, 0xbc, 0x63, 0xc6, 0x97, 0x35,
    0x6a, 0xd4, 0xb3, 0x7d, 0xfa, 0xef, 0xc5, 0x91,

    0x39, 0x72, 0xe4, 0xd3, 0xbd, 0x61, 0xc2, 0x9f,
    0x25, 0x4a, 0x94, 0x33, 0x66, 0xcc, 0x83, 0x1d,
    0x3a, 0x74, 0xe8, 0xcb, 0x8d, 0x01, 0x02, 0x04,
    0x08, 0x10, 0x20, 0x40, 0x80, 0x1b, 0x36, 0x6c,
    0xd8, 0xab, 0x4d, 0x9a, 0x2f, 0x5e, 0xbc, 0x63,
    0xc6, 0x97, 0x35, 0x6a, 0xd4, 0xb3, 0x7d, 0xfa,
    0xef, 0xc5, 0x91, 0x39, 0x72, 0xe4, 0xd3, 0xbd,
    0x61, 0xc2, 0x9f, 0x25, 0x4a, 0x94, 0x33, 0x66,
    0xcc, 0x83, 0x1d, 0x3a, 0x74, 0xe8, 0xcb, 0x8d,
    0x01, 0x02, 0x04, 0x08, 0x10, 0x20, 0x40, 0x80, 0x1b, 0x36,
    0x6c, 0xd8, 0xab, 0x4d, 0x9a, 0x2f,
    0x5e, 0xbc, 0x63, 0xc6, 0x97, 0x35, 0x6a, 0xd4,
    0xb3, 0x7d, 0xfa, 0xef, 0xc5, 0x91, 0x39, 0x72,
    0xe4, 0xd3, 0xbd, 0x61, 0xc2, 0x9f, 0x25, 0x4a,
```

```
    0x94, 0x33, 0x66, 0xcc, 0x83, 0x1d, 0x3a, 0x74,
    0xe8, 0xcb, 0x8d, 0x01, 0x02, 0x04, 0x08, 0x10,
    0x20, 0x40, 0x80, 0x1b, 0x36, 0x6c, 0xd8, 0xab,
    0x4d, 0x9a, 0x2f, 0x5e, 0xbc, 0x63, 0xc6, 0x97,
    0x35, 0x6a, 0xd4, 0xb3, 0x7d, 0xfa, 0xef, 0xc5,
    0x91, 0x39, 0x72, 0xe4, 0xd3, 0xbd, 0x61, 0xc2,
    0x9f, 0x25, 0x4a, 0x94, 0x33, 0x66, 0xcc, 0x83,
    0x1d, 0x3a, 0x74, 0xe8, 0xcb, 0x8d, 0x01, 0x02,
    0x04, 0x08, 0x10, 0x20, 0x40, 0x80, 0x1b, 0x36,
    0x6c, 0xd8, 0xab, 0x4d, 0x9a, 0x2f, 0x5e, 0xbc,
    0x63, 0xc6, 0x97, 0x35, 0x6a, 0xd4, 0xb3, 0x7d,
    0xfa, 0xef, 0xc5, 0x91, 0x39, 0x72, 0xe4, 0xd3,
    0xbd, 0x61, 0xc2, 0x9f, 0x25, 0x4a, 0x94, 0x33,
    0x66, 0xcc, 0x83, 0x1d, 0x3a, 0x74, 0xe8, 0xcb

};


void KeyExpansion()
{ int i, j;
    unsigned char temp[4], k;

    for (i = 0; i < Nk; i++)
    {
        RoundKey[i * 4] = Key[i * 4];
                RoundKey[i * 4 + 1] = Key[i * 4 + 1];
        RoundKey[i * 4 + 2] = Key[i * 4 + 2];
        RoundKey[i * 4 + 3] = Key[i * 4 + 3];
    }

    while (i < (Nb * (Nr + 1)))
    {
        for (j = 0; j < 4; j++)
        { temp[j] = RoundKey[(i - 1) * 4 + j];
        } if (i % Nk ==
        0)
```

