

# NAG Library Routine Document

## M01DEF

**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

M01DEF ranks the rows of a matrix of real numbers in ascending or descending order.

### 2 Specification

```
SUBROUTINE M01DEF (RM, LDM, M1, M2, N1, N2, ORDER, IRANK, IFAIL)
INTEGER          LDM, M1, M2, N1, N2, IRANK(M2), IFAIL
REAL (KIND=nag_wp) RM(LDM,N2)
CHARACTER(1)    ORDER
```

### 3 Description

M01DEF ranks rows M1 to M2 of a matrix, using the data in columns N1 to N2 of those rows. The ordering is determined by first ranking the data in column N1, then ranking any tied rows according to the data in column N1 + 1, and so on up to column N2.

M01DEF uses a variant of list-merging, as described on pages 165–166 in Knuth (1973). The routine takes advantage of natural ordering in the data, and uses a simple list insertion in a preparatory pass to generate ordered lists of length at least 10. The ranking is stable: equal rows preserve their ordering in the input data.

### 4 References

Knuth D E (1973) *The Art of Computer Programming (Volume 3)* (2nd Edition) Addison–Wesley

### 5 Parameters

- 1: RM(LDM,N2) – REAL (KIND=nag\_wp) array *Input*  
*On entry:* columns N1 to N2 of rows M1 to M2 of RM must contain real data to be ranked.
- 2: LDM – INTEGER *Input*  
*On entry:* the first dimension of the array RM as declared in the (sub)program from which M01DEF is called.  
*Constraint:* LDM  $\geq$  M2.
- 3: M1 – INTEGER *Input*  
*On entry:* the index of the first row of RM to be ranked.  
*Constraint:* M1  $>$  0.
- 4: M2 – INTEGER *Input*  
*On entry:* the index of the last row of RM to be ranked.  
*Constraint:* M2  $\geq$  M1.

- 5: N1 – INTEGER *Input*  
*On entry:* the index of the first column of RM to be used.  
*Constraint:*  $N1 > 0$ .
- 6: N2 – INTEGER *Input*  
*On entry:* the index of the last column of RM to be used.  
*Constraint:*  $N2 \geq N1$ .
- 7: ORDER – CHARACTER(1) *Input*  
*On entry:* if ORDER = 'A', the rows will be ranked in ascending (i.e., nondecreasing) order.  
 If ORDER = 'D', into descending order.  
*Constraint:* ORDER = 'A' or 'D'.
- 8: IRANK(M2) – INTEGER array *Output*  
*On exit:* elements M1 to M2 of IRANK contain the ranks of the corresponding rows of RM. Note that the ranks are in the range M1 to M2: thus, if the  $i$ th row of RM is the first in the rank order, IRANK( $i$ ) is set to M1.
- 9: IFAIL – INTEGER *Input/Output*  
*On entry:* IFAIL must be set to 0, -1 or 1. If you are unfamiliar with this parameter you should refer to Section 3.3 in the Essential Introduction for details.  
 For environments where it might be inappropriate to halt program execution when an error is detected, the value -1 or 1 is recommended. If the output of error messages is undesirable, then the value 1 is recommended. Otherwise, if you are not familiar with this parameter, the recommended value is 0. **When the value -1 or 1 is used it is essential to test the value of IFAIL on exit.**  
*On exit:* IFAIL = 0 unless the routine detects an error or a warning has been flagged (see Section 6).

## 6 Error Indicators and Warnings

If on entry IFAIL = 0 or -1, explanatory error messages are output on the current error message unit (as defined by X04AAF).

Errors or warnings detected by the routine:

IFAIL = 1

On entry,  $M2 < 1$ ,  
 or  $N2 < 1$ ,  
 or  $M1 < 1$ ,  
 or  $M1 > M2$ ,  
 or  $N1 < 1$ ,  
 or  $N1 > N2$ ,  
 or  $LDM < M2$ .

IFAIL = 2

On entry, ORDER is not 'A' or 'D'.

## 7 Accuracy

Not applicable.

## 8 Further Comments

The average time taken by the routine is approximately proportional to  $n \times \log n$ , where  $n = M2 - M1 + 1$ .

## 9 Example

This example reads a matrix of real numbers and ranks the rows in ascending order.

### 9.1 Program Text

```

Program m01defe

!      M01DEF Example Program Text

!      Mark 24 Release. NAG Copyright 2012.

!      .. Use Statements ..
Use nag_library, Only: m01def, nag_wp
!      .. Implicit None Statement ..
Implicit None
!      .. Parameters ..
Integer, Parameter          :: nin = 5, nout = 6
!      .. Local Scalars ..
Integer                    :: i, ifail, j, ldm, m1, m2, n1, n2
!      .. Local Arrays ..
Real (Kind=nag_wp), Allocatable :: rm(:, :)
Integer, Allocatable       :: irank(:)
!      .. Executable Statements ..
Write (nout,*) 'M01DEF Example Program Results'

!      Skip heading in data file
Read (nin,*)

      Read (nin,*) m2, n2
      ldm = m2
      Allocate (rm(ldm,n2),irank(m2))

      m1 = 1
      n1 = 1

      Do i = m1, m2
        Read (nin,*)(rm(i,j),j=n1,n2)
      End Do

      ifail = 0
      Call m01def(rm,ldm,m1,m2,n1,n2,'Ascending',irank,ifail)

      Write (nout,*)
      Write (nout,*) 'Data                Ranks'
      Write (nout,*)

      Do i = m1, m2
        Write (nout,99999)(rm(i,j),j=n1,n2), irank(i)
      End Do

99999 Format (1X,3F7.1,I11)
End Program m01defe

```

### 9.2 Program Data

```

M01DEF Example Program Data
12 3
6.0 5.0 4.0
5.0 2.0 1.0
2.0 4.0 9.0
4.0 9.0 6.0
4.0 9.0 5.0

```

```
4.0 1.0 2.0
3.0 4.0 1.0
2.0 4.0 6.0
1.0 6.0 4.0
9.0 3.0 2.0
6.0 2.0 5.0
4.0 9.0 6.0
```

### 9.3 Program Results

M01DEF Example Program Results

Data			Ranks
6.0	5.0	4.0	11
5.0	2.0	1.0	9
2.0	4.0	9.0	3
4.0	9.0	6.0	7
4.0	9.0	5.0	6
4.0	1.0	2.0	5
3.0	4.0	1.0	4
2.0	4.0	6.0	2
1.0	6.0	4.0	1
9.0	3.0	2.0	12
6.0	2.0	5.0	10
4.0	9.0	6.0	8

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