1 The Weapon Assignment Problem

```
*     ------------------------------------------------------------------
*     File t5weapon.f
*     Illustrates using SNOPT on a linearly constrained problem.
*
*     15 May 1998: First   version.
*     27 Oct 2003: Current version.
*     ------------------------------------------------------------------
      program
     &     t5main

      implicit
     &     none
      integer
     &     maxm, maxn, maxne
      parameter
     &   ( maxm   = 1000,
     &     maxn   = 1000,
     &     maxne  = 3000 )
      character
     &     PrbNms(5)*8, Names(maxm+maxn)*8
      integer
     &     indA(maxne), hs(maxn+maxm)
      integer
     &     locA(maxn+1)
      double precision
     &     Acol(maxne), bl(maxn+maxm), bu(maxn+maxm),
     &     x(maxn+maxm), pi(maxm), rc(maxn+maxm)

*     SQOPT workspace-----------------------------------------------------
      integer
     &     lencw, leniw, lenrw
      parameter
     &   ( lencw = 500, leniw = 10000, lenrw = 20000 )
      character
     &     cw(lencw)*8
      integer
     &     iw(leniw)
      double precision
     &     rw(lenrw)
*     ------------------------------------------------------------------
      logical
     &     byname
      character
     &     lfile*20
      integer
     &     Errors, iSpecs, iPrint, iSumm, i1, i2, INFO, iMPS, inewB,
     &     iObj, itnlim, m, mincw, miniw, minrw, n, ne, nInf, nName,
     &     nnCon, nnJac, nOut, nnObj, nS
      double precision
     &     Obj, ObjAdd, sInf
      external
     &     dummy, t5obj
*     ------------------------------------------------------------------
*     Specify some of the SNOPT files.
*     iSpecs  is the Specs file   (0 if none).
*     iPrint  is the Print file   (0 if none).
*     iSumm   is the Summary file (0 if none).
*
*     nOut    is an output file used here by t5weapon.

      iSpecs =  4
      iPrint =  9
      iNewB  = 11
      iSumm  =  6
      nOut   =  6
```

```
      byname = .true.

      if ( byname ) then

*        Unix and DOS systems.  Open the Specs and print files.

         lfile = 't5weapon.spc'
         open( iSpecs, file=lfile, status='OLD',     err=800 )

         lfile = 't5weapon.out'
         open( iPrint, file=lfile, status='UNKNOWN', err=800 )

         lfile = 't5weapon.newbasis'
         open( iNewB, file=lfile, status='UNKNOWN', err=800 )
      end if

*     ------------------------------------------------------------------
*     First,  snInit MUST be called to initialize optional parameters
*     to their default values.
*     ------------------------------------------------------------------
      call snInit
     &   ( iPrint, iSumm, cw, lencw, iw, leniw, rw, lenrw )

*     ------------------------------------------------------------------
*     Read a Specs file (Optional).
*     ------------------------------------------------------------------
      call snSpec
     &   ( iSpecs, INFO, cw, lencw, iw, leniw, rw, lenrw )

      if (INFO .ne. 101  .and.  INFO .ne. 107) then
         go to 990
      end if

*     ------------------------------------------------------------------
*     Set up the data structure for the linear constraints.
*     MPSinp needs to know the number of nonlinear variables, etc.
*     The following calls fetch values set in the SPECS file.
*     Optionally, these values can be set in-line.
*     ------------------------------------------------------------------
      Errors = 0

      call snGeti
     &   ( 'Nonlinear constraints        ', nnCon, Errors,
     &     cw, lencw, iw, leniw, rw, lenrw )
      call snGeti
     &   ( 'Nonlinear Jacobian  variables', nnJac, Errors,
     &     cw, lencw, iw, leniw, rw, lenrw )
      call snGeti
     &   ( 'Nonlinear Objective variables', nnObj, Errors,
     &     cw, lencw, iw, leniw, rw, lenrw )
      call snGeti
     &   ( 'MPS file                     ',  iMPS, Errors,
     &     cw, lencw, iw, leniw, rw, lenrw )

*     The problem name is not needed---it is set by MPSinp.
*     Specify the OBJECTIVE, RHS, RANGES and BOUNDS to be selected
*     from the MPS file.  Blank names mean "select the first one".

*     PrbNms(1) = '        '    ! PROBLEM   name
      PrbNms(2) = '        '    ! OBJECTIVE name
      PrbNms(3) = '        '    ! RHS       name
      PrbNms(4) = '        '    ! RANGES    name
      PrbNms(5) = '        '    ! BOUNDS    name

      if ( byname ) then

*        Unix and DOS systems.  Open the MPS file.
```

```
         lfile = 't5weapon.mps'
         open( iMPS, file=lfile, status='OLD', err=800 )
      end if

      call MPSinp
     &   ( iMPS, maxm, maxn, maxne,
     &     nnCon, nnJac, nnObj,
     &     m, n, ne,
     &     iObj, ObjAdd, PrbNms,
     &     Acol, indA, locA, bl, bu, Names,
     &     hs, x, pi,
     &     INFO, mincw, miniw, minrw, nS,
     &     cw, lencw, iw, leniw, rw, lenrw )
      close( iMPS )

      if (INFO .ne. 103) go to 990
      nName = m + n

*     ------------------------------------------------------------------
*     Specify any options not set in the Specs file.
*     i1 and i2 may refer to the Print and Summary file respectively.
*     Setting them to 0 suppresses printing.
*     ------------------------------------------------------------------
      itnlim = 1000
      i1     =    0
      i2     =    0
      call snSeti
     &   ( 'Iterations        ', itnlim, i1, i2, Errors,
     &     cw, lencw, iw, leniw, rw, lenrw )

*     ------------------------------------------------------------------
*     Go for it, using a Cold start.
*     hs     need not be set if a basis file is to be input.
*            Otherwise, each hs(1:n) should be 0, 1, 2, 3, 4, or 5.
*            The values are used by the Crash procedure m2crsh
*            to choose an initial basis B.
*            If hs(j) = 0 or 1, column j is eligible for B.
*            If hs(j) = 2, column j is initially superbasic (not in B).
*            If hs(j) = 3, column j is eligible for B and is given
*                          preference over columns with hs(j) = 0 or 1.
*            If hs(j) = 4 or 5, column j is initially nonbasic.
*     ------------------------------------------------------------------
      call snOptB
     &   ( 'Cold', m, n, ne, nName,
     &     nnCon, nnObj, nnJac,
     &     iObj, ObjAdd, PrbNms(1),
     &     dummy, t5obj,
     &     Acol, indA, locA, bl, bu, Names,
     &     hs, x, pi, rc,
     &     INFO, mincw, miniw, minrw,
     &     nS, nInf, sInf, Obj,
     &     cw, lencw, iw, leniw, rw, lenrw,
     &     cw, lencw, iw, leniw, rw, lenrw )

      if (INFO .eq. 82 .or. INFO .eq. 83 .or. INFO .eq. 84) then
         go to 910
      end if

      write(nOut, *) ' '
      write(nOut, *) 'snOpt finished.'
      write(nOut, *) 'Input errors  =', Errors
      write(nOut, *) 'snOptB INFO   =', INFO
      write(nOut, *) 'nInf          =', nInf
      write(nOut, *) 'sInf          =', sInf
      if (iObj .gt. 0) then
         write(nOut, *)
     &              'Obj           =', ObjAdd + x(n+iObj) + Obj
      else
```

```
         write(nOut, *)
     &               'Obj           =', ObjAdd + Obj
      end if
      if (INFO .gt. 30) go to 910

      stop

*     ------------------------------------------------------------------
*     Error exit.
*     ------------------------------------------------------------------
  800 write(nOut, 4000) 'Error while opening file', lfile
      stop

  910 write(nOut, *) ' '
      write(nOut, *) 'STOPPING because of error condition'

  990 stop

 4000 format(/  a, 2x, a  )

      end ! program t5main

*++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

      subroutine t5obj
     &   ( mode, n, x, f, g, nState,
     &     cw, lencw, iw, leniw, rw, lenrw )

      implicit
     &     none
      integer
     &     mode, n, nState, lencw, leniw, lenrw, iw(leniw)
      character
     &     cw(lencw)*8
      double precision
     &     f, x(n), g(n), rw(lenrw)

*     ------------------------------------------------------------------
*     t5obj  is funobj for the Weapon Assignment problem t5weapon.
*     It assumes the Specs file contains input data after the End card.
*     ------------------------------------------------------------------
      intrinsic          log
      double precision   zero
      integer            nweapn,      ntargt
      parameter        ( nweapn = 5,  ntargt = 20,  zero   = 0.0d+0 )
      double precision   q(nweapn,ntargt), ql(nweapn,ntargt), u(ntargt)
      save               q               , ql               , u
*     ------------------------------------------------------------------
      integer
     &     i, iSpecs, j,k
      double precision
     &     xk, t
*     ------------------------------------------------------------------
      if (nState .eq. 1) then
*        ---------------------------------------------------
*        First entry.  Read some data defining the objective.
*        ---------------------------------------------------
*        Weapon data follows the SPECS data.
*        The SPECS file unit number is defined by the call to snInit
*        and saved in SNOPT workspace.

         iSpecs = iw( 11) ! Specs (options) file

         do i = 1, nweapn
            read (iSpecs, '(18f4.2)') (q(i,j), j = 1, ntargt)
            do j = 1, ntargt
               ql(i,j) = log( q(i,j) )
            end do
```

```
         end do
         read (iSpecs, '(18f4.0)') u
      end if

*     -------------
*     Normal entry.
*     -------------
      k      = 0
      f      = zero

      do j = 1, ntargt
         t     = u(j)
         do i  = 1, nweapn
            xk = x(k+i)
            if (xk .gt. zero) t = t * q(i,j)**xk
         end do

         if (mode .eq. 2) then
            do i = 1, nweapn
               g(k+i) = t * ql(i,j)
            end do
         end if

         k     = k + nweapn
         f     = f + (t - u(j))
      end do

      end ! subroutine t5Obj

*++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

      subroutine dummy
     &   ( mode, nnCon, nnJac, neJac, x, fCon, gCon,
     &     nState, cu, lencu, iu, leniu, ru, lenru )

      implicit
     &     none

      integer
     &     mode, nnCon, nnJac, neJac, nState, lencu, leniu, lenru,
     &     iu(leniu)
      double precision
     &     x(nnJac), fCon(nnCon), gCon(neJac), ru(lenru)
      character
     &     cu(lencu)*8

*     ================================================================
*     Problem t5weapon.
*     No nonlinear constraints.
*     ================================================================

*     Relax

      end ! subroutine dummy
```

2 MINOS – Weapon Assignment Problem

```
     ==============================
     M I N O S  5.51     (Aug 2005)
     ==============================

     Begin t5weapon   (Weapon Assignment Problem)

        Problem number          1115
        Minimize
        Rows                     20
        Columns                 200
        Elements                200
        Upper bound           100.0

        Nonlinear variables     100
     *  Derivative level          0   * Test of FONLY linesearch
        Superbasics limit        20

        MPS file                 10
        NEW BASIS file           11

        Iterations              300
        Print level               1
        Print frequency           1
        Solution                Yes
     End

Reasonable Workspace limits are         0 ...   28471
Actual     Workspace limits are         0 ...50000000 ...50000000  words of  z.


Parameters
----------
MPS INPUT DATA.
Row limit.............        20       List limit.............         0       Lower bound default....  0.00E+00
Column limit...........       200       Error message limit....        10       Upper bound default....  1.00E+02
Elements limit ........       200       Phantom elements.......         0       Aij tolerance..........  1.00E-10

FILES.
MPS file ..............        10       Old basis file ........         0       (Card reader)..........         5
Solution file..........         0       New basis file ........        11       (Printer)..............         9
Insert file............         0       Backup basis file......         0       (Specs file)...........         4
Punch file.............         0       Load file..............         0       Dump file..............         0

FREQUENCIES.
Log frequency..........         1       Check row error........        60       Save new basis map.....       100
Summary frequency......       100       Factorize basis........        50       Expand frequency.......     10000

LP PARAMETERS.
Scale option...........         1       Feasibility tolerance..  1.00E-06       Iteration limit........       300
Scale tolerance........     0.900       Optimality tolerance...  1.00E-06       Partial  price.........         1
Crash option...........         3       Pivot tolerance........  3.25E-11       Multiple price.........         1
Crash tolerance........     0.100       Weight on objective....  0.00E+00

NONLINEAR PROBLEMS.
Nonlinear constraints..         0       Hessian dimension......        20       Function precision.....  3.00E-13
Nonlinear Jacobian vars         0       Superbasics limit......        20       Difference interval....  5.48E-07
Nonlinear objectiv vars       100       Linesearch tolerance...   0.10000       Central difference int.  6.69E-05
Problem number.........      1115       Subspace tolerance.....   0.50000       Derivative level.......         3
Unbounded objective val  1.00E+20       Unbounded step size....  1.00E+10       Verify level...........         0

MISCELLANEOUS.
