Numerical Analysis

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```
//e^(-3x/2)

#include<stdio.h>
#include<math.h>

int main(){

  double ans=0;
  for(double i=0.1; i<=2; i+=0.1){
    ans += exp((-1)*i*i*i/2);
  }

  printf("%lf", ans);
}
```

```
//5x^3 + e^(-2x)

#include<stdio.h>
#include<math.h>

int main(){

  double ans=0;
  for(double i=0.1; i<=2; i+=0.1){
    ans += 5*i*i*i + exp((-1)*2*i);
  }

  printf("%lf", ans);
}
```

Maclaurin Series

$$e^{x} = 1 + \frac{x^{1}}{1!} + \frac{x^{2}}{2!} + \cdots \cdots$$

$$\ln(1+x) = \frac{x}{1!} - \frac{x^{2}}{2!} + \frac{x^{3}}{3!} - \cdots$$

$$\ln(1-x) = -\left(x + \frac{x^{2}}{2!} + \frac{x^{3}}{3!} + \cdots \right)$$

```
//e^x
#include<stdio.h>
#include<math.h>

int main(){

  double ans=1;
  double x;
  scanf("%lf", &x);

  double factorial=1;

  for(double i=2; i<=6; i++){
    ans += pow(x, i-1)/factorial;
    factorial*=i;
  }

  printf("%lf", ans);
}
```

```
//ln(1+x)
#include<stdio.h>
#include<math.h>

int main(){

  double ans=0;
  double x;
  scanf("%lf", &x);

  double factorial=1;
  for(int i=1; i<=6; i++){
    if(i%2==0)
      ans -= pow(x, i)/factorial;
    else
      ans += pow(x, i)/factorial;

    factorial*=i;
  }

  printf("%lf", ans);
}
```

```
// ln (1-x)
#include<stdio.h>
#include<math.h>

int main(){

  double ans=0;
  double x;
  scanf("%lf", &x);

  double factorial=1;

  for(int i=1; i<=6; i++){
    ans += pow(x, i)/factorial;
    factorial*=i;
  }
  ans *= (-1);
  printf("%lf", ans);
}
```

* Bisection

$$\begin{array}{c} \overbrace{a, b} \\ f \end{array} \rightarrow c = \frac{(a+b)}{2} \rightarrow \begin{array}{l} \overbrace{f(c)} \times \overbrace{f(a)} < 0 \rightarrow b = c \\ f(c) \times f(b) < 0 \rightarrow a = c \end{array}$$

```
//Bisection Method

#include<stdio.h>
#include<math.h>
```

```
#define f(x) (exp(x)-3*x)

int main(){
  double a,b;
  scanf("%lf", &a);
  scanf("%lf", &b);

  while(true){
    double c = (a+b)/2;
    if(f(a)*f(c) < 0) b=c;
    else a=c;
    if(fabs((a)-(b)) <= 0.0001) break;
  }
  printf("%lf", a);
}


#include<stdio.h>
#include<math.h>

#define f(x) (x*log10(x)-1.2)

int main(){
  double a,b;
  scanf("%lf", &a);
  scanf("%lf", &b);

  while(true){
    double c = (a+b)/2;
    if(f(a)*f(c) < 0) b=c;
    else a=c;
    if(fabs((a)-(b)) <= 0.0001) break;
  }
  printf("%lf", a);
}


#include<stdio.h>
#include<math.h>

#define f(x) (x*x*x-6*x+4)

int main(){
  double a,b;
  scanf("%lf", &a);
  scanf("%lf", &b);

  while(true){
    double c = (a+b)/2;
    if(f(a)*f(c) < 0) b=c;
    else a=c;
    if(fabs((a)-(b)) <= 0.0001) break;
  }
  printf("%lf", a);
}
```

*

$$\overline{a,\ b} \quad f \rightarrow \boxed{c = \frac{a * f(b) - b * f(a)}{f(b) - f(a)}}$$

$$f(c) * f(a) < 0 \Rightarrow b = c$$

Otherwise → $a = c$

