

NAG Library Function Document

nag_dtrsv (f16pjc)

1 Purpose

nag_dtrsv (f16pjc) solves a system of equations given as a real triangular matrix.

2 Specification

```
#include <nag.h>
#include <nagf16.h>

void nag_dtrsv (Nag_OrderType order, Nag_UploType uplo, Nag_TransType trans,
               Nag_DiagType diag, Integer n, double alpha, const double a[],
               Integer pda, double x[], Integer incx, NagError *fail)
```

3 Description

nag_dtrsv (f16pjc) performs one of the matrix-vector operations

$$x \leftarrow \alpha A^{-1}x \quad \text{or} \quad x \leftarrow \alpha A^{-T}x,$$

where A is an n by n real triangular matrix, x is an n -element real vector and α is a real scalar. A^{-T} denotes A^{-T} or equivalently A^{-T} .

4 References

Basic Linear Algebra Subprograms Technical (BLAST) Forum (2001) *Basic Linear Algebra Subprograms Technical (BLAST) Forum Standard* University of Tennessee, Knoxville, Tennessee <http://www.netlib.org/blas/blast-forum/blas-report.pdf>

5 Arguments

1: **order** – Nag_OrderType *Input*

On entry: the **order** argument specifies the two-dimensional storage scheme being used, i.e., row-major ordering or column-major ordering. C language defined storage is specified by **order** = Nag_RowMajor. See Section 2.3.1.3 in How to Use the NAG Library and its Documentation for a more detailed explanation of the use of this argument.

Constraint: **order** = Nag_RowMajor or Nag_ColMajor.

2: **uplo** – Nag_UploType *Input*

On entry: specifies whether A is upper or lower triangular.

uplo = Nag_Upper
 A is upper triangular.

uplo = Nag_Lower
 A is lower triangular.

Constraint: **uplo** = Nag_Upper or Nag_Lower.

- 3: **trans** – Nag_TransType *Input*
On entry: specifies the operation to be performed.
trans = Nag_NoTrans
 $x \leftarrow \alpha A^{-1}x.$
trans = Nag_Trans or Nag_ConjTrans
 $x \leftarrow \alpha A^{-T}x.$
Constraint: **trans** = Nag_NoTrans, Nag_Trans or Nag_ConjTrans.
- 4: **diag** – Nag_DiagType *Input*
On entry: specifies whether A has nonunit or unit diagonal elements.
diag = Nag_NonUnitDiag
The diagonal elements are stored explicitly.
diag = Nag_UnitDiag
The diagonal elements are assumed to be 1 and are not referenced.
Constraint: **diag** = Nag_NonUnitDiag or Nag_UnitDiag.
- 5: **n** – Integer *Input*
On entry: n , the order of the matrix A .
Constraint: $n \geq 0$.
- 6: **alpha** – double *Input*
On entry: the scalar α .
- 7: **a**[*dim*] – const double *Input*
Note: the dimension, *dim*, of the array **a** must be at least $\max(1, \mathbf{pda} \times \mathbf{n})$.
On entry: the n by n triangular matrix A .
If **order** = Nag_ColMajor, A_{ij} is stored in **a**[($j - 1$) \times **pda** + $i - 1$].
If **order** = Nag_RowMajor, A_{ij} is stored in **a**[($i - 1$) \times **pda** + $j - 1$].
If **uplo** = Nag_Upper, the upper triangular part of A must be stored and the elements of the array below the diagonal are not referenced.
If **uplo** = Nag_Lower, the lower triangular part of A must be stored and the elements of the array above the diagonal are not referenced.
If **diag** = Nag_UnitDiag, the diagonal elements of A are assumed to be 1, and are not referenced.
- 8: **pda** – Integer *Input*
On entry: the stride separating row or column elements (depending on the value of **order**) of the matrix A in the array **a**.
Constraint: **pda** $\geq \max(1, \mathbf{n})$.
- 9: **x**[*dim*] – double *Input/Output*
Note: the dimension, *dim*, of the array **x** must be at least $\max(1, 1 + (\mathbf{n} - 1)|\mathbf{incx}|)$.
On entry: the right-hand side vector b .
On exit: the solution vector x .

