

NAG Library Routine Document

F07ADF (DGETRF)

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

F07ADF (DGETRF) computes the LU factorization of a real m by n matrix.

2 Specification

```
SUBROUTINE F07ADF(M, N, A, LDA, IPIV, INFO)
INTEGER          M, N, LDA, IPIV(min(M,N)), INFO
double precision A(LDA,*)
```

The routine may be called by its LAPACK name *dgetrf*.

3 Description

F07ADF (DGETRF) forms the LU factorization of a real m by n matrix A as $A = PLU$, where P is a permutation matrix, L is lower triangular with unit diagonal elements (lower trapezoidal if $m > n$) and U is upper triangular (upper trapezoidal if $m < n$). Usually A is square ($m = n$), and both L and U are triangular. The routine uses partial pivoting, with row interchanges.

4 References

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

5 Parameters

- 1: M – INTEGER *Input*
On entry: m , the number of rows of the matrix A .
Constraint: $M \geq 0$.
- 2: N – INTEGER *Input*
On entry: n , the number of columns of the matrix A .
Constraint: $N \geq 0$.
- 3: A(LDA,*) – **double precision** array *Input/Output*
Note: the second dimension of the array A must be at least $\max(1, N)$.
On entry: the m by n coefficient matrix A .
On exit: the factors L and U from the factorization $A = PLU$; the unit diagonal elements of L are not stored.
- 4: LDA – INTEGER *Input*
On entry: the first dimension of the array A as declared in the (sub)program from which F07ADF (DGETRF) is called.
Constraint: $LDA \geq \max(1, M)$.

- 5: IPIV(min(M,N)) – INTEGER array Output
On exit: the pivot indices. Row i of the matrix A was interchanged with row IPIV(i), for $i = 1, 2, \dots, \min(m, n)$.
- 6: INFO – INTEGER Output
On exit: INFO = 0 unless the routine detects an error (see Section 6).

6 Error Indicators and Warnings

Errors or warnings detected by the routine:

INFO < 0

If INFO = $-i$, the i th parameter had an illegal value. An explanatory message is output, and execution of the program is terminated.

INFO > 0

If INFO = i , $U(i, i)$ is exactly zero. The factorization has been completed, but the factor U is exactly singular, and division by zero will occur if it is used to solve a system of equations.

7 Accuracy

The computed factors L and U are the exact factors of a perturbed matrix $A + E$, where

$$|E| \leq c(\min(m, n))\epsilon P|L||U|,$$

$c(n)$ is a modest linear function of n , and ϵ is the *machine precision*.

8 Further Comments

The total number of floating-point operations is approximately $\frac{2}{3}n^3$ if $m = n$ (the usual case), $\frac{1}{3}n^2(3m - n)$ if $m > n$ and $\frac{1}{3}m^2(3n - m)$ if $m < n$.

A call to this routine with $m = n$ may be followed by calls to the routines:

F07AEF (DGETRS) to solve $AX = B$ or $A^T X = B$;

F07AGF (DGECON) to estimate the condition number of A ;

F07AJF (DGETRI) to compute the inverse of A .

The complex analogue of this routine is F07ARF (ZGETRF).

9 Example

This example computes the LU factorization of the matrix A , where

$$A = \begin{pmatrix} 1.80 & 2.88 & 2.05 & -0.89 \\ 5.25 & -2.95 & -0.95 & -3.80 \\ 1.58 & -2.69 & -2.90 & -1.04 \\ -1.11 & -0.66 & -0.59 & 0.80 \end{pmatrix}.$$

9.1 Program Text

```
*      F07ADF Example Program Text
*      Mark 15 Release. NAG Copyright 1991.
*      .. Parameters ..
      INTEGER          NIN, NOUT
      PARAMETER        (NIN=5,NOUT=6)
      INTEGER          MMAX, NMAX, LDA
      PARAMETER        (MMAX=8,NMAX=8,LDA=MMAX)
*      .. Local Scalars ..
```

```

      INTEGER          I, IFAIL, INFO, J, M, N
*    .. Local Arrays ..
      DOUBLE PRECISION A(LDA,NMAX)
      INTEGER          IPIV(NMAX)
*    .. External Subroutines ..
      EXTERNAL         DGETRF, X04CAF
*    .. Intrinsic Functions ..
      INTRINSIC        MIN
*    .. Executable Statements ..
      WRITE (NOUT,*) 'F07ADF Example Program Results'
*    Skip heading in data file
      READ (NIN,*)
      READ (NIN,*) M, N
      IF (M.LE.MMAX .AND. N.LE.NMAX) THEN
*
*        Read A from data file
*
*        READ (NIN,*) ((A(I,J),J=1,N),I=1,M)
*
*        Factorize A
*
*        CALL DGETRF(M,N,A,LDA,IPIV,INFO)
*
*        Print details of factorization
*
*        WRITE (NOUT,*)
*        IFAIL = 0
*        CALL X04CAF('General',' ',M,N,A,LDA,'Details of factorization',
+           IFAIL)
*
*        Print pivot indices
*
*        WRITE (NOUT,*)
*        WRITE (NOUT,*) 'IPIV'
*        WRITE (NOUT,99999) (IPIV(I),I=1,MIN(M,N))
*
*        IF (INFO.NE.0) WRITE (NOUT,*) 'The factor U is singular'
*
      END IF
*
99999 FORMAT ((3X,7I11))
      END

```

9.2 Program Data

F07ADF Example Program Data

4	4				:Values of M and N
1.80	2.88	2.05	-0.89		
5.25	-2.95	-0.95	-3.80		
1.58	-2.69	-2.90	-1.04		
-1.11	-0.66	-0.59	0.80		:End of matrix A

9.3 Program Results

F07ADF Example Program Results

Details of factorization

	1	2	3	4
1	5.2500	-2.9500	-0.9500	-3.8000
2	0.3429	3.8914	2.3757	0.4129
3	0.3010	-0.4631	-1.5139	0.2948
4	-0.2114	-0.3299	0.0047	0.1314

IPIV

2	2	3	4
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