Cryptography and **19115045**

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CS106402CS **6th Sem CSE**

LAB EXAM

1. Write a program to implement the concept of SHA-1 algorithm.

Code:

```
#include <stdint.h>
#include <string.h>
#include <stdio.h>
#include <stdlib.h>
#include <vector>

#define SHA1_HEX_SIZE (40 + 1)
#define SHA1_BASE64_SIZE (28 + 1)

class sha1 {
private:

    void add_byte_dont_count_bits(uint8_t x){
        buf[i++] = x;

        if (i >= sizeof(buf)){
            i = 0;
            process_block(buf);
        }
    }

    static uint32_t rol32(uint32_t x, uint32_t n){
        return (x << n) | (x >> (32 - n));
```

```
    }

    static uint32_t make_word(const uint8_t *p){
        return
            ((uint32_t)p[0] << 3*8) |
            ((uint32_t)p[1] << 2*8) |
            ((uint32_t)p[2] << 1*8) |
            ((uint32_t)p[3] << 0*8);
    }

    void process_block(const uint8_t *ptr){
        const uint32_t c0 = 0x5a827999;
        const uint32_t c1 = 0x6ed9eba1;
        const uint32_t c2 = 0x8f1bbcdc;
        const uint32_t c3 = 0xca62c1d6;

        uint32_t a = state[0];
        uint32_t b = state[1];
        uint32_t c = state[2];
        uint32_t d = state[3];
        uint32_t e = state[4];

        uint32_t w[16];

        for (int i = 0; i < 16; i++) w[i] = make_word(ptr
+ i*4);

#define SHA1_LOAD(i) w[i&15] = rol32(w[(i+13)&15] ^
w[(i+8)&15] ^ w[(i+2)&15] ^ w[i&15], 1);
#define SHA1_ROUND_0(v,u,x,y,z,i)              z += ((u &
(x ^ y)) ^ y) + w[i&15] + c0 + rol32(v, 5); u = rol32(u,
30);
```

```
#define SHA1_ROUND_1(v,u,x,y,z,i) SHA1_LOAD(i) z += ((u &
(x ^ y)) ^ y) + w[i&15] + c0 + rol32(v, 5); u = rol32(u,
30);

#define SHA1_ROUND_2(v,u,x,y,z,i) SHA1_LOAD(i) z += (u ^ x
^ y) + w[i&15] + c1 + rol32(v, 5); u = rol32(u, 30);

#define SHA1_ROUND_3(v,u,x,y,z,i) SHA1_LOAD(i) z += (((u |
x) & y) | (u & x)) + w[i&15] + c2 + rol32(v, 5); u =
rol32(u, 30);

#define SHA1_ROUND_4(v,u,x,y,z,i) SHA1_LOAD(i) z += (u ^ x
^ y) + w[i&15] + c3 + rol32(v, 5); u = rol32(u, 30);


        SHA1_ROUND_0(a, b, c, d, e,  0);
        SHA1_ROUND_0(e, a, b, c, d,  1);
        SHA1_ROUND_0(d, e, a, b, c,  2);
        SHA1_ROUND_0(c, d, e, a, b,  3);
        SHA1_ROUND_0(b, c, d, e, a,  4);
        SHA1_ROUND_0(a, b, c, d, e,  5);
        SHA1_ROUND_0(e, a, b, c, d,  6);
        SHA1_ROUND_0(d, e, a, b, c,  7);
        SHA1_ROUND_0(c, d, e, a, b,  8);
        SHA1_ROUND_0(b, c, d, e, a,  9);
        SHA1_ROUND_0(a, b, c, d, e, 10);
        SHA1_ROUND_0(e, a, b, c, d, 11);
        SHA1_ROUND_0(d, e, a, b, c, 12);
        SHA1_ROUND_0(c, d, e, a, b, 13);
        SHA1_ROUND_0(b, c, d, e, a, 14);
        SHA1_ROUND_0(a, b, c, d, e, 15);
        SHA1_ROUND_1(e, a, b, c, d, 16);
        SHA1_ROUND_1(d, e, a, b, c, 17);
        SHA1_ROUND_1(c, d, e, a, b, 18);
        SHA1_ROUND_1(b, c, d, e, a, 19);
        SHA1_ROUND_2(a, b, c, d, e, 20);
        SHA1_ROUND_2(e, a, b, c, d, 21);
```

```
SHA1_ROUND_2(d, e, a, b, c, 22);
SHA1_ROUND_2(c, d, e, a, b, 23);
SHA1_ROUND_2(b, c, d, e, a, 24);
SHA1_ROUND_2(a, b, c, d, e, 25);
SHA1_ROUND_2(e, a, b, c, d, 26);
SHA1_ROUND_2(d, e, a, b, c, 27);
SHA1_ROUND_2(c, d, e, a, b, 28);
SHA1_ROUND_2(b, c, d, e, a, 29);
SHA1_ROUND_2(a, b, c, d, e, 30);
SHA1_ROUND_2(e, a, b, c, d, 31);
SHA1_ROUND_2(d, e, a, b, c, 32);
SHA1_ROUND_2(c, d, e, a, b, 33);
SHA1_ROUND_2(b, c, d, e, a, 34);
SHA1_ROUND_2(a, b, c, d, e, 35);
SHA1_ROUND_2(e, a, b, c, d, 36);
SHA1_ROUND_2(d, e, a, b, c, 37);
SHA1_ROUND_2(c, d, e, a, b, 38);
SHA1_ROUND_2(b, c, d, e, a, 39);
SHA1_ROUND_3(a, b, c, d, e, 40);
SHA1_ROUND_3(e, a, b, c, d, 41);
