

NAG Library Routine Document

G05MCF

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

G05MCF generates a vector of pseudorandom integers from the discrete negative binomial distribution with parameter m and probability p of success at a trial.

2 Specification

```
SUBROUTINE G05MCF(MODE, M, P, N, X, IGEN, ISEED, R, NR, IFAIL)
INTEGER          MODE, M, N, X(N), IGEN, ISEED(4), NR, IFAIL
double precision P, R(NR)
```

3 Description

G05MCF generates n integers x_i from a discrete negative binomial distribution, where the probability of $x_i = I$ (I successes before m failures) is

$$P(x_i = I) = \frac{(m + I - 1)!}{I!(m - 1)!} \times p^I \times (1 - p)^m, \quad I = 0, 1, \dots$$

The variates can be generated with or without using a search table and index. If a search table is used then it is stored with the index in a reference vector and subsequent calls to G05MCF with the same parameter value can then use this reference vector to generate further variates.

One of the initialization routines G05KBF (for a repeatable sequence if computed sequentially) or G05KCF (for a non-repeatable sequence) must be called prior to the first call to G05MCF.

4 References

Knuth D E (1981) *The Art of Computer Programming (Volume 2)* (2nd Edition) Addison–Wesley

5 Parameters

1: MODE – INTEGER *Input*

On entry: a code for selecting the operation to be performed by the routine.

MODE = 0

Set up reference vector only.

MODE = 1

Generate variates using reference vector set up in a prior call to G05MCF.

MODE = 2

Set up reference vector and generate variates.

MODE = 3

Generate variates without using the reference vector.

Constraint: MODE = 0, 1, 2 or 3.

- 2: M – INTEGER *Input*
On entry: m , the number of failures of the distribution.
Constraint: $M \geq 0$.
- 3: P – *double precision* *Input*
On entry: p , the parameter of the negative binomial distribution representing the probability of success at a single trial.
Constraint: $0.0 \leq P < 1.0$.
- 4: N – INTEGER *Input*
On entry: n , the number of pseudorandom numbers to be generated.
Constraint: $N \geq 1$.
- 5: X(N) – INTEGER array *Output*
On exit: the n pseudorandom numbers from the specified negative binomial distribution.
- 6: IGEN – INTEGER *Input*
On entry: must contain the identification number for the generator to be used to return a pseudorandom number and should remain unchanged following initialization by a prior call to G05KBF or G05KCF.
- 7: ISEED(4) – INTEGER array *Communication Array*
On entry: contains values which define the current state of the selected generator.
On exit: contains updated values defining the new state of the selected generator.
- 8: R(NR) – *double precision* array *Communication Array*
On entry: if $\text{MODE} = 1$, the reference vector from the previous call to G05MCF.
On exit: the reference vector.
- 9: NR – INTEGER *Input*
On entry: the dimension of the array R as declared in the (sub)program from which G05MCF is called.
Suggested value:
if $\text{MODE} \neq 3$, $\text{NR} = 20 + (20\sqrt{M \times P} + 30 \times P)/(1 - P)$ approximately;
otherwise $\text{NR} = 1$.
Constraints:
if $\text{MODE} = 0$ or 2 ,
 $\text{NR} > \text{int}\left(\frac{M \times P + 7.15\sqrt{M \times P} + 20.15 \times P}{1 - P} + 8.5\right) - \max\left(0, \text{int}\left(\frac{M \times P - 7.15\sqrt{M \times P}}{1 - P}\right)\right) + 7$;
if $\text{MODE} = 1$, NR should remain unchanged from the previous call to G05MCF;
if $\text{MODE} = 3$, R is not referenced.
- 10: 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, $N < 1$.

IFAIL = 2

On entry, NR is too small when MODE = 0 or 2 (see Section 5).

IFAIL = 3

On entry, $P < 0.0$,
or $P \geq 1.0$.

IFAIL = 4

On entry, $M < 0$.

IFAIL = 5

On entry, MODE \neq 0, 1, 2 or 3.

IFAIL = 6

MODE = 0 or 2 and P is so close to 1 that NR would have to be larger than the largest representable integer. Use MODE = 3 in this case.

IFAIL = 7

P or M is not the same as when R was set up in a previous call with MODE = 0 or 2.

7 Accuracy

Not applicable.

8 Further Comments

None.

9 Example

This example prints five pseudorandom integers from a negative binomial distribution with parameters $m = 60$ and $p = 0.999$, generated by a single call to G05MCF, after initialization by G05KBF.

9.1 Program Text

```
*      G05MCF Example Program Text
*      Mark 20 Release. NAG Copyright 2001.
*      .. Parameters ..
INTEGER          NOUT, N, NR
PARAMETER       (NOUT=6,N=20,NR=1)
*      .. Local Scalars ..
DOUBLE PRECISION P
```

```

      INTEGER          I, IFAIL, IGEN, M
*    .. Local Arrays ..
      DOUBLE PRECISION R(NR)
      INTEGER          ISEED(4), X(N)
*    .. External Subroutines ..
      EXTERNAL         G05KBF, G05MCF
*    .. Executable Statements ..
      WRITE (NOUT,*) 'G05MCF Example Program Results'
      WRITE (NOUT,*)
*    Set the distribution parameter P
      P = 0.999D0
      M = 60
*    Initialize the seed to a repeatable sequence
      ISEED(1) = 1762543
      ISEED(2) = 9324783
      ISEED(3) = 42344
      ISEED(4) = 742355
*    IGEN identifies the stream.
      IGEN = 1
      CALL G05KBF(IGEN,ISEED)
*    Choose MODE = 3 because P close to 1
      IFAIL = 1
      CALL G05MCF(3,M,P,N,X,IGEN,ISEED,R,NR,IFAIL)
*
      IF (IFAIL.EQ.0) THEN
*
          WRITE (NOUT,99999) (X(I),I=1,N)
*
      ELSE
          WRITE (NOUT,99998) IFAIL
      END IF
*
99999 FORMAT (1X,I12)
99998 FORMAT (1X,' ** G05MCF returned with IFAIL = ',I5)
      END

```

9.2 Program Data

None.

9.3 Program Results

G05MCF Example Program Results

```

49822
73300
57798
64791
73197
58394
61279
57579
56346
70705
59782
58087
61213
81333
47030
57082
67922
56991
46611
62691

```