

NAG Toolbox for MATLAB

f08ck

1 Purpose

f08ck multiplies a general real m by n matrix C by the real orthogonal matrix Q from an RQ factorization computed by f08ch.

2 Syntax

```
[a, c, info] = f08ck(side, trans, a, tau, c, 'm', m, 'n', n, 'k', k)
```

3 Description

f08ck is intended to be used following a call to f08ch, which performs an RQ factorization of a real matrix A and represents the orthogonal matrix Q as a product of elementary reflectors.

This function may be used to form one of the matrix products

$$QC, \quad Q^T C, \quad CQ, \quad CQ^T,$$

overwriting the result on C , which may be any real rectangular m by n matrix.

A common application of this function is in solving underdetermined linear least squares problems, as described in the F08 Chapter Introduction, and illustrated in Section 9 of the document for f08ch.

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: **side** – string

Indicates how Q or Q^T is to be applied to C .

side = 'L'

Q or Q^T is applied to C from the left.

side = 'R'

Q or Q^T is applied to C from the right.

Constraint: **side** = 'L' or 'R'.

2: **trans** – string

Indicates whether Q or Q^T is to be applied to C .

trans = 'N'

Q is applied to C .

trans = 'T'

Q^T is applied to C .

Constraint: **trans** = 'N' or 'T'.

3: **a(lda,*) – double array**

The first dimension of the array **a** must be at least $\max(1, \mathbf{k})$

The second dimension of the array must be at least $\max(1, \mathbf{m})$ if **side** = 'L' and at least $\max(1, \mathbf{n})$ if **side** = 'R'

The i th row of **a** must contain the vector which defines the elementary reflector H_i , for $i = 1, 2, \dots, k$, as returned by f08ch.

4: **tau(*) – double array**

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

tau(i) must contain the scalar factor of the elementary reflector H_i , as returned by f08ch.

5: **c(ldc,*) – double array**

The first dimension of the array **c** must be at least $\max(1, \mathbf{m})$

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

The m by n matrix C .

5.2 Optional Input Parameters

1: **m – int32 scalar**

Default: The first dimension of the array **c**.

m , the number of rows of the matrix C .

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

2: **n – int32 scalar**

Default: The second dimension of the array **c**.

n , the number of columns of the matrix C .

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

3: **k – int32 scalar**

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

k , the number of elementary reflectors whose product defines the matrix Q .

Constraints:

if **side** = 'L', $\mathbf{m} \geq \mathbf{k} \geq 0$;
if **side** = 'R', $\mathbf{n} \geq \mathbf{k} \geq 0$.

5.3 Input Parameters Omitted from the MATLAB Interface

lda, ldc, work, lwork

5.4 Output Parameters

1: **a(lda,*)** – double array

The first dimension of the array **a** must be at least $\max(1, \mathbf{k})$

The second dimension of the array must be at least $\max(1, \mathbf{m})$ if **side** = 'L' and at least $\max(1, \mathbf{n})$ if **side** = 'R'

Is modified by f08ck but restored on exit.

2: **c ldc,*)** – double array

The first dimension of the array **c** must be at least $\max(1, \mathbf{m})$

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

c contains QC or $Q^T C$ or CQ or CQ^T as specified by **side** and **trans**.

3: **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: **side**, 2: **trans**, 3: **m**, 4: **n**, 5: **k**, 6: **a**, 7: **lda**, 8: **tau**, 9: **c**, 10: **ldc**, 11: **work**, 12: **lwork**, 13: **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.

7 Accuracy

The computed result differs from the exact result by a matrix E such that

$$\|E\|_2 = O\epsilon \|C\|_2$$

where ϵ is the *machine precision*.

8 Further Comments

The total number of floating point operations is approximately $2nk(2m - k)$ if **side** = 'L' and $2mk(2n - k)$ if **side** = 'R'.

The complex analogue of this function is f08cx.

9 Example

```
side = 'Left';
trans = 'Transpose';
a = [0.4338220307344681,    -0.2575903729991749,    7.41963189009125,
0.1856368416909003, ...
0.2488143224903187, -1.748711814871637;
0.1844127249577667,  0.4799895293926263,  0.4388842387374505,
6.202456324128018, ...
-1.891510133606282, -0.1372040879460516;
0.01994369578646629, -0.3167680294527986, -0.2364648648368558, -
0.6045739694884593, 5.664815253714481, 0.3603722260160129;
```

```
-0.2878755620736093, -0.01005279740574509, 0.1818642439766611, -  
0.2467504817773795, ...  
0.02376115750448839, -6.442227875510149];  
tau = [1.594191588947023;  
1.372667225735017;  
1.313917959741303;  
1.698516116933174];  
c = [0;  
0;  
-0.3844153250105887;  
0.07311228044065335;  
-0.616935815675838;  
-0.0698516116933174];  
[aOut, cOut, info] = f08ck(side, trans, a, tau, c)  
  
aOut =  
0.4338    -0.2576    7.4196    0.1856    0.2488    -1.7487  
0.1844     0.4800    0.4389    6.2025    -1.8915    -0.1372  
0.0199    -0.3168   -0.2365   -0.6046    5.6648    0.3604  
-0.2879   -0.0101    0.1819   -0.2468    0.0238   -6.4422  
cOut =  
0.2371  
-0.4575  
-0.0085  
-0.5192  
0.0239  
-0.0543  
info =  
0
```