```
        {
            k = temp[0];
            temp[0] = temp[1];
            temp[1] = temp[2];
            temp[2] = temp[3];
            temp[3] = k;

            temp[0] = getSBoxValue(temp[0]);
            temp[1] = getSBoxValue(temp[1]);
            temp[2] = getSBoxValue(temp[2]);
            temp[3] = getSBoxValue(temp[3]);

            temp[0] = temp[0] ^ Rcon[i / Nk];
        }
        else if (Nk > 6 && i % Nk == 4)
{
            temp[0] = getSBoxValue(temp[0]);
            temp[1] = getSBoxValue(temp[1]);
            temp[2] = getSBoxValue(temp[2]);
            temp[3] = getSBoxValue(temp[3]);
        }
        RoundKey[i * 4 + 0] = RoundKey[(i - Nk) * 4 + 0] ^
        temp[0];
        RoundKey[i * 4 + 1] = RoundKey[(i - Nk) * 4 + 1] ^
        temp[1];
        RoundKey[i * 4 + 2] = RoundKey[(i - Nk) * 4 + 2] ^
        temp[2]; RoundKey[i * 4 + 3] = RoundKey[(i - Nk) * 4 + 3]
        ^ temp[3]; i++;
    }
}

void AddRoundKey(int round)
{ int i, j;
    for (i
    = 0; i
    < Nb;
    i++)
```

```
    { for (j = 0; j < 4; j++)
        { state[j][i] ^= RoundKey[round * Nb * 4 + i * Nb + j];
        }
    }
}

void SubBytes()
{ int i, j;
    for (i = 0; i < 4; i++)
    { for (j = 0; j < Nb; j++)
        { state[i][j] = getSBoxValue(state[i][j]);
        }
    }
}

void ShiftRows()
{
    unsigned char temp;

    temp = state[1][0];
    state[1][0] = state[1][1];
    state[1][1] = state[1][2];
    state[1][2] = state[1][3];
    state[1][3] = temp;

    temp = state[2][0];
    state[2][0] = state[2][2];
    state[2][2] = temp;

    temp = state[2][1];
    state[2][1] = state[2][3];
    state[2][3] = temp;

    temp = state[3][0];
    state[3][0] = state[3][3];
    state[3][3] = state[3][2];
```

```
    state[3][2] = state[3][1];
    state[3][1] = temp;
}

#define xtime(x) ((x << 1) ^ (((x >> 7) & 1) * 0x1b))

void MixColumns()
    { int
    i;
    unsigned char Tmp, Tm, t;
    for (i = 0; i < Nb; i++)
    { t = state[0][i];
        Tmp = state[0][i] ^ state[1][i] ^ state[2][i] ^ state[3][i];
        Tm = state[0][i] ^ state[1][i];
        Tm = xtime(Tm);
        state[0][i] ^= Tm ^ Tmp;

        Tm = state[1][i] ^ state[2][i];
        Tm = xtime(Tm);
        state[1][i] ^= Tm ^ Tmp;

        Tm = state[2][i] ^ state[3][i];
        Tm = xtime(Tm);
        state[2][i] ^= Tm ^ Tmp;

        Tm = state[3][i] ^ t;
        Tm = xtime(Tm);
        state[3][i] ^= Tm ^ Tmp;
    }
}
void Cipher()
{ int i, j, round = 0;

    for (i = 0; i < Nb; i++)
    { for (j = 0; j < 4; j++)
        { state[j][i] = in[i * 4 + j];
        }
```

```
    }

    AddRoundKey(0);

    for (round = 1; round < Nr; round++)
    {
        SubBytes();
        ShiftRows();
        MixColumns();
        AddRoundKey(round);
    }