SHA1_ROUND_3(d, e, a, b, c, 42);
SHA1_ROUND_3(c, d, e, a, b, 43);
SHA1_ROUND_3(b, c, d, e, a, 44);
SHA1_ROUND_3(a, b, c, d, e, 45);
SHA1_ROUND_3(e, a, b, c, d, 46);
SHA1_ROUND_3(d, e, a, b, c, 47);
SHA1_ROUND_3(c, d, e, a, b, 48);
SHA1_ROUND_3(b, c, d, e, a, 49);
SHA1_ROUND_3(a, b, c, d, e, 50);
SHA1_ROUND_3(e, a, b, c, d, 51);
SHA1_ROUND_3(d, e, a, b, c, 52);
```

```
        SHA1_ROUND_3(c, d, e, a, b, 53);
        SHA1_ROUND_3(b, c, d, e, a, 54);
        SHA1_ROUND_3(a, b, c, d, e, 55);
        SHA1_ROUND_3(e, a, b, c, d, 56);
        SHA1_ROUND_3(d, e, a, b, c, 57);
        SHA1_ROUND_3(c, d, e, a, b, 58);
        SHA1_ROUND_3(b, c, d, e, a, 59);
        SHA1_ROUND_4(a, b, c, d, e, 60);
        SHA1_ROUND_4(e, a, b, c, d, 61);
        SHA1_ROUND_4(d, e, a, b, c, 62);
        SHA1_ROUND_4(c, d, e, a, b, 63);
        SHA1_ROUND_4(b, c, d, e, a, 64);
        SHA1_ROUND_4(a, b, c, d, e, 65);
        SHA1_ROUND_4(e, a, b, c, d, 66);
        SHA1_ROUND_4(d, e, a, b, c, 67);
        SHA1_ROUND_4(c, d, e, a, b, 68);
        SHA1_ROUND_4(b, c, d, e, a, 69);
        SHA1_ROUND_4(a, b, c, d, e, 70);
        SHA1_ROUND_4(e, a, b, c, d, 71);
        SHA1_ROUND_4(d, e, a, b, c, 72);
        SHA1_ROUND_4(c, d, e, a, b, 73);
        SHA1_ROUND_4(b, c, d, e, a, 74);
        SHA1_ROUND_4(a, b, c, d, e, 75);
        SHA1_ROUND_4(e, a, b, c, d, 76);
        SHA1_ROUND_4(d, e, a, b, c, 77);
        SHA1_ROUND_4(c, d, e, a, b, 78);
        SHA1_ROUND_4(b, c, d, e, a, 79);

#undef SHA1_LOAD
#undef SHA1_ROUND_0
#undef SHA1_ROUND_1
```

```
#undef SHA1_ROUND_2
#undef SHA1_ROUND_3
#undef SHA1_ROUND_4

        state[0] += a;
        state[1] += b;
        state[2] += c;
        state[3] += d;
        state[4] += e;
    }

public:

    uint32_t state[5];
    uint8_t buf[64];
    uint32_t i;
    uint64_t n_bits;

    sha1(const char *text = NULL): i(0), n_bits(0){
        state[0] = 0x67452301;
        state[1] = 0xEFCDAB89;
        state[2] = 0x98BADCFE;
        state[3] = 0x10325476;
        state[4] = 0xC3D2E1F0;
        if (text) add(text);
    }

    sha1& add(uint8_t x){
        add_byte_dont_count_bits(x);
        n_bits += 8;
        return *this;
```

```
}

sha1& add(char c){
    return add(*(uint8_t*)&c);
}

sha1& add(const void *data, uint32_t n){
    if (!data) return *this;

    const uint8_t *ptr = (const uint8_t*)data;

    // fill up block if not full
    for (; n && i % sizeof(buf); n--) add(*ptr++);

    // process full blocks
    for (; n >= sizeof(buf); n -= sizeof(buf)){
        process_block(ptr);
        ptr += sizeof(buf);
        n_bits += sizeof(buf) * 8;
    }

    // process remaining part of block
    for (; n; n--) add(*ptr++);

    return *this;
}

sha1& add(const char *text){
    if (!text) return *this;
    return add(text, strlen(text));
}
```

```
    sha1& finalize(){
        // hashed text ends with 0x80, some padding 0x00
and the length in bits
        add_byte_dont_count_bits(0x80);
        while (i % 64 != 56)
add_byte_dont_count_bits(0x00);
        for (int j = 7; j >= 0; j--)
add_byte_dont_count_bits(n_bits >> j * 8);

        return *this;
    }

    const sha1& print_hex(
        char *hex,
        bool zero_terminate = true,
        const char *alphabet = "0123456789abcdef"
    ) const {
        // print hex
        int k = 0;
        for (int i = 0; i < 5; i++){
            for (int j = 7; j >= 0; j--){
                hex[k++] = alphabet[(state[i] >> j * 4) &
0xf];
            }
        }
        if (zero_terminate) hex[k] = '\0';
        return *this;
    }

    const sha1& print_base64(char *base64, bool
zero_terminate = true) const {
```

