```
c===========================================================
c     newtsqrt:  Uses Newton's method to find (positive)
c     square root of number supplied on command line, i.e.
c     solves
c
c     f(x) = x^2 - a = 0
c
c     for given 'a'.  Optional second argument specifies
c     convergence criteria (relative dx).
c
c     Tracing output (written to standard error)
c     includes iteration number, estimated root (xn),
c     change in estimate (dxn), log10(dxn), residual and
c     log10(residual).
c===========================================================
      program        newtsqrt

      implicit       none

      integer        iargc
      real*8         r8arg,        drelabs

      real*8         r8_never
      parameter    ( r8_never = -1.0d-60 )
c-----------------------------------------------------------
c     Default convergence tolerance.
c-----------------------------------------------------------
      real*8         default_xtol
      parameter    ( default_xtol = 1.0d-8 )
c-----------------------------------------------------------
c     Maximum allowed number of Newton iterations.
c-----------------------------------------------------------
      integer        mxiter
      parameter    ( mxiter = 50 )
```

```
c-----------------------------------------------------------
c     Command-line arguments (see above).
c-----------------------------------------------------------
      real*8          a,            xtol
c-----------------------------------------------------------
c     Locals used in Newton iteration.
c-----------------------------------------------------------
      integer         iter
      real*8          xn,           resn,           dxn

c-----------------------------------------------------------
c     Argument parsing.
c-----------------------------------------------------------
      if( iargc() .lt. 1 ) go to 900
      a     = r8arg(1,r8_never)
      if( a .eq. r8_never .or. a .lt. 0.0d0 ) go to 900
      xtol  = r8arg(2,1.0d-8)
      if( xtol .le. 0.0d0 ) xtol = 1.0d-8

c-----------------------------------------------------------
c     Un-inspired initial guess: x^(0) = a / 2.
c-----------------------------------------------------------
      xn = 0.5d0 * a
```

```
c-----------------------------------------------------------
c     Newton loop.
c-----------------------------------------------------------
      write(0,*) 'Iter          xn                 '//
     &          'dxn     log10(dxn)    rn       log10(rn)'
      write(0,*)
      do iter = 1 , mxiter
         resn = xn**2 - a
         dxn  = resn / (2.0d0 * xn)
         xn   = xn - dxn
         write(0,1000) iter, xn, dxn, log10(abs(dxn)),
     &                 resn, log10(abs(resn))
1000     format(i2,1p,e26.16,e12.3,0p,f10.2,1p,e12.3,0p,f10.2)
c-----------------------------------------------------------
c        Jump out of Newton loop if soln has converged.
c-----------------------------------------------------------
         if( drelabs(dxn,xn,1.0d-10) .le. xtol ) go to 100
      end do
c-----------------------------------------------------------
c     No-convergence exit.
c-----------------------------------------------------------
      write(0,*) 'No convergence after ', mxiter,
     &          ' iterations'
      stop

c-----------------------------------------------------------
c     Normal exit, write input and estimated square root
c     to standard output.
c-----------------------------------------------------------
 100  continue
      write(0,*)
      write(*,*) a, xn
      stop
```

```
c-----------------------------------------------------------
c     Usage exit.
c-----------------------------------------------------------
 900  continue
         write(0,*) ’usage: newtsqrt <a> [<xtol>]’
      stop

      end

c===========================================================
c     drelabs:  Function useful for ’relativizing’ quantity
c     being monitored for detection of convergence.
c===========================================================
      real*8 function drelabs(dx,x,xfloor)

         implicit      none

         real*8        dx,     x,    xfloor

         if( abs(x) .lt. abs(xfloor) ) then
            drelabs = abs(dx)
         else
            drelabs = abs(dx/x)
         end if

         return

      end
```

```
############################################################
# Building 'newtsqrt' and sample output on sgi1
############################################################
sgi1% pwd; ls
/usr/people/phys410/nonlin/ex2
Makefile     newtsqrt.f

sgi1% make
f77 -g -64 -c newtsqrt.f
f77 -g -64 -L/usr/local/lib newtsqrt.o -lp410f -o newtsqrt

sgi1% newtsqrt
 usage: newtsqrt <a> [<xtol>]

############################################################
# Compute +sqrt(10) to default tolerance (1.0d-8)
#
# Note: Exact value to 16 digits is 3.162 2776 6016 8379
############################################################
sgi1% newtsqrt 10.0
Iter          xn                 dxn    log10(dxn)    rn       log10(rn)

1    3.5000000000000000E+00   1.500E+00     0.18   1.500E+01      1.18
2    3.1785714285714284E+00   3.214E-01    -0.49   2.250E+00      0.35
3    3.1623194221508828E+00   1.625E-02    -1.79   1.033E-01     -0.99
4    3.1622776604441363E+00   4.176E-05    -4.38   2.641E-04     -3.58
5    3.1622776601683795E+00   2.758E-10    -9.56   1.744E-09     -8.76

    10.00000000000000       3.162277660168380
```

```
############################################################
# Recompute with higher tolerance---an extra Newton step
# is taken, but the solution was already accurate to
# roughly machine epsilon, so there is very little change
# in the output.
############################################################
sgi1% newtsqrt 10.0 1.0e-15
Iter          xn                 dxn    log10(dxn)    rn       log10(rn)

1    3.5000000000000000E+00   1.500E+00     0.18   1.500E+01      1.18
2    3.1785714285714284E+00   3.214E-01    -0.49   2.250E+00      0.35
3    3.1623194221508828E+00   1.625E-02    -1.79   1.033E-01     -0.99
4    3.1622776604441363E+00   4.176E-05    -4.38   2.641E-04     -3.58
5    3.1622776601683795E+00   2.758E-10    -9.56   1.744E-09     -8.76
6    3.1622776601683791E+00   2.809E-16   -15.55   1.776E-15    -14.75

    10.00000000000000       3.162277660168379

############################################################
# Compute +sqrt(1/2) to default tolerance (1.0d-8)
#
# Note: Exact value to 16 digits is 0.7071 0678 1186 5475
############################################################
sgi1% newtsqrt 0.5
Iter          xn                 dxn    log10(dxn)    rn       log10(rn)

1    1.1250000000000000E+00  -8.750E-01    -0.06  -4.375E-01     -0.36
2    7.8472222222222221E-01   3.403E-01    -0.47   7.656E-01     -0.12
3    7.1094518190757128E-01   7.378E-02    -1.13   1.158E-01     -0.94
4    7.0711714297003669E-01   3.828E-03    -2.42   5.443E-03     -2.26
5    7.0710678126246607E-01   1.036E-05    -4.98   1.465E-05     -4.83
6    7.0710678118654757E-01   7.592E-11   -10.12   1.074E-10     -9.97

   0.500000000000000      0.7071067811865476
```