    SubBytes();
    ShiftRows();
    AddRoundKey(Nr);

    for (i = 0; i < Nb; i++)
    { for (j = 0; j < 4; j++)
        { out[i * 4 + j] = state[j][i];
        }
    }
}

int fillBlock(int sz, char *str, unsigned char *in)
{
    int j = 0; while (sz <
    strlen(str))
    { if (j >= Nb * 4)
        break;
        in[j++] = (unsigned char)str[sz];
        sz++;
    }

    if (sz >= strlen(str)) for
        (; j < Nb * 4; j++)
        in[j] = 0;
```

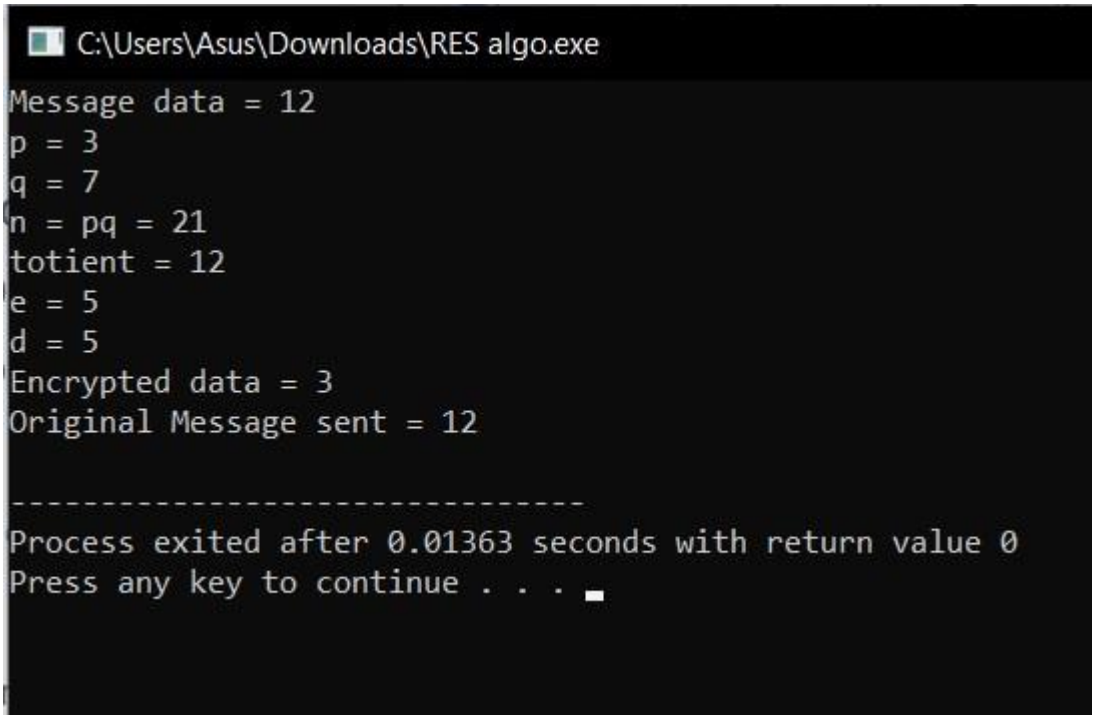
```
    return sz;
}

int main(int argc, char **argv)
{ int i;

    if (argc != 2)
    {
        cerr << "Usage: " << argv[0] << " <keysize: 1=128, 2=192,
3=256>\n";
        exit(0);
    }

    switch (atoi(argv[1]))
    {
    case 1:
        Nk = 4;
        break;
    case 2:
        Nk = 6;
        break;
    case 3:
        Nk = 8;
        break;
        default:
        Nk = 4;
        break;
    }

    Nr = Nk + 6;



    Key[0] = 0x2b;
    Key[1] = 0x7e;
    Key[2] = 0x15;
    Key[3] = 0x16;
    Key[4] = 0x28;
```

```
    Key[5] = 0xae;
    Key[6] = 0xd2;
    Key[7] = 0xa6;
    Key[8] = 0xab;
    Key[9] = 0xf7;
    Key[10] = 0x15;
    Key[11] = 0x88;
    Key[12] = 0x09;
    Key[13] = 0xcf;
    Key[14] = 0x4f;
    Key[15] = 0x3c;

    char str[1024];

    fgets(str, 1024, stdin);

