FINAL FOLLOWAGE

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Subject:

Numerical Analysis

Professor:

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Name **project**:

Alpha Numeric

Repository from where we work:

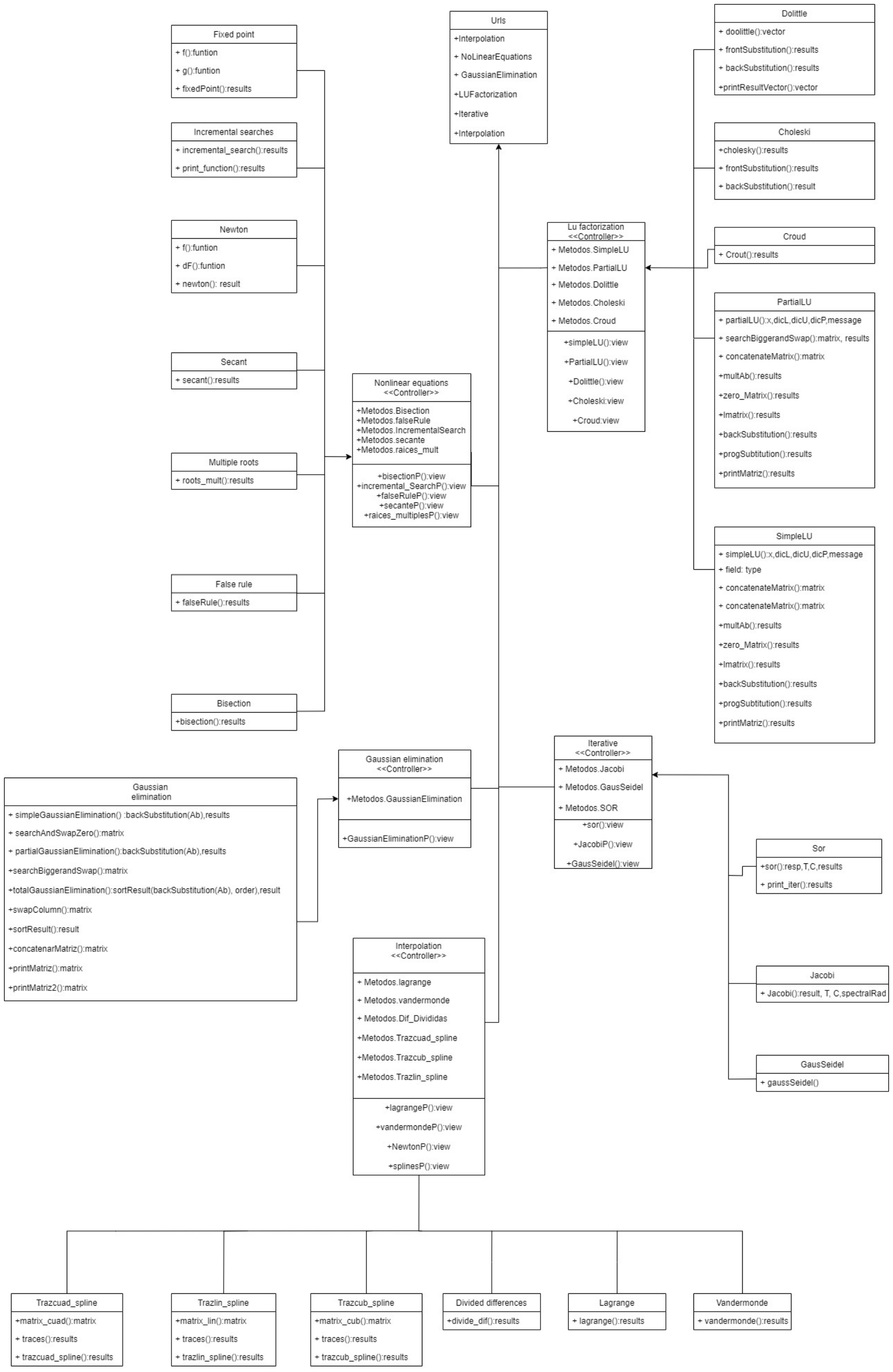
https://github.com/herreraalex/AlphaNumeric

Page from where we work:

https://dry-beyond-30251.herokuapp.com/

Contents

Class diagram



Use case diagram

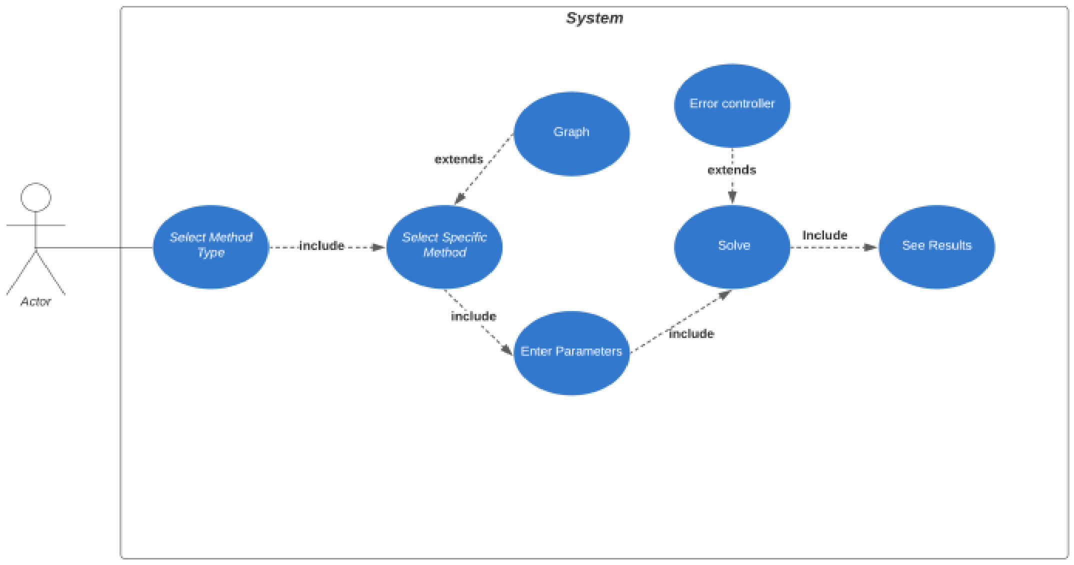
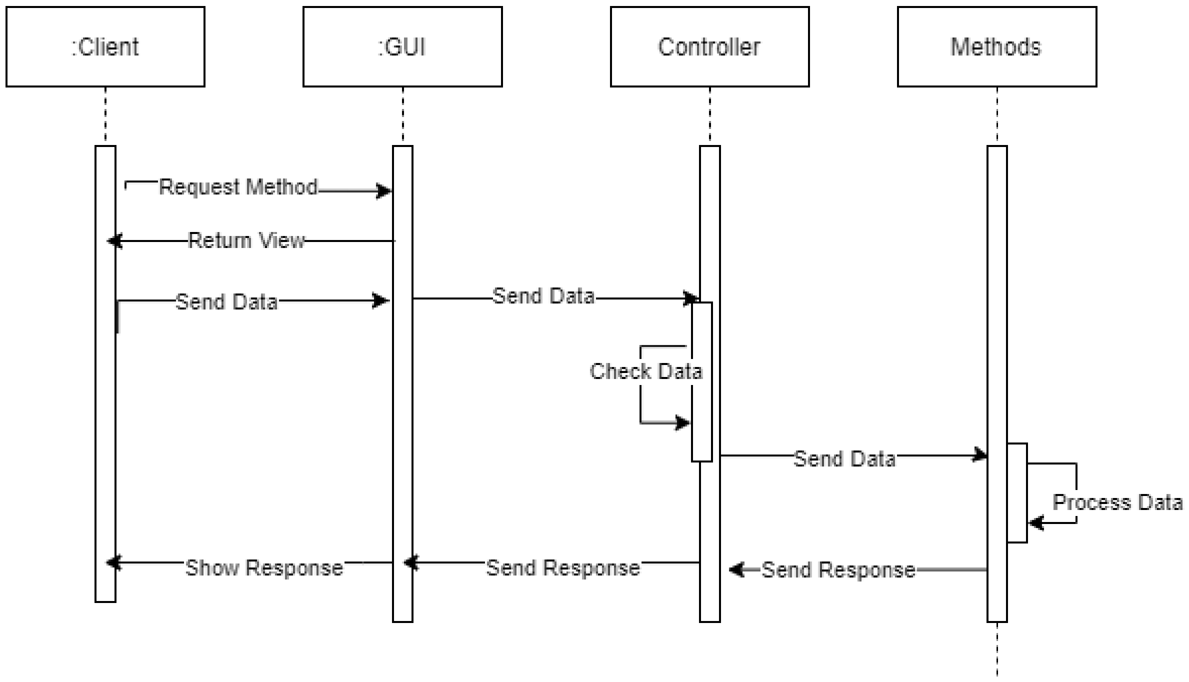