- 10: **incx** – Integer *Input*
On entry: the increment in the subscripts of **x** between successive elements of *x*.
Constraint: **incx** \neq 0.
- 11: **fail** – NagError * *Input/Output*
The NAG error argument (see Section 2.7 in How to Use the NAG Library and its Documentation).

6 Error Indicators and Warnings

NE_ALLOC_FAIL

Dynamic memory allocation failed.
See Section 3.2.1.2 in How to Use the NAG Library and its Documentation for further information.

NE_BAD_PARAM

On entry, argument $\langle value \rangle$ had an illegal value.

NE_INT

On entry, **incx** = $\langle value \rangle$.
Constraint: **incx** \neq 0.
On entry, **n** = $\langle value \rangle$.
Constraint: **n** \geq 0.

NE_INT_2

On entry, **pda** = $\langle value \rangle$, **n** = $\langle value \rangle$.
Constraint: **pda** \geq max(1, **n**).

NE_INTERNAL_ERROR

An unexpected error has been triggered by this function. Please contact NAG.
See Section 3.6.6 in How to Use the NAG Library and its Documentation for further information.

NE_NO_LICENCE

Your licence key may have expired or may not have been installed correctly.
See Section 3.6.5 in How to Use the NAG Library and its Documentation for further information.

7 Accuracy

The BLAS standard requires accurate implementations which avoid unnecessary over/underflow (see Section 2.7 of Basic Linear Algebra Subprograms Technical (BLAST) Forum (2001)).

8 Parallelism and Performance

nag_dtrsv (f16pjc) is not threaded in any implementation.

9 Further Comments

No test for singularity or near-singularity of *A* is included in nag_dtrsv (f16pjc). Such tests must be performed before calling this function.

10 Example

This example solves the real triangular system of linear equations $Ax = y$, where A is the 4 by 4 triangular matrix given by

$$A = \begin{pmatrix} 4.30 & & & \\ -3.96 & -4.87 & & \\ 0.40 & 0.31 & -8.02 & \\ -0.27 & 0.07 & -5.95 & 0.12 \end{pmatrix}$$

and where

$$y = (-12.90, 16.75, -17.55, -11.04)^T.$$

The vector y is stored in array \mathbf{x} and `nag_dtrsv (f16pjc)` returns the solution in \mathbf{x} .

10.1 Program Text

```

/* nag_dtrsv (f16pjc) Example Program.
 *
 * NAGPRODCODE Version.
 *
 * Copyright 2016 Numerical Algorithms Group.
 *
 * Mark 26, 2016.
 */

#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagf16.h>

int main(void)
{
    /* Scalars */
    double alpha;
    Integer exit_status, i, incx, j, n, pda, xlen;

    /* Arrays */
    double *a = 0, *x = 0;
    char nag_enum_arg[40];

    /* Nag Types */
    NagError fail;
    Nag_OrderType order;
    Nag_TransType trans;
    Nag_UploType uplo;
    Nag_DiagType diag;

#ifdef NAG_COLUMN_MAJOR
#define A(I, J) a[(J-1)*pda + I - 1]
    order = Nag_ColMajor;
#else
#define A(I, J) a[(I-1)*pda + J - 1]
    order = Nag_RowMajor;
#endif

    exit_status = 0;
    INIT_FAIL(fail);

    printf("nag_dtrsv (f16pjc) Example Program Results\n\n");

    /* Skip heading in data file */
#ifdef _WIN32
    scanf_s("%*[\n] ");
#else
    scanf("%*[\n] ");
#endif
}

