

NAG Toolbox for MATLAB

f08ja

1 Purpose

f08ja computes all the eigenvalues and, optionally, all the eigenvectors of a real symmetric n by n tridiagonal matrix A .

2 Syntax

```
[d, e, z, info] = f08ja(jobz, d, e, 'n', n)
```

3 Description

f08ja computes all the eigenvalues and, optionally, all the eigenvectors of A using a combination of the QR and QL algorithms, with an implicit shift.

4 References

Anderson E, Bai Z, Bischof C, Blackford S, Demmel J, Dongarra J J, Du Croz J J, Greenbaum A, Hammarling S, McKenney A and Sorensen D 1999 *LAPACK Users' Guide* (3rd Edition) SIAM, Philadelphia URL: <http://www.netlib.org/lapack/lug>

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

5 Parameters

5.1 Compulsory Input Parameters

1: **jobz** – string

If **jobz** = 'N', compute eigenvalues only.

If **jobz** = 'V', compute eigenvalues and eigenvectors.

Constraint: **jobz** = 'N' or 'V'.

2: **d**(*) – double array

Note: the dimension of the array **d** must be at least $\max(1, \mathbf{n})$.

The n diagonal elements of the tridiagonal matrix A .

3: **e**(*) – double array

Note: the dimension of the array **e** must be at least $\max(1, \mathbf{n} - 1)$.

The $(n - 1)$ subdiagonal elements of the tridiagonal matrix A .

5.2 Optional Input Parameters

1: **n** – int32 scalar

Default: The dimension of the array **d**.

n , the order of the matrix.

Constraint: $\mathbf{n} \geq 0$.

5.3 Input Parameters Omitted from the MATLAB Interface

ldz, work

5.4 Output Parameters

1: **d**(*) – double array

Note: the dimension of the array **d** must be at least $\max(1, \mathbf{n})$.

If **info** = 0, the eigenvalues in ascending order.

2: **e**(*) – double array

Note: the dimension of the array **e** must be at least $\max(1, \mathbf{n} - 1)$.

The contents of **e** are destroyed.

3: **z**(ldz,*) – double array

The first dimension, **ldz**, of the array **z** must satisfy

if **jobz** = 'V', $\mathbf{ldz} \geq \max(1, \mathbf{n})$;
 $\mathbf{ldz} \geq 1$ otherwise.

The second dimension of the array must be at least $\max(1, \mathbf{n})$

If **jobz** = 'V', then if **info** = 0, **z** contains the orthonormal eigenvectors of the matrix *A*, with the *i*th column of **z** holding the eigenvector associated with **d**(*i*).

If **jobz** = 'N', **z** is not referenced.

4: **info** – int32 scalar

info = 0 unless the function detects an error (see Section 6).

6 Error Indicators and Warnings

Errors or warnings detected by the function:

info = −*i*

If **info** = −*i*, parameter *i* had an illegal value on entry. The parameters are numbered as follows:

1: **jobz**, 2: **n**, 3: **d**, 4: **e**, 5: **z**, 6: **ldz**, 7: **work**, 8: **info**.

It is possible that **info** refers to a parameter that is omitted from the MATLAB interface. This usually indicates that an error in one of the other input parameters has caused an incorrect value to be inferred.

info > 0

If **info** = *i*, the algorithm failed to converge; *i* off-diagonal elements of **e** did not converge to zero.

7 Accuracy

The computed eigenvalues and eigenvectors are exact for a nearby matrix $(A + E)$, where

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

and ϵ is the *machine precision*. See Section 4.7 of Anderson *et al.* 1999 for further details.

8 Further Comments

The total number of floating-point operations is proportional to n^2 if **jobz** = 'N' and is proportional to n^3 if **jobz** = 'V'.

9 Example

```
jobz = 'Vectors';  
d = [1;  
     4;  
     9;  
    16];  
e = [1;  
     2;  
     3];  
[dOut, eOut, z, info] = f08ja(jobz, d, e)
```

```
dOut =  
    0.6476  
    3.5470  
    8.6578  
   17.1477  
eOut =  
    0  
    0  
    0  
z =  
    0.9396    0.3388   -0.0494    0.0034  
   -0.3311    0.8628   -0.3781    0.0545  
    0.0853   -0.3648   -0.8558    0.3568  
   -0.0167    0.0879    0.3497    0.9326  
info =  
      0
```