Diagram sequence



Pseudocodes

Bisection:

read xi, xs, tolerancia, niter, funcion

```
fxi = f(xi)
fxs = f(xs)

if (fxi == 0)
   write "xi es raíz"
else if (fxs == 0)
   write "xs es raíz"
else if (fxi * fxs < 0 then)

   xm = (xi + xs)/2
   fxm = f(xm)
   error = tolerancia + 1
   count = 1

   while ( fxm != 0 and error > tolerancia and contador < niter)
       if (fxi * fxm < 0 )
           xs = xm
        else
           xi = xm
           fxi = fxm
       end if

       xaux = xm
       xm = (xi + xs) / 2
       fxm = f(xm)
       error = abs(xm - xaux)
       count = count + 1
   end while

else
   write "el intervalo es inadecuado"
```

```
end if
end
```

Cholesky:

```
read A, b
 determinante=det(A);

 if determinante==0 then
   return "El sistema no tiene una única solución"
 end if
 n = lenght A
 L,U = Iniciar LU(n)
 for k=1 hasta n
   suma1=0;
   for p=1:k-1
       suma1=suma1+L(k,p)∗ U(p,k);

   end for
   L(k,k)∗ U(k,k)=A(k,k) - suma1;
   for i=k+1 hasta n
       suma2= 0;
       for p = 1 hasta k-1
           suma2= suma2+ L(i,p)∗ U(p,k);
       end for
       L(i,k) = (A(i,k)-suma2)/U(k,k);
   end for

   for j=k+1 hasta n
       suma3= 0;
       for p = 1hasta k-1
           suma3=suma3+ L(k,p)∗ U(p,j);
       end for
       U(k,j) = (A(k,j)- suma3)/L(k,k);
   end for
 end for
 return L,U
end
```

Crout:

```
read A, b
 n = lenght A
 L,U = Iniciar LU(n)
 for k=0 hasta n
   U(k,k)=1;
   for i=k hasta n
       suma1 = 0
       for p=0 hasta k
       suma1=suma1+L(k,p)$*$ U(p,k);

   end for
   U(k,j)=A(k,j) - suma1;

   for j=k+1 hasta n
       suma2= 0;
       for p = 0 hasta k
           suma2= suma2+ L(k,p)$*$ U(p,j);
       end for
       U(k,j) = (A(k,j)-suma2)/L(k,k);
   end for
 end for


 detA = 1;
 for i=1 hasta n
   detA = detA$*$ L(i,i)
 end for


 if (detA $\neq$ 0 then)
```

```
  z = sustituir(L,b)
  x = sustituir(U,z)
 else
  return "Hay infinitas soluciones o no tiene solución"
 end if
 return L,U
```

Divide diferencies:

```
leer x,y:

  n = longitud(x)
  D = matriz de 0

  D[:,0] = y->traspuesta

  para i hasta n:
      aux0 = D[i-1:n,i-1]
```

```
        aux1 = diferenciaAdyacente(aux0)
        aux2 = restaVectorial(x[i:n],x[0:n-1-i+1])
        D[i:n,i] = DivisionVectorial(aux1,traspuesta(aux2))
    fin

    res = diagonal(D)

    r = res[0]
    m = '(x' + (-x[0]) + ')'
    para i hasta n:
        r += res[i] + m
        m += '(x' + -x[i] + ')'
    fin
    escribir('Matrix D: \ n',D)
    escribir('Coef: ',res)
    escribir('Newton Polinom : ', r)
fin
```

Doolittle:

```
read A, b
 L,U = Iniciar LU(n)
 for k=0 hasta n
    L(k,k)=1;
    for j=k hasta n
        suma1 = 0
        for p=0 hasta k
        suma1=suma1+L(k,p)∗ U(p,k);

    end for
    U(k,j)=A(k,j) - suma1;
    for i=k+1 hasta n
        suma2= 0;
        for p = 0 hasta k
            suma2= suma2+ L(i,p)∗ U(p,k);
        end for
        L(i,k) = (A(i,k)-suma2)/U(k,k);
    end for
 end for

 detA = 1;
 for i=1 hasta n
    detA = detA∗ U(i,i)
 end for

 if (detA ≠ 0 then)
    z = sustituir(L,b)
    x = sustituir(U,z)
 else
    return "Hay infinitas soluciones o no tiene solución"
 end if

 return L,U
```

Fixed point:

```
read xa, tol, iter

y = f(xa)
cont = 0
error = tol + 1

while(y != 0 & error > tol & cont < iter)
   xn = g(xa)
   y = f(xn)
   error = abs(xn - xa)
   xa = xn
   cont += 1
end while
if (y == 0)
   write "xa is root"
else if (error < tol)
   write "xa approximate root with tolerance: tol)"
else
write "Fail in iteration: iter"
end if
```

Gaussian Elimination:

```
simpleGaussianElimination
read a, b
```

```
AB = concatenar(a, b)
n = len(AB)
while k < n do
  write step k
  write AB
  if AB[k][k] == 0
  AB = searchAndSwapZero(Ab, n, k)
  while i = k+1 < n do
      mult = Ab[i][k]/Ab[k][k]
      while j = k < n+1 do
          Ab[i][j] = Ab[i][j] - mult∗ Ab[k][j]
```

```
partialGaussianElimination
read a, b
AB = concatenar(a, b)
n = len(AB)
while k < n do
  write step k
  write AB
  AB = searchBiggerandSwap(Ab, n, k)
  while i = k+1 < n do
      mult = Ab[i][k]/Ab[k][k]
      while j = k < n+1 do
          Ab[i][j] = Ab[i][j] - mult∗ Ab[k][j]
```

```
totalGaussianElimination
read a, b
AB = concatenar(a, b)
```

```
n = len(AB)
while k < n do
   write step k
   write AB
   Ab, order = searchTheBiggestandSwap(Ab, n, k, order)
   while i = k+1 < n do
       mult = Ab[i][k]/Ab[k][k]
       while j = k < n+1 do
           Ab[i][j] = Ab[i][j] - mult* Ab[k][j]
```

Gauss Seidel:

```
read A,b,x0,tol,iter
 n = lenght A
 cont = 0
 error = tol + 1
 while(error > tol & cont < iter)
   for i=0 hasta n do
       sum=0
       for j=0 hasta i do
```

```
            sum = sum + A(i,j)* x(j)
        end for

        for j=i+1 hasta n do
            sum = sum + A(i,j)* x(j)
        end for
        x(i) = ((b(i)-sum)/A(i,i))
    end for

    error = errorAbsolute(x0,x)
    cont++
    for i=0 hasta n do
        x0(i)= x(i)
    end for
    mostrar cont vector x error
  end while

  if(error < tol)
    return "La solución del sistema es: "
    mostrar vector x
  else
    return "Fracaso en " cont
    mostrar vector x
end
```

IncrementalSearch:

```
read x_inicial, delta, limite_Iteraciones, funcion:
  if delta <= 0:
     write "El delta debe ser positivo"
     sys.exit(1)
  elif limite_Iteraciones > 0:

     x_anterior = x_inicial
     x_actual = x_anterior+delta
     f_anterior = f(x_anterior)
     f_actual = F(x_actual)
     contador = 0
     while (contador < limite_Iteraciones):
        if f_actual* f_anterior<0:
           resultados[contador] <- [x_anterior,x_actual]
        x_anterior = x_actual
        x_actual = x_actual + delta
        f_anterior = f_actual
        f_actual = f(x_actual)
        contador = contador + 1
     endwhile:
     devolver resultados
     write(aux)
  endif:
  else:
        write "Las iteraciones deben ser un numero positivo"
        sys.exit(1)
    end else:
end
```

Jacobi:

```
Jacobi ():
read A
read b
read t
read iter
read x0
n = length of A
l = length of A [0]
    if (n! = l):
```

```
    write ("A is not a square matrix please check and run again.")
if not:
    x = [with the size of nxn]
    aux = 0
    cont = 0
    error = t + 1
    iteration = 1
    T = [with the size of nxn]
    C = [with the size of n]
    while (error> t and cont <o = iter):
        write ("iteration: # " + str (iteration))
        error = 0
        for i from 0 to n:
            sum = 0
             for j from 0 to n:
                if (i! = j):
                    sum = sum + A [i] [j] * x0 [j]
                    T [i] [j] = -A [i] [j] / A [i] [i]
                    C [i] = b [i] / A [i] [i]




            x [i] = (b [i] - sum) / A [i] [i]
            aux = x [i] - x0 [i]
            error = error + math.pow (aux, 2)

        error = error raised to 0.5

        write (error)
        for i from 0 to n:
            x0 [i] = x [i]
            write ("x" + i + 1 + ":" + x0 [i])
```