LU factor tolerance....      5.00       Workspace (user).......         0       Debug level............         0
LU update tolerance....      5.00       Workspace (total)......  50000000       Linesearch debug after.   9999999
LU singularity tol.....  3.25E-11       eps (machine precision)  2.22E-16       nwordr, nwordi, nwordh.   2  2  2
LU swap tolerance......  1.22E-04       Timing level...........         3


MPS file
--------
     1    NAME          WEAPON ASSIGNMENT PROBLEM
     2    ROWS
    15    COLUMNS
===>  Warning - no linear objective selected
   116    RHS
   125    BOUNDS
   126    ENDATA


Names selected
--------------
Objective               (Min)       0
RHS            B                   12
RANGES                              0
BOUNDS                              0


Length of row-name hash table          101
Collisions during table lookup           0
No. of INITIAL  bounds  specified        0
No. of superbasics specified             0
```

```
Nonzeros allowed for in LU factors 24998874

Scale option  0,      Partial price       1
Partial price section size (A)          100
Partial price section size (I)           12


Matrix Statistics
-----------------
               Total      Normal        Free       Fixed     Bounded
Rows              12          12           0           0           0
Columns          100           0           0           0         100

No. of matrix elements                 135    Density      11.250
Biggest                          1.0000E+00  (excluding fixed columns,
Smallest                         1.0000E+00   free rows, and RHS)

No. of objective coefficients             0


Nonlinear constraints       0     Linear constraints      12
Nonlinear variables       100     Linear variables         0
Jacobian  variables         0     Objective variables    100

Initial basis
-------------
No basis file supplied


Crash option  3

Crash on linear E  rows:


Iterations
----------

Factor      1  Demand      0  Itn          0  Infeas       0
Nonlin      0  Linear      0  Slacks      12  Objective       0.00000000E+00
m          12 =n          12  Elems       12  Amax   1.0E+00  Density   8.33
Merit     0.0  lenL        0  L+U         12  Cmpressns    0  Incres    0.00
Utri       12  lenU       12  Ltol  5.00E+00  Umax   1.0E+00  Ugrwth 1.0E+00
Ltri        0  dense1      0  Lmax  0.00E+00
bump        0  dense2      0  DUmax  1.0E+00  DUmin  1.0E+00  condU  1.0E+00

Itn      0 -- linear E rows feasible.   Obj =   0.000000000E+00

Crash on linear LG rows:
Slacks      5  Free cols     0  Preferred     0
Unit        7  Double        0  Triangle      0  Pad     0

Factor      2  Demand      0  Itn          0  Infeas       1
Nonlin      7  Linear      0  Slacks       5  Sum infeas       0.00000000E+00
m          12 =n          12  Elems       19  Amax   1.0E+00  Density  13.19
Merit     0.0  lenL        0  L+U         19  Cmpressns    0  Incres    0.00
Utri       12  lenU       19  Ltol  5.00E+00  Umax   1.0E+00  Ugrwth 1.0E+00
Ltri        0  dense1      0  Lmax  0.00E+00
bump        0  dense2      0  DUmax  1.0E+00  DUmin  1.0E+00  condU  1.0E+00
Itn      0 -- infeasible.  Num =     1   Sum =   1.350000000E+02

   Itn ph pp     rg    +sbs  -sbs   -bs  step    pivot   ninf  sinf,objective     L     U ncp  nobj  ncon  nsb Hmod cond(H) conv
     1  1  1 -1.0E+00     2     2     1 3.0E+01  1.0E+00    1  1.35000000E+02     0    19   0
     2  1  1 -1.0E+00    27    27   102 7.0E+01  1.0E+00    1  1.05000000E+02     0    19   0
     3  1  1 -1.0E+00     3     3    27 3.0E+01 -1.0E+00    1  3.50000000E+01     1    19   0
     4  1  1 -1.0E+00    28    28    26 4.9E-11  1.0E+00    1  5.00000000E+00     1    20   0
     5  1  1 -1.0E+00    47    47     2 4.9E-11  1.0E+00    1  5.00000000E+00     1    20   0
     6  1  1  1.0E+00    27    27   101 5.0E+00 -1.0E+00    1  5.00000000E+00     2    20   0
Itn      6 -- linear constraints satisfied.
funobj  sets     100   out of     100   objective  gradients.

Cheap test on funobj...
The objective gradients seem to be OK.
Gradient projected in two directions  -1.29516275284E+02  -4.03369484689E+00
Difference approximations             -1.29515839887E+02  -4.03369455336E+00

Itn      6 -- feasible solution.  Objective =  -1.818044887E+02

     7  3  1 -1.7E+01    87     0     0 1.0E+00  0.0E+00    0 -2.77020571E+02     4    21   0     6     0    1  1 0 1.0E+00 FFTT
     8  3  1 -1.7E+01    72     0     0 1.9E-01  0.0E+00    0 -3.05336895E+02     4    21   0     8     0    2  1 0 5.5E+00 FFTT
     9  3  1 -2.3E+01    41     0     0 1.0E+00  0.0E+00    0 -4.43743832E+02     4    21   0     9     0    3  1 0 6.5E+00 FFFF
    10  4  1  6.6E-01     0     0     0 6.0E+00  0.0E+00    0 -5.64075338E+02     4    21   0    11     0    3  1 0 3.5E+00 FFTT
    11  3  1 -2.5E+01    67     0     0 5.2E-01  0.0E+00    0 -7.01796509E+02     4    21   0    13     0    4  1 0 3.7E+00 FFTF
    12  4  1  2.4E+00     0    41    27 4.3E+00  1.0E+00    0 -7.48278520E+02     4    21   0    15     0    3  1 1 1.2E+00 FFTF
    13  4  1  4.8E-01     0     0     0 8.4E+00  0.0E+00    0 -7.60021442E+02     4    19   0    20     0    3  1 0 6.9E+00 FFTT
    14  3  1 -2.4E+01    97    97    96 4.2E-01  1.0E+00    0 -8.61564730E+02     4    19   0    21     0    3  1 1 7.0E+00 FFTF
    15  4  1  9.0E-01     0     0     0 1.4E+00  0.0E+00    0 -8.71029782E+02     4    20   0    23     0    3  1 0 4.5E+00 TFTT
    16  3  1 -1.5E+01    77     0     0 6.1E-01  0.0E+00    0 -9.38433804E+02     4    20   0    25     0    4  1 0 4.8E+00 FFTF
    17  4  1  2.1E+00     0     0     0 1.4E+00  0.0E+00    0 -9.62094851E+02     4    20   0    28     0    4  1 0 3.9E+00 FFTF
    18  4  1  1.2E+00     0     0     0 1.3E+00  0.0E+00    0 -9.66526677E+02     4    20   0    30     0    4  1 0 3.4E+00 FTTF
    19  4  1  2.4E-01     0     0     0 2.5E+00  0.0E+00    0 -9.68552691E+02     4    20   0    32     0    4  1 0 3.0E+00 TTTT
    20  3  1 -1.4E+01    82     0     0 5.0E-01  0.0E+00    0 -1.01491982E+03     4    20   0    34     0    5  1 0 4.6E+00 FFTF
```

```
 21  4  1  1.8E+00     0     0     0 8.0E-01  0.0E+00    0 -1.02790334E+03     4    20    0    36     0     5  1 0 4.1E+00 FFTF
 22  4  1  5.2E-01     0     0     0 1.9E+00  0.0E+00    0 -1.02995538E+03     4    20    0    38     0     5  1 0 3.3E+00 TTTT
 23  3  1 -1.4E+01    92     0     0 4.6E-01  0.0E+00    0 -1.07102557E+03     4    20    0    40     0     6  1 0 4.8E+00 TFTF
 24  4  1  1.6E+00     0     0     0 1.0E+00  0.0E+00    0 -1.08202286E+03     4    20    0    41     0     6  1 0 4.0E+00 TFTF
 25  4  1  4.1E-01     0     0     0 1.9E+00  0.0E+00    0 -1.08385174E+03     4    20    0    43     0     6  1 0 3.7E+00 TTTT
 26  3  1 -1.2E+01    64     0     0 6.0E+00  0.0E+00    0 -1.20631260E+03     4    20    0    45     0     7  1 0 8.1E+00 FFTF
 27  4  1  3.7E-01     0     0     0 1.0E+00  0.0E+00    0 -1.20870638E+03     4    20    0    46     0     7  1 0 7.9E+00 TTTT
 28  3  1 -9.8E+00    17     0     0 4.6E-01  0.0E+00    0 -1.22903954E+03     4    20    0    48     0     8  1 0 1.0E+01 TFTF
 29  4  1  1.2E+00     0     0     0 1.3E+00  0.0E+00    0 -1.23796374E+03     4    20    0    50     0     8  1 0 8.4E+00 TTTF
 30  3  1 -6.1E+00     7     0     0 5.1E-01  0.0E+00    0 -1.24748819E+03     4    20    0    52     0     9  1 0 9.6E+00 TTTF
 31  3  1 -4.9E+00    36     0     0 2.6E+00  0.0E+00    0 -1.27422703E+03     4    20    0    55     0    10  1 0 9.5E+00 FFTF
 32  4  1  1.2E+00     0     0     0 7.3E-01  0.0E+00    0 -1.27668093E+03     4    20    0    57     0    10  1 0 9.6E+00 TTTF
 33  3  1 -4.8E+00    12     0     0 5.3E-01  0.0E+00    0 -1.28341928E+03     4    20    0    59     0    11  1 0 1.1E+01 TTTF
 34  3  1 -3.8E+00    59     0     0 4.4E+00  0.0E+00    0 -1.31619037E+03     4    20    0    62     0    12  1 0 1.2E+01 FFFF
 35  4  1  1.2E+00     0     0     0 1.7E+00  0.0E+00    0 -1.32370024E+03     4    20    0    64     0    12  1 0 1.2E+01 TTTF
 36  3  1 -3.7E+00    31     0     0 3.8E+00  0.0E+00    0 -1.35330966E+03     4    20    0    67     0    13  1 0 1.3E+01 FFFF
 37  4  1  8.1E-01     0     0     0 1.2E+00  0.0E+00    0 -1.35766173E+03     4    20    0    69     0    13  1 0 1.3E+01 TTTF
 38  3  1 -2.9E+00    50     0     0 6.0E+00  0.0E+00    0 -1.37933765E+03     4    20    0    71     0    14  1 0 1.5E+01 FFFF
 39  4  1  1.2E+00     0    72    47 2.6E+00  1.0E+00    0 -1.43165328E+03     4    20    0    73     0    13  1 1 1.7E+01 FFTF
 40  4  1  3.2E-01     0    50    46 1.6E+00  1.0E+00    0 -1.43475358E+03     4    21    0    75     0    12  1 1 1.7E+01 TTTF

Itn ph pp     rg    +sbs  -sbs   -bs  step    pivot   ninf  sinf,objective     L     U ncp  nobj  ncon  nsb Hmod cond(H) conv
 41  3  1 -3.1E+00    22     0     0 7.1E-01  0.0E+00    0 -1.43819188E+03     4    23    0    77     0    13  1 0 1.9E+01 TTTF
 42  3  1 -2.8E+00    54    59   104 2.5E+00  1.0E+00    0 -1.45447812E+03     4    23    0    79     0    13  1 1 1.0E+01 TFFF
 43  4  1  1.5E+00     0     0     0 3.2E+00  0.0E+00    0 -1.46392241E+03     4    23    0    82     0    13  1 0 2.7E+01 FTFF
 44  4  1  8.2E-01     0     0     0 2.7E+00  0.0E+00    0 -1.46609527E+03     4    23    0    84     0    13  1 0 2.6E+01 TTTF
 45  3  1 -2.6E+00    69     0     0 4.7E+00  0.0E+00    0 -1.48255034E+03     4    23    0    87     0    14  1 0 2.8E+01 FFFF
 46  4  1  2.5E+00     0     0     0 3.7E+00  0.0E+00    0 -1.50581833E+03     4    23    0    90     0    14  1 0 2.4E+01 FFFF
 47  4  1  1.4E+00     0    67     0 7.0E-01  6.1E+00    0 -1.51698258E+03     4    23    0    91     0    13  1 0 3.2E+01 TTFF
 48  4  1  8.6E-01     0     0     0 2.0E+00  0.0E+00    0 -1.53012605E+03     4    23    0    94     0    13  1 0 4.7E+01 FTTF
 49  4  1  5.2E-01     0     0     0 3.5E+00  0.0E+00    0 -1.53616616E+03     4    23    0    97     0    13  1 0 4.1E+01 FTTF
 50  4  1  1.6E-01     0     0     0 1.3E+00  0.0E+00    0 -1.53708822E+03     4    23    0    99     0    13  1 0 3.8E+01 TTTF
 51  3  1  2.1E+00   112     0     0 1.0E+00  0.0E+00    0 -1.53903722E+03     4    23    0   100     0    14  1 0 4.1E+01 TTTF
 52  3  1 -2.0E+00    98    69    66 1.1E+00  1.0E+00    0 -1.54204144E+03     4    23    0   102     0    14  1 1 4.6E+01 TTFF
 53  4  1  2.2E+00     0     0     0 5.8E+00  0.0E+00    0 -1.54955588E+03     4    23    0   104     0    14  1 0 4.6E+01 FTFF
 54  4  1  2.1E+00     0     0     0 4.8E+00  0.0E+00    0 -1.56189205E+03     4    23    0   107     0    14  1 0 2.7E+01 FTFF
 55  4  1  2.2E+00     0    98    97 1.1E+00  1.0E+00    0 -1.57551693E+03     4    23    0   109     0    13  1 1 3.5E+01 TTFF
 56  4  1  6.0E-01     0     0     0 1.6E+00  0.0E+00    0 -1.58684168E+03     4    22    0   111     0    13  1 0 3.2E+01 FTTF
 57  4  1  4.1E-01     0     0     0 2.4E+00  0.0E+00    0 -1.58958154E+03     4    22    0   113     0    13  1 0 3.7E+01 TTTF
 58  3  1 -1.2E+00    15     0     0 5.1E+00  0.0E+00    0 -1.59596550E+03     4    22    0   116     0    14  1 0 4.9E+01 FTFF
 59  4  1  1.1E+00     0   112    98 3.8E+00  1.0E+00    0 -1.60727530E+03     4    22    0   118     0    13  1 1 2.9E+01 FTFF
 60  4  1  6.1E-01     0    12     0 2.0E+00  1.9E+00    0 -1.61532135E+03     4    21    0   120     0    12  1 0 2.9E+01 TTFF
 61  4  1  3.5E-01     0     0     0 4.2E+00  0.0E+00    0 -1.61857507E+03     4    21    0   122     0    12  1 0 2.5E+01 FTFF
 62  4  1  5.5E-01     0     0     0 2.7E+00  0.0E+00    0 -1.62082699E+03     4    21    0   124     0    12  1 0 4.2E+01 TTTF
 63  3  1 -9.5E-01    88     0     0 6.0E+00  0.0E+00    0 -1.62569142E+03     4    21    0   126     0    13  1 0 5.9E+01 FTFF
 64  4  1  1.6E+00     0    15     0 4.9E+00 -8.2E+00    0 -1.63377812E+03     4    21    0   128     0    12  1 0 2.9E+01 FTFF
 65  4  1  6.2E-01     0     0     0 2.5E+00  0.0E+00    0 -1.63984927E+03     4    21    0   130     0    12  1 0 2.3E+01 FTFF
