

NAG Toolbox for MATLAB

f04aa

1 Purpose

f04aa calculates the approximate solution of a set of real linear equations with multiple right-hand sides, using an LU factorization with partial pivoting.

2 Syntax

```
[a, c, ifail] = f04aa(a, b, 'n', n, 'm', m)
```

3 Description

Given a set of real linear equations $AX = \mathbf{b}$, the function first computes an LU factorization of A with partial pivoting, $PA = LU$, where P is a permutation matrix, L is lower triangular and U is unit upper triangular. The columns x of the solution X are found by forward and backward substitution in $Ly = Pb$ and $Ux = y$, where b is a column of the right-hand side matrix B .

4 References

Wilkinson J H and Reinsch C 1971 *Handbook for Automatic Computation II, Linear Algebra* Springer-Verlag

5 Parameters

5.1 Compulsory Input Parameters

- 1: **a(lda,*)** – double array

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

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

The n by n matrix A .

- 2: **b(ldb,*)** – double array

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

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

The n by m right-hand side matrix B . See also Section 8.

5.2 Optional Input Parameters

- 1: **n** – int32 scalar

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

n , the order of the matrix A .

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

- 2: **m** – int32 scalar

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

m , the number of right-hand sides.

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

5.3 Input Parameters Omitted from the MATLAB Interface

lda, ldb, ldc, wkspce

5.4 Output Parameters

1: **a(lda,*) – double array**

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

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

The array contains the lower triangular matrix L and the off-diagonal elements of the upper triangular matrix U . The unit diagonal elements of U are not stored.

2: **c(ldc,*) – double array**

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

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

The n by m solution matrix X . See also Section 8.

3: **ifail – int32 scalar**

0 unless the function detects an error (see Section 6).

6 Error Indicators and Warnings

Errors or warnings detected by the function:

ifail = 1

The matrix A is singular, possibly due to rounding errors.

ifail = 2

On entry, $\mathbf{n} < 0$,
 or $\mathbf{m} < 0$,
 or $\mathbf{lda} < \max(1, \mathbf{n})$,
 or $\mathbf{ldb} < \max(1, \mathbf{n})$,
 or $\mathbf{ldc} < \max(1, \mathbf{n})$.

7 Accuracy

The accuracy of the computed solutions depends on the stability of the original matrix of coefficients. For a detailed error analysis see page 107 of Wilkinson and Reinsch 1971.

8 Further Comments

The time taken by f04aa is approximately proportional to n^3 .

If there is only one right-hand side, it is simpler to use f04ar.

9 Example

```
a = [33, 16, 72;  
     -24, -10, -57;  
     -8, -4, -17];  
b = [-359;  
     281;  
     85];
```

```
[aOut, c, ifail] = f04aa(a, b)
```

```
aOut =  
  -8.0000    0.5000    2.1250  
 -24.0000    2.0000   -3.0000  
  33.0000   -0.5000    0.3750
```

```
c =
```

```
  1
```

```
 -2
```

```
 -5
```

```
ifail =
```

```
  0
```
