**Princ.f90**

!

! main (nonlineq)

! Aug 3, 2022

!

! implicit real \*8 (a-h,o-z)

use msflib

logical chamada

parameter(neqmax=15)

dimension u(neqmax),g(neqmax),h(neqmax)

common /pert/ epsilon

common /method/ iflag

common /parpicard/ alfa

!

! input file

!

open (unit=1,file='inp1.txt',status='old')

!

! output file

!

open (unit=2,file='out1.txt',status='unknown')

open (10,file='dados1.txt')

open (11,file='dados2.txt')

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

!

! Decide what method to use (iflag = 1 - exact Newton; 2 - approximate Newton; 3 - Picard)

!

read(1,\*)iflag

write(\*,\*)'iflag=',iflag

read(1,\*)alfa

write(\*,\*)'alfa=',alfa

read (1,\*)maxit,neq,tol1,tol2,epsilon

write(\*,\*)'maxit=',maxit,'neq=',neq

write(\*,\*)'tol1=',tol1,'tol2=',tol2,'epsilon=',epsilon

!

! dados para o grafico das duas equacoes

!

xmax=1.

xmin=0.

dx=(xmax-xmin)/100

xx=xmin

do i=1,101

y1=cos(xx)

write(10,\*)xx,y1

! write(\*,\*)xx,y1

y2=asin(xx)

write(11,\*)xx,y2

! write(\*,\*)xx,y2

xx=xx+dx

enddo

close(10)

close(11)

chamada=systemqq('wgnuplot dados.gnu')

! stop

! read initial guesses

read(1,\*)(u(i),i=1,neq)

write(\*,\*)'the initial values are u(i):'

write(\*,\*)(i,u(i),i=1,neq)

! call fcn(neq,u,g)

! gnorm=rnorm2(neq,g,neqmax)

! write(2,\*)'--------------------------------------------------- i = ',i

! write(\*,\*)'gnorm=',gnorm

! write(2,\*)'gnorm=',gnorm

! stop

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

!

! solution of nonlinear equations

!

if(iflag.eq.1.or.iflag.eq.2) then

call mnewt(maxit,u,neq,tol1,tol2)

endif

if(iflag.eq.3) then

do i=1,maxit

call fcn(neq,u,g)

gnorm=rnorm2(neq,g,neqmax)

write(\*,\*)'gnorm=',gnorm

write(2,\*)'gnorm=',gnorm

if(gnorm.le.tol1) then

write(\*,\*)'converged in ',i-1,' iterations'

write(2,\*)'converged in ',i-1,' iterations'

stop

endif

write(\*,\*) 'Picard method'

write(2,\*) 'Picard method'

write(\*,\*)'--------------------------------------------------- i = ',i

write(2,\*)'--------------------------------------------------- i = ',i

call fcn2(neq,u,h)

do j=1,neq

u(j)=alfa\*u(j)+(1.-alfa)\*h(j)

write(\*,\*)'u(',j,')=',u(j)

write(2,\*)'u(',j,')=',u(j)

enddo

enddo

endif

close(1)

close(2)

chamada=systemqq('notepad out1.txt')

stop

end

!

!----------------------------------------------------------------

function rnorm2(n,x,nd)

!

! compute euclidean norm of a vector

!

! implicit real \*8 (a-h,o-z)

dimension x(nd)

sum=0.d0

do i=1,n

sum=sum+x(i)\*x(i)

enddo

aux=sqrt(sum)

rnorm2=aux

return

end

!------------------------------------------------------------

function rninf(n,x,nd)

!

! compute infinity norm of a vector

!

! implicit real \*8 (a-h,o-z)

dimension x(nd)

rmax=0.d0

do i=1,n

if(abs(x(i)).gt.rmax) then

rmax=abs(x(i))

endif

enddo

rninf=rmax

return

end

!------------------------------------------------------------------

subroutine usrfun(u,n,np,g,a)

!

! compute the values of g (through function fcn)

! for a given u and the jacobean

!

! implicit real \*8 (a-h,o-z)

parameter (np1=15)

dimension u(n),g(np),a(np,np),ge(np1)

common /pert/ epsilon

call fcn(n,u,g)

! do it=1,n

! write(\*,\*)'g(',it,')=',g(it)

! enddo

!

! build the jacobean numerically

!

! write(\*,\*)'epsilon=',epsilon

do j=1,n

u(j)=u(j)+epsilon

call fcn(n,u,ge)

u(j)=u(j)-epsilon

do i=1,n

a(i,j)=(ge(i)-g(i))/epsilon

! write(\*,\*)'ge(',i,')=',ge(i)

enddo

enddo

return

end

!234567890123456789012345678901234567890123456789012345678901234567890

!--------------------------------------------

**Inp1.txt**

1 ! iflag = 1 - exact Newton; 2 - approximate Newton; 3 - Picard (successive substitution)

0.1 ! alfa = parameter for Functional iteration and Picard methods (0<alfa<1)

100 2 1.d-6 1.d-6 1.d-5 ! maxit = Nr max iteracoes; neq = Nr equacoes; tol1 = 1a tol; tol2 = 2a tol; epsilon = delta para derivada numerica

1.d0 1.d0 ! u(i) = valores iniciais para o vetor de incógnitas

**lubksb.f90**

SUBROUTINE lubksb(a,n,np,indx,b)

! implicit real \*8 (a-h,o-z)

dimension indx(np),a(np,np),b(np)

ii=0

do 12 i=1,n

ll=indx(i)

sum=b(ll)

b(ll)=b(i)

if (ii.ne.0)then

do 11 j=ii,i-1

sum=sum-a(i,j)\*b(j)

11 continue

else if (sum.ne.0.) then

ii=i

endif

b(i)=sum

12 continue

do 14 i=n,1,-1

sum=b(i)

do 13 j=i+1,n

sum=sum-a(i,j)\*b(j)

