

NAG Library Routine Document

F08FFF (DORGTR)

Note: before using this routine, please read the Users' Note for your implementation to check the interpretation of ***bold italicised*** terms and other implementation-dependent details.

1 Purpose

F08FFF (DORGTR) generates the real orthogonal matrix Q , which was determined by F08FEF (DSYTRD) when reducing a symmetric matrix to tridiagonal form.

2 Specification

```
SUBROUTINE F08FFF(UPLO, N, A, LDA, TAU, WORK, LWORK, INFO)
  INTEGER          N, LDA, LWORK, INFO
  double precision A(LDA,*), TAU(*), WORK(max(1,LWORK))
  CHARACTER*1      UPLO
```

The routine may be called by its LAPACK name ***dorgtr***.

3 Description

F08FFF (DORGTR) is intended to be used after a call to F08FEF (DSYTRD), which reduces a real symmetric matrix A to symmetric tridiagonal form T by an orthogonal similarity transformation: $A = QTQ^T$. F08FEF (DSYTRD) represents the orthogonal matrix Q as a product of $n - 1$ elementary reflectors.

This routine may be used to generate Q explicitly as a square matrix.

4 References

Golub G H and Van Loan C F (1996) *Matrix Computations* (3rd Edition) Johns Hopkins University Press, Baltimore

5 Parameters

- 1: UPLO – CHARACTER*1 *Input*
On entry: this **must** be the same parameter UPLO as supplied to F08FEF (DSYTRD).
Constraint: UPLO = 'U' or 'L'.
- 2: N – INTEGER *Input*
On entry: n , the order of the matrix Q .
Constraint: $N \geq 0$.
- 3: A(LDA,*) – *double precision* array *Input/Output*
Note: the second dimension of the array A must be at least $\max(1, N)$.
On entry: details of the vectors which define the elementary reflectors, as returned by F08FEF (DSYTRD).
On exit: the n by n orthogonal matrix Q .

- 4: LDA – INTEGER *Input*
On entry: the first dimension of the array A as declared in the (sub)program from which F08FFF (DORGTR) is called.
Constraint: $LDA \geq \max(1, N)$.
- 5: TAU(*) – **double precision** array *Input*
Note: the dimension of the array TAU must be at least $\max(1, N - 1)$.
On entry: further details of the elementary reflectors, as returned by F08FEF (DSYTRD).
- 6: WORK($\max(1, LWORK)$) – **double precision** array *Workspace*
On exit: if INFO = 0, WORK(1) contains the minimum value of LWORK required for optimal performance.
- 7: LWORK – INTEGER *Input*
On entry: the dimension of the array WORK as declared in the (sub)program from which F08FFF (DORGTR) is called.
 If LWORK = -1, a workspace query is assumed; the routine only calculates the optimal size of the WORK array, returns this value as the first entry of the WORK array, and no error message related to LWORK is issued.
Suggested value: for optimal performance, $LWORK \geq (N - 1) \times nb$, where *nb* is the optimal **block size**.
Constraint: $LWORK \geq \max(1, N - 1)$ or LWORK = -1.
- 8: INFO – INTEGER *Output*
On exit: INFO = 0 unless the routine detects an error (see Section 6).

6 Error Indicators and Warnings

Errors or warnings detected by the routine:

INFO < 0

If INFO = -*i*, argument *i* had an illegal value. An explanatory message is output, and execution of the program is terminated.

7 Accuracy

The computed matrix *Q* differs from an exactly orthogonal matrix by a matrix *E* such that

$$\|E\|_2 = O(\epsilon),$$

where ϵ is the **machine precision**.

8 Further Comments

The total number of floating-point operations is approximately $\frac{4}{3}n^3$.

The complex analogue of this routine is F08FTF (ZUNGTR).

