Name: Shreeshail Mahajan
PRN: 2020BTECS00055
Batch: B4

Euclidean And Extended Euclidean Algorithm

Theory:

Euclidean Algorithm:

- The Euclidean Algorithm is a method for finding the greatest common divisor (GCD) of two integers.

- It works by repeatedly applying the division algorithm, replacing the larger number with the remainder of the division until the remainder is zero.

- The GCD is the last non-zero remainder.

- Example: GCD(48, 18) = 6, as 48 = 2 * 18 + 12, 18 = 1 * 12 + 6, 12 = 2 * 6, and the remainder is 0.

Extended Euclidean Algorithm:

- The Extended Euclidean Algorithm not only finds the GCD of two integers but also computes the coefficients of Bézout's identity.

- Bézout's identity states that for integers a and b, there exist integers x and y such that ax + by = GCD(a, b).

- The Extended Euclidean Algorithm finds these values x and y.

- Example: For a = 48 and b = 18, GCD(48, 18) = 6, and the Extended Euclidean Algorithm would give you x = 1 and y = -3 because 48 * 1 + 18 * (-3) = 6.

The Extended Euclidean Algorithm is particularly useful in modular arithmetic and cryptographic applications for solving linear congruences and finding modular multiplicative inverses.

Code:

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

class menu
{
    public :
   long long find_multiplicative_inverse(long long a, long long b) {
    long long q, r, t1 = 0, t2 = 1, t, main_a = a;
```

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```
cout<<"\n______________________________________________________________________________
_________________________________________________________________________\n";
    cout << "|\tQ\t|\tA\t|\tB\t|\tR\t|\tT1\t|\tT2\t|\tT\t|\n";
  cout<<"\n____________________________________________________________________________
___________________________________________________________________________\n";


    while (b > 0) {
        q = a / b;
        r = a % b;
        t = t1 -  (t2 * q );
        cout << "|\t" << q << "\t|\t" << a << "\t|\t" << b << "\t|\t" << r <<
"\t|\t" << t1 << "\t|\t" << t2 << "\t|\t" << t << "\t|\n";
      cout<<"\n________________________________________________________________
_____________________________________________________________________________\n
";

        a = b;
        b = r;
        t1 = t2;
        t2 = t;
    }

    cout << "|\t" << q << "\t|\t" << a << "\t|\t" << b << "\t|\t" << r <<
"\t|\t" << t1 << "\t|\t" << t2 << "\t|\t" << t << "\t|\n";
    cout<<"\n__________________________________________________________________
_____________________________________________________________________________\n";

    if (t1 < 0) {
        t1 += main_a;
    }
    return t1;
}

    long long find_large_number_gcd(long long a,long long b)
    {
        long long q,r;
            cout<<"\n__________________________________________________________
_____________________________________________________________________________
____\n";
            cout<<"|\t\tQ\t\t|\t\tA\t\t|\t\tB\t\t|\t\tR\t\t|\n";
          cout<<"\n____________________________________________________________
_____________________________________________________________________________
__\n";

            while(b>0)
            {
                    q=a/b;
```

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```
                    r=a%b;
                    cout<<"|\t\t"<<q<<"\t\t|\t\t"<<a<<"\t\t|\t\t"<<b<<"\t\t|\t
\t"<<r<<"\t\t|\n";
                 cout<<"\n_______________________________________________________
________________________________________________________________________
_________\n";
                    a=b;
                    b=r;
            }
             cout<<"|\t\t"<<q<<"\t\t|\t\t"<<a<<"\t\t|\t\t"<<b<<"\t\t|\t\t"<<r<
<"\t\t|\n";
    cout<<"\n_________________________________________________________________
____________________________________________________________________\n";

            cout<<endl;

            return a;
    }


};
int main()
{
    main_menu:
    cout<<"\n_________________________________________________________________
_______________\n";
    cout<<"\n1.Find Multiplicative Inverse (Extended Euclidien Algo ) \n2.Find
GCD Of large numbers(Euclideian Algo ) \n";
    cout<<"__________________________________________________________________
_____________\n";
    cout<<"Enter Choice Code :\t";
    menu object;
    int ch;
    cin>>ch;
    cout<<"\n";
    long long a,b,ans;

    switch(ch)
    {
        case 1 :

            cout<<"\nEnter  A and B ( must be A>B)  :\t";
            cin>>a>>b;
            ans=object.find_multiplicative_inverse(a,b);
            cout<<"Multiplicative Inverse Of  "<<a<<"\tAnd "<<b<<"\t
:\t"<<ans<<endl;
            goto main_menu;
```

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```cpp
        case 2:

            cout<<"\nEnter  A and B  :\t";
            cin>>a>>b;
             ans=object.find_large_number_gcd(a,b);
            cout<<"\nGCD Of   Of  "<<a<<"\tAnd "<<b<<"\t :\t"<<ans<<endl;
            goto main_menu;



        default:
            cout<<"Invalid Input !";
            break;
    }

    return 0;
}
```

Screenshot:

```
Enter  A and B ( must be A>B)  :       55 22

---------------------------------------------------------------------------------------------------------
-----------------------------------
|       Q       |       A       |       B       |       R       |       T1      |       T2      |       |

---------------------------------------------------------------------------------------------------------
-----------------------------------
|       2       |       55      |       22      |       11      |       0       |       1       |       -
2       |

---------------------------------------------------------------------------------------------------------
-----------------------------------
|       2       |       22      |       11      |       0       |       1       |       -2      |       |

---------------------------------------------------------------------------------------------------------
-----------------------------------
|       2       |       11      |       0       |       0       |       -2      |       5       |       |

---------------------------------------------------------------------------------------------------------
-----------------------------------
Multiplicative Inverse Of  55   And 22   :      53
```

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```
Enter  A and B  :      55 22

______________________________________________________________________________________________
__________________________________
|               Q               |               A               |               B               |       |

______________________________________________________________________________________________
__________________________________
|               2               |               55              |               22              |       1
1               |

______________________________________________________________________________________________
__________________________________
|               2               |               22              |               11              |       |

______________________________________________________________________________________________
__________________________________
|               2               |               11              |               0               |       |

______________________________________________________________________________________________
__________________________________


GCD Of   Of  55 And 22   :      11
```