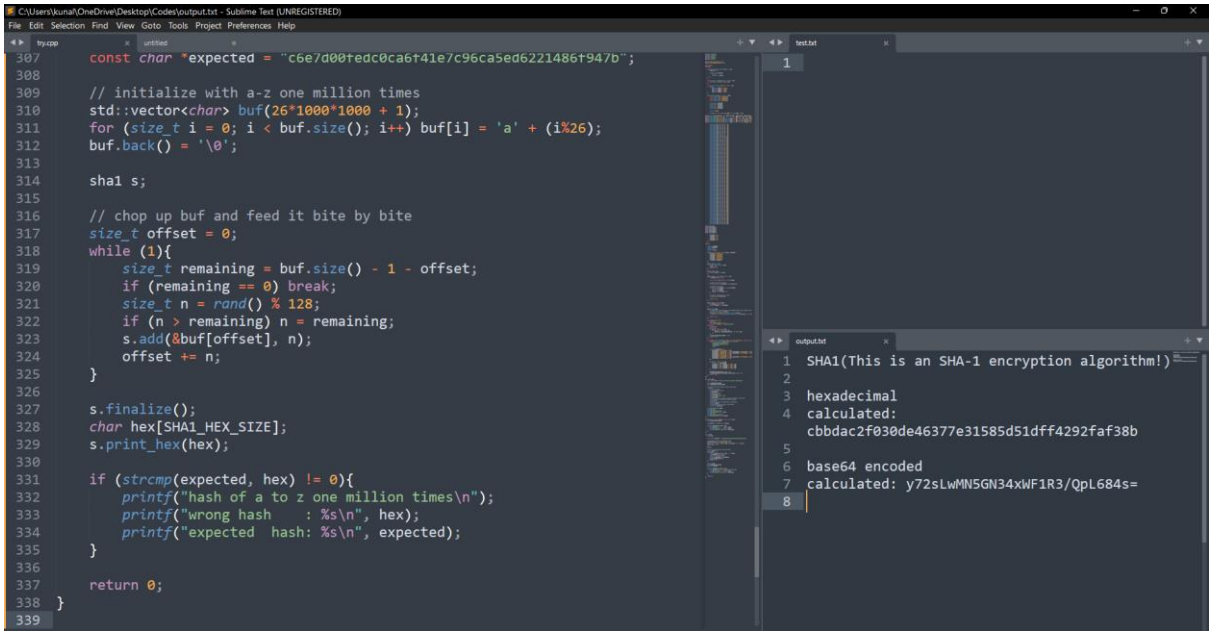
```
        static const uint8_t *table = (const uint8_t*)
            "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
            "abcdefghijklmnopqrstuvwxyz"
            "0123456789"
            "+/";

        uint32_t triples[7] = {
            ((state[0] & 0xffffff00) >> 1*8),
            ((state[0] & 0x000000ff) << 2*8) | ((state[1]
& 0xffff0000) >> 2*8),
            ((state[1] & 0x0000ffff) << 1*8) | ((state[2]
& 0xff000000) >> 3*8),
            ((state[2] & 0x00ffffff) << 0*8),
            ((state[3] & 0xffffff00) >> 1*8),
            ((state[3] & 0x000000ff) << 2*8) | ((state[4]
& 0xffff0000) >> 2*8),
            ((state[4] & 0x0000ffff) << 1*8),
        };

        for (int i = 0; i < 7; i++){
            uint32_t x = triples[i];
            base64[i*4 + 0] = table[(x >> 3*6) % 64];
            base64[i*4 + 1] = table[(x >> 2*6) % 64];
            base64[i*4 + 2] = table[(x >> 1*6) % 64];
            base64[i*4 + 3] = table[(x >> 0*6) % 64];
        }

        base64[SHA1_BASE64_SIZE - 2] = '=';
        if (zero_terminate) base64[SHA1_BASE64_SIZE - 1] =
'\0';
        return *this;
    }
```

```
};

void example(){
    const char *text = "This is an SHA-1 encryption algorithm!";

    char hex[SHA1_HEX_SIZE];
    char base64[SHA1_BASE64_SIZE];

    // constructor can be empty or take a const char*
    sha1("")
        // can be chained
        // can add single chars
        .add(text[0])
        // number of bytes
        .add(&text[1], 4)
        // 0-terminated const char*
        .add(&text[5])
        // finalize must be called, otherwise the hash is not valid
        // after that, no more bytes should be added
        .finalize()
        // print the hash in hexadecimal, 0-terminated
        .print_hex(hex)
        // print the hash in base64, 0-terminated
        .print_base64(base64);

    printf("SHA1(%s)\n",text);
    printf("\n");
    printf("hexadecimal\n");
    printf("calculated: %s\n", hex);
```

```
    printf("\n");
    printf("base64 encoded\n");
    printf("calculated: %s\n", base64);
}

void test(const char *expected, const char *text){
    char hex[SHA1_HEX_SIZE];

    sha1(text).finalize().print_hex(hex);

    if (strcmp(expected, hex) != 0){
        printf("hash of       : %s\n", text);
        printf("wrong hash    : %s\n", hex);
        printf("expected  hash: %s\n", expected);
    }
}

int main(){
    example();

    const           char           *expected           =
"c6e7d00fedc0ca6f41e7c96ca5ed6221486f947b";

    // initialize with a-z one million times
    std::vector<char> buf(26*1000*1000 + 1);
    for (size_t i = 0; i < buf.size(); i++) buf[i] = 'a' +
(i%26);
    buf.back() = '\0';

    sha1 s;
```

```
    // chop up buf and feed it bite by bite
    size_t offset = 0;
    while (1){
        size_t remaining = buf.size() - 1 - offset;
        if (remaining == 0) break;
        size_t n = rand() % 128;
        if (n > remaining) n = remaining;
        s.add(&buf[offset], n);
        offset += n;
    }

    s.finalize();
    char hex[SHA1_HEX_SIZE];
    s.print_hex(hex);

    if (strcmp(expected, hex) != 0){
        printf("hash of a to z one million times\n");
        printf("wrong hash    : %s\n", hex);
        printf("expected  hash: %s\n", expected);
    }

    return 0;
}
```