 66  4  1  8.7E-01     0    87     0 3.2E+00  1.5E+00    0 -1.64618657E+03     4    21    0   132     0    11  1 0 2.2E+01 FTFF
 67  4  1  6.5E-01     0     0     0 6.0E+00  0.0E+00    0 -1.65291343E+03     4    21    0   134     0    11  1 0 2.4E+01 FTFF
 68  4  1  3.8E-01     0     0     0 2.7E+00  0.0E+00    0 -1.65428621E+03     4    21    0   136     0    11  1 0 3.3E+01 TTTF
 69  3  1 -7.5E-01     5     0     0 7.2E+00  0.0E+00    0 -1.65825121E+03     4    21    0   139     0    12  1 0 4.7E+01 FTFF
 70  4  1  5.4E-01     0    88   103 1.4E+00  1.0E+00    0 -1.66092535E+03     4    21    0   141     0    11  1 1 2.3E+01 TTFF
 71  4  1  5.0E-01     0     0     0 2.3E+00  0.0E+00    0 -1.66436797E+03     4    21    0   143     0    11  1 0 2.3E+01 TTFF
 72  4  1  3.8E-01     0     5     3 5.1E+00  1.0E+00    0 -1.66852136E+03     4    21    0   145     0    10  1 1 2.2E+01 TTFF
 73  4  1  1.0E-01     0     0     0 1.8E+00  0.0E+00    0 -1.66901402E+03     4    21    0   147     0    10  1 0 2.3E+01 TTTF
 74  3  1 -7.0E-01    93     0     0 9.7E+00  0.0E+00    0 -1.67155073E+03     4    21    0   150     0    11  1 0 2.3E+01 TTFF
 75  4  1  1.1E+00     0     0     0 7.0E+00  0.0E+00    0 -1.67786755E+03     4    21    0   153     0    11  1 0 5.5E+01 FTFF
 76  4  1  1.2E+00     0    92     0 2.5E+00  3.5E+00    0 -1.68863575E+03     4    21    0   155     0    10  1 0 2.5E+01 FTFF
 77  4  1  4.0E-01     0     0     0 1.8E+00  0.0E+00    0 -1.69177480E+03     4    21    0   157     0    10  1 0 2.9E+01 TTFF
 78  4  1  1.6E-01     0     0     0 2.9E+00  0.0E+00    0 -1.69246357E+03     4    21    0   159     0    10  1 0 3.8E+01 TTTF
 79  3  1  4.1E-01   106     0     0 3.8E+00  0.0E+00    0 -1.69318878E+03     4    21    0   161     0    11  1 0 3.7E+01 TTFF
 80  4  1  4.4E-01     0     0     0 4.3E+00  0.0E+00    0 -1.69384653E+03     4    21    0   163     0    11  1 0 3.8E+01 TTFF

Itn ph pp     rg    +sbs  -sbs   -bs  step    pivot   ninf  sinf,objective     L     U ncp  nobj  ncon  nsb Hmod cond(H) conv
 81  4  1  2.3E-01     0     0     0 5.3E+00  0.0E+00    0 -1.69543741E+03     4    21    0   165     0    11  1 0 4.2E+01 TTFF
 82  4  1  2.8E-01     0     0     0 2.6E+00  0.0E+00    0 -1.69619214E+03     4    21    0   167     0    11  1 0 7.5E+01 TTFF
 83  4  1  7.5E-02     0     0     0 4.8E+00  0.0E+00    0 -1.69721259E+03     4    21    0   170     0    11  1 0 1.7E+02 TTTF
 84  3  1 -3.5E-01    10     0     0 2.6E+00  0.0E+00    0 -1.69770036E+03     4    21    0   172     0    12  1 0 2.2E+02 TTFF
 85  4  1  3.3E-01     0   106     5 5.5E+00  1.0E+00    0 -1.69900109E+03     4    21    0   174     0    11  1 1 3.4E+01 FTFF
 86  4  1  4.0E-01     0    10   105 5.3E+00  1.0E+00    0 -1.70012040E+03     4    20    0   176     0    10  1 1 3.4E+01 TTFF
 87  4  1  7.3E-02     0     0     0 2.3E+00  0.0E+00    0 -1.70088672E+03     4    20    0   178     0    10  1 0 3.3E+01 TTTF
 88  3  1 -3.2E-01    79     0     0 5.0E+00  0.0E+00    0 -1.70122847E+03     4    20    0   180     0    11  1 0 2.8E+01 TTFF
 89  4  1  3.5E-01     0     0     0 4.4E+00  0.0E+00    0 -1.70195121E+03     4    20    0   182     0    11  1 0 3.7E+01 TTFF
 90  4  1  2.5E-01     0     0     0 5.3E+00  0.0E+00    0 -1.70263620E+03     4    20    0   184     0    11  1 0 2.4E+01 TTFF
 91  4  1  1.6E-01     0     0     0 2.3E+00  0.0E+00    0 -1.70343192E+03     4    20    0   186     0    11  1 0 2.3E+01 TTTF
 92  3  1  2.4E-01    15     0     0 2.4E+00  0.0E+00    0 -1.70376038E+03     4    20    0   188     0    12  1 0 3.2E+01 TTFF
 93  4  1  2.3E-01     0     0     0 2.7E+00  0.0E+00    0 -1.70393661E+03     4    20    0   190     0    12  1 0 2.1E+01 TTFF
 94  4  1  4.7E-01     0     0     0 1.3E+01  0.0E+00    0 -1.70511156E+03     4    20    0   193     0    12  1 0 2.6E+01 TTFF
 95  4  1  3.1E-01     0     7     0 2.7E+00  1.7E+00    0 -1.70828443E+03     4    20    0   195     0    11  1 0 1.9E+01 FTFF
 96  4  1  3.7E-01     0     0     0 1.8E+00  0.0E+00    0 -1.71119499E+03     4    20    0   198     0    11  1 0 2.3E+01 TTFF
 97  4  1  5.6E-02     0     0     0 2.2E+00  0.0E+00    0 -1.71237014E+03     4    20    0   200     0    11  1 0 2.3E+01 TTTF
 98  3  1 -2.8E-01    65     0     0 2.2E+00  0.0E+00    0 -1.71255106E+03     4    20    0   202     0    12  1 0 2.8E+01 TTFF
 99  4  1  3.4E-01     0     0     0 1.7E+01  0.0E+00    0 -1.71360944E+03     4    20    0   205     0    12  1 0 2.3E+01 FTFF
100  4  1  3.2E-01     0    79    76 3.8E-01  1.0E+00    0 -1.71407029E+03     4    20    0   206     0    11  0 1 2.0E+01 TTFF

 NEW BASIS file saved on file  11    itn =    100
101  4  1  2.7E-01     0     0     0 5.2E+00  0.0E+00    0 -1.71655230E+03     4    20    0   208     0    11  1 0 2.2E+01 FTFF
102  4  1  3.2E-02     0     0     0 1.9E+00  0.0E+00    0 -1.71680322E+03     4    20    0   210     0    11  1 0 1.9E+01 TTTF
103  3  1  1.8E-01     5     0     0 3.3E+00  0.0E+00    0 -1.71690561E+03     4    20    0   212     0    12  1 0 1.7E+01 TTTF
104  4  1  1.8E-01     0     0     0 1.8E+00  0.0E+00    0 -1.71703173E+03     4    20    0   214     0    12  1 0 2.0E+01 TTFF
105  4  1  2.7E-01     0     0     0 6.9E+00  0.0E+00    0 -1.71809982E+03     4    20    0   217     0    12  1 0 2.9E+01 FTFF
106  4  1  1.1E-01     0    64     0 2.9E+00  4.3E+00    0 -1.72153901E+03     4    20    0   219     0    11  1 0 4.0E+01 FTFF
```

```
   107  4  1  8.6E-02     0     0     0 1.5E+00  0.0E+00    0 -1.72234193E+03     4    20   0   221     0   11  1 0 3.6E+01 TTTF
   108  3  1  2.4E-01   111     0     0 2.3E+00  0.0E+00    0 -1.72277305E+03     4    20   0   223     0   12  1 0 8.0E+01 TTFF
   109  4  1  2.6E-01     0     0     0 2.3E+00  0.0E+00    0 -1.72297119E+03     4    20   0   225     0   12  1 0 2.6E+01 TTFF
   110  4  1  1.3E-01     0     0     0 8.7E+00  0.0E+00    0 -1.72375821E+03     4    20   0   228     0   12  1 0 2.7E+01 TTFF
   111  4  1  5.0E-02     0     0     0 1.8E+00  0.0E+00    0 -1.72423345E+03     4    20   0   230     0   12  1 0 2.7E+01 TTFF
   112  3  1  1.5E-01    98     0     0 2.5E+00  0.0E+00    0 -1.72431015E+03     4    20   0   232     0   13  1 0 4.2E+01 TTFF
   113  4  1  1.5E-01     0     0     0 2.8E+00  0.0E+00    0 -1.72439761E+03     4    20   0   234     0   13  1 0 2.6E+01 TTFF
   114  4  1  1.1E-01     0     0     0 5.5E+00  0.0E+00    0 -1.72480014E+03     4    20   0   236     0   13  1 0 2.7E+01 TTFF
   115  4  1  1.3E-01     0     0     0 8.6E+00  0.0E+00    0 -1.72602463E+03     4    20   0   239     0   13  1 0 4.0E+01 FTFF
   116  4  1  5.5E-02     0     0     0 1.5E+00  0.0E+00    0 -1.72664479E+03     4    20   0   241     0   13  1 0 4.5E+01 TTTF
   117  3  1  1.5E-01   108     0     0 2.5E+00  0.0E+00    0 -1.72677959E+03     4    20   0   243     0   14  1 0 1.1E+02 TTFF
   118  4  1  1.3E-01     0     0     0 2.2E+00  0.0E+00    0 -1.72685048E+03     4    20   0   245     0   14  1 0 4.8E+01 TTFF
   119  4  1  7.5E-02     0     0     0 9.5E+00  0.0E+00    0 -1.72704303E+03     4    20   0   248     0   14  1 0 4.6E+01 TTTF
   120  4  1  3.9E-02    -6     0     0 2.9E+00  0.0E+00    0 -1.72727169E+03     4    20   0   250     0   14  1 0 4.5E+01 TTTF

   Itn ph pp     rg    +sbs  -sbs   -bs  step    pivot   ninf  sinf,objective     L     U ncp  nobj  ncon  nsb Hmod cond(H) conv
   121  3  1 -8.2E-02    83     0     0 1.9E+00  0.0E+00    0 -1.72732710E+03     4    20   0   252     0   15  1 0 1.4E+02 TTFF
   122  4  1  6.7E-02     0     0     0 2.5E+00  0.0E+00    0 -1.72735916E+03     4    20   0   254     0   15  1 0 5.7E+01 TTFF
   123  4  1  6.2E-02     0     0     0 2.7E+00  0.0E+00    0 -1.72737705E+03     4    20   0   256     0   15  1 0 4.0E+01 TTFF
   124  4  1  5.9E-02     0     0     0 1.1E+01  0.0E+00    0 -1.72747460E+03     4    20   0   259     0   15  1 0 4.2E+01 TTFF
   125  4  1  1.2E-01     0     0     0 9.0E+00  0.0E+00    0 -1.72797161E+03     4    20   0   262     0   15  1 0 6.3E+01 TTFF
   126  4  1  5.2E-02     0     0     0 1.9E+00  0.0E+00    0 -1.72833383E+03     4    20   0   264     0   15  1 0 8.1E+01 TTFF
   127  4  1  1.5E-02     0     0     0 1.0E+00  0.0E+00    0 -1.72845141E+03     4    20   0   265     0   15  1 0 7.9E+01 TTFF
   128  3  1 -9.1E-02    26     0     0 1.2E+00  0.0E+00    0 -1.72847918E+03     4    20   0   267     0   16  1 0 2.5E+02 TTFF
   129  4  1  9.9E-02     0     0     0 1.3E+00  0.0E+00    0 -1.72849421E+03     4    20   0   269     0   16  1 0 9.2E+01 TTFF
   130  4  1  1.0E-01     0     0     0 6.0E+00  0.0E+00    0 -1.72858710E+03     4    20   0   271     0   16  1 0 6.9E+01 TTFF
   131  4  1  1.1E-01     0     0     0 6.9E+00  0.0E+00    0 -1.72913546E+03     4    20   0   274     0   16  1 0 6.8E+01 TTFF
   132  4  1  1.7E-01     0     0     0 1.1E+00  0.0E+00    0 -1.72958637E+03     4    20   0   276     0   16  1 0 7.7E+01 TTFF
   133  4  1  5.4E-02     0     0     0 6.6E-01  0.0E+00    0 -1.73002270E+03     4    20   0   278     0   16  1 0 6.8E+01 TTFF
   134  4  1  8.9E-02     0     0     0 1.5E+00  0.0E+00    0 -1.73012839E+03     4    20   0   280     0   16  1 0 6.6E+01 TTFF
   135  4  1  9.0E-02     0     0     0 3.3E+00  0.0E+00    0 -1.73023597E+03     4    20   0   282     0   16  1 0 5.0E+01 TTFF
   136  4  1  1.2E-01     0     0     0 1.4E+01  0.0E+00    0 -1.73115975E+03     4    20   0   285     0   16  1 0 1.1E+02 FTFF
   137  4  1  1.1E-01     0    82     0 7.5E-02  2.9E+00    0 -1.73126170E+03     4    20   0   286     0   15  0 0 5.2E+01 TTFF
   138  4  1  1.4E-01     0     0     0 2.3E+00  0.0E+00    0 -1.73272036E+03     4    20   0   289     0   15  1 0 5.8E+01 FTFF
   139  4  1  9.5E-02     0     0     0 1.6E+00  0.0E+00    0 -1.73308254E+03     4    20   0   291     0   15  1 0 5.9E+01 TTFF
   140  4  1  5.7E-02     0     0     0 1.4E+00  0.0E+00    0 -1.73314085E+03     4    20   0   293     0   15  1 0 4.0E+01 TTFF
   141  4  1  5.2E-02     0     0     0 1.6E+00  0.0E+00    0 -1.73317011E+03     4    20   0   295     0   15  1 0 2.3E+01 TTFF
   142  4  1  6.9E-02     0     0     0 7.0E+00  0.0E+00    0 -1.73332256E+03     4    20   0   298     0   15  1 0 2.6E+01 TTFF
   143  4  1  2.8E-02     0     0     0 2.1E+00  0.0E+00    0 -1.73348923E+03     4    20   0   300     0   15  1 0 2.0E+01 TTTF
   144  3  1  1.4E-01   109     0     0 1.5E+00  0.0E+00    0 -1.73355885E+03     4    20   0   302     0   16  1 0 1.8E+02 TTFF
   145  4  1  1.1E-01     0     0     0 2.4E+00  0.0E+00    0 -1.73359537E+03     4    20   0   304     0   16  1 0 3.8E+01 TTFF
   146  4  1  6.3E-02     0     0     0 7.3E+00  0.0E+00    0 -1.73379014E+03     4    20   0   307     0   16  1 0 1.4E+01 TTTF
   147  4  1  2.6E-02    -7     0     0 2.3E+00  0.0E+00    0 -1.73396491E+03     4    20   0   309     0   16  1 0 1.6E+01 TTTF
   148  3  1 -6.4E-02     7     0     0 1.3E+00  0.0E+00    0 -1.73398674E+03     4    20   0   311     0   17  1 0 2.2E+02 TTTF
   149  3  1 -4.3E-02    73     0     0 2.6E+00  0.0E+00    0 -1.73399315E+03     4    20   0   313     0   18  1 0 1.6E+02 TTTF
   150  4  1  2.7E-02     0     0     0 1.5E+01  0.0E+00    0 -1.73404526E+03     4    20   0   316     0   18  1 0 1.4E+02 TTFF
   151  4  1  3.8E-02     0     0     0 4.4E+00  0.0E+00    0 -1.73418378E+03     4    20   0   318     0   18  1 0 1.4E+02 TTFF
   152  4  1  5.7E-02     0     0     0 1.5E+00  0.0E+00    0 -1.73422388E+03     4    20   0   320     0   18  1 0 1.3E+02 TTFF
   153  4  1  3.9E-02     0     0     0 4.3E+00  0.0E+00    0 -1.73424171E+03     4    20   0   322     0   18  1 0 3.0E+01 TTFF
   154  4  1  1.1E-01     0     0     0 2.4E+01  0.0E+00    0 -1.73443892E+03     4    20   0   325     0   18  1 0 3.1E+01 TTFF
   155  4  1  1.0E-01     0    26    28 1.0E+00  1.0E+00    0 -1.73474339E+03     4    20   0   327     0   17  1 1 1.9E+01 TTFF
