

NAG C Library Function Document

nag_dsterf (f08jfc)

1 Purpose

nag_dsterf (f08jfc) computes all the eigenvalues of a real symmetric tridiagonal matrix.

2 Specification

```
void nag_dsterf (Integer n, double d[], double e[], NagError *fail)
```

3 Description

nag_dsterf (f08jfc) computes all the eigenvalues of a real symmetric tridiagonal matrix, using a square-root-free variant of the QR algorithm.

The function uses an explicit shift, and, like nag_dsteqr (f08jec), switches between the QR and QL variants in order to handle graded matrices effectively (see Greenbaum and Dongarra (1980)).

4 References

Greenbaum A and Dongarra J J (1980) Experiments with QR/QL methods for the symmetric triangular eigenproblem *LAPACK Working Note No. 17 (Technical Report CS-89-92)* University of Tennessee, Knoxville

Parlett B N (1998) *The Symmetric Eigenvalue Problem* SIAM, Philadelphia

5 Parameters

- 1: **n** – Integer *Input*
On entry: n , the order of the matrix T .
Constraint: $n \geq 0$.
- 2: **d**[*dim*] – double *Input/Output*
Note: the dimension, *dim*, of the array **d** must be at least $\max(1, n)$.
On entry: the diagonal elements of the tridiagonal matrix T .
On exit: the n eigenvalues in ascending order, unless **fail** > 0 (in which case see Section 6).
- 3: **e**[*dim*] – double *Input/Output*
Note: the dimension, *dim*, of the array **e** must be at least $\max(1, n - 1)$.
On entry: the off-diagonal elements of the tridiagonal matrix T .
On exit: the array is overwritten.
- 4: **fail** – NagError * *Output*
The NAG error parameter (see the Essential Introduction).

6 Error Indicators and Warnings

NE_INT

On entry, **n** = $\langle \text{value} \rangle$.
Constraint: $n \geq 0$.

NE_CONVERGENCE

The algorithm has failed to find all the eigenvalues after a total of $30 \times \mathbf{n}$ iterations; $\langle value \rangle$ elements of $\mathbf{e}$ have not converged to zero.

NE_BAD_PARAM

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

NE_INTERNAL_ERROR

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please consult NAG for assistance.

7 Accuracy

The computed eigenvalues are exact for a nearby matrix $T + E$, where

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

and ϵ is the *machine precision*.

If λ_i is an exact eigenvalue and $\tilde{\lambda}_i$ is the corresponding computed value, then

$$|\tilde{\lambda}_i - \lambda_i| \leq c(n)\epsilon\|T\|_2,$$

where $c(n)$ is a modestly increasing function of n .

8 Further Comments

The total number of floating-point operations is typically about $14n^2$, but depends on how rapidly the algorithm converges. The operations are all performed in scalar mode.

There is no complex analogue of this function.

9 Example

To compute all the eigenvalues of the symmetric tridiagonal matrix T , where

$$T = \begin{pmatrix} -6.99 & -0.44 & 0.00 & 0.00 \\ -0.44 & 7.92 & -2.63 & 0.00 \\ 0.00 & -2.63 & 2.34 & -1.18 \\ 0.00 & 0.00 & -1.18 & 0.32 \end{pmatrix}.$$

9.1 Program Text

```
/* nag_dsterf (f08jfc) Example Program.
 *
 * Copyright 2001 Numerical Algorithms Group.
 *
 * Mark 7, 2001.
 */

#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagf08.h>

int main(void)
{
    /* Scalars */
    Integer i, n, d_len, e_len;
    Integer exit_status=0;
    NagError fail;
    /* Arrays */
    double *d=0, *e=0;
```

```

INIT_FAIL(fail);
Vprintf("f08jfc Example Program Results\n\n");

/* Skip heading in data file */
Vscanf("%*[^\\n] ");
Vscanf("%ld%*[^\\n] ", &n);
d_len = n;
e_len = n-1;

/* Allocate memory */
if ( !(d = NAG_ALLOC(d_len, double)) ||
    !(e = NAG_ALLOC(e_len, double)) )
{
    Vprintf("Allocation failure\n");
    exit_status = -1;
    goto END;
}
/* Read T from data file */
for (i = 0; i < d_len; ++i)
    Vscanf("%lf", &d[i]);
for (i = 0; i < e_len; ++i)
    Vscanf("%lf", &e[i]);
/* Calculate all the eigenvalues of T*/
f08jfc(n, d, e, &fail);
if (fail.code != NE_NOERROR)
{
    Vprintf("Error from f08jfc.\\n%s\\n", fail.message);
    exit_status = 1;
    goto END;
}
/* Print eigenvalues */
Vprintf(" Eigenvalues\\n");
for (i = 0; i < n; ++i)
    Vprintf("  %7.4lf", d[i]);
Vprintf("\\n");
END:
if (d) NAG_FREE(d);
if (e) NAG_FREE(e);
return exit_status;
}

```

9.2 Program Data

```

f08jfc Example Program Data
4                               :Value of N
-6.99   7.92   2.34   0.32
-0.44  -2.63  -1.18                               :End of matrix T

```

9.3 Program Results

f08jfc Example Program Results

```

Eigenvalues
-7.0037  -0.4059   2.0028   8.9968

```