LagrangeP:

```
read x, y

n = len(x)
l = []
ld = []

for i in x do
        l1 = ”
        l2 = 1
        for j in x do
                if i!=j then
                        if j<0 then
                                l1+= ’(x + ’+str(abs(j))+’) ’
                        else:
                                l1+= ’(x - ’+str(abs(j))+’) ’
                        l2 = l2* (i-j)
                l.append(l1)
        ld.append(l2)

i = 0
lf = []
l1 = 1
while i<len(y) do
        l1 = y[i]/ld[i]
      lf.append(l1)
      i+=1

i = 0
polinomio = ”

while i<len(l) do
        if(lf[i]>=0):
          polinomio+= ’ + ’+str(lf[i])+l[i]
      else:
          polinomio+= ’ ’+str(lf[i])+l[i]
      i+=1
print(polinomio)
```

Newton:

```
read x0, iter, tol
fx = f(x0)
dFx = dF(x0)
cont = 1
error = tol + 1

while fx != 0 and error > tol and dFx != 0 and cont < iter
   x1 = x0 - fx/dFx
   fx = f(x1)
   dFx = df(x1)
   error = abs(x1 -x0)
   x0 = x1
   cont += 1
end while

if fx = 0
   write "X0 is root"
else if error < tolerancia
   write "X0 approximate root with tolerance: tol"
else if dfx = 0
   write "X0 is probably a multiple root"
else
   write "Fail in iteration: iter"
end if
```

Partial LU:

```
leer A, b :
```

```
n = longitud(A)
u = MatrizdeCeros(n)
l = MatrizDiagonal(n)
p = MatrizDiagonal(n)

para k hasta (n):
    A, p = IntercambiarFilas(A, n, k, p)

    para i hasta(k + 1, n):
        mult = A[i][k] / A[k][k]
        l[i][k] = mult
        para j hasta (k, n):
            A[i][j] = A[i][j] - mult ∗ A[k][j]

    escribir('u step', k)
    para i hasta (n):
        u[k][i] = A[k][i]


Pb = Producto_Punto(p, b)
lpb = concatenarMatriz(l, Pb)
z = SustitucionProgresiva(lpb)
uz = concatenarMatriz(u, z)
x = SustitucionRegresiva(uz)
escribir('z', z)
escribir('x', x)
```

Multiple roots:

```
read tol, x0, nIteration, function1, function2, function3
fx = function1 (x0)
dfx = function2 (x0)
d2fx = function3 (x0)

counter = 0
error = tol + 1
den = (dfx ^ 2) - (fx * d2fx)
while (error> tol and fx <> 0 and den <> 0 counter <nIteration)
    x1 = x0 - ((fx * dfx) / den)
    fx = function1 (x1)
    dfx = function2 (x1)
    d2fx = function3 (x1)
    den = (dfx ^ 2) - (fx * d2fx)
    error = abs (x1-x0)
    x0 = x1
    counter = counter + 1
end while
if (fx == 0)
    x0 "is a root"
else if (error <tol)
    x1 "was found as an approximation to a root with a tolerance of =" tol
else if (den == 0)
    "it is an indeterminacy"
Else
 "method failed in" nIteraccion "iterations"
end if
```

Secant:

```
read x1, x0, tol, nIteration
fun0 = f (x0)
if (fun0 = 0)
  write "x0 is root"
else
    fun1 = f (x1)
    cont = 0
    error = tol + 1
    while (fun1 <> 0 and error> tol and den <> 0 and counter <nIteration)
        x2 = x1 - ((fun1 * (x1 x0)) / den)
        error = absolute_value ((x2 - x1) / x2)
        x0 = x1
        fun0 = fun1
        x1 = x2
        fun1 = f (x1)
        den = fun1-fun0
        cont = cont + 1
    end while

    if (fun1 = 0)
        write "x1 was found as root"
    else if (error <tol)
        write x1 + "Found as an approximation with a tolerance of" + tol
    else if (den = 0)
        write "There is a possible multiple root"
    else
        write "Failure in" + nIteration "+" iterations "
    end if
end if
```

Simple LU:

```
leer A, b:

   n = longitud(A)
   u = MatrizCeros(n)
   l = MatrizDiagonal(n)

   para k hasta (n):

       if (A[k][k] == 0):
           A = IntercambiarFilas(A, n, k)
```

```
        para i hasta(k + 1, n):
            mult = A[i][k] / A[k][k]
            l[i][k] = mult
            para j hasta (k, n):
                A[i][j] = A[i][j] - mult * A[k][j]

        escribir('u step', k)
        para i hasta(n):
            u[k][i] = A[k][i]
        escribir(u)
    escribir('u', u)
    lb = concatenarMatriz(l, b)
    z = SustitucionProgresiva(lb)
    uz = concatenarMatriz(u, z)
    x = SustitucionRegresiva(uz)
    escribir('z ', z)
    escribir('x ', x)
```

Sor:

```
leer sor A, b, x0, w, tol, Nmax:

    results = { }
    D = Diagonal(A)
    L = -TraingularIferior(A) + D
    U = -TraingularSuperiror(A) + D
    T = Inversa(D - (w * L)) * ((1 - w) * D + (w * U))
    C = w * Inversa(D - (w * L))* (b)
    xant = x0
    E = 1000
    cont = 0
    val = ValoresPropios(T)
    resp = max(abs(val))
    Mientras E > tol and cont < Nmax:
        xact = T* xant + C
        E = Normal(xant - xact)
        xant = xact
        cont = cont + 1
        results[cont] = [float(E), xact]
    fin
    x = xact
    escribir('Radio espectral', resp)
    escribir('X', x)
    escribir('T', T)
    escribir('C', C)
    escribir(results)
fin
```

Spline Quadratic:

```
matrix_cuad ():
read x
read b
    a = [[0 for i from 0 to ((length (x) -1) * 3)] for j from 0 to ((length (x) -1) * 3)]
    a [0] [0] = x [0] raised to the 2
    a [0] [1] = x [0]
    a [0] [2] = 1
    a [1] [0] = x [1] to the power of 2
    a [1] [1] = x [1]
    a [1] [2] = 1
```

```
j = 3
for i from 2 to length (x):
    a [i] [j] = x [i] raised to the 2
    a [i] [j + 1] = x [i]
    a [i] [j + 2] = 1
    j + = 3

i = 1
j = 0
for k of length (x) up to ((length (x) raised to the 2) -2)):
    b + = [0]
    a [k] [j] = x [i] raised to the 2
    a [k] [j + 1] = x [i]
    a [k] [j + 2] = 1
    a [k] [j + 3] = - (x [i] to the power of 2)
    a [k] [j + 4] = -x [i]
    a [k] [j + 5] = -1
    i + = 1
    j + = 3


i = 1
j = 0
for k from (length (x) raised to the 2) -2) to length (a) -1):
    b + = [0]
    a [k] [j] = 2 * x [i]
    a [k] [j + 1] = 1
    a [k] [j + 2] = 0
    a [k] [j + 3] = -2 * x [i]
    a [k] [j + 4] = -1
```

```
        a [k] [j + 5] = 0
        i + = 1
        j + = 3

    b + = [0]
    a [len (a) -1] [0] = 2
    return a, b

traces ():
    read x
    result = empty
    j = 0
    for i in from 0 to length (x):
        if j == 0:
            if x [i]> = 0.0:
                result + = x [i]) + "x * * 2"
            else:
                result + = x [i] + "x * * 2"
        elif j == 1:
            if x [i]> = 0.0:
                result + = "+" + x [i] + "x"
            else:
                result + = x [i] + "x"
        else:
            if x [i]> = 0.0:
                result + = "+" + x [i] + ""
            else:
                result + = x [i] + ""
            j = -1
    j + = 1
  write ("Traces:")
  for i in result.split (""):
    write (i)
```

