NAG Fortran Library Routine Document

G05MEF

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

G05MEF generates a vector of pseudo-random integers, each from a discrete Poisson distribution with differing parameter λ.

2 Specification

```
SUBROUTINE G05MEF(M, VLAMDA, X, IGEN, ISEED, IFAIL)
INTEGER           M, X(M), IGEN, ISEED(4), IFAIL
real              VLAMDA(M)
```

3 Description

G05MEF generates m integers x_j, each from a discrete Poisson distribution with mean λ_j, where the probability of $x_j = I$ is

$$P(x_j = I) = \frac{\lambda_j^I \times e^{-\lambda_j}}{I!}, \quad I = 0, 1, \ldots,$$

where

$$0 \leq \lambda_j, \quad j = 1, 2, \ldots, m.$$

The methods used by G05MEF have low set up times and are designed for efficient use when the value of the parameter λ changes during the simulation. For large samples from a distribution with fixed λ using G05MKF to set up and use a reference vector may be more efficient.

When $\lambda < 7.5$ the product of uniforms method is used, see for example Dagpunar (1988). For larger values of λ an envelope rejection method is used with a target distribution:

$$f(x) = \tfrac{1}{3} \qquad \text{if } |x| \leq 1,$$

$$f(x) = \tfrac{1}{3}|x|^{-3} \quad \text{otherwise.}$$

This distribution is generated using a ratio of uniforms method. A similar approach has also been suggested by Ahrens and Dieter (1989). The basic method is combined with quick acceptance and rejection tests given by Maclaren (1990). For values of $\lambda \geq 87$ Stirling's approximation is used in the computation of the Poisson distribution function, otherwise tables of factorials are used as suggested by Maclaren (1990).

One of the initialisation 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 G05MEF.

4 References

Ahrens J H and Dieter U (1989) A convenient sampling method with bounded computation times for Poisson distributions *Amer. J. Math. Management Sci.* 1–13

Dagpunar J (1988) *Principles of Random Variate Generation* Oxford University Press

Maclaren N M (1990) A Poisson random number generator *Personal Communication*

5 Parameters

1: M – INTEGER *Input*

On entry: the number, m, of Poisson distributions for which pseudo-random variates are required.

Constraint: M ≥ 1.

2: VLAMDA(M) – ***real*** array *Input*

On entry: the means, λ_j, for $j = 1, 2, \ldots,$ M, of the Poisson distributions.

Constraint: $0.0 \leq$ VLAMDA$(j) \leq$ MAXINT$/2$, where MAXINT is the largest integer representable on the machine (see X02BBF).

3: X(M) – INTEGER array *Output*

On exit: the m pseudo-random numbers from the specified Poisson distributions.

4: IGEN – INTEGER *Input*

On entry: must contain the identification number for the generator to be used to return a pseudo-random number and should remain unchanged following initialisation by a prior call to one of the routines G05KBF or G05KCF.

5: ISEED(4) – INTEGER array *Input/Output*

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.

6: IFAIL – INTEGER *Input/Output*

On entry: IFAIL must be set to 0, -1 or 1. Users who are unfamiliar with this parameter should refer to Chapter P01 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, for users 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, M < 1.

IFAIL $= 2$

On entry, VLAMDA$(j) \leq 0.0$ for at least one value of j.

IFAIL $= 3$

On entry, $2 \times$ VLAMDA$(j) >$ MAXINT for at least one value of j.

7 Accuracy

Not applicable.

8 Further Comments

None.

9 Example

The example program prints ten pseudo-random integers from five Poisson distributions with means $\lambda_1 = 0.5$, $\lambda_2 = 5$, $\lambda_3 = 10$, $\lambda_4 = 50$ and $\lambda_5 = 100$. These are generated by ten calls to G05MEF, after initialisation by G05KBF.

9.1 Program Text

Note: the listing of the example program presented below uses ***bold italicised*** terms to denote precision-dependent details. Please read the Users' Note for your implementation to check the interpretation of these terms. As explained in the Essential Introduction to this manual, the results produced may not be identical for all implementations.

```
*     G05MEF Example Program Text
*     Mark 20 Release. NAG Copyright 2001.
*     .. Parameters ..
      INTEGER          NOUT, M, N
      PARAMETER        (NOUT=6,M=5,N=10)
*     .. Local Scalars ..
      INTEGER          I, IFAIL, IGEN, J
*     .. Local Arrays ..
      real             VLAMDA(M)
      INTEGER          ISEED(4), X(M)
*     .. External Subroutines ..
      EXTERNAL         G05KBF, G05MEF
*     .. Executable Statements ..
      WRITE (NOUT,*) 'G05MEF Example Program Results'
      WRITE (NOUT,*)
*     Set the distribution parameter LAMBDA
      VLAMDA(1) = 0.5e0
      VLAMDA(2) = 5.0e0
      VLAMDA(3) = 1.0e1
      VLAMDA(4) = 5.0e2
      VLAMDA(5) = 1.0e3
*     Initialise the seed to a repeatable sequence
      ISEED(1) = 1762543
      ISEED(2) = 9324783
      ISEED(3) = 423442
      ISEED(4) = 742355
*     IGEN identifies the stream.
      IGEN = 1
      CALL G05KBF(IGEN,ISEED)
      IFAIL = 0
*     Generate integers and store in X
      DO 20 I = 1, N
         CALL G05MEF(M,VLAMDA,X,IGEN,ISEED,IFAIL)
*
         WRITE (NOUT,99999) (X(J),J=1,M)
   20 CONTINUE
      STOP
*
99999 FORMAT (1X,5(1X,I12))
      END
```

9.2 Program Data

None.

9.3 Program Results

```
 G05MEF Example Program Results

           1           3          13         482        1001
           1           4          12         494        1046
           1           2          11         548         941
           0           6           8         518         977
           0           6           8         504         943
           1           6           8         502         991
           0          11           7         475         991
           1           4           5         507        1012
           0           4          13         537        1016
           0           4           7         492        1072
```