

# NAG Library Routine Document

## F06QVF

**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

F06QVF transforms a real upper triangular matrix to an upper Hessenberg matrix by applying a given sequence of plane rotations.

### 2 Specification

```
SUBROUTINE F06QVF (SIDE, N, K1, K2, C, S, A, LDA)
  INTEGER          N, K1, K2, LDA
  REAL (KIND=nag_wp) C(*), S(*), A(LDA,*)
  CHARACTER(1)    SIDE
```

### 3 Description

F06QVF transforms an  $n$  by  $n$  real upper triangular matrix  $U$  to an upper Hessenberg matrix  $H$ , by applying a given sequence of plane rotations from either the left or the right, in planes  $k_1$  to  $k_2$ ;  $H$  has nonzero subdiagonal elements  $h_{k+1,k}$ , for  $k = k_1, \dots, k_2 - 1$  only.

If  $SIDE = 'L'$ , the rotations are applied from the left:

$$H = PU,$$

where  $P = P_{k_1} P_{k_1+1} \cdots P_{k_2-1}$ .

If  $SIDE = 'R'$ , the rotations are applied from the right:

$$H = UP^T,$$

where  $P = P_{k_2-1} \cdots P_{k_1+1} P_{k_1}$ .

In either case,  $P_k$  is a rotation in the  $(k, k+1)$  plane.

The 2 by 2 plane rotation part of  $P_k$  has the form

$$\begin{pmatrix} c_k & s_k \\ -s_k & c_k \end{pmatrix}.$$

### 4 References

None.

### 5 Parameters

1:  $SIDE$  – CHARACTER(1) *Input*

*On entry:* specifies whether  $U$  is operated on from the left or the right.

$SIDE = 'L'$

$U$  is pre-multiplied from the left.

$SIDE = 'R'$

$U$  is post-multiplied from the right.

*Constraint:*  $SIDE = 'L'$  or  $'R'$ .

- 2: N – INTEGER *Input*  
*On entry:*  $n$ , the order of the matrices  $U$  and  $H$ .  
*Constraint:*  $N \geq 0$ .
- 3: K1 – INTEGER *Input*  
4: K2 – INTEGER *Input*  
*On entry:* the values  $k_1$  and  $k_2$ .  
If  $K1 < 1$  or  $K2 \leq K1$  or  $K2 > N$ , an immediate return is effected.
- 5: C(\*) – REAL (KIND=nag\_wp) array *Input*  
**Note:** the dimension of the array C must be at least  $K2 - K1$ .  
*On entry:*  $C(k)$  must hold  $c_k$ , the cosine of the rotation  $P_k$ , for  $k = k_1, \dots, k_2 - 1$ .
- 6: S(\*) – REAL (KIND=nag\_wp) array *Input/Output*  
**Note:** the dimension of the array S must be at least  $K2 - K1$ .  
*On entry:*  $S(k)$  must hold  $s_k$ , the sine of the rotation  $P_k$ , for  $k = k_1, \dots, k_2 - 1$ .  
*On exit:*  $S(k)$  holds  $h_{k+1,k}$ , the subdiagonal element of  $H$ , for  $k = k_1, \dots, k_2 - 1$ .
- 7: A(LDA,\*) – REAL (KIND=nag\_wp) array *Input/Output*  
**Note:** the second dimension of the array A must be at least N.  
*On entry:* the  $n$  by  $n$  upper triangular matrix  $U$ .  
*On exit:* the upper triangular part of the upper Hessenberg matrix  $H$ .
- 8: LDA – INTEGER *Input*  
*On entry:* the first dimension of the array A as declared in the (sub)program from which F06QVF is called.  
*Constraint:*  $LDA \geq \max(1, N)$ .

## 6 Error Indicators and Warnings

None.

## 7 Accuracy

Not applicable.

## 8 Parallelism and Performance

Not applicable.

## 9 Further Comments

None.

## 10 Example

None.

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