Spline cubic:

```
def matrix_cub ():
read x
read b
  a = [[0 for i from 0 to ((length (x) -1) * 4)] for j from 0 to ((length (x) -1) * 4)]
  a [0] [0] = x [0] raised to the 3
  a [0] [1] = x [0] raised to the 2
  a [0] [2] = x [0]
  a [0] [3] = 1
  a [1] [0] = x [1] raised to the 3
  a [1] [1] = x [1] to the power of 2
  a [1] [2] = x [1]
  a [1] [3] = 1

  j = 4

  for i from 2 to length (x):
    a [i] [j] = x [i] raised to the 3
    a [i] [j + 1] = x [i] raised to the 2
    a [i] [j + 2] = x [i]
    a [i] [j + 3] = 1
    j + = 4

i = 1
j = 0

for k of length (x) up to ((length (x) raised to the 2) -2)):
    b + = [0]
    a [k] [j] = x [i] raised to the 3
    a [k] [j + 1] = x [i] raised to the 2
    a [k] [j + 2] = x [i]
    a [k] [j + 3] = 1
    a [k] [j + 4] = - (x [i] to the power of 3)
    a [k] [j + 5] = - (x [i] to the power of 2)
    a [k] [j + 6] = -x [i]
    a [k] [j + 7] = -1
    i + = 1
    j + = 4


i = 1
j = 0

for k from (length (x) raised to the 2) -2) to length (x) * 3 -4):
    b + = [0]
    a [k] [j] = 3 * (x [i] to the power of 2)
    a [k] [j + 1] = 2 * x [i]
    a [k] [j + 2] = 1
    a [k] [j + 3] = 0
    a [k] [j + 4] = - (3 * (x [i] to the power of 2))
    a [k] [j + 5] = - (2 * x [i])
    a [k] [j + 6] = -1
    a [k] [j + 7] = 0
    i + = 1
    j + = 4

i = 1
j = 0

for k from (length (x) raised to the 3) -4) to length ((x) * 4) -6):
    b + = [0]
    a [k] [j] = 6 * x [i]
    a [k] [j + 1] = 2
    a [k] [j + 2] = 0
    a [k] [j + 3] = 0
    a [k] [j + 4] = -6 * x [i]
    a [k] [j + 5] = -2
    a [k] [j + 6] = 0
    a [k] [j + 7] = 0
    i + = 1
    j + = 4

b + = [0] * 2
a [len (a) -2] [0] = 6 * x [0]
a [len (a) -2] [1] = 2
a [len (a) -1] [len (a) -4] = 6 * x [len (x) -1]
a [len (a) -1] [len (a) -3] = 2
```

```
  return a, b



def traces (x):
  result = empty
  j = 0
  for i from 0 to length (x):
     if j == 0:
        if x [i]> = 0.0:
           result + = "+" + x [i] + "x raised to 3"
        else:
           result + = x [i] + "x raised to 3"
     elif j == 1:
        if x [i]> = 0.0:
           result + = "+" + x [i] + "x raised to 2"
        else:
           result + = x [i] + "x raised to 2"
     elif j == 2:
        if x [i]> = 0.0:
           result + = "+" + x [i] + "x"
        else:
           result + = x [i] + "x"
     else:
        if x [i]> = 0.0:
           result + = "+" + x [i] + ""
        else:
           result + = x [i] + ""
        j = -1
        j + = 1
    write ("Traces: \ n")
    for i in result.split (""):
        write (i)
```

Spline linear:

```
matrix_lin ():
    read x
    read b

    a = [[0 for i from 0 to ((length (x) -1) * 2)] for j from 0 to ((length (x) -1) * 2)]
    a [0] [0] = x [0]
    a [0] [1] = 1
    a [1] [0] = x [1]
    a [1] [1] = 1

    j = 2
    for i from 2 to length (x):
        a [i] [j] = x [i]
        a [i] [j + 1] = 1
        j + = 2


    i = 1
    j = 0

    for k of length (x) up to ((length (x) raised to the 2) -2)):
        b + = [0]
        a [k] [j] = x [i]
        a [k] [j + 1] = 1
        a [k] [j + 2] = -x [i]
        a [k] [j + 3] = -1
        i + = 1
        j + = 2

    return a, b

traces ():
read x

    result = empty

    for i from 0 to length x:
        if i% 2 == 0:
            if x [i]> = 0.0:
                    result + = "+" + x [i] + "x"
            else:
                    result + = x [i] + "x"
        else:
            if x [i]> = 0.0:
                    result + = "+" + x [i] + ""
            else:
                    result + = x [i] + ""

    write ("Traces:")
    for i in result.split (""):
        write (i)
```

Vandermonde*:*

```
read x, y

matriz = []

while i < len(x) do
    matriz.append([])
    i++

fila = 0

for i in x do
    j = len(x)-1
    while j >= 0 do
        matriz[fila].append(i* * j)
    fila++
totalGaussianElimination(matriz,y)
```

Codes

Bisection*:*

```
import sympy as sm
```

```
def bisection(funcion, xi, xs, nIter, iter):
    results = { }
    if nIter > 0:
        x = sm.symbols('x')
        fxi = sm.sympify(funcion).subs(x, xi)
        fxs = sm.sympify(funcion).subs(x, xs)
        sm.plot(funcion)
        if (fxi == 0):
            print(fxi)
        elif (fxs == 0):
            print(fxs)
        elif (fxs * fxi < 0):
            xm = (xi + xs) / 2
            fxm = sm.sympify(funcion).subs(x, xm)
            count = 1
            error = iter + 1
            results[count] = [float(xi), float(xm), float(xs), float(fxm), float(error)]
            while ((error > iter) and (count < nIter)):
                if (fxi * fxm < 0):
                    xs = xm
                else:
                    xi = xm
                xaux = xm
                xm = (xi + xs) / 2
                fxm = sm.sympify(funcion).subs(x, xm)
                error = abs(xm - xaux)
                count += 1
                results[count] = [float(xi), float(xm), float(xs), float(fxm), float(error)]
            print(results)
        return results
    else:
        results['message'] = 'Error'
        print('el intervalo no sirve')
        return results
```

Cholesky***:***

```
import numpy as np
import math

def cholesky(A, b):
    # Inicialización
    n = len(A)
    L = np.eye(n)
    U = np.eye(n)

    # factorization
    for i in range(n-1):
        suma = 0
        for j in range(i):
            suma += (L[i][j] * U[j][i])
        L[i][i] = math.sqrt(A[i][i] - suma)
        U[i][i] = L[i][i]

        for k in range(i+1,n):
            suma = 0
            for j in range(i):
                suma += (L[k][j] * U[j][i])
            L[k][i] = (A[k][i] - suma) / U[i][i]

        for k in range(i+1,n):
            suma = 0
            for j in range(i):
                suma += (L[i][j] * U[j][k])
            U[i][k] = (A[i][k] - suma) / L[i][i]

    suma = 0
    for j in range(n-1):
        suma += (L[n-1][j] * U[j][n-1])
    L[n-1][n-1] = math.sqrt(A[n-1][n-1] - suma)
    U[n-1][n-1] = L[n-1][n-1]

    print("Matriz L")
    print(L)
    print("Matriz U")
    print(U)
    z = frontSubstitution(L, b)
    x = backSubstitution(U, z)
    print(x)

def frontSubstitution(A, b):
    n = len(A)
    x = np.zeros((n))
    for i in range(n):
        sum = 0
        for j in range(i):
            sum +=  A[i][j] *  x[j]
        x[i] = (b[i] - sum) / A[i][i]
    return x

def backSubstitution(A, b):
    n = len(A)
    x = np.zeros((n))
    for i in range(n-1, -1, -1):
        sum = 0.0
        for j in range (i+1, n):
            sum += A[i][j] *  x[j]
        x[i] = (b[i] - sum) / A[i][i]
    return x
```

Crout*:*

```
import numpy as np

def Crout(a, b):
    cout = 0
    m, n = a.shape
    if (m !=n ):
        print("Crout cannot be used.")
    else:
        l = np.zeros((n,n))
        u = np.zeros((n,n))
        s1 = 0
        s2 = 0

        for m in range(1,n+1):
            print("Stage " + str(m) + ": ")
            for i in range(n):
                l[i][0] = a[i][0]
                u[i][i] = 1
            for j in range(1, n):
                u[0][j] = a[0][j] / l[0][0]
            for k in range(1, n):
                for i in range(k, n):
                    for r in range(k): s1 += l[i][r] *  u[r][k]
                    l[i][k] = a[i][k] - s1
                    s1 = 0
                for j in range(k+1, n):
                    for r in range(k): s2 += l[k][r] *  u[r][j]
                    u[k][j] = (a[k][j] - s2) / l[k][k]
                    s2 = 0
            print("U: ")
            print(u)
            print("L: ")
            print(l)


        y = np.zeros(n)
        s3 = 0
        y[0] = b[0] / l[0][0
        for k in range(1, n):
            for r in range(k):
                s3 += l[k][r] *  y[r]
            y[k] = (b[k]-s3) / l[k][k]
            s3 = 0

        x = np.zeros(n)
        s4 = 0
        x[n-1] = y[n-1]
        for k in range(n-2, -1, -1):
            for r in range(k+1, n):
                s4 += u[k][r] *  x[r]
            x[k] = y[k] - s4
            s4 = 0

        for i in range(n):
            print("x" + str(i + 1) + " = ", x[i])
```

