

```
DIMENSION X(2), XN(2), XOPT(2), GRAD(2), S(2), GRADN(2),  
2Y(2), HY(2), G(4), GG(4), H(2,2), XMM(2,2), XNN(2,2)
```

```
COMMON/COUNT/NFUN, NGRAD  
COMMON/MITER/ITLIM  
COMMON/CONVER/MAXIN, MAXGR  
NFUN=0  
NGRAD=0  
ITLIM=2  
MAXIN=5  
MAXGR=3
```

```
DATA N, M, MAXPI, C, R, EPS, EPSS, STEPO  
2/2, 4, 4, 0.1, 50.0, 0.001, 0.01, 0.1/
```

```
X(1) = 1.99
```

```
X(2) = 6.02
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```
C X(3) = 3.0
```

```
K=1
```

```
30 CALL UNCON(N, M, R, EPS, EPSS, STEPO, X, XN, XOPT, H,  
2GRAD, S, GRADN, Y, HY, XMM, XNN, G, GG, F, OBJ, II)
```

```
IF (K.EQ.MAXPI) GOTO 20
```

```
R=C*R
```

```
DO 10 I=1, N
```

```
10 X(I) = XOPT(I)
```

```
K=K+1
```

```
GOTO 30
```

```
20 STOP
```

```
END
```

```
SUBROUTINE UNCON(N, M, R, EPS, EPSS, STEPO, X, XN, XOPT, H,  
2GRAD, S, GRADN, Y, HY, XMM, XNN, G, GG, F, OBJ, II)
```

```
COMMON/COUNT/NFUN, NGRAD
```

```
COMMON/MITER/ITLIM
```

```
COMMON/CONVER/MAXIN, MAXGR
```

```
DIMENSION X(N), XOPT(N), GRAD(N), S(N), Y(N), HY(N), GRADN(N),  
2H(N,N), XN(N), G(M), GG(M), XMM(N, N), XNN(N, N)
```

```
DO 10 I=1, N
```

```
DO 10 J=1, N
```

```
10 H(I, J)=0.0
```

```
DO 20 I=1, N
```

```
20 H(I, I)=1.0
```

```
II=1
```

```
CALL FTN(G, X, F, OBJ, N, M, R)
```

```
CALL GRADT(X, GG, N, M, R, GRAD, F)
```

```
WRITE(6, 111) R, F, OBJ
```

```
111 FORMAT(//, 'STARTING VALUES FOR UNCONSTRAINED MIN', /, 'R=', E12.5,  
2 'PF=', E15.8, 'OBJ=', E15.8)
```

```
WRITE(6, 112) (X(I), I=1, N)
```

```
112 FORMAT(11H X(I) ARE, /, 2X, 3E15.8, /, 2X, 3E15.8)
```

```
WRITE(6, 113) (G(I), I=1, M)
```

```

113 FORMAT(11H G(I) ARE,/, 2X, 3E15.8,/,2X, 3E15.8)
100 DO 30 I=1, N
    S(I) = 0.0
    DO 30 J=1, N
    30 S(I)=S(I)+H(I,J)*GRAD(J)
    DO 40 I=1, N
    40 S(I)= -S(I)
    SUM =0.0
    DO 1 I=1, N
    1 SUM=SUM+S(I)**2
    SUM=SQRT(SUM)
    DO 2 I=1, N
    2 S(I)=S(I)/ABS(SUM)
    CALL ONEDIM(N, M, R, EPSS, STEPO, SLAMDA, X, XN, S, F, FN, OBJ,
    2GRAD, GRADN, G, GG)
    DO 50 I=1, N
    50 X(I) = X(I) + SLAMDA*S(I)
    WRITE(6, 114) II, STEPO, FN, OBJ, NFUN, NGRAD
114 FORMAT(/, 6H ITER=, I3, 8H STEPO =, E12.5,/, 5H PF =, E12.5,
    16H OBJ =, E12.5, 7H NFUN =, I5, 8H NGRAD =, I5)
    WRITE(6,112) (XN(I),I=1, N)
    WRITE(6,113) (G(I),I=1, M)

    SUM=0.0
    DO 60 I= 1, N
    60 SUM=SUM+GRADN(I)**2
    SUM=SQRT(SUM)
    IF(SUM.LT.EPS) GOTO 110
    IF(II.EQ.ITLIM) GOTO 110
    DO 70 I=1, N
    70 Y(I) = GRADN(I)- GRAD(I)
    DEN =0.0
    DO 3 I= 1, N
    3 DEN=DEN+S(I)*Y(I)
    FAC=SLAMDA/DEN
    DO 5 I=1, N
    DO 5 J=1, N
    5 XMM(I, J)=S(I)*S(J)*FAC
    DO 4 I=1, N
    HY(I)=0.0
    DO 4 J=1, N
    4 HY(I)=HY(I)+H(I, J)*Y(J)
    DO 6 I=1, N
    DO 6 K=1, N
    6 XNN(I, K)=HY(I)*HY(K)
    DEN=0.0
    DO 7 J=1, N
    7 DEN=DEN+Y(J)*HY(J)