   156  4  1  1.9E-02     0     0     0 1.2E+00  0.0E+00    0 -1.73525497E+03     4    20   0   329     0   17  1 0 2.2E+01 TTTF
   157  4  1  1.0E-02    -6     0     0 1.3E+00  0.0E+00    0 -1.73528621E+03     4    20   0   331     0   17  1 0 2.2E+01 TTTF
   158  3  1 -2.8E-02    82     0     0 1.3E+00  0.0E+00    0 -1.73529128E+03     4    20   0   333     0   18  1 0 2.9E+02 TTFF
   159  4  1  2.4E-02     0     0     0 3.8E+00  0.0E+00    0 -1.73529279E+03     4    20   0   335     0   18  1 0 6.1E+01 TTFF
   160  4  1  1.4E-02     0     0     0 7.6E+00  0.0E+00    0 -1.73529926E+03     4    20   0   338     0   18  1 0 2.1E+01 TTFF

   Itn ph pp     rg    +sbs  -sbs   -bs  step    pivot   ninf  sinf,objective     L     U ncp  nobj  ncon  nsb Hmod cond(H) conv
   161  4  1  8.7E-03     0    73    71 4.0E+00  1.0E+00    0 -1.73532490E+03     4    20   0   340     0   17  1 1 9.6E+00 TTTF
   162  3  1 -3.5E-02     6     0     0 1.5E+00  0.0E+00    0 -1.73533264E+03     4    20   0   342     0   18  1 0 1.3E+02 TTFF
   163  4  1  2.9E-02     0     0     0 4.4E+00  0.0E+00    0 -1.73533613E+03     4    20   0   344     0   18  1 0 2.1E+01 TTFF
   164  4  1  2.1E-02     0     0     0 2.3E+01  0.0E+00    0 -1.73538322E+03     4    20   0   347     0   18  1 0 9.8E+00 TTFF
   165  4  1  3.0E-02     0     0     0 5.0E+00  0.0E+00    0 -1.73552254E+03     4    20   0   349     0   18  1 0 2.1E+01 TTFF
   166  4  1  1.2E-02     0     0     0 1.0E+00  0.0E+00    0 -1.73556095E+03     4    20   0   350     0   18  1 0 2.2E+01 TTTF
tolrg  reduced to  1.165E-03      lvltol = 1
   167  4  1  2.2E-03     0     0     0 1.0E+00  0.0E+00    0 -1.73556921E+03     4    20   0   351     0   18  1 0 2.2E+01 TTFF
   168  4  1  1.2E-03     0     0     0 7.7E-01  0.0E+00    0 -1.73556953E+03     4    20   0   353     0   18  1 0 2.1E+01 TTFF
   169  4  1  8.7E-05     0     0     0 1.0E+00  0.0E+00    0 -1.73556958E+03     4    20   0   354     0   18  1 0 2.0E+01 TTTT
tolrg  reduced to  8.704E-06      lvltol = 1
   170  4  1  3.7E-05     0     0     0 1.0E+00  0.0E+00    0 -1.73556958E+03     4    20   0   355     0   18  1 0 1.7E+01 TTFF
   171  4  1  9.4E-06     0     0     0 1.0E+00  0.0E+00    0 -1.73556958E+03     4    20   0   356     0   18  1 0 1.7E+01 TTFF
   172  4  1  1.6E-06     0     0     0 1.2E+00  0.0E+00    0 -1.73556958E+03     4    20   0   358     0   18  1 0 1.7E+01 TTTF
tolrg  reduced to  1.000E-06      lvltol = 2
   173  4  1  2.4E-07     0     0     0 1.0E+00  0.0E+00    0 -1.73556958E+03     4    20   0   359     0   18  1 0 1.7E+01 TTTF

Biggest dj =  3.583E-03 (variable     25)   norm rg =  2.369E-07   norm pi =  1.000E+00


EXIT -- optimal solution found

NEW BASIS file saved on file  11    itn =    173

Problem name                 WEAPON A
No. of iterations                173   Objective value     -1.7355695799E+03
No. of major iterations            1   Linear objective     0.0000000000E+00
Penalty parameter           1.000000   Nonlinear objective -1.7355695799E+03
No. of calls to funobj            359   No. of calls to funcon              0
No. of superbasics                 18   No. of basic nonlinears            10
No. of degenerate steps             2   Percentage                       1.16
Max x                      26 1.0E+02   Max pi                      2 2.2E-01
Max Primal infeas          26 4.9E-11   Max Dual infeas           109 2.4E-07
```

```
 NAME          WEAPON A              OBJECTIVE VALUE      -1.7355695799E+03

 STATUS        OPTIMAL SOLN          ITERATION    173    SUPERBASICS     18

 OBJECTIVE               (Min)
 RHS           B
 RANGES
 BOUNDS

 SECTION 1 - ROWS

  NUMBER  ...ROW.. STATE  ...ACTIVITY...  SLACK ACTIVITY  ..LOWER LIMIT.  ..UPPER LIMIT.  .DUAL ACTIVITY    ..I

     101  L1         UL       200.00000          .              None        200.00000        -0.05993      1
     102  L2         UL       100.00000          .              None        100.00000        -0.21769      2
     103  L3         UL       300.00000          .              None        300.00000        -0.06871      3
     104  L4         UL       150.00000          .              None        150.00000        -0.12358      4
     105  L5         UL       250.00000          .              None        250.00000        -0.07229      5
     106  G6         BS        50.81546      -20.81546        30.00000          None             .          6
     107  G7         LL       100.00000          .           100.00000          None          0.05993      7
     108  G8        SBS        51.13230      -11.13230        40.00000          None          0.00000      8
     109  G9        SBS        58.82376       -8.82376        50.00000          None          0.00000      9
     110  G10        LL        70.00000          .            70.00000          None          0.02700     10
     111  G11       SBS        41.28109       -6.28109        35.00000          None          0.00000     11
     112  G12        BS        62.41429      -52.41429        10.00000          None             .        12
1

 SECTION 2 - COLUMNS

  NUMBER  .COLUMN. STATE  ...ACTIVITY...  .OBJ GRADIENT.  ..LOWER LIMIT.  ..UPPER LIMIT.  REDUCED GRADNT    M+J

       1  X011       LL          .              .              .          100.00000          0.05993     13
       2  X012       LL          .           -0.15116          .          100.00000          0.06653     14
       3  X013       LL          .           -0.03539          .          100.00000          0.03332     15
       4  X014       LL          .              .              .          100.00000          0.12358     16
       5  X015      SBS        50.81546       -0.07229          .          100.00000          0.00000     17
       6  X021      SBS        13.51646       -0.05993          .          100.00000          0.00000     18
       7  X022      SBS         1.36046       -0.21769          .          100.00000          0.00000     19
       8  X023       LL          .           -0.05993          .          100.00000          0.00878     20
       9  X024       LL          .              .              .          100.00000          0.12358     21
      10  X025       BS        45.40820       -0.07229          .          100.00000             .        22
      11  X031       LL          .              .              .          100.00000          0.05993     23
      12  X032       LL          .           -0.14090          .          100.00000          0.07679     24
      13  X033       LL          .           -0.03539          .          100.00000          0.03332     25
      14  X034       LL          .              .              .          100.00000          0.12358     26
      15  X035      SBS        48.62885       -0.07229          .          100.00000          0.00000     27
      16  X041       LL          .              .              .          100.00000          0.05993     28
      17  X042      SBS        23.48953       -0.21769          .          100.00000          0.00000     29
      18  X043       LL          .           -0.05097          .          100.00000          0.01774     30
      19  X044       LL          .              .              .          100.00000          0.12358     31
      20  X045       LL          .           -0.06404          .          100.00000          0.00825     32
      21  X051       LL          .              .              .          100.00000          0.05993     33
      22  X052      SBS        20.89961       -0.21769          .          100.00000          0.00000     34
      23  X053       LL          .           -0.05468          .          100.00000          0.01403     35
      24  X054       LL          .              .              .          100.00000          0.12358     36
      25  X055       LL          .           -0.06871          .          100.00000          0.00358     37
      26  X061     D BS        100.00000        0.00000          .          100.00000          0.00000     38
      27  X062       LL          .            0.00000          .          100.00000          0.15777     39
      28  X063       LL          .            0.00000          .          100.00000          0.00878     40
      29  X064       LL          .              .              .          100.00000          0.06366     41
      30  X065       LL          .            0.00000          .          100.00000          0.01236     42
      31  X071      SBS        39.10004       -0.05993          .          100.00000          0.00000     43
      32  X072       LL          .           -0.11985          .          100.00000          0.09784     44
      33  X073       LL          .           -0.04743          .          100.00000          0.02128     45
      34  X074       LL          .              .              .          100.00000          0.12358     46
      35  X075       LL          .           -0.01149          .          100.00000          0.06080     47
      36  X081      SBS        27.06673       -0.05993          .          100.00000          0.00000     48
      37  X082       LL          .           -0.07318          .          100.00000          0.14452     49
      38  X083       LL          .           -0.03478          .          100.00000          0.03393     50
      39  X084       LL          .              .              .          100.00000          0.12358     51
      40  X085       LL          .              .              .          100.00000          0.07229     52
      41  X091       BS        20.31677       -0.05993          .          100.00000             .        53
      42  X092       LL          .           -0.05993          .          100.00000          0.15777     54
      43  X093       LL          .           -0.02239          .          100.00000          0.04631     55
      44  X094       LL          .              .              .          100.00000          0.12358     56
      45  X095       LL          .              .              .          100.00000          0.07229     57
      46  X101       LL          .              .              .          100.00000          0.05993     58
      47  X102       LL          .           -0.10348          .          100.00000          0.11421     59
      48  X103       LL          .           -0.03519          .          100.00000          0.03351     60
      49  X104       LL          .           -0.02801          .          100.00000          0.09558     61
      50  X105       BS        51.13230       -0.07229          .          100.00000             .        62
      51  X111       LL          .              .              .          100.00000          0.05993     63
      52  X112       LL          .              .              .          100.00000          0.21769     64
      53  X113       LL          .           -0.01317          .          100.00000          0.05554     65
      54  X114      SBS        33.19737       -0.12358          .          100.00000          0.00000     66
      55  X115       LL          .           -0.06721          .          100.00000          0.00508     67
      56  X121       LL          .              .              .          100.00000          0.05993     68
      57  X122       LL          .           -0.02994          .          100.00000          0.18775     69
      58  X123       LL          .           -0.02994          .          100.00000          0.03876     70
      59  X124       BS        40.93424       -0.12358          .          100.00000             .        71
      60  X125       LL          .           -0.06050          .          100.00000          0.01179     72
```

```
     61  X131        LL          .              .              .            100.00000        0.05993     73
     62  X132        LL          .              .              .            100.00000        0.21769     74