Output:



---

2. Write a program to implement the concept of Elliptic Curve Cryptosystem.

Code:

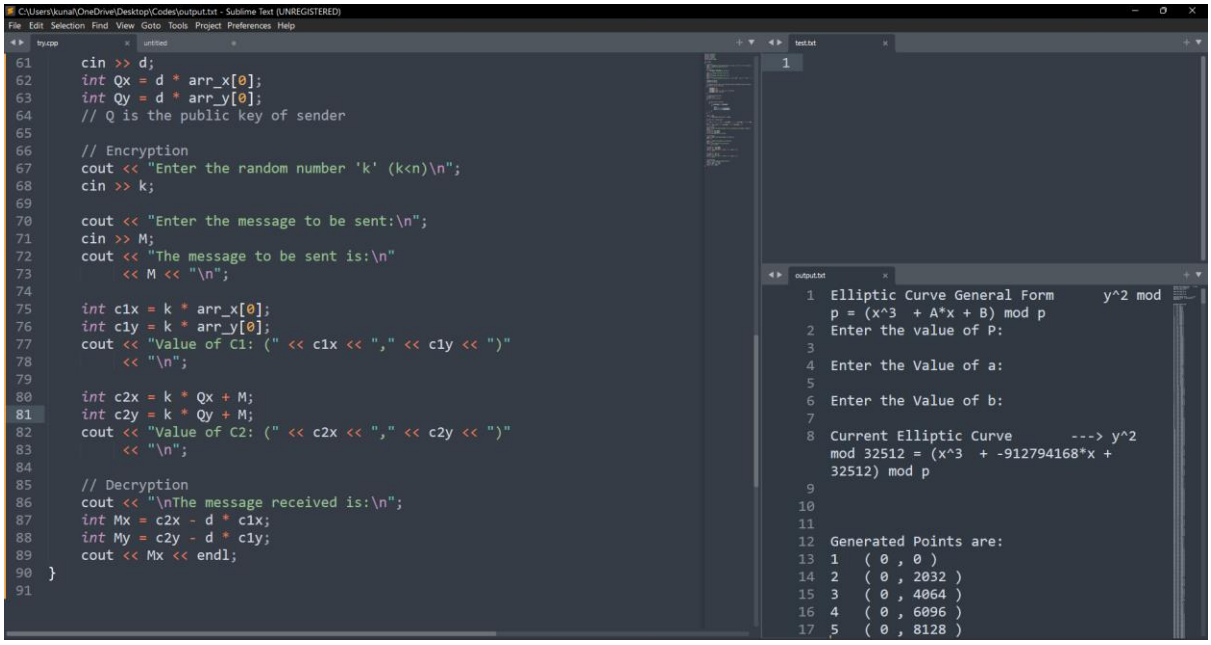
```
#include <iostream>
#include <math.h>
#include <cstdlib>
#include <vector>
using namespace std;


int main()
{
    int n, p;
    cout << "Elliptic Curve General Form \t y^2 mod p = (x^3  + A*x + B) mod p \n";
    cout << "Enter the value of P: \n";
    cin >> p;
    n = p;
    int LHS[2][n], RHS[2][n], a, b, i, j;
```