Divide diferences:

```
import numpy as np
```

```
def divide_dif(x,y):
    n = len(x)
    D = np.zeros((n,n))

    D[:,0] = np.conjugate(y)

    for i in range(1,n):
        aux0 = D[i-1:n,i-1]
        aux1 = np.diff(aux0)
        aux2 = np.subtract(x[i:n],x[0:n-1-i+1])
        D[i:n,i] = np.divide(aux1,np.transpose(aux2))

    res = np.diag(D)

    r = '' + '{ 0:+} '.format(res[0])
    m = '(x' + '{ 0:+} '.format(-x[0]) + ')'
    for i in range(1,n):
        r += '{ 0:+} '.format(res[i]) + m
        m += '(x' + '{ 0:+} '.format(-x[i]) + ')'
    r = r.replace('x+0','x')
    print('Matrix D: \ n',D)
    print('Coef: ',res)
    print('Newton Polinom : ', r)

    return (r,D)
```

Doolittle:

```
import sympy as sm
import math
import sys
import json
import base64
import numpy as np

def doolittle(A,b,size):
    A = np.array(A)
    b = np.array(b)
    L = np.eye(size)
    U = np.eye(size)
    print("Etapa 0:")
    print("Matriz L: ")
    print(L)
    print("Matriz U: ")
    print(U)
    for i in range(size):
        print("Etapa " + str(i+1))
        for k in range(i, size):
            suma = 0;
            for j in range(i):
                suma += (L[i][j] * U[j][k]);
            U[i][k] = A[i][k] - suma;
        for k in range(i, size):
            if (i == k):
                L[i][i] = 1;
            else:
                suma = 0;
                for j in range(i):
                    suma += (L[k][j] * U[j][i]);
                L[k][i] = ((A[k][i] - suma)/U[i][i]);

        print("Matriz L: ")
        print(L)
        print("Matriz U: ")
        print(U)
    z = frontSubstitution(L, b)
    x = backSubstitution(U, z)
    printResultVector(x)

def frontSubstitution(A, b):
    n = len(A)
    x = np.zeros((n))
    for i in range(n):
        sum = 0
        for j in range(i):
            sum += A[i][j] * x[j]
        x[i] = (b[i] - sum) / A[i][i]
    return x

def backSubstitution(A, b):
    n = len(A)
    x = np.zeros((n))
    for i in range(n-1, -1, -1):
        sum = 0.0
        for j in range (i+1, n):
            sum += A[i][j] * x[j]
        x[i] = (b[i] - sum) / A[i][i]
    return x

def printResultVector(vector):
    n = len(vector)
    for i in range(n):
        print('x' + str(i + 1) + ': ' + str(vector[i]))
```

FalseRule*:*

```
import sympy as sm
import math
import sys

def falseRule(a, b, funcion, limite_iteraciones, tolerancia):
    results = { }
    x = sm.symbols('x')
    funcion = sm.sympify(funcion)
    fa = funcion.subs(x, a)
    fb = funcion.subs(x, b)
    if(fa == 0):
        print('a es raiz')
    elif(fb == 0):
        print('b es raiz')
```

```
elif(fa * fb < 0):
    error = 1
    cont = 1
    c = (fb* a - fa* b)/(fb - fa)
    fc = funcion.subs(x, c)
    print('iter|     a     |     c     |     b     |     fc     |     error')
    while(fc != 0 and cont < limite_iteraciones and error > tolerancia):
        results[cont]=[float(a),float(c),float(b),float(fc),float(error)]
        print(cont,a,c,b,fc,error)
        if (fa * fc < 0):
            b = c
            fb = funcion.subs(x, c)
        else:
            a = c
            fa = funcion.subs(x, c)
        caux = c
        c = (fb* a - fa* b)/(fb - fa)
        fc = funcion.subs(x, c)
        error = abs(caux - c)
        cont+=1
    if (fc == 0):
        print('c is a root '+ str(c))
        results['message']='c is a root '+ str(c)
    elif (error < tolerancia):
    print('c is an approximation of the root c: '+ str(c) +' error: '+ str(error)+ ' in the iteration '+str(cont))
            results['message']='c is an approximation of the root c: '+ str(c) +' error: '+ str(error)+ ' in the iteration '+str(cont)
    else:
        print('number of maximum iterations reached, convergence was not reached')
    results['message']='number of maximum iterations reached, convergence was not reached'
else:
    print('inadequate interval, does not satisfy the theorem fa ∗  fb < 0')
   results['message']='inadequate interval, does not satisfy the theorem fa ∗  fb < 0'
return results
```

Fixed Point:

```
import math
def f(x):
    return x∗ ∗ 3 + 4 ∗  x∗ ∗ 2 - 10
def g(x):
    return math.sqrt(10/(x+4))

def fixedPoint(xa, iter, tol):
    fx = f(xa)
    cont = 0
    error = tol + 1
    xn = 0

    while((fx != 0) and error > tol and cont < iter):
        xn = g(xa)
        fx = f(xn)
        error = abs(xn - xa)
        xa = xn
        cont += 1
    if fx == 0:
        print("Xa: ", xa, " is a root")
    elif error < tol :
        print("Xa: ", xa, " approximate root with tolerance: ", tol)
    else:
        print("Fail in iteration: ", iter)
```

Gaussian Elimination:

```
import numpy as np
import math
import copy

def simpleGaussianElimination(A, b):
    Ab = concatenarMatriz(A, b)
    n = len(Ab)
    result = { }
    for k in range(n):
        print('step ',k)
        print(Ab)
        result[k]=copy.deepcopy(Ab)
        if(Ab[k][k]==0):
            Ab = searchAndSwapZero(Ab, n, k)
        for i in range(k+1, n):
            mult = Ab[i][k]/Ab[k][k]
            for j in range(k, n+1):
                Ab[i][j] = Ab[i][j] - mult* Ab[k][j]
    print('x ',backSubstitution(Ab))
    return(backSubstitution(Ab),result)

def searchAndSwapZero(Ab, n, i):
    for j in range(i+1,n):
        if(Ab[j][i]!=0):
            temp = Ab[i]
            Ab[i] = Ab[j]
            Ab[j] = temp
            break
    return Ab

def partialGaussianElimination(A, b):
    Ab = concatenarMatriz(A, b)
    order = []
    result = { }
    n = len(Ab)
    for k in range(n):
        print('step ',k)
        printMatriz(Ab)
        result[k]=copy.deepcopy(Ab)
        Ab = searchBiggerandSwap(Ab, n, k)
        for i in range(k+1, n):
            mult = Ab[i][k]/Ab[k][k]
            for j in range(k, n+1):
                Ab[i][j] = Ab[i][j] - mult* Ab[k][j]
    print('X ',backSubstitution(Ab))
    return(backSubstitution(Ab),result)

def searchBiggerandSwap(Ab, n, i):
    row = i
    for j in range(i+1,n):
        if(abs(Ab[row][i]) < abs(Ab[j][i])):
            row = j
    temp = Ab[i]
    Ab[i] = Ab[row]
    Ab[row] = temp
    return Ab

def totalGaussianElimination(A, b):
    order = []
    result = { }
    Ab = concatenarMatriz(A, b)
    n = len(Ab)
    for k in range(n):
        print('step ',k)
        printMatriz(Ab)
        result[k]=copy.deepcopy(Ab)
        Ab, order = searchTheBiggestandSwap(Ab, n, k, order)
        for i in range(k+1, n):
            mult = Ab[i][k]/Ab[k][k]
            for j in range(k, n+1):
                Ab[i][j] = Ab[i][j] - mult* Ab[k][j]
    # retorna las x
    return(sortResult(backSubstitution(Ab), order),result)

def searchTheBiggestandSwap(Ab, n, k, order):
    row = k
    column = k
    for i in range(k,n):
        for j in range(k,n):
            if(abs(Ab[row][column]) < abs(Ab[i][j])):
                row = i
                column = j
    temp = Ab[k]
    Ab[k] = Ab[row]
    Ab[row] = temp
    Ab = swapColumn(Ab, k, column)
    order.append((k, column))
    return (Ab, order)

def swapColumn(Ab, c1, c2):
    for i in range(len(Ab)):
        temp = Ab[i][c1]
        Ab[i][c1] = Ab[i][c2]
        Ab[i][c2] = temp
    return Ab

def sortResult(x, order):
    for i in range(len(order)-1, -1, -1):
        temp = x[order[i][0]]
        x[order[i][0]] = x[order[i][1]]
        x[order[i][1]] = temp
    return x

def concatenarMatriz(A, b):
    n = len(A)
    for i in range(n):
        A[i].append(b[i])
    return A
```

```
# b = [[4],[5],[6]] this is the format
def concatenar(a,b):
    a = np.array(a)
    b =np.array(b)
    matriz = np.concatenate((a, b), axis=1)
    return matriz

def backSubstitution(Ab):
    n= len(Ab)
    x = []
    for i in range(n):
        x.append(0)

    for i in range(n-1, -1, -1):
        sum = 0
        for j in range(i+1, n):
            sum+= Ab[i][j]* x[j]
        x[i] = (Ab[i][n]-sum)/Ab[i][i]
    return x

def printMatriz(M):
    result=”
    for i in range(len(M)):
        print(M[i])

def printMatriz2(M,k,result):
    for i in range(len(M)):
        print(M[i])
    result[k]=M
    return result
```