     63  X133        LL          .           -0.00770          .            100.00000        0.06100     75
     64  X134        LL          .           -0.07229          .            100.00000        0.05129     76
     65  X135       SBS        54.01520       -0.07229          .            100.00000        0.00000     77
     66  X141        LL          .              .              .            100.00000        0.05993     78
     67  X142        LL          .           -0.18947          .            100.00000        0.02823     79
     68  X143        LL          .           -0.02994          .            100.00000        0.03876     80
     69  X144        BS         58.82376       -0.12358          .            100.00000         .          81
     70  X145        LL          .           -0.02994          .            100.00000        0.04235     82
     71  X151        LL          .              .              .            100.00000        0.03293     83
     72  X152        BS         26.21118       -0.19070          .            100.00000         .          84
     73  X153        BS         43.78882       -0.04171          .            100.00000         .          85
     74  X154        LL          .           -0.02766          .            100.00000        0.06892     86
     75  X155        LL          .           -0.01376          .            100.00000        0.03153     87
     76  X161        LL          .              .              .            100.00000        0.05993     88
     77  X162       SBS        24.23646       -0.21769          .            100.00000        0.00000     89
     78  X163        LL          .           -0.03440          .            100.00000        0.03430     90
     79  X164        BS         17.04463       -0.12358          .            100.00000         .          91
     80  X165        LL          .           -0.01712          .            100.00000        0.05518     92
     81  X171        LL          .              .              .            100.00000        0.05993     93
     82  X172       SBS         3.80275        -0.21769          .            100.00000        0.00000     94
     83  X173       SBS        72.03384       -0.06871          .            100.00000        0.00000     95
     84  X174        LL          .              .              .            100.00000        0.12358     96
     85  X175        LL          .              .              .            100.00000        0.07229     97
     86  X181        LL          .           -0.04227          .            100.00000        0.01766     98
     87  X182        LL          .           -0.14367          .            100.00000        0.07403     99
     88  X183        BS         57.55154       -0.06871          .            100.00000         .         100
     89  X184        LL          .              .              .            100.00000        0.12358    101
     90  X185        LL          .              .              .            100.00000        0.07229    102
     91  X191        LL          .              .              .            100.00000        0.05993    103
     92  X192        LL          .           -0.15387          .            100.00000        0.06383    104
     93  X193       SBS        64.21151       -0.06871          .            100.00000        0.00000    105
     94  X194        LL          .              .              .            100.00000        0.12358    106
     95  X195        LL          .              .              .            100.00000        0.07229    107
     96  X201        LL          .              .              .            100.00000        0.05993    108
     97  X202        LL          .           -0.13392          .            100.00000        0.08378    109
     98  X203       SBS        62.41429       -0.06871          .            100.00000        0.00000    110
     99  X204        LL          .              .              .            100.00000        0.12358    111
    100  X205        LL          .              .              .            100.00000        0.07229    112

funobj called with nstate =   2

Time for MPS input                          0.00 seconds
Time for solving problem                    0.01 seconds
Time for solution output                    0.01 seconds
Time for constraint functions               0.00 seconds
Time for objective function                 0.01 seconds
Endrun
```

3 SNOPT – Weapon Assignment Problem

```
       ==============================
       S N O P T  7.2-5    (May 2007)
       ==============================

SPECS file
----------

     Begin t5weapon   (Weapon Assignment Problem)

     *  MPS   input data----------------------

        Problem number               1115
        MPS file                       10
        Rows                           20
        Columns                       200
        Elements                      200
        Upper bound                   100.0
        Nonlinear Objective variables  100

     *  SNOPT input data----------------------

        Minimize
        Superbasics limit               80
        NEW BASIS file                  11
        Iterations                    1000
        Print level                      0
        Solution                       Yes
     End

SNSPEC EXIT 100 -- finished successfully
SNSPEC INFO 101 -- SPECS file read


MPS Input Data
==============
MPS file ..............       10
Row limit..............       20       Problem Number.........      1115       Lower bound default....  0.00E+00
Column limit...........      200       List limit.............         0       Upper bound default....  1.00E+02
Elements limit ........      200       Error message limit....        10       Aij tolerance..........  1.00E-10


MPS file
--------
     1    NAME          WEAPON ASSIGNMENT PROBLEM
     2    ROWS
    15    COLUMNS
===>  Warning - no linear objective selected
   116    RHS
   125    BOUNDS
   126    ENDATA

Names selected
--------------
Objective               (Min)       0
RHS            B                   12
RANGES                              0
BOUNDS                              0

Length of row-name hash table          2003
Collisions during table lookup            0
No. of INITIAL  bounds  specified         0
No. of superbasics specified              0


MPSinp EXIT 100 -- finished successfully
MPSinp INFO 103 -- MPS file read


Parameters
==========

Files
-----
Solution file..........         0       Old basis file ........         0       Standard input.........         5
Insert file............         0       New basis file ........        11       (Printer)..............         9
Punch file.............         0       Backup basis file......         0       (Specs file)...........         4
Load file..............         0       Dump file..............         0       Standard output........         6

Frequencies
-----------
Print frequency........       100       Check frequency........        60       Save new basis map.....       100
Summary frequency......       100       Factorization frequency        50       Expand frequency.......     10000

QP subproblems
--------------
QPsolver Cholesky......
Scale tolerance........     0.900       Minor feasibility tol..  1.00E-06       Iteration limit........      1000
Scale option...........         0       Minor optimality  tol..  1.00E-06       Minor print level......         0
Crash tolerance........     0.100       Pivot tolerance........  3.25E-11       Partial price..........         1
Crash option...........         3       Elastic weight.........  1.00E+00       Prtl price section ( A)       100
```

```
                                   New superbasics........        99       Prtl price section (-I)        12

The SQP Method
--------------
Minimize.....................      Cold start.............                 Proximal Point method..         1
Nonlinear objectiv vars       100  Major optimality tol...  2.00E-06       Function precision.....  3.00E-13
Unbounded step size....  1.00E+20  Superbasics limit......        80       Difference interval....  5.48E-07
Unbounded objective....  1.00E+15  Reduced Hessian dim....        80       Central difference int.  6.70E-05
Major step limit.......  2.00E+00  Derivative linesearch..                 Derivative level.......         3
Major iterations limit.      1000  Linesearch tolerance...   0.90000       Verify level...........         0
Minor iterations limit.       500  Penalty parameter......  0.00E+00       Major Print Level......         1

Hessian Approximation
---------------------
Limited-Memory Hessian.           Hessian updates........        10       Hessian frequency......  99999999
                                                                          Hessian flush..........  99999999

Miscellaneous
-------------
LU factor tolerance....      3.99  LU singularity tol.....  3.25E-11       Timing level...........         3
LU update tolerance....      3.99  LU swap tolerance......  1.22E-04       Debug level............         0
LU partial  pivoting...            eps (machine precision)  2.22E-16       System information.....        No


Matrix statistics
-----------------
               Total      Normal        Free       Fixed     Bounded
Rows              12          12           0           0           0
Columns          100           0           0           0         100

No. of matrix elements                 135     Density      11.250
Biggest                          1.0000E+00  (excluding fixed columns,
Smallest                         1.0000E+00   free rows, and RHS)

No. of objective coefficients            0

Nonlinear constraints       0     Linear constraints      12
Nonlinear variables       100     Linear variables         0
Jacobian  variables         0     Objective variables    100
Total constraints          12     Total variables        100


The user has defined     100   out of     100   objective  gradients.

Cheap test of user-supplied problem derivatives...

The objective  gradients seem to be OK.

Gradient projected in one direction  -4.03125705174E+00
Difference approximation             -4.03125603274E+00


  Itns Major Minors    Step   nObj Feasible  Optimal      Objective     L+U BSwap     nS  condHz
    64     0     57             1           8.5E-01 -1.8180449E+02      21          55 2.8E+01 _  r
    65     1      1 2.9E-01      2           8.3E-01 -2.5194798E+02      21          55 2.8E+01 _n rl
    76     2     11 2.9E-01      3           2.8E+00 -3.1666166E+02      21          61 3.0E+01 _s  l
    81     3      5 1.0E+00      4           4.5E+00 -1.1872383E+03      21          63 1.8E+01 _
    83     4      2 1.0E+00      5           2.4E+00 -1.4313221E+03      21          62 1.9E+01 _
    85     5      2 1.0E+00      6           9.1E-01 -1.5918066E+03      23          61 1.6E+01 _
    89     6      4 1.0E+00      7           4.6E-01 -1.6459306E+03      25          62 2.2E+01 _

NEW BASIS file saved on file  11    itn =    100
   107     7     18 1.0E+00      8           4.1E-01 -1.6528545E+03      24          71 1.7E+02 _
   109     8      2 1.0E+00      9           3.1E-01 -1.6723432E+03      26          70 1.5E+02 _
   115     9      6 1.0E+00     10           2.2E-01 -1.6897391E+03      26          73 1.6E+02 _
   132    10     17 1.0E+00     11           2.2E-01 -1.6919696E+03      26          60 2.1E+01 _
   137    11      5 1.0E+00     12           2.6E-01 -1.6944559E+03      26          56 2.6E+01 _
   139    12      2 1.0E+00     13           1.2E-01 -1.7029722E+03      26          57 2.1E+01 _  R
   153    13     14 3.3E+00     15           1.1E-01 -1.7039206E+03      28          44 1.0E+01 _s
   158    14      5 1.0E+00     16           1.3E-01 -1.7211669E+03      28          42 9.9E+00 _
   165    15      7 1.0E+00     17           1.5E-01 -1.7247438E+03      29          37 6.1E+00 _