    KeyExpansion();

    int sz = 0;

    while (sz < strlen(str))
    { sz = fillBlock(sz, str, in);

        Cipher();
        for (i = 0; i < Nb * 4; i++)
            cout << (int)out[i] << " ";
    }
    printf("\n\n");
}
```

Implementing RSA algorithm

```
#include<bits/stdc++.h>
using namespace std;

int gcd(int a, int h) {
    int temp;
    while(1) { temp
    = a%h;
    if(temp==0)
    return h; a = h;
    h = temp;
    }
}

int main()
{
    double p = 3; double q = 7;
    double n=p*q; double
    count; double totient = (p-
    1)*(q-1); double e=2;

    while(e<totient)
        {
      count = gcd(e,totient); if(count==1)
        break;
      else
        e++;
    }

    double d; double k = 2;
    d = (1 + (k*totient))/e;
    double msg = 12;
    double c = pow(msg,e);
    double m = pow(c,d);
    c=fmod(c,n);
    m=fmod(m,n);
```

```
    cout<<"Message data = "<<msg<<endl;
    cout<<"p = "<<p<<endl; cout<<"q =
    "<<q<<endl; cout<<"n = pq = "<<n<<endl;
    cout<<"totient = "<<totient<<endl; cout<<"e =
    "<<e<<endl; cout<<"d = "<<d<<endl;
    cout<<"Encrypted data = "<<c<<endl;
    cout<<"Original Message sent = "<<m<<endl;
    return 0;
}
```



Implementing ElGlgamal Algorithm

```
import random from math

import pow a =

random.randint(2, 10)

def gcd(a, b):
    if a < b:
        return gcd(b, a)
    elif a % b == 0:
        return b;
```

```
    else: return gcd(b, a
% b) def gen_key(q):

    key = random.randint(pow(10, 20), q)
    while gcd(q, key) != 1: key =
    random.randint(pow(10, 20), q) return
    key
def power(a, b, c):
    x = 1
    y = a

    while b > 0:
        if b % 2 != 0:
            x = (x * y) % c;
            y = (y * y) % cb = int(b / 2) return x

     % c def encrypt(msg, q, h, g):

    en_msg = [] k =
    gen_key(q) s =
    power(h, k, q) p =
    power(g, k, q)

    for i in range(0, len(msg)):
        en_msg.append(msg[i])

    print("g^k used : ", p)
    print("g^ak used : ", s) for i in
    range(0, len(en_msg)):
        en_msg[i] = s *

ord(en_msg[i]) return en_msg, p

def decrypt(en_msg, p, key, q):
```

```
    dr_msg = [] h = power(p, key,
    q) for i in range(0,
    len(en_msg)):
        dr_msg.append(chr(int(en_msg[i]/h)))

                        return dr_msg def main():

    msg = 'avengers assemble'
    print("Original Message :", msg)

    q = random.randint(pow(10, 20), pow(10, 50))
    g = random.randint(2, q)

    key = gen_key(q) h
    = power(g, key, q)
    print("g used : ", g)
    print("g^a used : ", h)

    en_msg, p = encrypt(msg, q, h, g)
    dr_msg = decrypt(en_msg, p, key, q)
    dmsg = ''.join(dr_msg)
    print("Decrypted Message :", dmsg);

if __name__ == '__main__':
    main()
```

Output

```
Original Message : avengers assemble
g used :  145172361975597191840207068224499456987535116674 80
g^a used :  5455127405447353349123040696148627888930513572 4516
g^k used :  3640730424761679456127549721028567595366301433 8298
g^ak used :  2376822134314059386752041401871846039199215520 9234
Decrypted Message : avengers assemble
```

Implementation of Rabin Algorithm