Gauss Seidel:

```
import math

import numpy as np

def gaussSeidel(A, b, t, iter, x0) :
    n = len(A)
    l = len(A)
    if (n != l) :
        print("A is nor a square matrix.")
        return 0
    else:
        x = [None]* n
        aux = 0
        cont = 0
        E = t + 1
        iteration = 1
        while (E > t and cont <= iter):
            print("iter: " , iteration)
            E = 0
            for i in range(0,n):
                suma = 0
                for j in range(0,n):
                    if (i != j):
                        suma = suma + A[i][j] *  x0[j]
                x[i] = ( ((b[i] - suma) / A[i][i]))
                aux = x[i] - x0[i]
                E = E + math.pow(aux, 2)
                x0[i] = x[i]
                print("x" , (i + 1) , ": " , x0[i])
            E = math.pow(E, 0.5)
            print("E = " , E)
            print("")
            iteration = iteration + 1
            cont = cont+1

        if (E < t):
            return x
        else:
            print("Can not find a solution in " , iter , " iterations")
            return 0



A = [[4, -1, 0, 3],
    [1, 15.5, 3, 8],
    [0, -1.3, -4, 1.1],
    [14, 5, -2, 30]]
b = [1, 1, 1, 1]
x0 = [0, 0, 0, 0]
t = math.pow(10, -7)
iter = 100
gaussSeidel(A, b, t, iter, x0)

D = np.diag(np.diag(A))
U = -np.triu(A,1)
L = -np.tril(A,-1)
T = (np.dot((np.linalg.inv(D-L)), U))
C = (np.dot((np.linalg.inv(D-L)), b))
```

```
print("T: ")
print(T)
print("C:")
print(C)
values, normalized_eigenvectors = np.linalg.eig(T) #  T es la matriz
spectral_radius = max(abs(values))
print("\ nSpectral Radius: ", spectral_radius)
```

Incremental search:

```
import sympy as sm
import sys
import pandas as pd

def incremental_search(funcion,xi, delta, nIter):
    results = { }
    if delta <= 0:
        print("El delta debe ser positivo")
        sys.exit(1)
    elif nIter > 0:

        x = sm.symbols('x')
        x_a = xi
        current_X = x_a+delta
        f_a = sm.sympify(funcion).subs(x,x_a)
        currentF = sm.sympify(funcion).subs(x,current_X)
        contador = 0
        while (contador < nIter):
            if currentF* f_a<0:
                results[contador] = [float(x_a),float(current_X)]
            x_a = current_X
            current_X = current_X + delta
            f_a = currentF
            currentF = sm.sympify(funcion).subs(x,current_X)
            contador = contador + 1

        return results

    else:
        print("Las iteraciones deben ser un numero positivo")
        results['message'] = 'Error'
        print('el intervalo no sirve')
        return results

def print_function(results):
    index = []
    x1 = []
    x2 = []
    for i in results:
        index.append(i)
        x1.append(results[i][0])
        x2.append(results[i][1])

    data = { 'xi': x1,
            'xs': x2,
            }
    df = pd.DataFrame(data, index=index)
    print(df)
```

Jacobi:

```
import math
import numpy as np
def Jacobi(A, b, t, iter, x0):
    n = len(A)
    l = len(A[0])
    result = { }
    if (n!=l):
        return("A is not a square matrix please check and run again.")
    else:
        x =[None] * n
        aux=0
```

```
cont = 0
error = t + 1
iteration = 1
T = np.zeros((n, n))
C = np.zeros(n)

while(error > t and cont <= iter):
    error = 0
    for i in range(0,n):
        sum = 0
        for j in range(0,n):
            if (i != j):
                sum = sum + A[i][j] * x0[j]
                T[i][j] = -A[i][j] / A[i][i]
                C[i] = b[i] / A[i][i]

        x[i] = (b[i] - sum) / A[i][i]
        aux = x[i] - x0[i]
        error = error + math.pow(aux, 2)

    error = math.pow(error, 0.5)

    for i in range(0,n):
        x0[i] = x[i]
        print("x"+str(i+1)+": "+str(round(x0[i],4)))

    result[iteration]=(float(error),x)
    iteration=iteration+1
    cont = cont+1

print(result)
print("")
print("T: \ n"+str(T))
print("")
print("C: \ n"+str(C))
print("")
spectralRadius = np.amax(abs(T))
print("Spectral radius: \ n"+str(spectralRadius))


if (error < t):
    return(result, T, C,spectralRadius )
else:
    print ("no solution reached in " + str (iter) + " iterations")
    return
```

Lagrange:

```
import math

def lagrange(x, y):
    n = len(x)
    l = []
    ld = []
    for i in x:
        l1 = ”
        l2 = 1
        for j in x:
            if(i!=j):
                if(j<0):
                    l1+= '(x + '+str(abs(j))+') '
                else:
                    l1+= '(x - '+str(abs(j))+') '
                l2 = l2* (i-j)
        l.append(l1)
        ld.append(l2)

    i = 0
    lf = []
    l1 = 1
    while(i<len(y)):
        l1 = y[i]/ld[i]
        lf.append(l1)
        i+=1


    i = 0
    polinomio = ”
    while(i<len(l)):
        if(lf[i]>=0):
            polinomio+= ' + '+str(lf[i])+l[i]
        else:
            polinomio+= ' '+str(lf[i])+l[i]
        i+=1
    return(polinomio)
```

Newton:

```
import numpy as np
import matplotlib.pyplot as plt

def f(x):
    return x* * 3 - np.cos(x)

def dF(x):
    return 3 *  x* * 2 + np.sin(x)

def newton(x0, iter, tol):
    fx = f(x0)
    dFx = dF(x0)
    cont = 1
    error = tol + 1

    while( (fx != 0) and error > tol and (dFx != 0) and cont < iter):
        x1 = x0 - fx/dFx
        fx = f(x1)
        dFx = dF(x1)
        error = abs(x1-x0)
        x0 = x1
        cont += 1

    if fx == 0:
        print("X0: " ,x0, " is root")
    elif error < tol:
        print("X0: ", x0, " approximate root with tolerance: ", tol)
    elif dFx == 0:
        print("X0: ", x0, " is probably a multiple root")
    else:
        print("Fail in iteration: ", iter)

def draw():
    x = np.linspace(-2, 2, 100)
    plt.plot(x, x* * 3 - np.cos(x))
    plt.grid()
    plt.show()
```

```
draw()
```