   168    16      3 1.0E+00     18           9.0E-02 -1.7273860E+03      29          37 6.1E+00 _
   173    17      5 1.0E+00     19           8.3E-02 -1.7294380E+03      29          33 6.2E+00 _
   175    18      2 1.0E+00     20           2.9E-02 -1.7315917E+03      31          32 5.6E+00 _
   177    19      2 1.0E+00     21           1.4E-02 -1.7322578E+03      31          31 6.2E+00 _

  Itns Major Minors    Step   nObj Feasible  Optimal      Objective     L+U BSwap     nS  condHz
   178    20      1 1.0E+00     22           1.8E-02 -1.7326914E+03      31          31 6.0E+00 _
   180    21      2 1.0E+00     23           4.0E-02 -1.7331862E+03      31          30 5.8E+00 _
   184    22      4 1.0E+00     24           3.8E-02 -1.7338590E+03      33          27 3.7E+00 _
   185    23      1 1.0E+00     25           1.7E-02 -1.7343597E+03      33          27 4.6E+00 _  R
   186    24      1 1.0E+00     26           1.0E-02 -1.7345145E+03      33          27 5.3E+00 _s
   188    25      2 1.0E+00     27           1.3E-02 -1.7347505E+03      33          26 5.8E+00 _
   191    26      3 1.0E+00     28           1.9E-02 -1.7349531E+03      35          24 5.1E+00 _
   194    27      3 1.0E+00     29           1.3E-02 -1.7350896E+03      35          22 5.2E+00 _
   196    28      2 1.0E+00     30           1.2E-02 -1.7351809E+03      35          21 4.9E+00 _
   197    29      1 1.0E+00     31           1.1E-02 -1.7351929E+03      35          21 5.1E+00 _
   198    30      1 1.0E+00     32           3.3E-03 -1.7352118E+03      35          21 4.8E+00 _
   199    31      1 1.0E+00     33           1.6E-03 -1.7352189E+03      35          21 6.2E+00 _

NEW BASIS file saved on file  11    itn =    200
   200    32      1 1.0E+00     34           7.7E-03 -1.7352364E+03      35          21 9.0E+00 _
```

```
   202    33      2 1.0E+00     35           1.1E-02 -1.7352728E+03      35          20 1.1E+01 _
   205    34      3 1.0E+00     36           1.3E-02 -1.7353469E+03      35          22 6.8E+00 _  R
   207    35      2 1.0E+00     37           5.1E-03 -1.7353811E+03      35          21 6.7E+00 _s
   208    36      1 1.0E+00     38           4.1E-03 -1.7354025E+03      35          21 6.8E+00 _
   209    37      1 1.0E+00     39           1.7E-03 -1.7354153E+03      35          21 7.0E+00 _
   210    38      1 1.0E+00     40           2.2E-03 -1.7354256E+03      35          21 8.5E+00 _
   212    39      2 1.0E+00     41           6.3E-03 -1.7354433E+03      35          20 8.2E+00 _

  Itns Major Minors    Step   nObj Feasible  Optimal      Objective     L+U BSwap     nS  condHz
   214    40      2 1.0E+00     42           1.2E-02 -1.7354797E+03      35          19 7.8E+00 _
   217    41      3 1.0E+00     43           7.1E-03 -1.7355232E+03      35          19 1.2E+01 _
   218    42      1 1.0E+00     44           3.1E-03 -1.7355530E+03      35          19 9.8E+00 _
   219    43      1 1.0E+00     45           1.2E-03 -1.7355628E+03      35          19 1.0E+01 _
   221    44      2 1.0E+00     46           2.3E-03 -1.7355670E+03      35          18 8.5E+00 _
   222    45      1 1.0E+00     47           7.0E-04 -1.7355686E+03      35          18 9.9E+00 _  R
   223    46      1 1.0E+00     48           7.0E-04 -1.7355690E+03      35          18 9.3E+00 _s
   224    47      1 1.0E+00     49           4.3E-04 -1.7355693E+03      35          18 9.3E+00 _
   225    48      1 1.0E+00     50           7.9E-04 -1.7355694E+03      35          18 8.9E+00 _
   226    49      1 1.0E+00     51           2.8E-04 -1.7355696E+03      35          18 9.2E+00 _
   227    50      1 1.0E+00     52           3.3E-04 -1.7355696E+03      35          18 7.0E+00 _
   228    51      1 1.0E+00     53           5.0E-05 -1.7355696E+03      35          18 7.2E+00 _
   229    52      1 1.0E+00     54           1.2E-04 -1.7355696E+03      35          18 6.9E+00 _
   230    53      1 1.0E+00     55           1.4E-05 -1.7355696E+03      35          18 7.2E+00 _
   231    54      1 1.0E+00     56           1.3E-05 -1.7355696E+03      35          18 7.2E+00 _
   232    55      1 1.0E+00     57           7.8E-06 -1.7355696E+03      35          18 7.0E+00 _
   233    56      1 1.0E+00     58           3.9E-06 -1.7355696E+03      35          18 1.1E+01 _  R
   234    57      1 1.0E+00     59           3.8E-06 -1.7355696E+03      35          18 9.2E+00 _s
   235    58      1 1.0E+00     60           4.0E-06 -1.7355696E+03      35          18 9.8E+00 _
   236    59      1 4.6E-01     62           2.5E-06 -1.7355696E+03      35          18 7.7E+00 _

  Itns Major Minors    Step   nObj Feasible  Optimal      Objective     L+U BSwap     nS  condHz
   237    60      1 1.0E+00     63          (1.8E-06)-1.7355696E+03      35          18 8.3E+00 _


SNOPTB EXIT   0 -- finished successfully
SNOPTB INFO   1 -- optimality conditions satisfied

NEW BASIS file saved on file  11    itn =    237

Problem name                 WEAPON A
No. of iterations                 237   Objective value     -1.7355695799E+03
No. of major iterations            60   Linear objective     0.0000000000E+00
Penalty parameter           0.000E+00   Nonlinear objective -1.7355695799E+03
No. of calls to funobj             64   No. of calls to funcon              0
No. of superbasics                 18   No. of basic nonlinears            11
No. of degenerate steps            16   Percentage                       6.75
Max x                      26 1.0E+02   Max pi                    2 2.2E-01
Max Primal infeas          26 7.1E-14   Max Dual infeas           72 3.6E-06
```

```
Name            WEAPON A                Objective Value     -1.7355695799E+03

Status          Optimal Soln            Iteration    237    Superbasics    18

Objective               (Min)
RHS             B
Ranges
Bounds

Section 1 - Rows
```

Number	...Row..	State	...Activity...	Slack Activity	..Lower Limit.	..Upper Limit.	.Dual Activity	..i
101	L1	UL	200.00000	.	None	200.00000	-0.05993	1
102	L2	UL	100.00000	.	None	100.00000	-0.21769	2
103	L3	UL	300.00000	.	None	300.00000	-0.06871	3
104	L4	UL	150.00000	.	None	150.00000	-0.12358	4
105	L5	UL	250.00000	.	None	250.00000	-0.07229	5
106	G6	SBS	50.81521	20.81521	30.00000	None	.	6
107	G7	LL	100.00000	.	100.00000	None	0.05993	7
108	G8	SBS	51.13236	11.13236	40.00000	None	0.00000	8
109	G9	SBS	58.82388	8.82388	50.00000	None	.	9
110	G10	LL	70.00000	.	70.00000	None	0.02700	10
111	G11	BS	41.28105	6.28105	35.00000	None	.	11
112	G12	SBS	62.41426	52.41426	10.00000	None	.	12

Section 2 - Columns

Number	.Column.	State	...Activity...	.Obj Gradient.	..Lower Limit.	..Upper Limit.	Reduced Gradnt	m+j
1	X011	LL	.	.	.	100.00000	0.05993	13
2	X012	LL	.	-0.15117	.	100.00000	0.06653	14
3	X013	LL	.	-0.03539	.	100.00000	0.03331	15
4	X014	LL	.	.	.	100.00000	0.12358	16
5	X015	BS	50.81521	-0.07229	.	100.00000	0.00000	17
6	X021	SBS	13.51675	-0.05993	.	100.00000	0.00000	18
7	X022	N SBS	1.36027	-0.21769	.	100.00000	0.00000	19
8	X023	LL	.	-0.05993	.	100.00000	0.00878	20
9	X024	LL	.	.	.	100.00000	0.12358	21
10	X025	N SBS	45.40886	-0.07229	.	100.00000	0.00000	22
11	X031	LL	.	.	.	100.00000	0.05993	23
12	X032	LL	.	-0.14091	.	100.00000	0.07679	24
13	X033	LL	.	-0.03539	.	100.00000	0.03331	25
14	X034	LL	.	.	.	100.00000	0.12358	26
15	X035	BS	48.62859	-0.07229	.	100.00000	0.00000	27
16	X041	LL	.	.	.	100.00000	0.05993	28
17	X042	N SBS	23.48951	-0.21770	.	100.00000	0.00000	29
18	X043	LL	.	-0.05097	.	100.00000	0.01774	30
19	X044	LL	.	.	.	100.00000	0.12358	31
20	X045	LL	.	-0.06404	.	100.00000	0.00825	32
21	X051	LL	.	.	.	100.00000	0.05993	33
22	X052	SBS	20.89970	-0.21769	.	100.00000	0.00000	34
23	X053	LL	.	-0.05468	.	100.00000	0.01403	35
24	X054	LL	.	.	.	100.00000	0.12358	36
25	X055	LL	.	-0.06871	.	100.00000	0.00359	37
26	X061	D BS	100.00000	0.00000	.	100.00000	0.00000	38
27	X062	LL	.	0.00000	.	100.00000	0.15776	39
28	X063	LL	.	0.00000	.	100.00000	0.00878	40
29	X064	LL	.	.	.	100.00000	0.06366	41
30	X065	LL	.	0.00000	.	100.00000	0.01237	42
31	X071	BS	39.09996	-0.05993	.	100.00000	0.00000	43
32	X072	LL	.	-0.11986	.	100.00000	0.09784	44
33	X073	LL	.	-0.04743	.	100.00000	0.02128	45
34	X074	LL	.	.	.	100.00000	0.12358	46
35	X075	LL	.	-0.01149	.	100.00000	0.06080	47
36	X081	SBS	27.06666	-0.05993	.	100.00000	0.00000	48
37	X082	LL	.	-0.07318	.	100.00000	0.14451	49
38	X083	LL	.	-0.03478	.	100.00000	0.03393	50
39	X084	LL	.	.	.	100.00000	0.12358	51
40	X085	LL	.	.	.	100.00000	0.07229	52
41	X091	SBS	20.31662	-0.05993	.	100.00000	0.00000	53
42	X092	LL	.	-0.05993	.	100.00000	0.15776	54
43	X093	LL	.	-0.02239	.	100.00000	0.04631	55
44	X094	LL	.	.	.	100.00000	0.12358	56
45	X095	LL	.	.	.	100.00000	0.07229	57
46	X101	LL	.	.	.	100.00000	0.05993	58
47	X102	LL	.	-0.10348	.	100.00000	0.11421	59
48	X103	LL	.	-0.03519	.	100.00000	0.03351	60
49	X104	LL	.	-0.02801	.	100.00000	0.09558	61
50	X105	BS	51.13236	-0.07229	.	100.00000	0.00000	62
51	X111	LL	.	.	.	100.00000	0.05993	63
52	X112	LL	.	.	.	100.00000	0.21769	64
53	X113	LL	.	-0.01317	.	100.00000	0.05554	65
54	X114	SBS	33.19739	-0.12358	.	100.00000	0.00000	66
55	X115	LL	.	-0.06721	.	100.00000	0.00508	67
56	X121	LL	.	.	.	100.00000	0.05993	68
57	X122	LL	.	-0.02994	.	100.00000	0.18775	69
58	X123	LL	.	-0.02994	.	100.00000	0.03876	70
59	X124	SBS	40.93424	-0.12358	.	100.00000	0.00000	71
60	X125	LL	.	-0.06050	.	100.00000	0.01179	72

61	X131		LL	.	.	.	100.00000	0.05993	73
62	X132		LL	.	.	.	100.00000	0.21769	74
63	X133		LL	.	-0.00770	.	100.00000	0.06100	75
64	X134		LL	.	-0.07229	.	100.00000	0.05129	76
65	X135		SBS	54.01498	-0.07229	.	100.00000	0.00000	77
66	X141		LL	.	.	.	100.00000	0.05993	78
67	X142		LL	.	-0.18947	.	100.00000	0.02823	79
68	X143		LL	.	-0.02994	.	100.00000	0.03876	80
69	X144		BS	58.82388	-0.12358	.	100.00000	0.00000	81
70	X145		LL	.	-0.02994	.	100.00000	0.04235	82
71	X151		LL	.	.	.	100.00000	0.03293	83
72	X152		BS	26.21108	-0.19070	.	100.00000	0.00000	84
73	X153		BS	43.78892	-0.04171	.	100.00000	0.00000	85
74	X154		LL	.	-0.02766	.	100.00000	0.06892	86
75	X155		LL	.	-0.01376	.	100.00000	0.03153	87
76	X161		LL	.	.	.	100.00000	0.05993	88
77	X162		SBS	24.23656	-0.21769	.	100.00000	0.00000	89
78	X163		LL	.	-0.03440	.	100.00000	0.03430	90
79	X164		BS	17.04449	-0.12358	.	100.00000	0.00000	91
80	X165		LL	.	-0.01712	.	100.00000	0.05518	92
81	X171		LL	.	.	.	100.00000	0.05993	93
82	X172	N	SBS	3.80288	-0.21769	.	100.00000	0.00000	94
83	X173		SBS	72.03389	-0.06871	.	100.00000	0.00000	95
84	X174		LL	.	.	.	100.00000	0.12358	96
85	X175		LL	.	.	.	100.00000	0.07229	97
86	X181		LL	.	-0.04227	.	100.00000	0.01766	98
87	X182		LL	.	-0.14367	.	100.00000	0.07402	99
88	X183		BS	57.55143	-0.06871	.	100.00000	0.00000	100
89	X184		LL	.	.	.	100.00000	0.12358	101
90	X185		LL	.	.	.	100.00000	0.07229	102
91	X191		LL	.	.	.	100.00000	0.05993	103
92	X192		LL	.	-0.15387	.	100.00000	0.06383	104
93	X193		SBS	64.21150	-0.06871	.	100.00000	0.00000	105
94	X194		LL	.	.	.	100.00000	0.12358	106
95	X195		LL	.	.	.	100.00000	0.07229	107
96	X201		LL	.	.	.	100.00000	0.05993	108
97	X202		LL	.	-0.13392	.	100.00000	0.08377	109
98	X203		BS	62.41426	-0.06871	.	100.00000	0.00000	110
99	X204		LL	.	.	.	100.00000	0.12358	111
100	X205		LL	.	.	.	100.00000	0.07229	112

```
Time for MPS input                          0.00 seconds
Time for solving problem                    0.01 seconds
Time for solution output                    0.00 seconds
Time for constraint functions               0.00 seconds
Time for objective function                 0.00 seconds
```

4 Spring Optimal Control Problem

```
*     ------------------------------------------------------------------
*     File springb.f for snOptB
*
*     This is a main program to generate an optimal control problem
*     of arbitrary size and solve it by calling SNOPT as a subroutine.
*
*     The problem size depends on a parameter T.  There are
*     2T constraints and 3T + 2 variables, as well as bounds
*     on the variables.  The first T constraints are quadratic in
*     T + 1 variables, and the objective function is quadratic in
*     T + 1 other variables.