```
// False Position

#include<stdio.h>
#include<math.h>

#define f(x) (x*x*x-6*x+4)

int main(){
  double a,b;
  scanf("%lf", &a);
  scanf("%lf", &b);
  double ans=a;
  while(true){
    double c = ((a*f(b) - b*f(a))/(f(b)-f(a)));
    if(f(a)*f(c) < 0) b=c;
    else a=c;
    ans=c;
    if(fabs(f(a)-f(b)) <= 0.0001) break;
  }
  printf("%lf", ans);
}
```

*

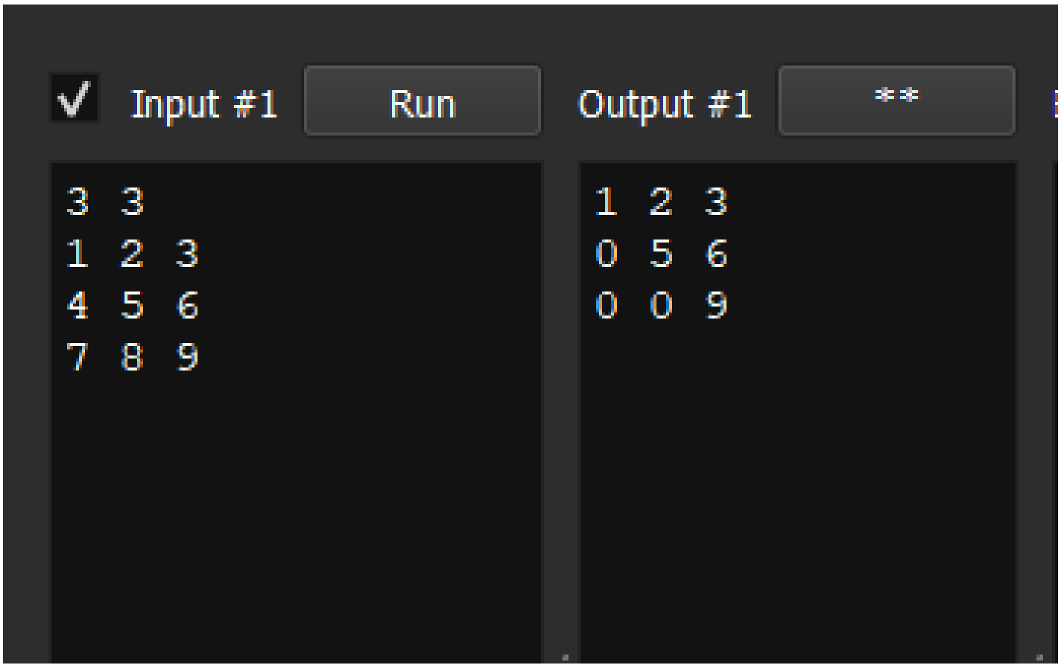
x_0

$f \longrightarrow x = x_0 - \frac{f(x_0)}{f'(x)}$

f'

$$\left[\, |x - x_0| \leq 10^{-4} \,\right]$$

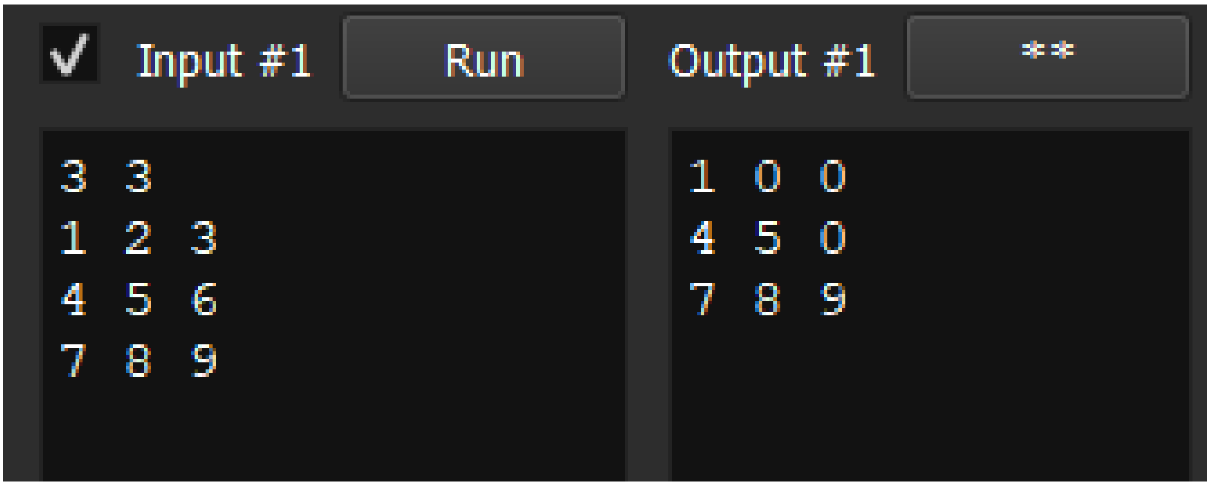
```
// Newton Raphson

