

NAG Library Routine Document

M01CAF

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

M01CAF rearranges a vector of ***double precision*** numbers into ascending or descending order.

2 Specification

```
SUBROUTINE M01CAF(RV, M1, M2, ORDER, IFAIL)
INTEGER          M1, M2, IFAIL
double precision RV(M2)
CHARACTER*1      ORDER
```

3 Description

M01CAF is based on Singleton's implementation of the 'median-of-three' Quicksort algorithm (see Singleton (1969)), but with two additional modifications. First, small subfiles are sorted by an insertion sort on a separate final pass (see Sedgewick (1978)). Second, if a subfile is partitioned into two very unbalanced subfiles, the larger of them is flagged for special treatment: before it is partitioned, its end points are swapped with two random points within it; this makes the worst case behaviour extremely unlikely.

4 References

Sedgewick R (1978) Implementing Quicksort programs *Comm. ACM* **21** 847–857

Singleton R C (1969) An efficient algorithm for sorting with minimal storage: Algorithm 347 *Comm. ACM* **12** 185–187

5 Parameters

- 1: RV(M2) – ***double precision*** array *Input/Output*
On entry: elements M1 to M2 of RV must contain ***double precision*** values to be sorted.
On exit: these values are rearranged into sorted order.
- 2: M1 – INTEGER *Input*
On entry: the index of the first element of RV to be sorted.
Constraint: M1 > 0.
- 3: M2 – INTEGER *Input*
On entry: the index of the last element of RV to be sorted.
Constraint: M2 ≥ M1.
- 4: ORDER – CHARACTER*1 *Input*
On entry: if ORDER = 'A', the values will be sorted into ascending (i.e., nondecreasing) order.
If ORDER = 'D', into descending order.
Constraint: ORDER = 'A' or 'D'.

5: 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.

On exit: IFAIL = 0 unless the routine detects an error (see Section 6).

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.**

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 M1 < 1,
or M1 > M2.

IFAIL = 2

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

7 Accuracy

Not applicable.

8 Further Comments

The average time taken by M01CAF is approximately proportional to $n \times \log n$, where $n = M2 - M1 + 1$. The worst case time is proportional to n^2 but this is extremely unlikely to occur.

9 Example

This example reads a list of *double precision* numbers and sorts them into ascending order.

9.1 Program Text

```
*      M01CAF Example Program Text
*      Mark 14 Revised. NAG Copyright 1989.
*      .. Parameters ..
      INTEGER          NMAX
      PARAMETER        (NMAX=100)
      INTEGER          NIN, NOUT
      PARAMETER        (NIN=5,NOUT=6)
*      .. Local Scalars ..
      INTEGER          I, IFAIL, N
*      .. Local Arrays ..
      DOUBLE PRECISION RV(NMAX)
*      .. External Subroutines ..
      EXTERNAL         M01CAF
*      .. Executable Statements ..
      WRITE (NOUT,*) 'M01CAF Example Program Results'
*      Skip heading in data file
      READ (NIN,*)
      READ (NIN,*) N
      IF (N.GE.1 .AND. N.LE.NMAX) THEN
```

```

      READ (NIN,*) (RV(I),I=1,N)
      IFAIL = 0
*
      CALL M01CAF(RV,1,N,'Ascending',IFAIL)
*
      WRITE (NOUT,*)
      WRITE (NOUT,*) 'Sorted numbers'
      WRITE (NOUT,*)
      WRITE (NOUT,99999) (RV(I),I=1,N)
END IF
*
99999 FORMAT (1X,10F7.1)
END

```

9.2 Program Data

M01CAF Example Program Data

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1.3 5.9 4.1 2.3 0.5 5.8 1.3 6.5
 2.3 0.5 6.5 9.9 2.1 1.1 1.2 8.6

9.3 Program Results

M01CAF Example Program Results

Sorted numbers

0.5	0.5	1.1	1.2	1.3	1.3	2.1	2.3	2.3	4.1
5.8	5.9	6.5	6.5	8.6	9.9				
