**Warning:** Subroutine EA09 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 symmetric tri-diagonal** matrix, i.e. finds the eigenvalues $\lambda_i$, $i$=1,2,...,$m$ from the solutions of the equation

$$\det(\mathbf{A}-\lambda\mathbf{I})=0$$

for a matrix of the form

$$\mathbf{A}=\begin{bmatrix} a_1 & b_2 & & & & \\ b_2 & a_2 & b_3 & & & \\ & b_3 & a_3 & b_4 & & \\ & & * & * & * & \\ & & & b_{m-1} & a_{m-1} & b_m \\ & & & & b_m & a_m \end{bmatrix}$$

**ATTRIBUTES — Version:** 1.0.0. **Types:** EA09C; EA09CD. **Calls:** FA05A. **Original date:** February 1970. **Origin:** J.K.Reid, Harwell.

## 2 HOW TO USE THE PACKAGE

### 2.1 The argument list

*The single precision version*

```
CALL EA09C(A,B,VALUE,M,W)
```

*The double precision version*

```
CALL EA09CD(A,B,VALUE,M,W)
```

A is a REAL (DOUBLE PRECISION in the D version) array of length at least $m$ which must be set by the user to the diagonal elements $a_i$, $i$=1,2,...,$m$ of the matrix.

B is a REAL (DOUBLE PRECISION in the D version) array of length at least $m$ which the user must set to the upper off-diagonal elements $b_i$, $i$=2,3,...,$m$ of the matrix as defined in §1. Note that B(1) is not set.

VALUE is a REAL (DOUBLE PRECISION in the D version) array of length at least $m$ which will be set by the subroutine to the eigenvalues $\lambda_i$, $i$=1,2,...,$m$. These are not necessarily in any order.

M is an INTEGER variable which must be set by the user to $m$ the order of the matrix.

W is a REAL (DOUBLE PRECISION in the D version) array of length at least $m$ which is used by the subroutine as workspace.

## 3 GENERAL INFORMATION

**Use of common:** None.

**Workspace:** See argument W.

**Other routines called directly:** None.

**Input/output:** None.

## 4 METHOD

The QR algorithm is used. At each iteration the eigenvalue at the bottom 2 by 2 submatrix, which is nearest to the last diagonal element, is used as a shift and this shift is introduced implicitly by applying the first plane rotation to the matrix itself and then applying a succession of plane rotations to return the matrix to tri-diagonal form.