#include<stdio.h>
#include<math.h>

#define f(x) (x*x*x-6*x+4)
#define diff(x) (3*x*x - 6)
int main(){
  double x0;
  scanf("%lf", &x0);
  double x=x0;
  while(true){
    x = x0 - (f(x)/diff(x));
    if(fabs(f(x)-f(x0)) <= 0.0001) break;
    x0=x;
  }
  printf("%lf", x);
}
```



```
3 3
1 2 3
4 5 6
7 8 9
```

```
1 2 3
0 5 6
0 0 9
```

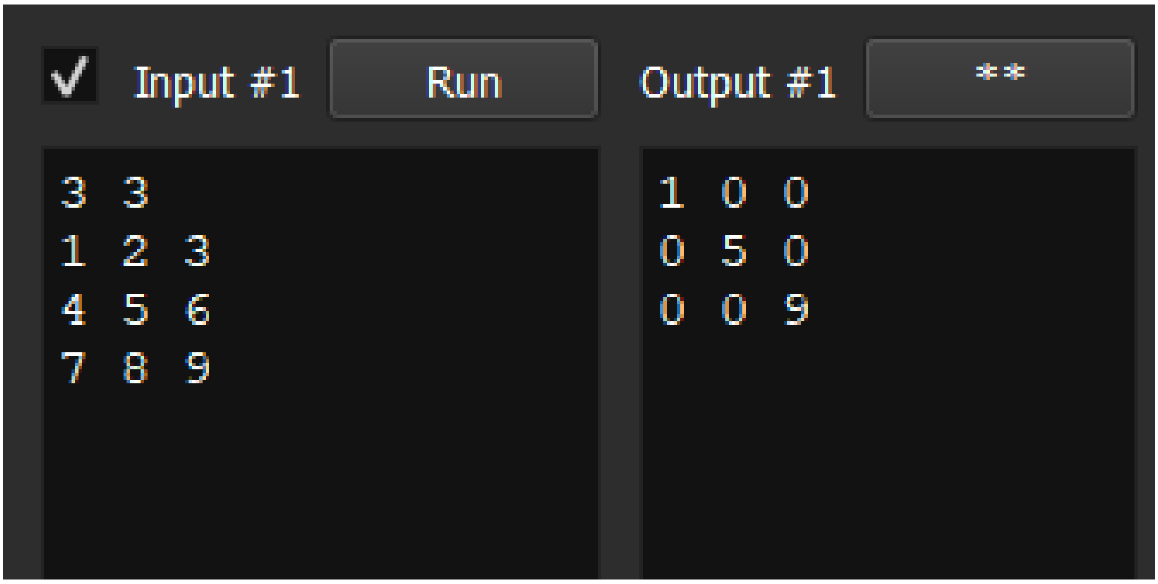
```
// Upper-triangular method

#include<stdio.h>
#include<math.h>

#define ll int

int main(){
  int n,m;
  scanf("%d %d", &n, &m);
  int a[n][m];

  for(ll i=0; i<n; i++)
    for(ll j=0; j<m; j++)
      scanf("%d", &a[i][j]);

  for(ll i=0; i<n; i++){
    for(ll j=0; j<i; j++) printf("0 ");
    for(ll j=i; j<m; j++){
      printf("%d ", a[i][j]);
    }
    printf("\n");
  }
}
```