    DO 8 I=1, N
    DO 8 J=1, N
    8 XNN(I, J)=-XNN(I,J)/DEN
    DO 80 I=1, N
    DO 80 J=1, N
80 H(I, J)=H(I, J)+XMM(I, J)+XNN(I, J)
    IF (II/N*N.NE.II) GOTO 39
    DO 37 I=1, N
    DO 37 J=1, N

```

```

37 H(I,J)=0.0
   DO 38 I=1, N
38 H(I,I)=1.0
39 CONTINUE
   II=II+1
   F=FN
   DO 90 I=1, N
90 GRAD(I) = GRADN(I)
   GOTO 100
110 DO 120 I=1, N
120 XOPT(I)=X(I)
   RETURN
   END

   SUBROUTINE ONEDIM(N, M, R, EPSS, STEPO, SLAMDA, X, XN, S,
2F, FN, OBJ, GRAD, GRADN, G, GG)

   COMMON/COUNT/NFUN, NGRAD
   COMMON/CONVER/MAXIN, MAXGR

   DIMENSION X(N), XN(N), GRAD(N), S(N), GRADN(N), G(M), GG(M)
   NNFUN=0
   NNGRAD=0
   WRITE(6, 191) (S(I), I=1, N)
191 FORMAT(/,2X,'CUBIC INTERPOLATION STARTS',/, 2X, 'S(I)=',
24E12.4,/, (3X,4E12.4))

   SUM=0.0
   DO 10 I=1, N
10 SUM=SUM+GRAD(I)*S(I)
   A=0.0
   FA=F
   FAP=SUM
40 DO 20 I=1, N
20 XN(I)=X(I)+STEPO*S(I)
   CALL FTN(G,XN,FN,OBJ,N,M,R)
   NNFUN=NNFUN+1
   DO 21 J=1, M
   IF (G(J).GE.0.0) GOTO 22
21 CONTINUE
   GOTO 41
22 STEPO=STEPO*0.9
   GOTO 40
41 CONTINUE
   CALL GRADT(XN, GG, N, M, R, GRADN, FN)
   NNGRAD=NNGRAD+1
   SUM=0.0
   DO 30 I=1, N
30 SUM=SUM+GRADN(I)*S(I)
   FB=FN
   FBP=SUM
   IF (FBP.GT.0.0) GOTO 110
   FA=FB
   FAP=FBP
   A=STEPO
   STEPO=STEPO*1.2
   GOTO 40

```

```

110 II=0
    B=STEPO
160 Z=3.0*(FA-FB)/(B-A)+FAP+FBP
    Q=SQRT(Z*Z-FAP*FBP)
    SLAMDA=A+(FAP+Z+Q)*(B-A)/(FAP+FBP+2.0*Z)
    II=II+1
    DO 120 I=1, N
120 XN(I)=X(I)+SLAMDA*S(I)
    CALL FTN(G, XN, FN, OBJ, N, M, R)
    NNFUN=NNFUN+1
    CALL GRADT(XN, GG, N, M, R, GRADN, FN)
    NNGRAD=NNGRAD+1
    SUM=0.0
    SUM1=0.0
    SUM2=0.0
    DO 130 I=1, N
    SUM=SUM+GRADN(I)*S(I)
    SUM1=SUM1+GRADN(I)**2
130 SUM2=SUM2+S(I)**2
    SUM1=SQRT(SUM1)
    SUM2=SQRT(SUM2)
    CONV=ABS(SUM/(SUM1*SUM2))
    IF (CONV.LE.EPSS) GOTO 140
    IF (II.GE.MAXIN) GOTO 140
    IF (SUM.GT.0.0) GOTO 150
    A=SLAMDA
    FA=FN
    FAP=SUM
    GOTO 160
150 B=SLAMDA
    FB=FN
    FBP=SUM
    GOTO 160
140 STEPO=SLAMDA
170 RETURN
    END

SUBROUTINE GRADT(X, GG, N, M, R, GRAD, FF)
    DIMENSION X(N), GRAD(N), GG(M)
    COMMON/COUNT/NFUN, NGRAD
    NGRAD=NGRAD+1
    DO 12 I=1, N
    XIP=X(I)
    X(I)=1.01*XIP
    IF (XIP.LE.0.1) X(I)=XIP+0.05
    CALL FTN(GG, X, FBP, OBJ1, N, M, R)
    X(I)=XIP
    GRAD(I)=(FBP-FF)/(0.01*X(I))
    IF (X(I).LE.0.1) GRAD(I)=(FBP-FF)/0.05
12 CONTINUE
    RETURN
    END

SUBROUTINE FTN(G, X, F, OBJ, N, M, R)
    DIMENSION X(N), G(M)
    COMMON/COUNT/NFUN, NGRAD
    NFUN=NFUN+1
    OBJ=X(1)**2+X(2)**2

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```
      G(1)=(X(1)-6.)**2+(X(2)-9.)**2-25.  
      G(2)=-(X(1)-6.)**2-(X(2)-7.)**2+16.  
      G(3)=-X(1)  
      G(4)=-X(2)  
      F=OBJ  
      DO 10 I=1,M  
10      F=F-R/G(I)  
      RETURN  
      END
```