*
*     The control problem models a spring, mass and damper system.
*     It is of the form
*
*    ------------------------------------------------------------------
*    | minimize    1/2 sum x(t)**2   (t = 0 to T)                       |
*    |                                                                  |
*    | subject to                                                       |
*    |     y(t+1)  =  y(t)  -  0.01 y(t)**2  -  0.004 x(t)  +  0.2 u(t) |
*    |                                                                  |
*    |     x(t+1)  =  x(t)  +  0.2  y(t),                               |
*    |                                                                  |
*    |     y(t)   >=  -1,     -0.2  <=  u(t)  <=  0.2,                  |
*    |                                                                  |
*    |                (all for t = 0 to T-1)                            |
*    | and                                                              |
*    |     y(0)    =   0,      y(T)  =  0,       x(0) = 10.             |
*    ------------------------------------------------------------------
*
*     For large enough T (e.g. T >= 90), the optimal objective value
*     is about 1186.382.
*
*     This model with T = 100 was used as test problem 5.11 in
*     B. A. Murtagh and M. A. Saunders (1982), A projected Lagrangian
*     algorithm and its implementation for sparse nonlinear constraints,
*     Mathematical Programming Study 16, 84--117.
*
*     14 Nov 1994: First version of spring.f, derived from manne.f.
*     26 Sep 1997: Updated for SNOPT 5.3.
*     15 Dec 2004: Current version.
*     ------------------------------------------------------------------
      program            springb

      implicit
     &     none
      integer
     &     maxT, maxm, maxn, maxne, nName
      parameter
     &   ( maxT   = 2000,
     &     maxm   = 2*maxT,
     &     maxn   = 3*maxT + 2,
     &     maxne  = 7*maxT,
     &     nName  = 1 )

      character
     &     ProbNm*8, Names(nName)*8
      integer
     &     indA(maxne) , hs(maxm+maxn), locA(maxn+1)
      double precision
     &     Acol(maxne) , bl(maxm+maxn), bu(maxm+maxn),
     &     x(maxm+maxn), pi(maxm)     , rc(maxm+maxn)

*     ------------------------------------------------------------------
*     USER workspace (none required)
```

```
      integer
     &     lenru, leniu, lencu
      parameter
     &   (  lenru = 1,
     &      leniu = 1,
     &      lencu = 1)
      integer
     &     iu(leniu)
      double precision
     &     ru(lenru)
      character
     &     cu(lencu)*8
*     ------------------------------------------------------------------
*     SNOPT workspace

      integer
     &     lenrw, leniw, lencw
      parameter
     &   (  lenrw = 1000000,
     &      leniw =  500000,
     &      lencw =     500)
      integer
     &     iw(leniw)
      double precision
     &     rw(lenrw)
      character
     &     cw(lencw)*8
*     ------------------------------------------------------------------
      logical
     &     byname
      character
     &     lfile*20
      integer
     &     Errors, INFO, iObj, iSpecs, iPrint, iSumm, m, mincw, miniw,
     &     minrw, n, ne, nnCon, nnObj, nnJac, nOut, nS, ninf, T
      double precision
     &     ObjAdd, sinf, Obj
      external
     &     SprCon, SprObj
*     ------------------------------------------------------------------
*     Specify some of the SNOPT files.
*     iSpecs  is the Specs file   (0 if none).
*     iPrint  is the Print file   (0 if none).
*     iSumm   is the Summary file (0 if none).
*     nOut    is an output file used here by the main program.

      iSpecs = 4
      iPrint = 9
      iSumm  = 6
      nOut   = 6

      byname = .true.

      if ( byname ) then

*        Unix and DOS systems.  Open the Specs and print files.

         lfile = 'springb.spc'
         open( iSpecs, file=lfile, status='OLD',     err=800 )

         lfile = 'springb.out'
         open( iPrint, file=lfile, status='UNKNOWN', err=800 )
      end if

*     ------------------------------------------------------------------
*     Set options to their default values.
*     ------------------------------------------------------------------
      call snInit
```

```
     &   ( iPrint, iSumm, cw, lencw, iw, leniw, rw, lenrw )

*     ------------------------------------------------------------------
*     Read a Specs file.  This must include "Problem number  T"
*     for some integer T.
*     ------------------------------------------------------------------
      call snSpec
     &   ( iSpecs, INFO, cw, lencw, iw, leniw, rw, lenrw )

      if (INFO .ne. 101  .and.  INFO .ne. 107) then
         stop
      end if

*     ------------------------------------------------------------------
*     The following call fetches T, which defines the number of
*     nonlinear constraints.
*     It is specified at runtime in the SPECS file.
*     ------------------------------------------------------------------
      Errors = 0

      call snGeti
     &   ( 'Problem number', T, Errors,
     &     cw, lencw, iw, leniw, rw, lenrw )

      if (T .le. 1  .or.  T .gt. maxm/2) then
         write(nOut, *) 'Invalid no. of Nonlinear constraints:', T
         stop
      end if

*     Write T into the problem name.

      write(ProbNm, '(i8)') T
      if      (T .lt.   100) then
         ProbNm(1:6) = 'Spring'
      else if (T .lt.  1000) then
         ProbNm(1:5) = 'Sprng'
      else if (T .lt. 10000) then
         ProbNm(1:4) = 'Spri'
      else
         ProbNm(1:3) = 'Spr'
      end if

      write(nOut, *) 'Spring optimal control problem.    T =', T

*     ------------------------------------------------------------------
*     Generate an T-period problem.
*     ------------------------------------------------------------------
      call spdata
     &   ( T, maxm, maxn, maxne, Errors,
     &     m, n, ne, nnCon, nnObj, nnJac,
     &     Acol, indA, locA, bl, bu, hs, x, pi )

      if (Errors .gt. 0) then
         write(nOut, *) 'Not enough storage to generate a problem ',
     &                  'with  Nonlinear constraints =', T
         stop
      end if

*     ------------------------------------------------------------------
*     Go for it, using a Cold start.
*     iObj   = 0 means there is no linear objective row in Acol(*).
*     Objadd = 0.0 means there is no constant to be added to the
*            objective.
*     hs     need not be set if a basis file is to be input.
*            Otherwise, each hs(1:n) should be 0, 1, 2, 3, 4, or 5.
*            The values are used by the Crash procedure
*            to choose an initial basis B.
*            If hs(j) = 0 or 1, column j is eligible for B.
```

```
*           If hs(j) = 2, column j is initially superbasic (not in B).
*           If hs(j) = 3, column j is eligible for B and is given
*                         preference over columns with hs(j) = 0 or 1.
*           If hs(j) = 4 or 5, column j is initially nonbasic.
*     ------------------------------------------------------------------
      iObj   = 0
      ObjAdd = 0.0d+0

      call snOptB
     &   ( 'Cold', m, n, ne, nName,
     &     nnCon, nnObj, nnJac,
     &     iObj, ObjAdd, ProbNm,
     &     SprCon, SprObj,
     &     Acol, indA, locA, bl, bu, Names,
     &     hs, x, pi, rc,
     &     INFO, mincw, miniw, minrw,
     &     nS, ninf, sinf, Obj,
     &     cu, lencu, iu, leniu, ru, lenru,
     &     cw, lencw, iw, leniw, rw, lenrw )

      if (INFO .eq. 82 .or. INFO .eq. 83 .or. INFO .eq. 84) then
         go to 900
      end if

      write(nOut, *) ' '
      write(nOut, *) 'snOpt finished.'
      write(nOut, *) 'Input  errors =', Errors
      write(nOut, *) 'snOptB INFO   =', INFO
      write(nOut, *) 'nInf          =', nInf
      write(nOut, *) 'sInf          =', sInf
      if (iObj .gt. 0) then
         write(nOut, *)
     &               'Obj          =', ObjAdd + x(n+iObj) + Obj
      else
         write(nOut, *)
     &               'Obj          =', ObjAdd + Obj
      end if
      if (INFO .ge. 30) go to 900
      stop

*     ------------------------------------------------------------------
*     Error exit.
*     ------------------------------------------------------------------
  800 write(nOut, 4000) 'Error while opening file', lfile
      stop

  900 write(nOut, *) ' '
      write(nOut, *) 'STOPPING because of error condition'
      stop

 4000 format(/  a, 2x, a  )

      end ! program springb

*+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

      subroutine spdata
     &   ( T, maxm, maxn, maxne, Errors,
     &     m, n, ne, nnCon, nnObj, nnJac,
     &     Acol, indA, locA, bl, bu, hs, x, pi )

      implicit
     &     none
      integer
     &     Errors, m, maxm, maxn, maxne, n, ne, nnCon, nnObj, nnJac, T,
     &     indA(maxne), hs(maxn+maxm), locA(maxn+1)
      double precision
     &     Acol(maxne)    , bl(maxn+maxm), bu(maxn+maxm),
```

```
     &     x(maxn+maxm), pi(maxm)

*     ------------------------------------------------------------------
*     spdata generates data for the "Spring" optimal control problem.
*     The constraints take the form
*              c(x) + A*x - s = 0,
*     where the Jacobian for c(x) + Ax is stored in Acol(*), and any
*     terms coming from c(x) are in the TOP LEFT-HAND CORNER of Acol(*),
*     with dimensions  nnCon x nnJac.
*     Note that the right-hand side is zero.
*     s is a set of slack variables whose bounds contain any constants
*     that might have formed a right-hand side.
*
*     The objective function is
*             f(x) + d'x
*     where d would be row iobj of A (but there is no such row in
*     this example).  f(x) involves only the FIRST nnObj variables.
*
*     On entry,
*     T       is the number of time periods.
*     maxm, maxn, maxne are upper limits on m, n, ne.
*
*     On exit,
*     Errors  is 0 if there is enough storage, 1 otherwise.
*     m       is the number of nonlinear and linear constraints.
*     n       is the number of variables.
*     ne      is the number of nonzeros in Acol(*).
*     nnCon   is the number of nonlinear constraints (they come first).
*     nnObj   is the number of nonlinear objective variables.
*     nnJac   is the number of nonlinear Jacobian variables.
*     a       is the constraint matrix (Jacobian), stored column-wise.
*     indA      is the list of row indices for each nonzero in Acol(*).
*     locA      is a set of pointers to the beginning of each column of a.
*     bl      is the lower bounds on x and s.
*     bu      is the upper bounds on x and s.
*     hs(1:n) is a set of initial states for each x  (0,1,2,3,4,5).
*     x (1:n) is a set of initial values for x.
*     pi(1:m) is a set of initial values for the dual variables pi.
*
*     14 Nov 1994: First version of spdata.
*     ------------------------------------------------------------------
      integer
     &     i, j, k, nb
*     ------------------------------------------------------------------
      double precision zero,              one
      parameter      ( zero   = 0.0d+0,   one    = 1.0d+0 )
      double precision bplus,             dummy
      parameter      ( bplus  = 1.0d+20,  dummy  = 0.111111d+0 )
*     ------------------------------------------------------------------
*     T defines the dimension of the problem.

      m      = T*2
      n      = T*3 + 2
      nb     = n   + m
      nnCon  = T
      nnObj  = T*2 + 2  ! y(0:T) and x(0:T)
      nnJac  = T   + 1  ! y(0:T)
      ne     = T*7

*     Check if there is enough storage.

      Errors = 0
      if (m      .gt. maxm ) Errors = 1
      if (n      .gt. maxn ) Errors = 1
      if (ne     .gt. maxne) Errors = 1
      if (Errors .gt.   0  ) return

*     ------------------------------------------------------------------
```

```
*     Generate columns for y(t), t = 0 to T.
*     The first T rows are nonlinear, and the next T are linear.
*     The Jacobian is T x (T+1) upper bidiagonal.
*     We generate the sparsity pattern here.
*     We put in dummy numerical values for the nonlinear gradients.
*     The true non-constant values are computed by funcon.
*     ------------------------------------------------------------------
      j      = 0   ! counts the variables
      ne     = 0   ! counts the Jacobian and linear constraint entries

      do   k = 0, T
         j       =   j  + 1
         locA(j) =   ne + 1
         bl(j)   = - one
         bu(j)   =   bplus
         x (j)   = - one
         hs(j)   =   0      ! Make the y(t) nonbasic.

*        There are two Jacobian nonzeros per column,
*        except in the first and last column.

         if (k .gt. 0) then    !  Aij = 1
            ne       =   ne + 1
            indA(ne) =   k
            Acol(ne) =   one
         end if

         if (k .lt. T) then    !  Aij = .02y - 1  (nonlinear)
            ne       =   ne + 1
            indA(ne) =   k  + 1
            Acol(ne) =   dummy
         end if

*        Below the Jacobian the linear constraints are diagonal.

         if (k .lt. T) then
            ne       =   ne + 1
            indA(ne) =   T  + k + 1
            Acol(ne) = - 0.2d+0
         end if
      end do

*     ------------------------------------------------------------------
*     Generate columns for x(t), t = 0 to T.
*     They form 0.004*I in the first T rows,
*     and an upper-bidiagonal in the last T rows.
*     ------------------------------------------------------------------
      do       k = 0, T
         j       =   j  + 1
         locA(j) =   ne + 1
         bl(j)   = - bplus
         bu(j)   =   bplus
         x (j)   =   zero
         hs(j)   =   3     ! Make the x(t) basic.

*        Part of 0.004*I.

         if (k .lt. T) then
            ne       =   ne + 1
            indA(ne) =   k  + 1
            Acol(ne) =   0.004d+0
         end if

*        The bidiagonal parts have two entries
*        except in the first and last columns.

