



Warning: Subroutine EB09 performs functions which are adequately treated by routines in other standard subroutine libraries (for example, LAPACK). The use of this routine is not recommended, and it may be removed from future releases of this library.

1 SUMMARY

Finds **all the eigenvalues of a real n by n upper Hessenberg matrix**, i.e. finds solutions λ_i of

$$\det(\mathbf{H} - \lambda_i \mathbf{I}) = 0 \quad i=1,2,\dots,n$$

where $\mathbf{H} = \{h_{ij}\}_{n \times n}$ is a real matrix which has all zero elements $h_{ij} = 0$ for $i > j+1$.

A QR method is used, see EB08A.

ATTRIBUTES — **Version:** 1.0.0. **Types:** EB09A; EB09AD. **Calls:** FD05. **Original date:** June 1973. **Origin:** HQR from references given for EB08A, modified for Harwell by S.Marlow.

2 HOW TO USE THE PACKAGE

2.1 The argument list and calling sequence

The single precision version:

```
CALL EB09A(H, IH, E, N, LFAIL)
```

The double precision version:

```
CALL EB09AD(H, IH, E, N, LFAIL)
```

H is a two-dimensional REAL (DOUBLE PRECISION in the D version) array of dimensions at least $n \times n$ (first dimension specified in **IH**), which must be set by the user to contain the elements of the matrix. The elements below the sub-diagonal need not be set to zero (since the matrix is upper Hessenberg) as they are assumed to be zero. The matrix including the part below the sub-diagonal is overwritten by the subroutine.

IH is an INTEGER variable which must be set by the user to the first dimension of the array **H**. **Restriction:** $\text{IH} \geq n$

E is a two-dimensional REAL (DOUBLE PRECISION in the D version) array of first dimension 2 which will be set by the subroutine to contain the eigenvalues. $E(1, I)$, $E(2, I)$ containing the real and imaginary parts of the I th eigenvalue.

N is an INTEGER variable which must be set by the user to n the order of the matrix.

LFAIL is an INTEGER variable and is an error return parameter which will be set by the subroutine to have one of the following values.

- 0 successful return
- 1 value of **N** was non-positive
- $k > 0$ the QR method failed to converge for the k^{th} eigenvalue

2.2 The Common area

The subroutine uses a Common area which the user may reference by including a statement of the form

The single precision version:

```
COMMON/EB09B/ LP, ITSM
```

The double precision version:

```
COMMON/EB09BD/ LP, ITSM
```

LP is an INTEGER variable (default 6, line printer) that refers to the stream number on which diagnostic messages appear. To suppress these messages set LP to 0.

ITSM is an INTEGER variable (default 30) and is the limit on the number of iterations in finding an eigenvalue.

3 GENERAL INFORMATION

Use of Common: uses Common area EB09B/BD, (see §2.2).

Workspace: none.

Other subroutines: calls FD05.

Input/Output: error messages may be printed, (see §2.2).

4 METHOD

The eigenvalues are found by applying the QR method. See Handbook of Automatic Computation, Linear Algebra, J.H. Wilkinson, C. Reinsch, Springer-Verlag.