```
3 3
1 2 3
4 5 6
7 8 9
```

```
1 0 0
4 5 0
7 8 9
```

```
// lower triangular
#include<stdio.h>
#include<math.h>

#define ll int

int main(){
  int n,m;
  scanf("%d %d", &n, &m);
  int a[n][m];

  for(ll i=0; i<n; i++)
    for(ll j=0; j<m; j++)
      scanf("%d", &a[i][j]);

  for(ll i=0; i<n; i++){
    for(ll j=0; j<=i; j++){
      printf("%d ", a[i][j]);
    }
    for(ll j=i+1; j<m; j++) printf("0 ");
    printf("\n");
  }
}
```



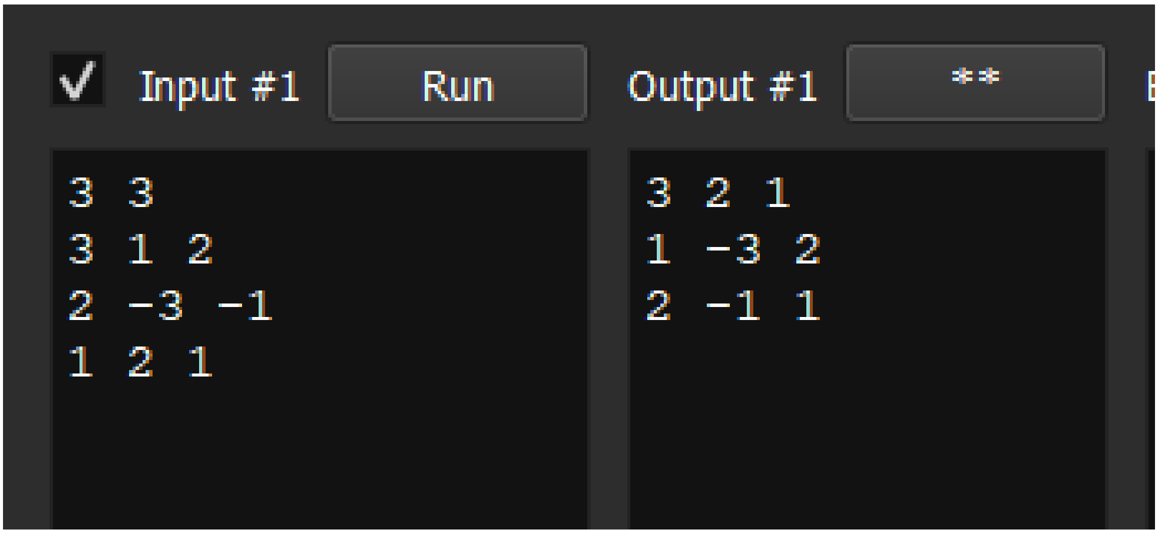
```
3 3
1 2 3
4 5 6
7 8 9
```

```
1 0 0
0 5 0
0 0 9
```

```
//Diagonal Matrix
#include<stdio.h>
#include<math.h>

#define ll int

int main(){
  int n,m;
  scanf("%d %d", &n, &m);
  int a[n][m];

  for(ll i=0; i<n; i++)
    for(ll j=0; j<m; j++)
      scanf("%d", &a[i][j]);

  for(ll i=0; i<n; i++){
    for(ll j=0; j<m; j++){
      if(i==j) printf("%d ", a[i][j]);
      else printf("0 ");
    }
    printf("\n");
  }
}
```

$$a[0][i]\{a[1][(i+1)\%n] \times a[2][(i+1)\%n]$$
$$- a[1][(i+2)\%n] \times a[2][(i+1)\%n]\}$$

```
// Deteminant

#include<stdio.h>
#include<math.h>

#define ll int

int main(){
  int n,m;
  scanf("%d %d", &n, &m);
  int a[n][m];

  for(ll i=0; i<n; i++)
    for(ll j=0; j<m; j++)
      scanf("%d", &a[i][j]);

  double determinant=0;
  for(ll i=0; i<n; i++)
    determinant += a[0][i]*(a[1][(i+1)%n]*a[2][(i+2)%n] - a[1][(i+2)%n]*a[2][(i+1)%n]);

  printf("%lf\n", determinant);
}
```



```
3 3
3 1 2
2 -3 -1
1 2 1
```

```
3 2 1
1 -3 2
2 -1 1
```

```
//Transpose Matrix
#include<stdio.h>
#include<math.h>

#define ll int

int main(){
  int n,m;
  scanf("%d %d", &n, &m);
  int a[n][m];