         if (k .gt. 0) then    !  Aij = 1
            ne       =   ne + 1
```

```
            indA(ne) =   T  + k
            Acol(ne) =   one
         end if

         if (k .lt. T) then    !  Aij = - 1
            ne       =   ne + 1
            indA(ne) =   T  + k + 1
            Acol(ne) = - one
         end if
      end do

*     ------------------------------------------------------------------
*     Generate columns for u(t), t = 0 to T-1.
*     They form -0.2I in the first T rows.
*     ------------------------------------------------------------------
      do k = 0, T - 1
         j       =   j  + 1
         locA(j) =   ne + 1
         bl(j)   = - 0.2d+0
         bu(j)   =   0.2d+0
         x (j)   =   zero
         hs(j)   =   3     ! Make the u(t) basic.

         ne       =   ne + 1
         indA(ne) =   k  + 1
         Acol(ne) = - 0.2d+0
      end do

*     locA(*) has one extra element.
*     Some of the variables are fixed.

      locA(n+1) = ne + 1
      bl(1)   = zero      ! y(0) = 0
      bu(1)   = zero
      bl(T+1) = zero      ! y(T) = 0
      bu(T+1) = zero
      bl(T+2) = 10.0d+0   ! x(0) = 10
      bu(T+2) = 10.0d+0

*     ------------------------------------------------------------------
*     Set bounds on the slacks.
*     We don't need to set initial values and states for slacks
*     (assuming SNOPT does a cold start).
*     ------------------------------------------------------------------
      do      j = n + 1, nb
         bl(j)  = zero
         bu(j)  = zero
      end do

*     Initialize pi.
*     SNOPT requires only pi(1:nnCon) to be initialized.
*     We initialize all of pi just in case.

      do       i = 1, T
         pi(i)   =   zero
         pi(T+i) =   zero
      end do

      end ! subroutine spdata

*+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

      subroutine SprObj
     &   ( mode, n, x, f, g, nState,
     &     cu, lencu, iu, leniu, ru, lenru )

      implicit
     &     none
```

```
      integer
     &     lencu, leniu, lenru, mode, n, nState, iu(leniu)
      double precision
     &     f, x(n), g(n), ru(lenru)
      character
     &     cu(lencu)*8
*     ------------------------------------------------------------------
*     This is funobj for problem Spring  (an optimal control problem).
*     ------------------------------------------------------------------
      integer
     &     jy, jx, k, T
      double precision
     &     u
*     ------------------------------------------------------------------
      double precision   zero
      parameter        ( zero = 0.0d+0 )
*     ------------------------------------------------------------------
      T      = (n - 2)/2
      f      = zero
      jy     = 0
      jx     = T + 1

      do k = 0, T
         jy    = jy + 1
         jx    = jx + 1
         u     = x(jx)
         f     = f  +  u**2
         g(jy) = zero
         g(jx) = u
      end do

      f = f / 2.0d+0

      end ! subroutine SprObj

*+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

      subroutine SprCon
     &   ( mode, m, n, njac, x, f, g, nState,
     &     cu, lencu, iu, leniu, ru, lenru )

      implicit
     &     none
      integer
     &     lencu, leniu, lenru, mode, m, n, njac, nState, iu(leniu)
      double precision
     &     x(n), f(m), g(njac), ru(lenru)
      character
     &     cu(lencu)*8

*     ------------------------------------------------------------------
*     This is funcon for problem Spring  (Optimal Control Problem).
*     The Jacobian is upper bidiagonal,
*     and only the diagonal terms are nonlinear.
*     The constant 1's in the Jacobian are not regenerated here.
*     ------------------------------------------------------------------
      integer
     &     i, jg, jy, T
      double precision
     &     yt, ytp1
*     ------------------------------------------------------------------
      double precision   one
      parameter        ( one = 1.0d+0 )
*     ------------------------------------------------------------------
      T     = n - 1
      jy    =     0    ! Counts y(t) variables
      jg    =   - 1    ! Counts nonlinear Jacobian elements
```

```
      do i = 1, T
         jy     = jy + 1
         jg     = jg + 2
         yt     = x(jy)
         ytp1   = x(jy + 1)
         f(i)   = 0.01d+0 * yt**2  +  (ytp1  -  yt)
         g(jg)  = 0.02d+0 * yt               -  one
*--      g(jg+1)= one      ! Constant element set by spdata.
      end do

      end ! subroutine SprCon
```

5 SNOPT – Spring Problem

```
       ==============================
       S N O P T  7.2-5    (May 2007)
       ==============================

SPECS file
----------

     Begin Spring  (optimal control problem)
        Problem number           100  *  The generator uses this to set T

        Major iterations         500
        Minor iterations       10000

     *  Superbasics limit        200  * Set this in spring.f
     *  Iterations              1000  *     ditto

        Major Print level     000001
     *                       (JFLXBT)
        Minor Print level      00001
        Solution                 No
     End   Spring


SNSPEC EXIT 100 -- finished successfully
SNSPEC INFO 101 -- SPECS file read


Parameters
==========

Files
-----
Solution file.........         0      Old basis file ........         0      Standard input.........         5
Insert file...........         0      New basis file ........         0      (Printer)..............         9
Punch file............         0      Backup basis file......         0      (Specs file)...........         4
Load file.............         0      Dump file..............         0      Standard output........         6

Frequencies
-----------
Print frequency........       100      Check frequency........        60      Save new basis map.....       100
Summary frequency......       100      Factorization frequency        50      Expand frequency.......     10000

QP subproblems
--------------
QPsolver Cholesky......
Scale tolerance........     0.900      Minor feasibility tol..  1.00E-06      Iteration limit........     10000
Scale option...........         1      Minor optimality  tol..  1.00E-06      Minor print level......         1
Crash tolerance........     0.100      Pivot tolerance........  3.25E-11      Partial price..........         1
Crash option...........         3      Elastic weight.........  1.00E+04      Prtl price section ( A)       302
                                       New superbasics........        99      Prtl price section (-I)       200

The SQP Method
--------------
Minimize...............                Cold start.............                Proximal Point method..         1
Nonlinear objectiv vars       202      Major optimality tol...  2.00E-06      Function precision.....  3.00E-13
Unbounded step size....  1.00E+20      Superbasics limit......       203      Difference interval....  5.48E-07
Unbounded objective....  1.00E+15      Reduced Hessian dim....       203      Central difference int.  6.70E-05
Major step limit.......  2.00E+00      Derivative linesearch..                Derivative level.......         3
Major iterations limit.       500      Linesearch tolerance...   0.90000      Verify level...........         0
Minor iterations limit.     10000      Penalty parameter......  0.00E+00      Major Print Level......         1

Hessian Approximation
---------------------
Limited-Memory Hessian.               Hessian updates........        10      Hessian frequency......  99999999
                                                                             Hessian flush..........  99999999

Nonlinear constraints
---------------------
Nonlinear constraints..       100      Major feasibility tol..  1.00E-06      Violation limit........  1.00E+06
Nonlinear Jacobian vars       101

Miscellaneous
-------------
LU factor tolerance....      3.99      LU singularity tol.....  3.25E-11      Timing level...........         3
LU update tolerance....      3.99      LU swap tolerance......  1.22E-04      Debug level............         0
LU partial  pivoting...                eps (machine precision)  2.22E-16      System information.....        No



Matrix statistics
-----------------
              Total      Normal        Free       Fixed     Bounded
Rows            200           0           0         200           0
Columns         302           0         100           3         199

No. of matrix elements                 700     Density       1.159
Biggest                          1.0000E+00  (excluding fixed columns,
Smallest                         4.0000E-03   free rows, and RHS)

No. of objective coefficients            0
```

```
Nonlinear constraints     100     Linear constraints     100
Nonlinear variables       202     Linear variables       100
Jacobian  variables       101     Objective variables    202
Total constraints         200     Total variables        302


   Itn       LPmult  LPstep   nInf   SumInf             LPobjective   +SBS   -SBS    -BS    Pivot     L+U ncp
   100              1.8E-01     99  5.1E+01                            301    301                      400


The user has defined     100   out of     200   constraint gradients.
==>  Some constraint derivatives are missing,  assumed constant.

The user has defined     202   out of     202   objective  gradients.

Cheap test of user-supplied problem derivatives...

The constraint gradients seem to be OK.

-->  The largest discrepancy was    8.30E-11  in constraint   383


The objective  gradients seem to be OK.

Gradient projected in one direction   1.00846814396E-03
Difference approximation              1.00882947232E-03


   Itn       LPmult  LPstep   nInf   SumInf             LPobjective   +SBS   -SBS    -BS    Pivot     L+U ncp
   201     -1.8E+01 4.5E-05      1  2.2E+01                            54     54    257 -1.0E+00    1462


  Itns Major Minors    Step   nCon Feasible  Optimal  MeritFunction     L+U BSwap     nS  condHz Penalty
   298     0    197              1  1.5E+00  1.8E+00  2.2627181E+07     810                          _  r i
   310     1     12 1.3E-02      2  1.5E+00  1.7E+00  2.2418464E+07     614            1 1.1E+06         _n rli
   330     2     20 4.7E-02      4  1.5E+00  1.7E+00  2.1643906E+07     768     1      1 1.7E+02         _sM li
   340     3     10 7.9E-01      6  1.6E-01  1.2E+00  4.5598863E+06     661                          _n  li
   395     4     55 1.0E+00      8  3.6E-02  1.3E+00 -4.8371058E+05     868                          _ m
   439     5     44 1.0E+00      9  7.0E-04  5.3E-02  7.6907391E+03     690            2 2.1E+01 2.5E+05 _
   484     6     45 1.0E+00     10  2.8E-04  9.2E-02  1.4926034E+03     860            7 1.8E+03 5.5E+02 _
   507     7     23 1.0E+00     11  6.7E-05  2.8E-02  1.2188541E+03     723            1 2.6E+03 4.0E+01 _
   514     8      7 1.0E+00     12  2.4E-06  8.0E-03  1.2017630E+03     615            3 3.6E+00 1.5E+01 _
   522     9      8 1.0E+00     13 (3.3E-07) 1.2E-02  1.1992743E+03     632            4 1.0E+02 1.5E+01 _
   536    10     14 1.0E+00     14  1.3E-06  9.9E-03  1.1970784E+03     624            4 9.0E+01 1.5E+01 _
   550    11     14 1.0E+00     15  5.7E-06  8.4E-03  1.1936216E+03     604            3 7.3E+01 1.5E+01 _
   560    12     10 1.0E+00     16  1.2E-05  8.1E-03  1.1895660E+03     623            3 1.4E+01 1.5E+01 _
   572    13     12 1.0E+00     17  4.1E-06  9.3E-04  1.1877252E+03     592           14 3.2E+03 1.5E+01 _  R
   587    14     15 1.0E+00     18 (4.7E-08) 8.9E-04  1.1876372E+03     550    14     12 2.9E+03 1.5E+01 _s
   590    15      3 1.0E+00     19  3.6E-05  4.1E-05  1.1863900E+03     571           14 3.9E+03 1.5E+01 _
   592    16      2 1.0E+00     20 (1.1E-07) 4.5E-05  1.1863870E+03     571           13 7.4E+03 1.5E+01 _
   594    17      2 1.0E+00     21 (5.2E-07) 2.3E-05  1.1863836E+03     571           12 7.4E+03 1.5E+01 _
   596    18      2 1.0E+00     22 (3.6E-07) 1.0E-05  1.1863824E+03     571           13 7.0E+03 1.5E+01 _
   598    19      2 1.0E+00     23 (3.7E-08) 8.5E-06  1.1863823E+03     571           14 8.6E+03 1.5E+01 _

  Itns Major Minors    Step   nCon Feasible  Optimal  MeritFunction     L+U BSwap     nS  condHz Penalty
   599    20      1 1.0E+00     24 (1.0E-07) 4.7E-06  1.1863821E+03     571           14 1.2E+04 1.5E+01 _
   601    21      2 1.0E+00     25 (2.6E-08) 3.7E-06  1.1863821E+03     571           13 7.4E+03 1.5E+01 _
   602    22      1 1.0E+00     26 (2.0E-09)(1.4E-06) 1.1863821E+03     571           13 7.4E+03 1.5E+01 _


SNOPTB EXIT   0 -- finished successfully
SNOPTB INFO   1 -- optimality conditions satisfied

Problem name                Sprng100
No. of iterations                602   Objective value      1.1863820520E+03
No. of major iterations           22   Linear objective     0.0000000000E+00
Penalty parameter          1.549E+01   Nonlinear objective  1.1863820520E+03
No. of calls to funobj            27   No. of calls to funcon            27
No. of superbasics                13   No. of basic nonlinears          171
No. of degenerate steps            0   Percentage                      0.00
Max x       (scaled)      102 1.0E+01   Max pi      (scaled)        1 5.8E+02
Max x                     102 1.0E+01   Max pi                      1 5.8E+02
Max Prim inf(scaled)        0 0.0E+00   Max Dual inf(scaled)      194 8.2E-04
Max Primal infeas           0 0.0E+00   Max Dual infeas           194 8.2E-04
Nonlinear constraint violn    4.6E-08

Time for MPS input                          0.00 seconds
Time for solving problem                    0.08 seconds
Time for solution output                    0.00 seconds
Time for constraint functions               0.00 seconds
Time for objective function                 0.00 seconds
```