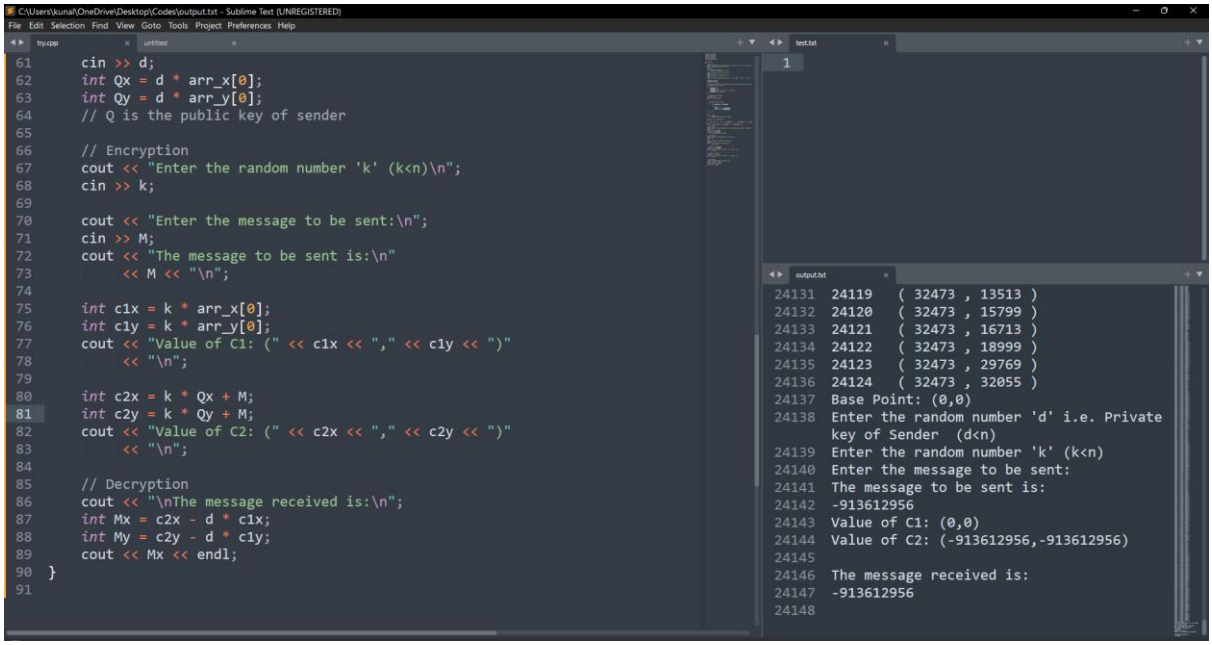
```
    cout << "\nEnter the Value of a: \n";
    cin >> a;
    cout << "\nEnter the Value of b: \n";
    cin >> b;
    cout << "\nCurrent Elliptic Curve \t\t ---> y^2 mod " << p << " = (x^3  + " << a << "*x + " << b << ") mod p\n\n\n";

    vector<int> arr_x;
    vector<int> arr_y;
    // Equating LHS and RHS as per arbitrary index to generate range of values.
    for (int i = 0; i < n; i++)
    {
        LHS[0][i] = i;
        RHS[0][i] = i;
        LHS[1][i] = ((i * i * i) + a * i + b) % p;
        RHS[1][i] = (i * i) % p;
    }

    // Generating Base Points
    int in_c = 0;
    for (i = 0; i < n; i++)
    {

        for (j = 0; j < n; j++)
        {
            if (LHS[1][i] == RHS[1][j])
            {
                in_c++;
                arr_x.push_back(LHS[0][i]);
```

```
                arr_y.push_back(RHS[0][j]);
            }
        }
    }
    cout << endl
         << "Generated Points are:" << endl;
    for (i = 0; i < in_c; i++)
    {
        cout << i + 1 << "\t( " << arr_x[i] << " , " <<
arr_y[i] << " )" << endl;
    }
    cout << "Base Point: (" << arr_x[0] << "," << arr_y[0]
<< ")"
         << "\n";
    int k, d, M;
    cout << "Enter the random number 'd' i.e. Private key
of Sender  (d<n)\n";
    cin >> d;
    int Qx = d * arr_x[0];
    int Qy = d * arr_y[0];
    // Q is the public key of sende
    // Encryption
    cout << "Enter the random number 'k' (k<n)\n";
    cin >> k;
    cout << "Enter the message to be sent:\n";
    cin >> M;
    cout << "The message to be sent is:\n"
         << M << "\n";

    int c1x = k * arr_x[0];