  for(ll i=0; i<n; i++)
    for(ll j=0; j<m; j++)
      scanf("%d", &a[i][j]);

  for(ll i=0; i<n; i++){
    for(ll j=0; j<n; j++){
      printf("%d ", a[j][i]);
    }
    printf("\n");
  }
}
```

1) $$\text{adj}[i][j] = a[(i+1)\%n][(j+1)\%n] \times a[(i+2)\%n][(j+2)\%n]$$
$$- a[(i+1)\%n][(j+2)\%n] \times a[(i+2)\%n][(j+1)\%n];$$

2) transpose (adj) = adjoint

```
//Adjoint Matrix
#include<stdio.h>
#include<math.h>

#define ll int

int main(){
  int n,m;
  scanf("%d %d", &n, &m);
  int a[n][m];

  for(ll i=0; i<n; i++)
    for(ll j=0; j<m; j++)
      scanf("%d", &a[i][j]);


  int adj[n][m];
  for(ll i=0; i<n; i++){
    for(ll j=0; j<n; j++){
      adj[i][j] = a[(i+1)%n][(j+1)%n]*a[(i+2)%n][(j+2)%n]
            - a[(i+1)%n][(j+2)%n]*a[(i+2)%n][(j+1)%n];
    }
  }

  for(ll i=0; i<n; i++)
  {
    for(ll j=0; j<m; j++){
      printf("%d ", adj[j][i]);
    }
    printf("\n");
  }

}
```

1)

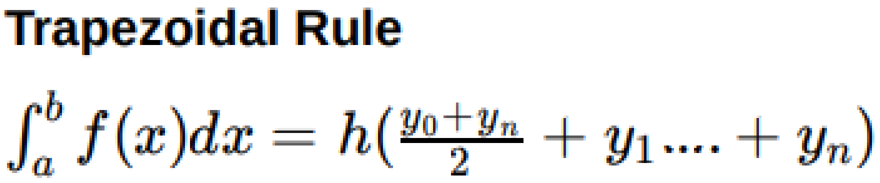
$$\frac{adj[j][i]}{determenant}$$

```
//Inverse Matrix

#include<stdio.h>
#include<math.h>

#define ll int

int main(){
  int n,m;
  scanf("%d %d", &n, &m);
  int a[n][m];

  for(ll i=0; i<n; i++)
    for(ll j=0; j<m; j++)
      scanf("%d", &a[i][j]);


  double determinant = 0;
  for(ll i=0; i<n; i++)
    determinant += a[0][i]*(a[1][(i+1)%n]*a[2][(i+2)%n]- a[1][(i+2)%n]*a[2][(i+1)%n]);

  double adj[n][m];
  for(ll i=0; i<n; i++)
    for(ll j=0; j<m; j++)
      adj[i][j] = a[(i+1)%n][(j+1)%n]*a[(i+2)%n][(j+2)%n]
                  - a[(i+1)%n][(j+2)%n]*a[(i+2)%n][(j+1)%n];


  for(ll i=0; i<n; i++){
    for(ll j=0; j<m; j++){
      printf("%0.4lf ", adj[j][i]/determinant);
    }
    printf("\n");
  }

}
```

```
// Gauss Elimination

#include<stdio.h>
#include<math.h>

#define ll int

int main(){
  int n;
  scanf("%d", &n);
  double a[n+1][n+2];

  for(ll i=1; i<=n; i++){
    for(ll j=1; j<=n; j++){
      scanf("%lf", &a[i][j]);
    }
  }

  for(ll i=1; i<=n; i++)
    scanf("%lf", &a[i][n+1]);

  double c;
  for(ll j=1; j<=n; j++){
    for(ll i=1; i<=n; i++){
      if(i > j){
        c=a[i][j]/a[j][j];
        for(ll k=1; k<=n+1; k++){
          a[i][k]=a[i][k]-c*a[j][k];
        }
      }
    }
  }

  double x[n+1];
  x[n]=a[n][n+1]/a[n][n];
  for(ll i=n-1; i>=1; i--){
    double sum=0;
    for(ll j=i+1; j<=n; j++){
      sum += a[i][j]*x[j];
    }
    x[i]=(a[i][n+1]-sum)/a[i][i];
  }

  for(ll i=1; i<=n; i++) printf("%lf\n", x[i]);