13 continue

b(i)=sum/a(i,i)

14 continue

return

END

**ludcmp.f90**

SUBROUTINE ludcmp(a,n,np,indx,d)

! implicit real \*8 (a-h,o-z)

PARAMETER (NMAX=10,TINY=1.0e-20)

dimension indx(np),a(np,np),vv(NMAX)

d=1.

do 12 i=1,n

aamax=0.

do 11 j=1,n

if (abs(a(i,j)).gt.aamax) aamax=abs(a(i,j))

11 continue

if (aamax.eq.0.) then

! do ja=1,n

! do jb=1,n

! write(\*,\*)'a(',ja,',',jb,')=',a(ja,jb)

! enddo

! enddo

pause 'singular matrix in ludcmp'

endif

vv(i)=1./aamax

12 continue

do 19 j=1,n

do 14 i=1,j-1

sum=a(i,j)

do 13 k=1,i-1

sum=sum-a(i,k)\*a(k,j)

13 continue

a(i,j)=sum

14 continue

aamax=0.

do 16 i=j,n

sum=a(i,j)

do 15 k=1,j-1

sum=sum-a(i,k)\*a(k,j)

15 continue

a(i,j)=sum

dum=vv(i)\*abs(sum)

if (dum.ge.aamax) then

imax=i

aamax=dum

endif

16 continue

if (j.ne.imax)then

do 17 k=1,n

dum=a(imax,k)

a(imax,k)=a(j,k)

a(j,k)=dum

17 continue

d=-d

vv(imax)=vv(j)

endif

indx(j)=imax

if(a(j,j).eq.0.)a(j,j)=TINY

if(j.ne.n)then

dum=1./a(j,j)

do 18 i=j+1,n

a(i,j)=a(i,j)\*dum

18 continue

endif

19 continue

return

END

**mnewt.f90**

SUBROUTINE mnewt(ntrial,x,n,tolx,tolf)

! implicit real \*8 (a-h,o-z)

common /method/ iflag

PARAMETER (NP=15)

dimension x(n),indx(NP)

! USES lubksb,ludcmp,usrfun

dimension fjac(NP,NP),fvec(NP),p(NP)

do 14 k=1,ntrial

write(\*,\*)'---------------k=',k

if(iflag.eq.2) then

write(\*,\*)'Approximate Newton Method'

write(2,\*)'Approximate Newton Method'

call usrfun(x,n,NP,fvec,fjac)

endif

if(iflag.eq.1) then

write(\*,\*)'Exact Newton Method'

write(2,\*)'Exact Newton Method'

call usrfunex(x,n,NP,fvec,fjac)

endif

errf=0.

do 11 i=1,n

errf=errf+abs(fvec(i))

11 continue

write(\*,\*)'errf=',errf

write(2,\*)'errf=',errf

if(errf.le.tolf) then

write(\*,\*)'converged in ',k,' iterations'

write(2,\*)'converged in ',k,' iterations'

return

endif

! if(errf.le.tolf)return

do 12 i=1,n

p(i)=-fvec(i)

12 continue

call ludcmp(fjac,n,NP,indx,d)

call lubksb(fjac,n,NP,indx,p)

errx=0.

do 13 i=1,n

errx=errx+abs(p(i))

x(i)=x(i)+p(i)

write(\*,\*)'x(',i,')=',x(i)

write(2,\*)'x(',i,')=',x(i)

13 continue

enorm=rnorm2(n,p,np)

write(\*,\*)'enorm=',enorm,'errx=',errx

write(2,\*)'enorm=',enorm,'errx=',errx

if(errx.le.tolx.or.enorm.le.tolx) then

write(\*,\*)'converged in ',k,' iterations'

write(2,\*)'converged in ',k,' iterations'

return

endif

14 continue

return

END

**sysaula.f90**

subroutine fcn(n,fi,f)

!

! the system of equations

!

! implicit real \*8 (a-h,o-z)

dimension fi(n),f(n)

f(1)=cos(fi(1))-fi(2)

f(2)=fi(1)-sin(fi(2))

! Sistema para o livro Calc Num

!

! f(1)=fi(1)\*\*3+2\*fi(2)\*\*2-fi(3)-20.

! f(2)=2\*fi(1)-fi(1)\*fi(2)+fi(3)-2.

! f(3)=fi(1)+fi(2)-fi(3)-5.

!

return

end

!-----------------------------------------------------------------

subroutine usrfunex(u,n,np,g,a)

!

! compute the values of g (through function fcn)

! for a given u and the jacobean

!

! implicit real \*8 (a-h,o-z)

dimension u(n),g(np),a(np,np)

!

! evaluate the values of g

!

call fcn(n,u,g)

!

! build the jacobean exactly

!

a(1,1)=-sin(u(1))

a(1,2)=-1.

a(2,1)=1.

a(2,2)=-cos(u(2))

return

end

!-----------------------------------------------------------------

subroutine fcn2(n,fi,f)

!

! the system of equations

!

! implicit real \*8 (a-h,o-z)

dimension fi(n),f(n)

! Sistema para o livro Calc Num

!

! f(1)=(-2\*fi(2)\*\*2+fi(3)+20.)\*\*(1./3.)

! f(2)=(2\*fi(1)+fi(3)-2.)/fi(1)

! f(3)=fi(1)+fi(2)-5.

!

f(1)=sin(fi(2))

f(2)=cos(fi(1))

return

end

!-----------------------------------------------------------------

**dados.gnu**

set data style linespoints

set grid

set xlabel 'variavel x'

set ylabel 'variavel y'

set title 'Sistema de 2 equacoes e 2 incognitas'

plot 'dados1.txt','dados2.txt'

pause -1