    int c1y = k * arr_y[0];
    cout << "Value of C1: (" << c1x << "," << c1y << ")"
```

```
            << "\n";
        int c2x = k * Qx + M;
        int c2y = k * Qy + M;
        cout << "Value of C2: (" << c2x << "," << c2y << ")"
             << "\n";

        // Decryption
        cout << "\nThe message received is:\n";
        int Mx = c2x - d * c1x;
        int My = c2y - d * c1y;
        cout << Mx << endl;
    }
```

Output:




C:\Users\kunal\OneDrive\Desktop\Codes\output.txt - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
try.cpp
untitled
test.txt
output.txt
cin >> d;
int Qx = d * arr_x[0];
int Qy = d * arr_y[0];
// Q is the public key of sender
// Encryption
cout << "Enter the random number 'k' (k<n)\n";
cin >> k;
cout << "Enter the message to be sent:\n";
cin >> M;
cout << "The message to be sent is:\n"
<< M << "\n";
int c1x = k * arr_x[0];
int c1y = k * arr_y[0];
cout << "Value of C1: (" << c1x << "," << c1y << ")"
<< "\n";
int c2x = k * Qx + M;
int c2y = k * Qy + M;
cout << "Value of C2: (" << c2x << "," << c2y << ")"
<< "\n";
// Decryption
cout << "\nThe message received is:\n";
int Mx = c2x - d * c1x;
int My = c2y - d * c1y;
cout << Mx << endl;
}
24119 (32473 , 13513)
24120 (32473 , 15799)
24121 (32473 , 16713)
24122 (32473 , 18999)
24123 (32473 , 29769)
24124 (32473 , 32055)
Base Point: (0,0)
Enter the random number 'd' i.e. Private key of Sender (d<n)
Enter the random number 'k' (k<n)
Enter the message to be sent:
The message to be sent is:
-913612956
Value of C1: (0,0)
Value of C2: (-913612956,-913612956)
The message received is:
-913612956