}
```

```
// Matrix Inversion Method

#include<stdio.h>
#include<math.h>

#define ll int

int main(){
  int n;
  scanf("%d", &n);
  double a[n][n], b[n];

  for(ll i=0; i<n; i++){
    for(ll j=0; j<n; j++){
      scanf("%lf", &a[i][j]);
    }
  }

  for(ll i=0; i<n; i++)
    scanf("%lf", &b[i]);

  double determinant=0;
  for(ll i=0; i<n; i++)
    determinant += a[0][i]*(a[1][(i+1)%n]*a[2][(i+2)%n]
              - a[1][(i+2)%n]*a[2][(i+1)%n]);

  double adj[n][n];
  for(ll i=0; i<n; i++)
```

```
    for(ll j=0; j<n; j++)
      adj[i][j] = a[(i+1)%n][(j+1)%n]*a[(i+2)%n][(j+2)%n]
            - a[(i+1)%n][(j+2)%n]*a[(i+2)%n][(j+1)%n];

  double adjoint[n][n];
  for(ll i=0; i<n; i++)
    for(ll j=0; j<n; j++)
      adjoint[j][i]=(adj[i][j]);

  for(ll i=0; i<n; i++){
    double sum=0;
    for(ll j=0; j<n; j++){
      sum += b[j]*adjoint[i][j];
    }
    printf("%0.4lf\n", (sum/determinant));
  }
}
```



Trapezoidal Rule

$$\int_a^b f(x)dx = h(\frac{y_0+y_n}{2} + y_1 .... + y_n)$$

```
// Trapezoidal Rule

#include<stdio.h>
#include<math.h>

#define ll int

int main(){
  ll n; scanf("%d", &n);
  double a[n], b[n];

  for(ll i=0; i<n; i++)
    scanf("%lf %lf", &a[i], &b[i]);
  double xi, xf, h;
  scanf("%lf %lf %lf", &xi, &xf, &h);

  double ans=(b[0]+b[n-1])/2;
  for(ll i=1; i<n-1; i++) ans += b[i];
  ans *= h;

  printf("%lf", ans);

}
```

Simpson one-third rule

$$\int_a^b f(x)dx = \frac{h}{3}(y_0 + y_n + 4(y_1 + y_3 + ...) + 2(y_2 + y_4 + ...))$$

Applicable for only **even intervals.**

```
// Simpson one-third rule

#include<stdio.h>
#include<math.h>

#define ll int

int main(){
  ll n; scanf("%d", &n);
  double a[n], b[n];

  for(ll i=0; i<n; i++)
    scanf("%lf %lf", &a[i], &b[i]);
  double xi, xf, h;
  scanf("%lf %lf %lf", &xi, &xf, &h);

  double ans=(b[0]+b[n-1]);
  for(ll i=1; i<n-1; i+=2) ans += 4*b[i];
  for(ll i=2; i<n-1; i+=2) ans += 2*b[i];
  ans *= (h/3);

  printf("%lf", ans);
}
```

```
//Newton Forward Interpolation

#include <stdio.h>
#include <math.h>

int main()
{
  int n;
  printf("The number of x and f(x)");
  scanf("%d", &n);
  double x[n], y[n], xi;
  printf("Write the number of x:");
  for (int i = 0; i < n; i++)
  {
    scanf("%lf", &x[i]);
  }
  printf("Write the number of f(x):");
  for (int i = 0; i < n; i++)
  {
    scanf("%lf", &y[i]);
  }

  printf("X = ");
  scanf("%lf", &xi);

  double da[n][n];
  for (int j = 0; j < n; j++)
  {
    da[j][0] = y[j];
  }

  for (int i = 1; i < n; i++)
  {

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

      da[j][i] = (da[j + 1][i - 1] - da[j][i - 1]);
    }
  }

  double p = (xi - x[0]) / (x[1] - x[0]);
  double ans = y[0];
  double fact=1;
  for (int i = 1; i < n; i++)
  {
    double localP = p * 1.00;
    fact *= 1.00;

    for (int j = 1; j < i; j++)
    {
      localP *= (p - j);
    }
    ans += (localP / fact) * da[0][i];
  }