```

```

    /* Read the problem dimensions */
#ifdef _WIN32
    scanf_s("%" NAG_IFMT "%*[\n] ", &n);
#else
    scanf("%" NAG_IFMT "%*[\n] ", &n);
#endif

    /* Read the uplo storage parameter */
#ifdef _WIN32
    scanf_s("%39s%*[\n] ", nag_enum_arg, (unsigned)_countof(nag_enum_arg));
#else
    scanf("%39s%*[\n] ", nag_enum_arg);
#endif
    /* nag_enum_name_to_value (x04nac).
     * Converts NAG enum member name to value
     */
    uplo = (Nag_UploType) nag_enum_name_to_value(nag_enum_arg);
    /* Read the transpose parameter */
#ifdef _WIN32
    scanf_s("%39s%*[\n] ", nag_enum_arg, (unsigned)_countof(nag_enum_arg));
#else
    scanf("%39s%*[\n] ", nag_enum_arg);
#endif
    /* nag_enum_name_to_value (x04nac), see above. */
    trans = (Nag_TransType) nag_enum_name_to_value(nag_enum_arg);
    /* Read the unit-diagonal parameter */
#ifdef _WIN32
    scanf_s("%39s%*[\n] ", nag_enum_arg, (unsigned)_countof(nag_enum_arg));
#else
    scanf("%39s%*[\n] ", nag_enum_arg);
#endif
    /* nag_enum_name_to_value (x04nac), see above. */
    diag = (Nag_DiagType) nag_enum_name_to_value(nag_enum_arg);

    /* Read scalar parameters */
#ifdef _WIN32
    scanf_s("%lf%*[\n] ", &alpha);
#else
    scanf("%lf%*[\n] ", &alpha);
#endif
    /* Read increment parameter */
#ifdef _WIN32
    scanf_s("%" NAG_IFMT "%*[\n] ", &incx);
#else
    scanf("%" NAG_IFMT "%*[\n] ", &incx);
#endif

    pda = n;
    xlen = MAX(1, 1 + (n - 1) * ABS(incx));

    if (n > 0) {
        /* Allocate memory */
        if (!(a = NAG_ALLOC(pda * n, double)) || !(x = NAG_ALLOC(xlen, double)))
        {
            printf("Allocation failure\n");
            exit_status = -1;
            goto END;
        }
    }
    else {
        printf("Invalid n\n");
        exit_status = 1;
        return exit_status;
    }

    /* Input matrix A and vector x */

    if (uplo == Nag_Upper) {
        for (i = 1; i <= n; ++i) {
            if (diag == Nag_NonUnitDiag)

```

```

#ifdef _WIN32
    scanf_s("%lf", &A(i, i));
#else
    scanf("%lf", &A(i, i));
#endif
    for (j = i + 1; j <= n; ++j)
#ifdef _WIN32
        scanf_s("%lf", &A(i, j));
#else
        scanf("%lf", &A(i, j));
#endif
    }
#ifdef _WIN32
    scanf_s("%*[\n] ");
#else
    scanf("%*[\n] ");
#endif
    }
    else {
        for (i = 1; i <= n; ++i) {
            for (j = 1; j < i; ++j)
#ifdef _WIN32
                scanf_s("%lf", &A(i, j));
#else
                scanf("%lf", &A(i, j));
#endif
            if (diag == Nag_NonUnitDiag)
#ifdef _WIN32
                scanf_s("%lf", &A(i, i));
#else
                scanf("%lf", &A(i, i));
#endif
            }
#ifdef _WIN32
            scanf_s("%*[\n] ");
#else
            scanf("%*[\n] ");
#endif
        }
        for (i = 0; i < xlen; ++i)
#ifdef _WIN32
            scanf_s("%lf%*[\n] ", &x[i]);
#else
            scanf("%lf%*[\n] ", &x[i]);
#endif
    }

    /* nag_dtrsv (f16pjc).
     * Solution of real triangular system of linear equations.
     */
    nag_dtrsv(order, uplo, trans, diag, n, alpha, a, pda, x, incx, &fail);
    if (fail.code != NE_NOERROR) {
        printf("Error from nag_dtrsv (f16pjc).\n%s\n", fail.message);
        exit_status = 1;
        goto END;
    }

    /* Print output vector x */
    printf("%s\n", " Solution x:");
    for (i = 0; i < xlen; ++i) {
        printf("%11f\n", x[i]);
    }

END:
    NAG_FREE(a);
    NAG_FREE(x);

    return exit_status;
}

```

10.2 Program Data

```
nag_dtrsv (f16pjc) Example Program Data
  4                               :Value of n
  Nag_Lower                       :Storage of A
  Nag_NoTrans                     :Transpose A?
  Nag_NonUnitDiag                 :Unit diagonal elements?
  1.0                             :Value of alpha
  1                               :Value of incx
  4.30
 -3.96  -4.87
  0.40  0.31  -8.02
 -0.27  0.07  -5.95  0.12  :End of matrix A
-12.90
 16.75
-17.55
-11.04                          :End of vector x
```

10.3 Program Results

```
nag_dtrsv (f16pjc) Example Program Results
```

```
Solution x:
-3.000000
-1.000000
 2.000000
 1.000000
```