9 Example

This example computes all the eigenvalues and eigenvectors of the matrix A , where

$$A = \begin{pmatrix} 2.07 & 3.87 & 4.20 & -1.15 \\ 3.87 & -0.21 & 1.87 & 0.63 \\ 4.20 & 1.87 & 1.15 & 2.06 \\ -1.15 & 0.63 & 2.06 & -1.81 \end{pmatrix}.$$

Here A is symmetric and must first be reduced to tridiagonal form by F08FEF (DSYTRD). The program then calls F08FFF (DORGTR) to form Q , and passes this matrix to F08JEF (DSTEQR) which computes the eigenvalues and eigenvectors of A .

9.1 Program Text

```
*      F08FFF Example Program Text
*      Mark 16 Release. NAG Copyright 1992.
*      .. Parameters ..
      INTEGER          NIN, NOUT
      PARAMETER        (NIN=5,NOUT=6)
      INTEGER          NMAX, LDA, LWORK, LDZ
      PARAMETER        (NMAX=8,LDA=NMAX,LWORK=64*NMAX,LDZ=NMAX)
*      .. Local Scalars ..
      INTEGER          I, IFAIL, INFO, J, N
      CHARACTER        UPLO
*      .. Local Arrays ..
      DOUBLE PRECISION A(LDA,NMAX), D(NMAX), E(NMAX), TAU(NMAX),
+      WORK(LWORK), Z(LDZ,NMAX)
*      .. External Subroutines ..
      EXTERNAL         DORGTR, DSTEQR, DSYTRD, F06QFF, X04CAF
*      .. Executable Statements ..
      WRITE (NOUT,*) 'F08FFF Example Program Results'
*      Skip heading in data file
      READ (NIN,*)
      READ (NIN,*) N
      IF (N.LE.NMAX) THEN
*
*          Read A from data file
*
*          READ (NIN,*) UPLO
*          IF (UPLO.EQ.'U') THEN
*              READ (NIN,*) ((A(I,J),J=I,N),I=1,N)
*          ELSE IF (UPLO.EQ.'L') THEN
*              READ (NIN,*) ((A(I,J),J=1,I),I=1,N)
*          END IF
*
*          Reduce A to tridiagonal form T = (Q**T)*A*Q
*
*          CALL DSYTRD(UPLO,N,A,LDA,D,E,TAU,WORK,LWORK,INFO)
*
*          Copy A into Z
*
*          CALL F06QFF(UPLO,N,N,A,LDA,Z,LDZ)
*
*          Form Q explicitly, storing the result in Z
*
*          CALL DORGTR(UPLO,N,Z,LDZ,TAU,WORK,LWORK,INFO)
*
*          Calculate all the eigenvalues and eigenvectors of A
*
*          CALL DSTEQR('V',N,D,E,Z,LDZ,WORK,INFO)
*
*          WRITE (NOUT,*)
*          IF (INFO.GT.0) THEN
*              WRITE (NOUT,*) 'Failure to converge.'
*          ELSE
*
*              Print eigenvalues and eigenvectors
*

```

```

      WRITE (NOUT,*) 'Eigenvalues'
      WRITE (NOUT,99999) (D(I),I=1,N)
      WRITE (NOUT,*)
      IFAIL = 0
*
      CALL X04CAF('General',' ',N,N,Z,LDZ,'Eigenvectors',IFAIL)
*
      END IF
      END IF
*
99999 FORMAT (3X,(8F8.4))
      END

```

9.2 Program Data

F08FFF Example Program Data

```

4                               :Value of N
'L'                             :Value of UPLO
2.07
3.87 -0.21
4.20  1.87  1.15
-1.15  0.63  2.06 -1.81      :End of matrix A

```

9.3 Program Results

F08FFF Example Program Results

Eigenvalues

```
-5.0034 -1.9987  0.2013  8.0008
```

Eigenvectors

	1	2	3	4
1	0.5658	-0.2328	-0.3965	0.6845
2	-0.3478	0.7994	-0.1780	0.4564
3	-0.4740	-0.4087	0.5381	0.5645
4	0.5781	0.3737	0.7221	0.0676