  printf(" %lf ", ans);

  return 0;
}
```

```
//Newton Backward

#include <stdio.h>
```

```
#include <math.h>

int main()
{
  int n;
  printf("The number of x and f(x)");
  scanf("%d", &n);
  double x[n], y[n], xi;
  printf("Write the number of x:");
  for (int i = 0; i < n; i++)
  {
    scanf("%lf", &x[i]);
  }
  printf("Write the number of f(x):");
  for (int i = 0; i < n; i++)
  {
    scanf("%lf", &y[i]);
  }

  printf("X = ");
  scanf("%lf", &xi);

  double da[n][n];
  for (int j = 0; j < n; j++)
  {
    da[j][0] = y[j];
  }

  for (int i = 1; i < n; i++)
  {

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

      // printf(" %lf  %lf ", da[j + 1][i - 1], da[j][i - 1]);
      da[j][i] = (da[j + 1][i - 1] - da[j][i - 1]);
      // printf(" %lf \n ", da[j][i]);
    }
  }

  double p = (xi - x[n - 1]) / (x[1] - x[0]);
  double ans = y[n - 1];
  for (int i = n - 1; i >= 1; i--)
  {
    double localP = p * 1.00;
    double fact = 1.00;

    for (int j = 1; j <= n - i - 1; j++)
    {
      fact = fact * j;
    }
    for (int j = 1; j < n - i - 1; j++)
    {
      localP *= (p - j);
    }
    ans += (localP / fact) * da[n - i - 1][i];
  }
  printf("%lf ", ans);

  return 0;
}
```

```
//Newton Devided Difference

#include <stdio.h>
#include<stdlib.h>
#include <math.h>


int main()
{
  int n;
  //taking the total number of x
  printf("Enter number of x and y or f(x)\n");
  scanf("%d", &n);
  double x[n], y[n], X;


  // taking the value of X
  printf("jot down the value of x\n");
  for (int i = 0; i < n; i++)
    scanf("%lf", &x[i]);

  // taking the value of y/f(x)
  printf("write down the number of y or f(x):\n");
  for (int i = 0; i < n; i++)
    scanf("%lf", &y[i]);

  //taking the value of question
  printf("The X you want to get = ");
  scanf("%lf", &X);

  double table[n][n];
  for (int j = 0; j < n; j++)
    table[j][0] = y[j];


  for (int i = 1; i < n; i++)
    for (int k = 0; k < n - i; k++)
    table[k][i] = (table[k + 1][i - 1] - table[k][i - 1]) / (x[i + k] - x[k]);

  double ans = y[0];
  for (int i = 1; i < n-1; i++)
  {
    double ansa = 1.00;
    for (int k = 0; k <= i-1; k++)
      ansa *= (X - x[k]);
    ans += (ansa)*table[0][i];
  }
  //printing ans
  printf("Ans: %lf ", ans);
  return 0;
}
```

```
//Numerical Differentiation

#include <stdio.h>
#include <stdlib.h>
#include <math.h>
int n;
int main()
{
  //taking the total number of x
  printf("Enter number of x and y or f(x)\n");
  scanf("%d", &n);
  double x[n], y[n], X;


  // taking the value of X
  printf("jot down the value of x\n");
  for (int i = 0; i < n; i++)
    scanf("%lf", &x[i]);

  // taking the value of y/f(x)
  printf("write down the number of y or f(x):\n");
  for (int i = 0; i < n; i++)
    scanf("%lf", &y[i]);

  //taking the value of question
  printf("The X you want to get = ");
  scanf("%lf", &X);

  int Xindex;

  for(int i=0; i<n; i++){
    if(X == x[i]) Xindex=i;
  }

  double table[n][n];
  for (int j = 0; j < n; j++)
  {
    table[j][0] = y[j];
  }

  for (int i = 1; i < n; i++)
    for (int j = 0; j < n - i; j++)
      table[j][i] = (table[j + 1][i - 1] - table[j][i - 1]);

  double ans = 0.000000;
  for (int i = 0; i < n; i++)
  {
    if(i%2 == 1)
      ans-=(1/(i+1))*(table[Xindex-i][i]);