Partial LU:

```
import copy
import numpy as np

def partialLU(A, b):
    n = len(A)
    message = ”
    det = np.linalg.det(A)
    if(det != 0):
        u = zero_Matrix(n)
        l = lmatrix(n)
        p = lmatrix(n)
        dicL = { }
        dicU = { }
        dicP = { }
        for k in range(n):
```

```
        print('step ', k)
        printMatriz(A)
        print('L step', k)
        printMatriz(l)
        dicL[k] = copy.deepcopy(l)
        dicU[k] = copy.deepcopy(u)
        A, p = searchBiggerandSwap(A, n, k, p)
        for i in range(k + 1, n):
            mult = A[i][k] / A[k][k]
            l[i][k] = mult
            for j in range(k, n):
                A[i][j] = A[i][j] - mult *  A[k][j]

        print('u step', k)
        for i in range(n):
            u[k][i] = A[k][i]
        printMatriz(u)
        dicU[k] = copy.deepcopy(u)
        print('P step', k)
        printMatriz(p)
        dicP[k] = copy.deepcopy(p)

    Pb = multAb(p, b)
    lpb = concatenateMatrix(l, Pb)
    z = progSubtitution(lpb)
    uz = concatenateMatrix(u, z)
    x = backSubstitution(uz)
    print('det', det)
    return (x,dicL,dicU,dicP,message)
else:
        message = 'Error'
        return ('','','','',message)

def searchBiggerandSwap(Ab, n, i, p):
    row = i

    for j in range(i + 1, n):
        if (abs(Ab[row][i]) < abs(Ab[j][i])):
            row = j
    temp = Ab[i]
    aux = p[i]
    Ab[i] = Ab[row]
    p[i] = p[row]
    Ab[row] = temp
    p[row] = aux
    return Ab, p

def concatenateMatrix(A, b):
    n = len(A)
    for i in range(n):
        A[i].append(b[i], )
    return A

def multAb(A, b):
    n = len(A)
    mult = []
    for i in range(n):
        suma = 0
        for j in range(n):
            suma += b[j] * A[i][j]
        mult.append(suma)
    return mult

def zero_Matrix(n):
    u = []
    for i in range(n):
        u.append([0] * n)
    return u

def lmatrix(n):
    l = zero_Matrix(n)
    for i in range(n):
        l[i][i] = 1
    return l

def backSubstitution(Ab):
    n = len(Ab)
    x = []
    for i in range(n):
        x.append(0)

    for i in range(n - 1, -1, -1):
        sum = 0
        for j in range(i + 1, n):
            sum += Ab[i][j] * x[j]
        x[i] = (Ab[i][n] - sum) / Ab[i][i]
    return x

def progSubtitution(Ab):
    n = len(Ab)
    x = []
    for i in range(n):
        x.append(0)

    for i in range(n):
        sum = 0
        for j in range(i):
            sum += Ab[i][j] * x[j]
        x[i] = ((Ab[i][n] - sum) / Ab[i][i])
    return x
def printMatriz(M):
    for i in range(len(M)):
        print(M[i])
```

Multiple roots:

```
import sympy as sm
import math

def roots_mult(x0, nInterations, tol, function, function2, function3):
    results = { }
    add = { }
    x = sm.symbols ('x')
    fx0 = sm.sympify (function) .subs (x, x0)
    dfx0 = sm.sympify (function2) .subs (x, x0)
    d2fx0 = sm.sympify (function3) .subs (x, x0)

    cont = 0
    error = tol + 1
    xn = 0
    det = (math.pow (dfx0,2)) - (fx0 * d2fx0)
    results [cont] = [float (x0), float (fx0), float (0)]
    while (fx0!= 0 and error> tol and det != 0 and cont <nInterations):
        xn = x0 - ((fx0 * dfx0) / det)
        fx0 = sm.sympify (function) .subs (x, xn)
        dfx0 = sm.sympify (function2) .subs (x, xn)
        d2fx0 = sm.sympify (function3) .subs (x, xn)
        det = (math.pow (dfx0,2)) - (fx0 * d2fx0)
        error = abs (xn-x0)
        x0 = xn
        cont = cont + 1
     results [cont] =([round(float (x0),18), round(float (fx0),18), round(float (error),18)])
    if (fx0 == 0):
        add =(str (x0) + "is a root")

    elif (error<tol):
      add =(str (x0) + "was found as an approximation with a tolerance of =" + str (tol))


    elif (det == 0):
        add =("is an indeterminacy")

    else:
        add =("The method failed in" + str (nInterations) + "iterations")


    return results,add
```

Secant:

```
import abc
import sympy as sm

def secant(x0, x1, nInterations, tol, function):
    results = { }
```

```
add = { }

x = sm.symbols('x')
fx0 = sm.sympify(function).subs(x, x0)

if (fx0 == 0):
    print(x0 + "is root")
else:
    fx1 = sm.sympify(function).subs(x, x1)
    cont = 1
    error = tol + 1
    det = fx1 - fx0
    xi = 0
    results [cont-1] = [float (x0), float (fx0), float (0)]
    results [cont] = [float (x1), float (fx1), float (0)]
    while (fx1 != 0 and error> tol and det!= 0 and cont <nInterations):

        xi = x1 -((fx1 *  (x1-x0)) / det)
        error = abs(xi-x1)
        x0 = x1
        fx0 = fx1
        x1 = xi
        fx1 = sm.sympify(function).subs(x, x1)
        det = fx1 - fx0
        cont = cont + 1
         results [cont] = ([round(float (xi),10), round(float (fx1),10), round(float (er-
ror),10)])
```

```
        if (fx1 == 0):

            add = (str(x0)+" is a root")


        elif (error <tol):
        add= (str(x1)+" was found as an approximation with a tolerance of = "+str(tol))

        elif (det == 0):
            add= (str(x1)+"is a possible multiple root")

        else:
            add=("The method failed in "+str(nInterations)+ " iterations")

    return results,add
```

Simple LU:

```
import numpy as np
import math as math
import copy

def simpleLU(A, b):

    n = len(A)
    det = np.linalg.det(A)
    message = ”
    if(det != 0):
```

```
u = zero_Matrix(n)
l = lmatrix(n)
dicL = { }
dicU = { }

for k in range(n):
    print('step ', k)
    printMatriz(A)
    print('L step', k)
    printMatriz(l)
    dicL[k] = copy.deepcopy(l)
    dicU[k] = copy.deepcopy(u)
    if (A[k][k] == 0):
        A = searchAndSwapZero(A, n, k)
    for i in range(k + 1, n):
        mult = A[i][k] / A[k][k]

        l[i][k] = mult
        for j in range(k, n):
            A[i][j] = A[i][j] - mult *  A[k][j]

    print('u step', k)
    for i in range(n):
        u[k][i] = A[k][i]
    printMatriz(u)
    dicU[k] = copy.deepcopy(u)

print('u', dicU)
lb = concatenateMatrix(l, b)
z = progSubtitution(lb)
```

```
        uz = concatenateMatrix(u, z)
        x = backSubstitution(uz)
        print('x ', x)

        return (x,dicL,dicU,message)
    else:
        message = 'Error'
        return ('', '', '', message)

def searchAndSwapZero(Ab, n, i):
    for j in range(i + 1, n):
        if (Ab[j][i] != 0):
            temp = Ab[i]
            Ab[i] = Ab[j]
            Ab[j] = temp
            break
    return Ab

def concatenateMatrix(A, b):
    n = len(A)
    for i in range(n):
        A[i].append(b[i], )
    return A

def multAb(A, b):
    n = len(A)
    mult = []
    for i in range(n):
        suma = 0
        for j in range(n):
            suma += b[j] * A[i][j]
        mult.append(suma)
    return mult

def zero_Matrix(n):
    u = []
    for i in range(n):
        u.append([0] * n)
    return u

def lmatrix(n):
    l = zero_Matrix(n)
    for i in range(n):
        l[i][i] = 1
    return l

def backSubstitution(Ab):
    n = len(Ab)
    x = []
    for i in range(n):
        x.append(0)

    for i in range(n - 1, -1, -1):
        sum = 0
        for j in range(i + 1, n):
            sum += Ab[i][j] * x[j]
        x[i] = (Ab[i][n] - sum) / Ab[i][i]
    return x

def progSubtitution(Ab):
    n = len(Ab)
    x = []
    for i in range(n):
        x.append(0)

    for i in range(n):
        sum = 0
        for j in range(i):
            sum += Ab[i][j] * x[j]
        x[i] = ((Ab[i][n] - sum) / Ab[i][i])
    return x
def printMatriz(M):
    for i in range(len(M)):
        print(M[i])
```

Sor:

```
import numpy as np
from scipy import linalg as LA
import pandas as pd
import copy

def sor(A, b, x0, w, tol, Nmax):
    results = { }
    det = np.linalg.det(A)
    if(det != 0):
        d = np.diag(A)
        D = np.diagflat(d)
        L = -np.tril(A) + D
        U = -np.triu(A) + D
        T = np.linalg.inv(D - (w * L)).dot((1 - w) * D + (w * U))
        C = w * np.linalg.inv(D - (w * L)).dot(b)
        xant = x0
        E = 1000
        cont = 0
        val, evec = np.linalg.eig(T)
        resp = max(abs(val))
        while E > tol and cont < Nmax:
            xact = np.dot(T, xant) + C
            short = ['{ :.6f} '.format(elem) for elem in xact]
            E = np.linalg.norm(xant - xact)
            xant = xact
            cont = cont + 1
            results[cont] = [float(E), short]

        print_iter(results)
        print('Spectral Radious ', resp)
        print('T', T)
        print('C', C)

        return (resp,T,C,results)
    else:
        results['message'] = 'Error'
        return ('','','',results)

def print_iter(results):
    index = []
    x = []
    error = []
    for i in results:
        index.append(i)
        error.append(results[i][0])
        x.append(results[i][1])

    data = { 'Error': error,
            'X': x
            }
    df = pd.DataFrame(data, index=index)
    print(df)
```

