Lab 1
Name: Yuvraj Singh
Roll No: 23072021
M.Tech CSE

Problem: Write a program of Euclid's algorithm in C++

Euclid's algorithm:

1. Start

2. Input: Get a positive integer `a` and `b` from the user, where `a` is less than `b`.

3. `a mod b = R`.

4. Let `a = b` and `b = R`.

5. Repeat Steps 3 and 4 until `a mod b` is greater than 0.

6. `GCD = b`.

7. End

Implementation in C++

```
1 #include<stdio.h>
2 #include<math.h>
3 using namespace std;
4
5 int gcd(int a, int b) {
6     if (a==0) return b;
7     if (b % a == 0) return a;
8     return gcd(b % a, a);
9 }
10
11 int main() {
12     int a, b;
13     if (a > b) {
14         int temp = a;
15         a = b;
16         b = temp;
17     }
18     a = abs(a); b = abs(b);
19     printf("Please Enter two numbers (a & b) : ");
20     scanf("%d %d", &a, &b);
21     printf("gcd(%d, %d) = %d", a, b, gcd(a, b));
22     return 0;
23 }
```

Time Complexity: $\mathbf{O}(\log \min(a, b))$

```
input : a = 16, b = 34
output : gcd(16, 34) = 2

input : a = 10, b = 121
output : gcd(10, 121) = 1
```

Problem: Write a program of Extended Euclid's algorithm in C++

The extended Euclidean algorithm is an extension of Euclid's algorithm for finding the greatest common divisor (GCD) of two numbers. It not only finds the GCD of two numbers but also finds integers x and y such that $ax + by = gcd(a, b)$.

The steps for the extended Euclidean algorithm are as follows:

1. Start

2. Input: two positive integers a and b.

3. If b is equal to 0, then a is the GCD and $x = 1$ and $y = 0$. The algorithm terminates. go to step 8.

4. If b is not equal to 0, we calculate the remainder r of a divided by b, and find the values of $x1$ and $y1$ such that $bx1 + (a - b * r/b) * y1 = gcd(b, r)$.

5. We set $x = y1$ and $y = x1 - floor(r/b) * y1$.

6. We replace a with b, b with r, and repeat steps 3 to 5 until b is equal to 0.

7. The final values of x and y are the solutions to the equation $ax + by = gcd(a, b)$.

8. End

Implementation in C++

```cpp
1 #include<stdio.h>
2 using namespace std;
3
4 int gcd(int a, int b, int &x, int &y) {
5     if (a == 0) {
6         x = 1;
7         y = 0;
8         return b;
9     }
10    int x1, y1;
11    int d = gcd(b % a, a, x1, y1);
12    x = y1;
13    y = x1 - y1 * (b / a);
14    return d;
```

```
15 }
16
17 int main () {
18     int a, b, x, y;
19     bool f_a = false, f_b = false;
20     printf("Please Enter two numbers (a & b) : ");
21     scanf("%d %d", &a, &b);
22
23     if (a < 0) f_a = true, a = -a;
24     if (b < 0) f_b = true, b = -b;
25
26     if (a>b) {
27         int temp = a;
28         a = b;
29         b = temp;
30     }
31
32     printf("gcd(%d, %d) = %d\n", a, b, gcd(a, b, x, y));
33
34     if (f_a) x = -x;
35     if (f_b) y = -y;
36     printf("x = %d, y = %d\n", y, x);
37
38     return 0;
39 }
```

Time Complexity: $\mathbf{O}(\log\min(a,b))$

```
input : a = 16, b = 34
output : gcd(16, 34) = 2, x = -2, y = 1

input : a = 60, b = 48
output : gcd(60, 48) = gcd(48, 60) = 12, x = 1, y = -1

input : a = 10, b = 121
output : gcd(10, 121) = 1, x = -12, y = 1
```