    else
      ans+=(1/(i+1))*(table[Xindex-i][i]);
  }

  printf("Ans for the 3rd derivative  :  %lf ", ans);

  return 0;
}
```

```
//Lagrange Interpolation

#include <stdio.h>
#include <math.h>

int main()
{
    int n;
    printf("The number of x and f(x)");
    scanf("%d", &n);
    double x[n], y[n], xi;
    printf("Write the number of x:");
    for (int i = 0; i < n; i++)
    {
        scanf("%lf", &x[i]);
    }
    printf("Write the number of f(x):");
    for (int i = 0; i < n; i++)
    {
        scanf("%lf", &y[i]);
    }

    printf("X = ");
    scanf("%lf", &xi);

    double da[n][n];
    for (int j = 0; j < n; j++)
    {
        da[j][0] = y[j];
    }

    double ans = 0;
    for (int i = 0; i < n; i++)
    {
        double localAns = 1;
        for (int j = 0; j < n; j++)
        {
            if (i == j)
                continue;
            localAns *= (xi - x[j]);
            localAns /= (x[i] - x[j]);
        }
        ans += localAns * y[i];
    }
    printf(" %lf ", ans);

    return 0;
}
```

```
//Iterative Method

#include <stdio.h>
#include <math.h>

#define f(x) (x * x * x + x * x - 1)
#define phi(x) 1 / sqrt(1 + x)
#define diffPhi(x) (0.5 / sqrt(1 + x))

int main()
{
  double a = 0, b = 0;
  double x1 = 0, x2 = 0;

  // Step 1 : finding the value of x1 and x2
  while (1)
  {
    /*
      ekhane dui bhabe check kortechi,
      dhoren,
      1) (0 1), (1,2) , ...
      2) (0,-1), (-1,-2), ....
      ig, yk why.
    */
    if (f(a) * f((a - (double)1.0000)) < 0)
    {
      printf("%lf %lf", f(a), f((a - (double)1.0000)));
      x1 = a;
      x2 = a - 1;

      break;
    }
    if (f(b) * f((b + (double)1.0000)) < 0)
    {
      x1 = b;
      x2 = b + 1;
      break;
    }
    a--;
    b++;
  }
  // Step 2 & 3 : finding the root
  // we'll just jot down the steps which are written on the blog
  double ans = 1e9; // Just assume a number which can never be the answer
  double x0 = (x1 + x2) / 2;

  if (abs(diffPhi(x0)) < 1)
  {
    while (1)
    {
      double xn = phi(x0);
      if (fabs(xn - x0) <= 0.001)
      {
        ans = xn;
        break;
      }
      x0 = xn;
    }
  }
  else
  {
    printf("NOT FOUND");
    return 0;
  }

  // Printing the answer
  printf("%lf", ans);
  return 0;
}
```

```
//Secant Method

#include <stdio.h>
#include <math.h>
#define f(x) (x * x * x - 2 * x - 5)

int main()
{
  double a = 0, b = 0;
  double x1 = 0, x2 = 0;

  // Step 1 : finding the value of x1 and x2
  while (1)
  {
    /*
      ekhane dui bhabe check kortechi,
      dhoren,
      1) (0 1), (1,2) , ...
      2) (0,-1), (-1,-2), ....
      ig, yk why.
    */
    if (f(a) * f((a - (double)1.0000)) < 0)
    {
      printf("%lf %lf", f(a), f((a - (double)1.0000)));
      x1 = a;
      x2 = a - 1;
      break;
    }
    if (f(b) * f((b + (double)1.0000)) < 0)
    {
      x1 = b;
      x2 = b + 1;
      break;
    }
    a--;
    b++;
  }
  // Step 2 & 3 : finding the root

  // we'll just jot down the steps which are written on the blog
  double ans = 1e9; // Just assume a number which can never be the answer
  while (1)
  {
    double prevAns = ans;
    double x = ((x1 * f(x2) - x2 * f(x1)) / (f(x2) - f(x1)));
    ans = x;
    x1 = x2;
    x2 = x;
    // Calculating the the  literation of last two answer
    if (fabs((prevAns) - (ans)) <= 0.001)
    {
      break;
    }
  }

  // Printing the answer
  printf("%lf", ans);
  return 0;
}
```