Spline Quadratic

```
from Metodos.GaussianElimination_splines import simpleGaussianElimination,partialGaussianEliminati
Substitution, sortResult

def matrix_cuad(x, b):
    a = [[0 for i in range((len(x)-1)* 3)] for j in range((len(x)-1)* 3)]
    a[0][0] = x[0]* * 2
    a[0][1] = x[0]
    a[0][2] = 1
    a[1][0] = x[1]* * 2
    a[1][1] = x[1]
    a[1][2] = 1

    j = 3
    for i in range(2,len(x)):
        a[i][j] = x[i]* * 2
        a[i][j+1] = x[i]
        a[i][j+2] = 1
        j += 3

    i = 1
    j = 0
    for k in range(len(x),((len(x)* 2)-2)):
        b += [0]
        a[k][j] = x[i]* * 2
        a[k][j+1] = x[i]
        a[k][j+2] = 1
        a[k][j+3] = -(x[i]* * 2)
        a[k][j+4] = -x[i]
        a[k][j+5] = -1
        i += 1
        j += 3

    i = 1
    j = 0
    for k in range(((len(x)* 2)-2),len(a)-1):
        b += [0]
        a[k][j] = 2* x[i]
        a[k][j+1] = 1
        a[k][j+2] = 0
        a[k][j+3] = -2* x[i]
        a[k][j+4] = -1
        a[k][j+5] = 0
        i += 1
        j += 3

    b += [0]
```

```
    a[len(a)-1][0] = 2
    return a,b

def traces(x):
    result = ""
    j = 0
    for i in range(len(x)):
        if j == 0:
          #   print(x[i])
            if x[i] >= 0.0:
                result += "+"+str(x[i])+"x* * 2"
            else:
                result += str(x[i])+"x* * 2"
        elif j == 1:
            if x[i] >= 0.0:
                result += "+"+str(x[i])+"x"
            else:
                result += str(x[i])+"x"
        else:
            if x[i] >= 0.0:
                result += "+"+str(x[i])+" "
            else:
                result += str(x[i])+" "
            j = -1
        j += 1

    return(result)



def trazcuad_spline(x,y,d):
```

```
”’ x = [-1,0,3,4]
y = [15.5,3,8,1]”’

b = y
A, b = matrix_cuad(x,b)

if(d=="T"):
    t1=totalGaussianElimination(A, b)
    return traces(t1[0]),A,b,t1[1],t1[0]

elif(d=="P"):
    t2=partialGaussianElimination(A, b)
    return traces(t2[0]),A,b,t2[1],t2[0]
elif(d=="S"):
    t3=simpleGaussianElimination(A, b)
    return traces(t3[0]),A,b,t3[1],t3[0]
```

Spline Linear:

```
from Metodos.GaussianElimination_splines import simpleGaussianElimination,partialGaussianEliminati

def matrix_lin(x, b):
    a = [[0 for i in range((len(x)-1)* 2)] for j in range((len(x)-1)* 2)]
    a[0][0] = x[0]
    a[0][1] = 1
    a[1][0] = x[1]
    a[1][1] = 1

    j = 2
    for i in range(2,len(x)):
        a[i][j] = x[i]
        a[i][j+1] = 1
        j += 2



    i = 1
    j = 0
    for k in range(len(x),((len(x)* 2)-2)):
        b += [0]
        a[k][j] = x[i]
        a[k][j+1] = 1
        a[k][j+2] = -x[i]
        a[k][j+3] = -1
        i += 1
        j += 2

    return a,b
```

```
def traces(x):



    result = ""
    for i in range(len(x)):
        if i %  2 == 0:
            if x[i] >= 0.0:
                    result += "+"+str(x[i])+"x"
            else:
                    result += str(x[i])+"x"
        else:
            if x[i] >= 0.0:
                    result += "+"+str(x[i])+" "
            else:
                    result += str(x[i])+" "


    return(result)


def trazlin_spline(x,y,d):

    b = y
    A, b = matrix_lin(x,b)

    if(d=="T"):
        t1=totalGaussianElimination(A, b)
        return traces(t1[0]),A,b,t1[1],t1[0]

    elif(d=="P"):
        t2=partialGaussianElimination(A, b)
        return traces(t2[0]),A,b,t2[1],t2[0]
    elif(d=="S"):
        t3=simpleGaussianElimination(A, b)
        return traces(t3[0]),A,b,t3[1],t3[0]
```

Spline Cubic

```
from Metodos.GaussianElimination_splines import simpleGaussianElimination,partialGaussianEliminati
Substitution, sortResult

def matrix_cub(x, b):
    a = [[0 for i in range((len(x)-1)∗ 4)] for j in range((len(x)-1)∗ 4)]
    a[0][0] = x[0]∗ ∗ 3
    a[0][1] = x[0]∗ ∗ 2
    a[0][2] = x[0]
    a[0][3] = 1
    a[1][0] = x[1]∗ ∗ 3
```

```
a[1][1] = x[1]* * 2
a[1][2] = x[1]
a[1][3] = 1

j = 4
for i in range(2,len(x)):
    a[i][j] = x[i]* * 3
    a[i][j+1] = x[i]* * 2
    a[i][j+2] = x[i]
    a[i][j+3] = 1
    j += 4

i = 1
j = 0
for k in range(len(x),((len(x)* 2)-2)):
    b += [0]
    a[k][j] = x[i]* * 3
    a[k][j+1] = x[i]* * 2
    a[k][j+2] = x[i]
    a[k][j+3] = 1
    a[k][j+4] = -(x[i]* * 3)
    a[k][j+5] = -(x[i]* * 2)
    a[k][j+6] = -x[i]
    a[k][j+7] = -1
    i += 1
    j += 4


i = 1
j = 0
for k in range(((len(x)* 2)-2),((len(x)* 3)-4)):
    b += [0]
    a[k][j] = 3* (x[i]* * 2)
    a[k][j+1] = 2* x[i]
    a[k][j+2] = 1
    a[k][j+3] = 0
    a[k][j+4] = -(3* (x[i]* * 2))
    a[k][j+5] = -(2* x[i])
    a[k][j+6] = -1
    a[k][j+7] = 0
    i += 1
    j += 4

i = 1
j = 0
for k in range(((len(x)* 3)-4),((len(x)* 4)-6)):
    b += [0]
    a[k][j] = 6* x[i]
    a[k][j+1] = 2
    a[k][j+2] = 0
    a[k][j+3] = 0
    a[k][j+4] = -6* x[i]
    a[k][j+5] = -2
    a[k][j+6] = 0
    a[k][j+7] = 0
    i += 1
    j += 4

b += [0]* 2
a[len(a)-2][0] = 6* x[0]
```

```
    a[len(a)-2][1] = 2
    a[len(a)-1][len(a)-4] = 6* x[len(x)-1]
    a[len(a)-1][len(a)-3] = 2

    return a, b

def traces(x):
    result = ""
    j = 0
    for i in range(len(x)):
        if j == 0:
            if x[i] >= 0.0:
                result += "+"+str(x[i])+"x* * 3"
            else:
                result += str(x[i])+"x* * 3"
        elif j == 1:
            if x[i] >= 0.0:
                result += "+"+str(x[i])+"x* * 2"
            else:
                result += str(x[i])+"x* * 2"
        elif j == 2:
            if x[i] >= 0.0:
                result += "+"+str(x[i])+"x"
            else:
                result += str(x[i])+"x"
        else:
            if x[i] >= 0.0:
                result += "+"+str(x[i])+" "
            else:
                result += str(x[i])+""
            j = -1
        j += 1

    return(result)

def trazcub_spline(x,y,d):

    b = y
    A, b = matrix_cub(x,b)

    if(d=="T"):
        t1=totalGaussianElimination(A, b)
        return traces(t1[0]),A,b,t1[1],t1[0]

    elif(d=="P"):
        t2=partialGaussianElimination(A, b)
        return traces(t2[0]),A,b,t2[1],t2[0]
    elif(d=="S"):
        t3=simpleGaussianElimination(A, b)
        return traces(t3[0]),A,b,t3[1],t3[0]
```

Vandermonde:

```
from Metodos.GaussianElimination import *

def vandermonde(x, y):
    matriz = []
    for i in range(len(x)):
        matriz.append([])
    fila = 0

    for i in x:
        for j in range(len(x)-1,-1,-1):
            matriz[fila].append(i* * j)
        fila+=1
    print('A:')
    printMatriz(matriz)
    return totalGaussianElimination(matriz, y)[0]
```