```
#include
<bits/stdc++.h> using
namespace std; int p =
151, q = 43; int n = p *
q;

int encrypter(int m, int n)
{
    int c = (m *
m)%n; return c; }

int mod(int k, int b, int m)
{ int i=0; int
    a=1;
    vector<int>
    t; while(k>0){
        t.push_back(k%2);
        k=(k-t[i])/2;
        i++;
    } for(int j=0; j<i;
    j++){ if(t[j]==1){
            a=(a*b)%m;
            b=(b*b)%m;
        } else{
            b=(b*b)%m;
        }
    } return
    a;
}

int modulo (int a, int b)
{
    return a >= 0 ? a % b : ( b - abs ( a%b ) ) % b;
}
```

```
vector<int> Extended_Euclid(int a, int b)
{ if (b>a) {
        int temp=a; a=b; b=temp;
    } int x=0; int
    y=1; int
    lastx=1; int
    lasty=0;
    while (b!=0) {
        int q= a/b; int
        temp1= a%b;
        a=b; b=temp1;
        int temp2 = x;
        x=lastx-q*x;
        lastx = temp2;
        int temp3 = y;
        y = lasty-q*y;
        lasty=temp3;
    }
    vector<int>arr(3);
    arr[0] = lastx;
    arr[1] = lasty;
    arr[2] = 1; return
    arr;
}

int decrypter(int c, int p, int q)
{
    int mp = mod((p+1)/4, c, p); int mq =
    mod((q+1)/4, c, q); vector<int> arr =
    Extended_Euclid(p, q); int rootp =
    arr[0]*p*mq; int rootq = arr[1]*q*mp;
    double r = modulo((rootp+rootq), n);
    if( r < 128) return r;
    int negative_r = n - r;
    if (negative_r < 128)
    return negative_r;
```

```
    int s = modulo((rootp-rootq), n);
    if( s < 128) return s;
    int negative_s = n - s;
        return negative_s;
}

int main()
{
    vector<int>e;
    vector<int>d;

    string message ="avengers assemble";
    cout << "Plain text: " << message << endl;
    int len = strlen(message.c_str()); cout <<
    "Encrypted text: "; for(int i = 0; i <= len;
    i++)
    {
        e.push_back(encrypter(message[i], n));
        cout << e[i];
    }
    cout << endl;
    for(int i = 0; i < len; i++)
    {
        d.push_back(decrypter(e[i], p, q));
    }
    cout << "Decrypted text: ";
    for(int i=0;i<d.size();i++)
      cout << char(d[i]);
    cout << endl;
    return 0;
}
```

```
Plain text: avengers assemble
Encrypted text: 291693837085607411637081023910242916239239370853883111517137080
Decrypted text: avengers assemble

--------------------------------
Process exited after 0.01465 seconds with return value 0
Press any key to continue . . .
```

Implementation RSA digital signature

```
def euclid(m, n):

    if n == 0:
        return m
    else:
        r = m % n return

euclid(n, r) def

exteuclid(a, b):

    r1 = a r2 = b
    s1 = int(1)
    s2 = int(0)
    t1 = int(0) t2
    = int(1)
    while r2 > 0:

        q = r1//r2 r =
        r1-q * r2 r1
        = r2 r2 = r s
        = s1-q * s2
        s1 = s2
        s2 = s t =
        t1-q * t2 t1
        = t2 t2 = t

    if t1 < 0:
        t1 = t1 % a

    return (r1, t1)

p = 823 q = 953 n =

p * q Pn = (p-1)*(q-
```

```
1) key = [] for i in

range(2, Pn): gcd =

euclid(Pn, i)

    if gcd == 1:
        key.append(i)

e = int(313)

r, d = exteuclid(Pn, e) if r == 1:
d = int(d) print("decryption key
is: ", d)

else: print("Multiplicative inverse does not
    exist.")

M = 19070

S = (M**d) % n
M1 = (S**e) % n

if M == M1:
    print("Accept the message sent by Alice")
else:
    print("Do not accept the message sent by Alice")
```